THE EFFECT OF 5E LEARNING CYCLE MODEL ON ELEVENTH GRADE STUDENTS' CONCEPTUAL UNDERSTANDING OF ACIDS AND BASES CONCEPTS AND MOTIVATION TO LEARN CHEMISTRY

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

AYLA ÇETİN DİNDAR

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF DOCTOR OF PHILOSOPHY
IN
SECONDARY SCIENCE AND MATHEMATICS EDUCATION

MARCH 2012

Approval of the thesis:

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submitted by **AYLA ÇETİN DİNDAR** in partial fulfillment of the requirements for the degree of **Doctor of Philosophy in Secondary Science and Mathematics Education Department, Middle East Technical University** by,

Prof. Dr. Canan Özgen ___________
Dean, Graduate School of **Natural and Applied Sciences**

Prof. Dr. Ömer Geban ___________
Head of Department, **Secondary Science and Mathematics Edu.**

Prof. Dr. Ömer Geban ___________
Supervisor, **Secondary Science and Mathematics Edu. Dept., METU**

Examining Committee Members:

Prof. Dr. Ayhan Yılmaz
Secondary Science and Mathematics Edu. Dept., Hacettepe University ___________

Prof. Dr. Ömer Geban
Secondary Science and Mathematics Edu. Dept., METU ___________

Assoc. Prof. Dr. Esen Uzuntiryaki
Secondary Science and Mathematics Edu. Dept., METU ___________

Assoc. Prof. Dr. Yezdan Boz
Secondary Science and Mathematics Edu. Dept., METU ___________

Assist. Prof. Dr. Ömer Faruk Özdemir
Secondary Science and Mathematics Edu. Dept., METU ___________

Date: 30/03/2012

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Name, Last name: Ayla Çetin Dindar

Signature :

ABSTRACT

THE EFFECT OF 5E LEARNING CYCLE MODEL ON ELEVENTH GRADE STUDENTS' CONCEPTUAL UNDERSTANDING OF ACIDS AND BASES CONCEPTS AND MOTIVATION TO LEARN CHEMISTRY

Çetin Dindar, Ayla

Ph.D., Department of Secondary Science and Mathematics Education

Supervisor: Prof. Dr. Ömer Geban

March 2012, 350 pages

The purpose of this study was to investigate the effect of 5E learning cycle model compared to traditional teacher-centered instruction on eleventh grade students' conceptual understanding of acids and bases concepts and student motivation to learn chemistry. The measuring tools were Three-tier Acids-Bases Test (TABT) and Chemistry Motivation Questionnaire (CMQ). There were two groups, which were the experimental and traditional group, consisting of 78 students. Before the implementation, the tools were administered as pre-tests to both groups and the semi-structured pre-interviews were conducted with eight students to determine students' prior knowledge about acids-bases and motivation to learn chemistry. During the implementation, 5E learning cycle model was used in the experimental group and the traditional teacher-centered instruction was used in the traditional group throughout eight weeks. After the implementation, the tools were administered as post-tests to both groups and the semi-structured post-interviews were conducted with the same students to determine their post knowledge about acids-bases and motivation to learn chemistry. Afterwards, the data were analyzed and descriptive and inferential statistics were obtained. Based on MANCOVA results, there was a statistical significant mean difference between the groups in favor of experimental group. Similarly, the students from experimental group scored higher motivation and this difference was found to be statistically significant. The results were analyzed in terms of gender as well, and there was found no statistically significant differences between the post-test mean scores of girls and boys for the effect of the implementation on understanding of acids-bases concepts or motivation to learn. The inferential statistics results were also supported with the students interviews.

Keywords: 5E Learning Cycle Model, Chemistry Education, Motivation to Learn Chemistry, Acids and Bases

ÖZ

5E ÖĞRENME MODELİNİN 11. SINIF ÖĞRENCİLERİNİN ASİTLER VE BAZLAR KONUSUNDAKİ KAVRAMSAL ANLAMALARINA VE KİMYA DERSİNİ ÖĞRENMEYE YÖNELİK MOTİVASYONLARI ÜZERİNE ETKİSİ

Çetin Dindar, Ayla

Doktora, Ortaöğretim Fen ve Matematik Alanları Eğitimi Bölümü

Tez Yöneticisi: Prof. Dr. Ömer Geban

Mart 2012, 350 sayfa

Bu çalışmanın amacı, 11. sınıf öğrencilerinin asitler ve bazlar konusundaki kavramsal anlamalarına ve kimya dersini öğrenmeye yönelik öğrenci motivasyonlarına geleneksel öğretmen-merkezli yöntemine kıyasla 5E öğrenme modelinin anlamlı bir etkisinin olup olmadığını incelemektir. Çalışmada kullanılan ölçme araçları Üç-Aşamalı Asitler-Bazlar Testi (ÜABT) ve Kimya Motivasyon Ölçeği (KMÖ)'dir. Çalışmada deney ve geleneksel grup olmak üzere iki farklı grup kullanılmıştır. Uygulamaya Ankara'da bir okuldan 78 öğrenci katılmış ve 2009-2010 eğitim-öğretim döneminin bahar döneminde gerçekleştirilmiştir. Uygulamadan önce öğrencilerin asitler ve bazlar konusundaki ön bilgilerini ve kimya öğrenmeye yönelik motivasyonlarını tespit etmek amacıyla her iki gruba ÜABT ve KMÖ ölçme araçları ön-test şeklinde uygulanmış ve sekiz öğrenci ile de yarı-yapılandırılmış ön-mülakatlar gerçekleştirilmiştir. Sekiz hafta süren uygulama sürecinde, deney grubundaki öğrenciler 5E öğrenme model ile geleneksel gruptaki öğrenciler ise geleneksel öğretmen-merkezli yöntem ile öğrenim görmüşlerdir. Uygulama sonrasında, öğrencilerin asitler-bazlar konusundaki asit-baz bilgilerini ve kimya öğrenmeye yönelik motivasyonlarını tespit etmek amacıyla her iki gruba da son-test olarak ÜABT ve KMÖ ölçme araçları uygulanmış ve aynı sekiz öğrenci ile yarı-yapılandırılış son-mülakatlar yapılmıştır. Uygulama sürecinde elde edilen veriler doğrultusunda tanımlayıcı ve çıkarımsal analizler gerçekleştirilmiştir. Çok değişkenli varyans analizi (MANCOVA) sonucuna göre, gruplar arasında istatistiksel olarak deney grubu lehine anlamlı bir fark tespit edilmiştir. Aynı şekilde, iki grup arasındaki KMÖ verileri incelendiğinde deney grubundaki öğrenciler lehine istatistiksel olarak anlamlı bir fark bulunmuştur. Sonuçlar cinsiyet açısından incelendiğinde, kız ve erkek öğrencilerin asitler ve bazlar kavramlarını anlamaları veya kimya öğrenmeye yönelik motivasyon son-test ortalama puanları arasında istatistiksel olarak anlamlı bir fark bulunmamıştır. Öğrencilerle yapılan mülakat verileri çıkarımsal analizleri desteklemektedir.

Anahtar Kelimeler: 5E Öğrenme Modeli, Kimya Eğitimi, Kimya Öğrenmeye Ilişkin Motivasyon, Asitler ve Bazlar

To my dear husband Bülent

&

My family

ACKNOWLEDGEMENTS

I would like to express my thanks and deepest gratitude to my supervisor Prof. Dr. Ömer Geban for his guidance and support throughout the study. His knowledge of chemistry education and experience were invaluable in completing this dissertation. In addition, he deserves special thanks for always being understanding in any situation we are and has made the environment in the department like a big family.

I would like to extend my thanks and appreciation to my committee members, Prof. Dr. Ayhan Yilmaz, Assoc. Prof. Dr. Esen Uzuntiryaki, Assoc. Prof. Dr. Yezdan Boz, and Assist. Prof. Dr. Ömer Faruk Özdemir for their valuable guidance and suggestions.

I would also like to thank Dr. M. Shawn Glynn, Assoc. Prof. Dr. Esen Uzuntiryaki, and Assoc. Prof. Dr. Yezdan Boz for their contribution and guidance during the examination of measuring tools and their constant support throughout completing this dissertation.

I reserve thanks for all my friends who held my hand and have always supported and encouraged me to keep going when the process was difficult and helped me with their guidance, patience, and understanding throughout this study. Particularly, I would like to give special thanks to Zubeyde Demet Kirbulut, Oktay Bektas, Cansel Kadioglu, Muhammed Sait & Nurgul Gokalp, Gulsum Gul Comert, Haki Pesman, and Sevgi Aydin.

I would like to also acknowledge The Scientific and Technological Research Council of Turkey (TUBITAK) for financial support during the PhD study through the National Scholarship Program (the program coded as 2211) and the Study Abroad Scholarship Program (the program coded as 2214).

I would like to specially thank my mom and dad, Gülbeyaz and Hayati Çetin. I am thankful to them for their endless love, patience, and always believing in me even though I could not always create enough time to spend with them. I am also thankful to my twin, Nejla Çetin-Kırca and my brother, Vedat Çetin. They always believed in me. I am grateful to their encouragement and supports during the current study.

Finally, but not the least, I wish to express my gratitude to my lovely husband Bülent Dindar for his patience and this dissertation could not have been completed without his support throughout the study. His constant words of encouragement kept me going throughout the process and I am truly grateful for his love and support. I am thankful to him for the joy he brought to our life.

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LIST OF ABBREVIATIONS

EX	: Experimental Group
TR	: Traditional Group
Method	: Teaching Method
TI	: Traditional Instruction
5E	: 5E Learning Cycle Model
TABT	: Three-tier Acids and Bases Test
Pre-TABT	: Three-tier Acids and Bases Pre-test
Post-TABT	: Three-tier Acids and Bases Post-test
SMQ	: Science Motivation Questionnaire
CMQ	: Chemistry Motivation Questionnaire
Pre-CMQ	: Pre-test Scores of Chemsitry Motivation Questionnaire
Post-CMQ	: Post-test Scores of Chemsitry Motivation Questionnaire
Pre-Efficacy	: Pre-test Scores of Self-Efficacy in Learning Chemistry
Pre-Anxiety	: Pre-test Scores of Anxiety about Chemistry Assessment
Pre-Goals	: Pre-test Scores of Relevance of Learning Chemistry to Personal Goals
Pre-Instrinsic	: Pre-test Scores of Intrinsically Motivated Chemistry Learning
Pre-Determination	: Pre-test Scores of Self-Determination for Learning Chemistry
Post-Efficacy	: Post-test Scores of Self-Efficacy in Learning Chemistry
Post-Anxiety	: Post-test Scores of Anxiety about Chemistry Assessment
Post-Goals	: Post-test Scores of Relevance of Learning Chemistry to Personal Goals
Post-Instrinsic	: Post-test Scores of Intrinsically Motivated Chemistry Learning
Post-Determination	: Post-test Scores of Self-Determination for Learning Chemistry
CFA	: Confirmatory Factor Analysis
I	: Interviewee
R	: Researcher
CCM	: Conceptual Change Model

CCL	: Conceptual Change Learning Strategy
CCTS	: Conceptual Change Teaching Strategies
CTS	: Constructivist Teaching Strategies
LCM	: Learning Cycle Model
DVs	: Dependent Variables
IVs	: Independent Variables

CHAPTER I

INTRODUCTION

A recurring issue in science education over 100 years has been a concern with the understanding of how students learn and how permanent learning occurs. During instructions students are often overloaded with facts; unfortunately, at the end of the instruction most of them usually leave the class with very little or no knowledge (Duit & Treagust, 2003; Glynn & Duit, 1995). For educators, the important goal is to figure out the way how students learn effectively and retain knowledge. Lately, more student-centered approaches on behalf of active learning and teaching have been used rather than traditional teacher-centered methods in which students' participation is just copying notes from the board. Many studies in various branches of science reported that student-centered approaches are more effective in meaningful learning to be occurred and student understanding of scientific concepts are more enduring compared to traditional teacher-centered methods. What makes student-centered approaches more efficient and powerful than teacher-centered methods? Why students learn more efficiently in student-centered approaches compared to traditional teacher-centered methods? The answers of these questions were searched throughout the current study.

Learning is an active process and it is crucial to engage the learner in this process, Vygostsky's belief about the nature of human intelligence was that an individual develops its mental abilities while interacting with the world (Gredler, 1992). Accordingly, Vygotsky (1986) defined the Zone of Proximal Development (ZPD) as the distance between what a child can accomplish with the guidance and without the guidance. Vygotsky's theory reflects that a learner gradually internalizes the new knowledge via using signs and symbols and a teacher interact with a learner to generate the teaching goals and achieve the tasks. While students construct the new knowledge, they are active through tasks through self-talk, inner speech, guided-participation, scaffolding, apprenticeships, and peer-interaction. According to Vygotsky, the ZPD concept encourages students to stretch the limits of what they know and can do by presenting challenging situations and tasks to promote cognitive development, and ZPD is generated during this learning and teaching interactions.

During in chemistry learning process, students often experience difficulties and lack conceptual understanding of basic concepts even though their effort (Ben-Zvi, Eylon, & Silberstein, 1986; Krajcik, 1991; Nakhleh, 1992; Osborne & Cosgrove, 1983). On the other hand, although students give correct responses to scientific question, they often have difficulties in-depth explanation of them (Ben-Zvi et al., 1982; Osborne & Cosgrove, 1983). The reason of the difficulties is most probably because of students' own conceptions that are differed from those accepted by the scientific community (Nakhleh, 1992), labeled as alternative conceptions in this present study. These alternative conceptions are obstacles for student learning since students are not able to make meaningful connections with their own conceptions and new learned conceptions, and they are occurred because of various reasons such as their personal experiences, peers, culture and language, real life experiences, media, or lack of understanding from the previous school courses; and students bring these pre-existing knowledge to the classroom (Ben-Zvi et al., 1986; Fellows, 1994; Hewson & Hewson, 1983; Nakhleh, 1992). In the current study, acids and bases concepts were investigated, which is one of the fundamental topics in chemistry. Students usually find these concepts difficult to understand because of the abstract nature of the concepts and generally develop alternative conceptions on this topic, such as all acids are strong acids, concentration is the same as strength, a strong acid has a higher pH than a weak acid, and strong acids produce more hydrogen when reacted with a metal than do weak acids (Ross & Munby, 1991) or neutralization reactions always resulted with a pH of 7 (Schmidt, 1991). In order to prevent or eliminate alternative conceptions of students, one of the efficient factors is the teaching methods used during instruction.

Changing students' alternative conceptions is not an easy task to do (DiSessa, 1982; Posner, Strike, Hewson, Gertzog, 1982). For depth of understanding, students should have opportunities to investigate natural phenomena, use their science process, higher-order thinking, and critical-thinking skills, and be encouraged to think about their pre-existing knowledge. Recently, constructivist teaching strategies have been suggested for conceptual and meaningful understanding and prevent student alternative conceptions (Glynn, Yeany, Britton, 1991; Lee & Fraser, 2000; Yager, 1995). Based on constructivism, students constructs the knowledge on their own prior knowledge and constructivist teachers help them connect new situations to previous ones (Yager, 1995).

Various trends have been emerged such as cooperative learning, discovery learning, concept maps, conceptual change model, learning cycle and inquiry, and all are based on the constructivist approach (Colburn, 2000). The entire constructivist teaching strategies aim to enable students for developing their higher-order thinking skills through guided or assisted by teachers during learning process (Posner et al., 1982). The constructivist strategies are aware of students' prior knowledge and the crucial point for them is emphasizing students' alternative conceptions and designing lessons based on their existing conceptions (Chi & Roscoe, 2002; Vosniadou, 2002; Yager, 1995) while traditional teacher-centered instructions do not consider students' alternative conceptions or integrate students in learning process.

In terms of teaching, knowledge of science is important if teachers are to be effective, not only in teaching science concepts to their students but also in encouraging their students' academic curiosity. Science educators today agree that a lack of adequate preparation of teachers to teach science often presents serious problems for effective science instruction and meaningful science learning in the schools. Specifically, a lack of science subject matter preparation and understanding of science concepts on the part of school teachers can restrict what they teach and how effectively they teach it (Anderson & Mitchener, 1994; Bruning, Schraw, & Ronning, 1999). Yager (1995) listed some strategies used by constructivist teachers such as encouraging student autonomy, initiation, and leadership; allowing student thinking to drive lessons; encouraging students to interact with each other; asking students to articulate their theories about concepts; looking for students alternative conceptions and design lessons to address any of these conceptions which do not represent those held by scientists; and encouraging students to connect ideas to phenomena in their daily lives.

The constructivist von Glaserfeld (1989, p.136) stated that "Knowledge is never acquired passively because novelty cannot be handled except through assimilation to a cognitive structure the experiencing subject already has." Based on the constructivists, accommodation and assimilation processes are crucial in terms of learning since according to them students are not empty vessels as supported by the behaviorist to transmit the knowledge from teachers. Piaget (1985) pointed out distinction between assimilation and accommodation and with accommodation to be occurred Posner, Strike, Hewson, and Gertzog (1982) proposed conceptual change model with four conditions, which were dissatisfaction with the existing concepts, intelligibility, plausibility, and fruitfulness. In science teaching, conceptual change approach based on constructivism has been underlined in recent decades, in which learners actively constructs their own knowledge or understanding, and learning is possible only to the extent that the new knowledge is built upon previous knowledge. For conceptual change to be facilitated, learning cycle model is a common strategy used (Wilder & Shuttleworth, 2004). Learning cycle model is based on constructivist learning and enables to facilitate conceptual change and meaningful learning. 5E model of instruction is extended form of learning cycle in order to be more understandable for science teachers (Lawson, 1995). Basically, students explore, explain and expand concepts during the learning process and through this process various techniques could be used such as analogy, concept mapping, hands-on activities, instructional games, minds-on activities regarding to instruction. Therefore in this study, the design of the implementation was constructed based on the 5E model of instruction taking students' prior knowledge into account and actively involving them into learning process.

In addition to cognitive perspective of learning process, affective perspective of learning process should also be taken into account such as attitudinal or motivational process. In other words, for in-depth conceptual understanding not only teaching strategies but also it is essential to take students' attitudes, motivation, or self-efficacy into account (Pintrich, Marx, & Boyle, 1993). Similarly, for students to be involved in the learning process, students should be motivated to learn by arousing their curiosity (Liem, 1987; Pintrich, Marx, & Boyle, 1993; Pintrich, 1999). Involving and participation in learning process give students motivation to learn, enjoyment, and satisfaction. Constructivist teaching strategies engage students to learning process and they experience by active participation, which increase student motivation (Ames & Archer, 1988; Britner & Pajares, 2006; Pintrich, 2003; Pintrich & De Groot, 1990; Schunk & Pajares, 2002). Considering this theoretical background in this current study, student motivation to learn chemistry was aimed to be increased via using constructivist strategies during the implementation.

Students in chemistry course should attain a depth of understanding of fundamental and a reasonable competence in dealing with chemical problems. Students often struggle to learn chemistry, because of possible reasons such as not constructing a in-depth understanding of fundamental concepts (Bektas, 2003; Ben-Zvi, Eylon, & Silberstein, 1986; Gabel, Samuel, Hunn, 1987; Nakhleh, 1992), abstract nature of chemistry (Carter & Brickhouse, 1989), difficulty in understanding the meaning of representations in terms of microscopic and macroscopic notions (Ben-Zvi, Eylon, & Silberstein, 1986; Novick & Nussbaum, 1978), or difference in concepts' daily life and scientific meaning (Nakhleh, 1992). In order to deal with student difficulties, Yager (2000) suggested that real life events should be on the focus of science teaching and learning. In addition, Starnes and Paris (2000) emphasized the importance of engaging the minds of students and it was science teachers a key role in motivating students to engage in learning. Studies have revealed that students in constructivist learning environments where students discover and inquire in chemistry perform better than peers in more teacher-centered or text-book-oriented classes on measures of general chemistry achievement or skills (Bektas, 2003).

In addition, it has always been a concern in science education research whether girls and boys differ in achievement. Studies in science literature are inconsistent in gender differences in terms of achievement. Most studies, which found significant gender differences, reported that boys performed better than girls in science courses, particularly in physical science (Brynes, 1996; Lee & Burkam, 1996; Linn & Hyde, 1989; Steinkamp & Maehr, 1984); however, there are also studies which reported that the gender differences are in favor of girls (Anderman & Young, 1994; Britner, 2008; Britner & Pajares, 2006). When motivation to learn science is taken into account, some studies also reported gender differences favoring boys (Meece, Glienke, & Burg, 2006) and particularly, in favor of boys in physical sciences and in favor of girls in biological science and chemistry (Steinkamp & Maehr, 1984). Gender difference has also been found in terms of self-efficacy beliefs of students. Girls tend to have stronger self-efficacy in earth and environmental science classes (Britner, 2008); however, some studies reported this gender difference in favor of boys (Anderman & Young, 1994;

Glynn, Taasoobshirazi, & Brickman, 2009; Lau & Roeser, 2002; Pajares, 1996; Pintrich & DeGroot, 1990). Gender differences in science mainly can be seen in terms of point of interest; girls are generally more interested in biology and chemistry and boys are generally more interested in physical sciences (Kahle et al., 1993). In this current study, gender difference was also investigated whether girls or boys differ in terms of conceptual understanding and motivation to learn chemistry.

Consequently, the purpose of this study covers high school environment, specifically 11^{th} grade high school students. High school education is compulsory in Turkiye and science learning is one of the basic subjects in the curriculum content. One of the fundamental issues of the curriculum is to educate physically, mentally, morally, spiritually, and emotionally stable, constructive, creative, and productive individuals who are also healthy in a personality and character, have a broad world view and the power of the independent and scientific thinking, respect for human rights, value personality and enterprise, and feel responsibility towards society (Ortaöğretim Kimya Dersi Öğretim Programı, 2007).

To summarize, this study will contribute to Turkish high school students' motivation to learn chemistry, their awareness of the importance of learning about chemistry, and the role of chemistry knowledge in their daily life. Students will have in-depth understanding of acids and bases concepts since traditionally these concept are difficult concepts to conceptualize; students have a great deal of difficulty keeping various types of acids and bases definitions, acids and bases reactions, strength or weakness of acids and bases. In addition, students should reveal in-depth understanding of some basic concepts such as particulate nature of matter, chemical reactions and chemical equilibrium in order to understand acids and bases concepts.

Therefore, this study focused on the constructivist approach on learning acids and bases concepts, which emphasizes that students construct their own knowledge through the interaction of what they already know and believe the ideas, events, and activities they encounter. Since based on constructivist approach in terms of learning process, students' active involvement during the intellectual development is important; construction of knowledge happens as connecting new experiences into pre-existing ones (Hewson & Hewson, 1983). The purpose of the current study was determined as the following:

- To investigate whether these is a significant effect of 5E learning cycle model oriented instruction as compared to traditionally designed teacher-centered chemistry instruction and gender on 11^{th} grade students' conceptual understanding of acids and bases concepts
- To investigate whether these is a significant effect of 5E learning cycle model oriented instruction as compared to traditionally designed teacher-centered chemistry instruction and gender on 11^{th} grade students' motivation to learn chemistry

1.1 The Main Problems

The main problem, sub-problems, and hypotheses were stated in this section. The purpose of this study is twofold: (1) to investigate the effect of 5E learning cycle oriented instruction and gender on high school student conceptual understanding of acids and bases concepts and (2) to investigate the effect of 5E learning cycle oriented instruction and gender on high school student motivation to learn chemistry. The main problems can be given as the following based on the aforementioned purpose:

1. What are the effects of 5E learning cycle model oriented instruction as compared to traditionally designed teacher-centered chemistry instruction and gender on 11th grade high school students' conceptual understanding of acids and bases concepts?
2. What are the effects of 5E learning cycle model oriented instruction as compared to traditionally designed teacher-centered chemistry instruction and gender on 11th grade high school students' motivation to learn chemistry?

1.1.1 The Sub-Problems

The sub-problems of the study are as stated below:

1. Do methods of teaching (5E learning cycle model oriented teaching versus traditionally designed teacher-centered chemistry teaching) make difference on student conceptual understanding of acids and bases concepts when the effects

of the acids and bases concepts pre-test scores and motivation to learn chemistry pre-test scores are controlled?

2. Do girls and boys differ on their conceptual understanding of acids and bases concepts when the effects of the acids and bases concepts pre-test scores and motivation to learn chemistry pre-test scores are controlled?
3. Is there any interaction between method of teaching and gender on student conceptual understanding of acids and bases concepts when the effects of the acids and bases concepts pre-test scores and motivation to learn chemistry pre-test scores are controlled?
4. Do methods of teaching (5E learning cycle model oriented teaching versus traditionally designed chemistry teaching) make difference on student motivation to learn chemistry when the effects of the acids and bases concepts pre-test scores and motivation to learn chemistry pre-test scores are controlled?
5. Do girls and boys differ on their motivation to learn chemistry when the effects of the acids and bases concepts pre-test scores and motivation to learn chemistry pre-test scores are controlled?
6. Is there any interaction between method of teaching and gender on student motivation to learn chemistry when the effects of the acids and bases concepts pre-test scores and motivation to learn chemistry pre-test scores are controlled?
7. What is students' conceptual understanding on acids and bases concepts before and after the implementation?
8. What is students' motivation to learn chemistry before and after the implementation?

1.2 The Null Hypotheses

The problems aforementioned above were tested with the following hypotheses. Hypothesis 1, 2 and 3 are related to main problems and the rest covers the sub-problems:

$H_0$1: There is no statistically significant overall effect of teaching methods taking into account 5E learning cycle model oriented teaching and traditionally designed chemistry teaching on the population mean of the collective dependent variables of eleventh grade students' post-test scores of acids and bases concepts and motivation to learn chemistry when the pre-test scores of acids and bases concepts and the pre-test scores of motivation to learn science are controlled.

$H_0$2: There is no statistically significant mean difference between girls and boys on the population means of the collective dependent variables of eleventh grade students' post-test scores of acids and bases concepts and motivation to learn chemistry when the pre-test scores of acids and bases concepts and the pre-test scores of motivation to learn science are controlled.

$H_0$3: There is no statistically significant interaction between the methods of teaching and gender on the population means of collective dependent variables of eleventh grade students' acids and bases concepts post-test scores and motivation to learn chemistry post-test scores when the pre-test scores of acids and bases concepts and the pre-test scores of motivation to learn science are controlled.

$H_0$4: There is no statistically significant difference between the post-test mean scores of students taught via 5E learning cycle model and who taught via traditionally designed chemistry instruction on the population means of acids and bases concepts post-test scores when the pre-test scores of acids and bases concepts and the pre-test scores of motivation to learn science are controlled.

$H_0$5: There is no statistically significant difference on the post-test mean scores between girls and boys on students' understanding of acids and bases concepts when the pre-test scores of acids and bases concepts and the pre-test scores of motivation to learn science are controlled.

$H_0$6: There is no statistically significant interaction between methods of teaching and gender on students' understanding of acids and bases concepts when the pre-test scores of acids and bases concepts and the pre-test scores of motivation to learn science are controlled.

$H_0$7: There is no statistically significant difference between the post-test mean scores of students taught via 5E learning cycle model oriented teaching and who taught via traditionally designed chemistry teaching on the population means of motivation to learn chemistry post-test scores when the pre-test scores of acids and bases concepts and the pre-test scores of motivation to learn science are controlled.

$H_0 8$: There is no statistically significant difference on the post-test mean scores between girls and boys on students' motivation to learn chemistry when the pre-test scores of acids and bases concepts and the pre-test scores of motivation to learn science are controlled.

$H_0 9$: There is no statistically significant interaction between methods of teaching and gender on students' motivation to learn chemistry when the pre-test scores of acids and bases concepts and the pre-test scores of motivation to learn science are controlled.

1.3 Definition of Important Terms

The terms used in the present study are given below:

- Alternative Conceptions: Any student beliefs or ideas about scientific concepts that are differed from those accepted by the scientific community.
- Constructivist Teaching Strategies: Based on constructivist strategies students' active involvement during the intellectual development is important and construction of knowledge happens as connecting new experiences into pre-existing ones, specifically emphasizing on alternative conceptions, through the interaction of what they already know and believe the ideas, events, and activities they encounter.
- Conceptual Change: A meaningful learning process in students by emphasizing their pre-existing knowledge, specifically alternative conceptions, requiring accommodating concepts (Yager, 2009).
- 5E Learning Cycle Model oriented Instruction: A model consisting five steps, which are engagement, exploration, explanation, elaboration, and evaluation, in order to enhance students' conceptual change.

- Motivation to Learn Chemistry: Students' interest or enthusiasm about and willingness to put effort into learning chemistry (Brophy, 1998).
- Traditional Chemistry Teacher-Centered Instruction: During this instruction, teachers do their teaching in a regular way without any intervention, which is usually teacher-centered.

1.4 Significance of the Study

Today, every citizen is expected to be a scientifically literate person by means of being able to understand real life events, having the joy of knowledge about the natural world, applying scientific processes in personal life, asking and suggesting reasonable solutions for questions, make decisions, be good at social communication, and able to use technology.

Chemistry is such a branch that any event in real life may be explained with the help of chemistry. Students encounter many real life events from an early age and they relate to what they already know and construct coherent understanding of these events. In a situation when students have alternative conceptions, students may experience difficulty in understanding of new concepts and when their alternative conceptions are identified, chemistry instruction can be modified by constructivist teaching strategies. There are many chemistry topics (such as matter, solids and liquids, gases, solutions, chemical reactions, chemical equilibrium, acids and bases, electrochemistry, etc.) enlighten daily events that are observed in real life. For the detailed explanation in any chemistry topic teachers can find related daily events or objects to apply in classroom, which can also encourages student curiosity and makes sense why they learn chemistry. Conceptual understanding has been a curriculum goal for many years in chemistry education. Specifically the final developed curriculum in Turkiye (Ortaöğretim Kimya Dersi Öğretim Programı, 2007) emphasizes the importance of observation, research and doing an experiment in order to develop conceptual understanding and learning. It is also mentioned in the curriculum that experiencing real life events, doing a research on science and technology, and working collaboratively are further effective factors on understanding and learning. Similarly in this study, purposive real life applications were embedded in the implementation process since students experience many substances or events related acids and bases concepts in their everyday life.

Students usually tend to learn factual knowledge presented and tries to grasp the knowledge that just they need for exams, without making any meaningful connections to what they already know or constructing an understanding of the underlying concepts, they only hold their own coherent understanding based on their prior knowledge and experience (Nakhleh, 1992; Osborne & Wittrock, 1983). In the case of Turkish high school students, students are mostly focused on the university entrance examination and performance rather than learning, the important points for them to take high grades in exams, make good memorization to answer the questions rather than inquiring for scientific facts. Based on student's performance expectations, science teachers give little attention to develop student's inquiry skills, communication skills, expressing their ideas, decision-making skills, imagination, creative thinking, attitudes concerning science and motivation to learn science, teach about scientific processes to solve problems in daily life, integrate science, or apply learned science in real life situations.

Even students are successful in conventional test, this success does not reveal that the students' understandings of given concepts. A student could get a high performance by chance and luck factor; which did not reveal meaning learning. The effectiveness of applied chemistry instructions was assessed by three-tier acids and bases concept test in order to measure students' understanding of chemistry concepts. Two-tier (Tan, Goh, Chia, & Treagust, 2002; Treagust & Chandrasegaran, 2007) and three-tier test are reported to be more efficient in assessing students' understanding of scientific concepts than conventional multiple-choice tests (Eryilmaz & Surmeli, 2002; Pesman & Eryilmaz, 2010). Teachers may have a better understanding of students' alternative conceptions or learning difficulties in required scientific concepts by assessing student understanding through three-tier concept tests; therefore, a three-tier acids and bases concept test was develop in order to assess students' alternative conceptions and their understanding in acids and bases in this current study.

The main emphasis of this study was to facilitate meaningful learning which enables in students' higher levels of understanding of chemistry concepts and promote student motivation to learn chemistry. As Vygotsky proposed, in this current study, in order to promote both cognitive development and classroom achievement efficiently in students for learning chemistry, collaboratively structured learning/teaching was aimed until students were able to accomplish the tasks. Since motivated students are more eagerly to involve in class activities, activities that motivate students to learn chemistry were aimed to develop as well as taking the importance of social interactions during learning and benefits of experiencing firsthand into account. Activities which are taken from real-world context were aimed to be developed to make students ensure about they are discovering the reasons why they are learning chemistry and how they are going to use that knowledge and skills in the future.

Although the role of constructivist strategies in increasing the comprehension of acids and bases concepts has been explored previously, this study has contributions in several ways. In the literature, there are not much studies related to increase student motivation to learn chemistry and its importance to facilitate conceptual change. This study extends previous research by examining the role of hands-on activities, those enriched with real life materials and events, have on comprehension and inferential learning. This study also makes contributions to other areas of practical and theoretical research; such as the research investigating the role that motivation to learn chemistry plays in learning. Koballa (1992) suggests that most of the science related attitudes held by teachers are acquired incidentally rather than as a result of planned efforts. This present study examines the use of hands-on activities embedded in learning cycle oriented teaching as planned instructional strategies as a causal factor in improving high school students' motivation to learn chemistry. The purpose of the study was to investigate the effectiveness of 5E learning cycle model oriented instruction on students' conceptual understanding and their motivation to learn chemistry, and to provide evidence for students' conceptual understandings of acids and bases concepts and motivation to learn chemistry between the experimental and traditional groups. As this purpose taken into consideration, this study will contribute to chemistry education in terms of chemistry learning to facilitate chemistry learning, stimulate students' motivation to learn chemistry, and promote their interest in chemistry. From a pedagogical perspective, the findings of this study will have implications for chemistry teachers as well as for chemistry teaching in general.

CHAPTER II

REVIEW OF THE RELATED LITERATURE

In this chapter, the information is given about alternative conceptions, alternative conceptions in acids and bases, theoretical background of constructivism in which constructivist teaching strategies, conceptual change approach, 5E learning cycle model was given in detail, theoretical background of motivation, motivation to learn, and gender differences in science and motivation.

2.1 Alternative Conceptions

Students own beliefs and formed by their personal experiences with everyday phenomena, media, books, parents, siblings, teachers, or peers (Carin & Bass, 2001; Driver et al., 1994). The student difficulties are crucial for science education as they may persist even after a teaching sequence and work adequately in their everyday lives; students may take on board new terms but fail essentially to change their ideas (Nussbaum, 1980); students' erroneous ideas may place an entirely different perspective on an activity from that anticipated by the teacher (Osborne and Freyberg, 1993); students may to appear to have understood the taught ideas or principles but revert to their alternative frameworks when faced with new or novel situations (Driver, 1983). These students' difficulties, incomplete or erroneous ideas have been labeled by many terms as the following:

- Alternative conceptions (Haidar & Abraham, 1991; Gilbert & Swift, 1985 as cited in Tsaparlis, 1997; Wandersee, Mintzes, & Novak, 1994),
- Alternative frameworks (Driver, 1981; Driver & Easley, 1978 as cited in Guzzetti, Snyder, Glass, & Gamas, 1993; Driver & Erickson, 1983 as cited in Nakhleh, 1992)
- Children's beliefs (Aguirre, 1978; Catherall, 1981; Nakhleh, 1992; Ross & Shuell, 1993),

- Children's science (Gilbert, Osborne, & Fensham, 1982 as cited in Guzzetti, Snyder, Glass, & Gamas, 1993; Osborne, Bell & Gilbert, 1983 as cited in Griffiths & Preston, 1992; Harrison & Treagust, 1996; Osborne & Freyberg, 1985 as cited in Nakhleh, 1992),
- Intuitive beliefs (McCloskey, 1983 as cited in Griffiths & Preston, 1992),
- Intuitive conceptions (Duit, 1995)
- Intuitive science (Perez & Alis, 1985 as cited in Guzzetti, Snyder, Glass, & Gamas, 1993),
- Misconceptions (Griffiths & Preston, 1992; Nahkleh, 1992) (Griffiths & Preston, 1992; Driver & Easley, 1978 as cited in Nakhleh, 1992; Stavy, 1988; Novak, 1988 as cited in Tsaparlis, 1997),
- Misunderstandings (Abraham, Grzybowski, Renner, and Marek, 1992; Shepherd & Renner, 1982),
- Naive beliefs (Caramazza, McCloskey, & Green, 1981 as cited in Griffiths & Preston, 1992),
- Naive Conceptions (Champagne, Gunstone, & Klopfer, 1983 as cited in Guzzetti, Snyder, Glass, & Gamas, 1993)
- Preconceptions (Andersson & Smith, 1983 as cited in Griffiths & Preston, 1992; Driver & Easley, 1978 as cited in Nakhleh, 1992; Eylon & Linn, 1988 as cited in Tsaparlis, 1997),
- Spontaneous reasoning (Viennot, 1979 as cited in Griffiths & Preston, 1992),
- Student conceptions (Duit & Treagust, 1995),
- Students' descriptive and explanatory systems (Champange, Klopfer, & Gunstone, 1982 as cited in Nakhleh, 1992),

The term alternative conception, which describes student ideas and their alternative frameworks for the organization of ideas, was used in the current study. This usage covers any student beliefs or ideas about scientific concepts that are differed from those accepted by the scientific community.

2.1.1 Sources of Alternative Conceptions

Students could hold alternative conceptions in any branch of science and student could hold these alternative conceptions from varied sources. Driver (1983;) emphasized that children construct some beliefs about natural phenomena in their efforts to make sense of everyday experiences. The other possible sources are listed as the following (Duit & Treagust, 1995; Harrison & Treagust, 1996):

- School text books
- Culture and language
- Daily usage of concepts
- Mass Media
- Teachers
- Personal real-life experiences
- Sensual experiences
- Lack of understandings from previous school courses

2.1.2 Determining Alternative Conceptions

Different types of assessments are used in science education in order to identify students' alternative conceptions such as interviews (Boo, 1998; Montfort, Brown, & Findley, 2008; Osborne & Gilbert, 1980; Thompson & Logue, 2006), open-ended questions (Calik & Ayas, 2005; Chou, 2002; Tsaparlis & Papaphotis, 2002), concept maps (Goh & Chia, 1991), oral-examinations (Hesse & Anderson, 1992), and multiple-choice questions (Schmidt, 1997; Uzuntiryaki & Geban, 2005), which both have advantages and disadvantages in practical usage (Osborne & Gilbert, 1980; Tsai & Chou, 2002).

Multiple-choice tests are often more preferable in science classes since they are easy to apply and evaluate students' understanding of the related subject; however, multiple-choice tests have some limitations in applying such as determining whether a student gives a correct response to a test consciously or just by a chance. On the other hand, interviews, open-ended questions, or oral-examinations can give more detailed information about students' alternative conceptions and their understanding on a particular concept, but a large amount of time is needed to conduct interviews, open-ended questions, or oral-examinations with many students for generalizing their alternative conceptions. Because aforementioned techniques have some limitations for practical use in classes, two tier tests are proposed to identify students' alternative conceptions (Treagust, 1986; Treagust, 1995). In order to strengthen the advantages of multiple-choice tests, two-tier tests were developed (Tan, Goh, Chia, & Treagust, 2002). First-tier of each question is a conventional multiple-choice question and second-tier of the question includes possible alternatives for the response in the first-tier. Two-tier tests are such an assessment tools that can make available for teachers or researchers to determine students' alternative conceptions and whether a student gives a correct response to a question by understanding the related subject since the second-tier of a test asks for a reason for the response in the first-tier. Therefore, this type of tests differentiates student responses from lack of knowledge as well as chance factor. Treagust (1995) also suggests that when diagnostic tests are used either at the beginning or at the end of a topic, an instructor can identify students' alternative conceptions on a related topic and based on these detected alternative conceptions the instructor can modify the related lesson plan in order to remedy students' alternative conceptions. There are some studies on the development of three-tier test in physics (Eryilmaz & Surmeli, 2002; Pesman & Eryilmaz, 2009) and chemistry (Costu, Ayas, Niaz, Unal, & Calik, 2007; Kirbulut, Geban, & Beeth, 2010), in which as an addition to two-tiers the last third tier is added to ask for whether students are sure about their responses to the previous two tiers.

2.1.3 Alternative Conceptions in Acids and Bases

There are many studies on students' conceptions of acids and bases which report that students hold many alternative conceptions in acids and bases concepts through their everyday life experiences and students bring them to class (Driver & Oldham, 1986). Students have a great deal of difficulty keeping various types of acids and bases definitions, acids and bases reactions, strength or weakness of acids and bases. The origin of student difficulties in acids and bases concepts besides the abstractness of the subject (Herron, 1975) could be as well as having alternative conceptions in acids and based concepts (Demerouti et al., 2004; Demircioglu, 2005; Hand, 1989; Hand & Treagust, 1988; Schmidt, 1997; Sheppard, 1997), the lack of understanding of the particulate nature of matter (Nakhleh, 1994; Nakhleh & Kracjik, 1993; Smith & Metz, 1996), the various definitions of acids and bases based on different theories (Carr, 1984; Schmidt, 1995; Vidyapati & Seetharamappa, 1995; Sheppard, 1997; Furio-Mas et al., 2005; Kousathana, Demerouti, & Tsaparlis, 2005), or experiencing confusing terminology in real world (Schmidt, 1991, 1995). Therefore, students should reveal in-depth understanding of some basic concepts such as particulate nature of matter, chemical reactions and chemical equilibrium in order to understand acids and bases concepts.

There have been conducted many researches that address students' difficulties and alternative conceptions in acids and bases at different level in schools; some of which are reviewed below:

Cros, Maurin, Amouroux, Chastrette, Leber, and Fayol (1986) made a study with freshman university students using semi-structured interviews and questionnaire; the findings of their study revealed that students were more knowledgeable about acids; however, had difficulties in naming three bases, in defining the pH concepts, in neutralization reactions, and in connecting their acids and bases knowledge to everyday phenomena. Students defined acids and bases more based on Bronsted-Lowry theory than Arrhenius theory. The researchers, Cros, Chastrette, and Fayol (1988), conducted the follow-up study on the same university students for the next year using a modified questionnaire and their findings addressed that students' ideas on acids and bases not much changed, still holding difficulties in naming bases. On the other hand, students made progress in defining acids and bases and likewise the prior study used more often Bronsted-Lowry theory than Arrhenius theory to define acids and bases. The determined alternative conceptions by the researchers are basic ones in acids and bases concepts therefore they were included into interview schedule and concept test in this current study.

Hand and Treagust (1988) revealed the students' ideas on acids and bases that they were: "acids eat materials away, acids can burn you, testing for acids can only be done by trying to eat something away, strong acids eat materials away faster than weak acids, reactions of acids with metals and carbonates are examples of acids eating something away, a base is something that makes up an acid, neutralization is the breakdown of an acid or to change from being an acid." Hand and Treagust determined these aforementioned alternative conceptions before the topic of acids and bases and during the topic students were enabled to do activities, each of which aimed to remedy one of the aforementioned alternative conceptions. Before the activity students were asked to accept or reject the alternative conception, and then students conducted their activity. The researchers used the strategy of conceptual conflict and concluded that this strategy was somehow successful in some alternative conceptions, but not effective in neutralization and strength of acids. Beyond conceptual understanding, the researcher also emphasized that students attitudes toward chemistry improved. A follow-up study conducted by Hand and Treagust (1991) revealed that students taught with the conceptual conflict strategy were more successful on the end of semester tests than students taught by traditional methods. The determined alternative conceptions by the researchers are basic ones in acids and bases concepts therefore they were also included into interview schedule and concept test in this current study.

Ross and Munby (1991) conducted a study with high school students on acids and bases via concepts maps and interviews; their findings revealed that students hold alternative conceptions on acids and bases, such as all acids are strong acids, concentration is the same as strength, a strong acid has a higher pH than a weak acid, and strong acids produce more hydrogen when reacted with a metal than do weak acids. The researchers emphasized that students assumed acids to be more powerful and had difficulties in understanding of bases concepts. This study supported the findings of Cros et al. (1986) about student difficulties in bases than acids. The determined alternative conceptions by the researchers are basic ones in acids and bases concepts therefore they were included into interview schedule and concept test in this current study.

Schmidt (1991) search for high school students ideas about the concepts of neutralization and specifically whether students assumed that neutralization reactions always resulted with a pH of 7. The findings revealed that students understand neutralization concept in its original meaning and neutralization reactions always end up with neutral solution having a pH of 7 regardless an acid or a base was strong or weak. The determined alternative conceptions by the researchers are basic ones in acids and bases concepts therefore they were included into interview schedule and concept test in this current study.

Driver, Squires, Rushworth, and Wood-Robinson (1994) emphasized that students were more aware of acids than bases in real-life experiences such as tasting sour foods or drinks, or news about the effects of acid rain; however, students were not much aware of bases in their everyday life. In order to investigate whether the students in this current study were aware of acids and bases in their everyday life, the questions on this purpose were developed.

Nakhleh (1992) conducted a study with high school students in order to get student models of matter via semi-structured interviews in which students were asked a set of questions about acids, bases, and pH before and after performing a series of titrations. This study disclosed another point of view on acids and bases, expressing that students had poor knowledge of acids and bases since they had lack of understanding of the particulate nature of matter. Additionally, students had difficulties in transforming verbal definitions to drawings because of confusion in representations of matter as particulate and continuous. Nakhleh and Krajcik (1993, 1994) analyzed groups using three different technologies, chemical indicators, pH meters, and microcomputer-based laboratories; based on students' concept maps, verbal commentaries and performance MBL group differentiated among others in understanding of acids and bases concepts.

Schmidt (1995) conducted a study with high school students and investigated their ideas about Bronsted-Lowry theory. Two alternative conceptions were addressed, which were students confused non-conjugate and conjugate acid-base pairs and also regarded positively and negatively charged ions as conjugate acid-base pairs. It was concluded that these misunderstanding emerged from misleading terminology, likewise the prior study of Schmidt (1991).

Vidyapati and Seetharamappa (1995) interviewed higher secondary school students and compiled a questionnaire regarding acids and bases. The researchers found that students had an alternative conception that acids and bases reactions always resulted in a neutral solution; a similar finding to that of the Schmidt (1991) study. Additionally, the researchers argued that students were not able to connected acids and bases with real life experiences since they just gave examples of acids and bases from their textbooks. Conversely to Cros et al. (1986), it was mentioned in the study that students were knowledgeable about bases as much as acids.

Smith and Metz (1996) conducted a study with graduate and undergraduate chemistry students to evaluate their understanding of acid strength and solution chemistry. The findings of students microscopic representations revealed students had difficulties in representations although they did not have any problems in solving mathematical problems in acids and bases. Students misrepresented ions, bonding and dissociation on acid strength though they successfully defined acid strength verbally. Some alternative conceptions were reported such as strong acids had strong bonds or opposite charged ions attracted strongly, and weak acids ionized partially since having weak bonds. The researchers also implied that graduate students had difficulties in expressing their representations, especially on the weak acid question. The aforementioned alternative conceptions are fundamental in strength of acids and bases concepts; therefore, these conceptions were included in the current study.

Toplis (1998) investigated 12-13 year-old students' ideas about acids and bases via interviews and classroom observations of working groups. Similar findings with Cros et al., (1986) were found on bases that students had confusions about bases and more clear on acids in giving everyday and laboratory examples. Likewise, Driver et al., (1994)'s study it was emphasized that the students had difficulties in giving examples related to acids and bases from their daily lives.

Morgil, Yilmaz, Sen, & Yavuz (2002) administrated an acids and bases test, including pH, strenght of acids and bases, conjugate acid-base pairs, neutralization, indicator, and concentration of acids and bases concepts to pre-service chemistry teachers and their findings revealed that pre-service chemistry teachers hold similar alternative conceptions with the related literature (Cross et al., 1986, 1988; Ross et al., 1991; Vidyapati et al., 1995). Demerouti, Kousathana, and Tsaparlis (2004) also investigated students' alternative conceptions on 12th grade students and their results revealed that students had difficulties in acids and bases concepts such as definition of Bronsted-Lowry, dissociation, ionization, and degree of ionization, pH, neutralization, and buffer solutions. Lin, Chiu, and Liang (2004) focused to identify student mental models on acids and bases concepts and their study emphasized that the mental models of high achievers and low achievers differed in being valid in favor of high achievers; in addition the researchers concluded that students' alternative conceptions were based on their everyday experiences and their previous instructions. Similarly, Demircioglu, Ayas and Demircioglu (2005) conducted a study on students' understanding of acids and bases concepts and found similar alternative conceptions with Hand and Treagust (1988), Nakhleh et al., (1994) and Ross et al., (1991). In addition in their study, they concluded that the students' alternative conceptions were mainly based on their daily lives and in order to create meaningful understanding for acids and bases concepts it was crucial to embedded real life events into instructions.

The alternative conceptions found in the literature on acids and bases concepts are summarized as the following and some of these alternative conceptions were used to develop the acids and bases concept test:

- Proton donor substances have basic characteristics (Morgil, Yilmaz, Sen & Yavuz, 2002)
- All substances including OH in their formulas have basic characteristics (Demircioğlu, Ayas, & Demircioğlu, 2005)
- The strength of acids/bases is related to concentration (Ross & Munby, 1991)
- The strength of acids/bases is related to pH (Demircioğlu, Ayas, & Demircioğlu, 2005; Ross & Munby, 1991)
- The pH value is positively correlated with the number of hydronium ion concentration in the solution (Demircioğlu, Ayas, & Demircioğlu, 2005)
- Mixing an acid with a base (without regard to quantities) neutralizes the base resulting in a neutral salt solution (Horton, 2007; Zoller, 1990; Schmidt, 1991; Demircioğlu, Ayas, & Demircioğlu, 2005; Bradley & Mosimege, 1998; Vidyapati & Seetharamappa, 1995)
- Acids are stronger and more dangerous than bases (Ross & Munby, 1991; Sheppard, 2006)
- In neutralization all the H and OH ions are cancelled (Horton, 2007; Demircioğlu, Ayas, & Demircioğlu, 2005)
- Mixing equal molar quantities of H_3O^+ and OH^- to distilled water results in neutral water (Horton, 2007; Demircioğlu, Ayas, & Demircioğlu, 2005)
- The strength concept in acids/bases is related with ion interactions (Smith & Metz, 1996)

- Strong acids do not dissociate because they have strong bonds (Demircioğlu, Ayas, & Demircioğlu, 2005; Ross and Munby, 1991; Smith & Metz, 1996)
- The strength of acids/bases is based on the rate of color change in litmus paper
- As the number of hydrogen atoms increases in the formula of acids/bases, their acidity/basicity becomes stronger (Demircioğlu, Ayas, & Demircioğlu, 2005)
- The pH value of a solution is only related to acidic solutions, not about basic solutions (or OH^- ions): pH is a measurement of the degree of acidity (Cros, Maurin, Amouroux, Chastrette, Leber, & Fayol, 1986)
- Strong acids/bases eat materials away faster than weak acids/bases (Hand & Treagust, 1988, p.55)
- Bubbles or bubbling is a sign of chemical reaction or strength (Nakhleh and Krajcik, 1994; Demircioğlu, Ayas, & Demircioğlu, 2005; Ross & Munby, 1991)
- As the number of hydrogen atoms increases in the formula of an acid, its acidity becomes stronger (Demircioğlu, Ayas, & Demircioğlu, 2005)
- Acids are more dangerous than bases (Nakhleh & Krajcik, 1994)
- Acids turn red litmus paper into blue (Demircioğlu, Ayas, & Demircioğlu, 2005; Bradley & Mosimege, 1998)
- Bases turn blue litmus paper into red (Demircioğlu, Ayas, & Demircioğlu, 2005)
- Indicators are used to test whether an acid is strong or weak (Bradley & Mosimege, 1998)
- In a titration reaction, a reaction does not occur unless there is an indicator (Demircioğlu, Ayas, & Demircioğlu, 2005)
- A neutralization reaction always ends with a neutral solution, without regard to strength of acids or bases (Schmidt, 1991; Vidyapati & Seetharamappa, 1995)
- Weak acids/bases dissociate easily since they have weak bonds (Smith & Metz, 1996)

The literature review reveals that students have some ideas about acids and bases; however, their ideas are not consistent with the scientists and they generally find chemistry abstract, complex and difficult to learn. The literature review revels that students' opinions on acids are more than bases and they have many alternative conceptions on acids and bases, including definitions of acids and bases, particulate nature of acids and bases, dissociation and ionization, strength of acids and bases, acid-base neutralization reactions, pH, or indicators. Hence, these aforementioned difficulties that students hold are mainly focused in this present study.

2.2 Constructivism

As mentioned in the previous section, students come into class with their previous knowledge which may be inconsistent scientifically, called as misconceptions, alternation conceptions, pre-conceptions, naive conceptions, etc. have been widely investigated in science education (the term alternative conception is used in the current study). The students' alternative conceptions are often resistant to change in traditional teaching and students form coherent understanding through their invalid conceptual structures (Driver & Easley, 1978). Since students are satisfied with their own alternative conceptions or find new conceptions incomprehensible, students could not construct meaningful understanding. For meaningful learning, it is essential for a student to realize these alternative conceptions are incorrect and contradict with knowledge that scientists accept; when a student is aware of its own knowledge contradict with what a teacher talk about, then the meaningful learning occurs (Driver & Bell, 1986).

Constructivist theory emphasizes learning is an active process based on students' prior knowledge and for meaningful understanding that it is crucial to develop multiple representation of ideas such as texting, symbolizing, graphing, or manipulating materials since different students can respond to different way of learning consistent with their individual strength. Such representations are translation of students' understanding, in which students could make connections between these representations; therefore, students integrate their understandings to apply into new situations.

Constructivist view demands very specific ways of teaching and learning, it is crucial to discuss students' pre-conceptions before instruction and teachers act as facilitators in contrasting students' ideas with scientific ones. In terms of teaching, it could be assumed that "what is taught is what is learned" (Driver & Scott, 1996, p. 106), which is not valid for the constructivist approaches. Teachers encourage students to inquire, involve actively students in learning process, bring out students' prior knowledge, and create friendly classroom environment based on the constructivism

(Yager, 1991). Therefore, constructivist approaches are students-centered, give emphasis to the applicability of science knowledge in situations in which students are interested, give emphasis in teaching nature of science concepts as well as basic ideas, replace scientific concepts to students' minds while changing students' alternative conceptions, and classroom interaction is essential in science learning. Cognitive conflict strategies, underlying Piaget's disequilibrium, focus on conceptual change by inquiring students' existing knowledge and predictions for instructional activity and then contrasting their pre-ideas with the experimental results (Dykstra, 1992). The important point in cognitive conflict is whether students realize the confliction since it may be discrepant for teachers but may not really contradictory for students.

While restructuring of traditional settings for constructivist approaches, classroom climate, students' success, and chemistry content was concerned. The implication studies of constructivist theories have been conducted by many researchers, specifically conceptual change approach (e.g. Cetin, 2009; Nussbaum & Novick, 1982; Posner, Strike, Hewson, & Gertzog, 1982), learning cycle model (e.g. Akar, 2005; Bektas, 2011; Ceylan, 2008; Pabuccu, 2008), argumentation activities (e.g. Niaz, Aguilera, Maza, & Liendo, 2002; Yalcin-Celik, 2010), meta-conceptual process (e.g. Yuruk, 2005), cooperative learning (e.g. Tastan, 2009), concept mapping (e.g. Uzuntiryaki & Geban, 2005; Yavuz, 2005) etc. In chemistry, constructivist investigations have led to significant reorganization of the teaching of such topics as the particulate nature of matter (e.g. Bektas, 2011; Gunay, 2005), solutions (e.g. Calik, Ayas, & Coll, 2008), solids and liquids (e.g. Calik, 2008), gases (e.g. Azizoglu, 2004; Cetin, 2009), chemical bonding (e.g. Pabuccu, 2004; Uzuntiryaki, 2003), chemical reactions (Ceylan, 2004), rate of reaction (e.g. Kaya, 2011; Tastan, 2009); chemical equilibrium (e.g. Akkus, Kadayifci, Atasoy, & Geban, 2003), acids and bases (e.g. Akar, 2005; Ayhan, 2004), and electrochemistry concepts (e.g. Huddle, White, & Rogers, 2000; Niaz, 2002; Tasdelen, 2011).

Conceptual change approach in taken into account in this current study and as mentioned in the previous research is more efficient in conceptual understanding and meaningful learning than traditional ones. Conceptual change approaches provide a strategy that guides teachers and students in addressing alternative conceptions and replacing them with appropriate science concepts that are reflected in the goals of instruction.

2.2.1 Conceptual Change

Learner's alternative conceptions may persist even into adulthood unless reexamining the erroneous ideas. In order to build meaningful learning, students' alternative conceptions should be changed with more accurate concepts and explanations as proposed in conceptual change model by Posner, Strike, Hewson, & Gertzog (1982). The conceptual change research has been a dominant area in science education over the past three decades based on the foundations of constructivist learning. Although this theory has been subjected to many criticisms, it still remains as an enduring subject over the past three decades. During this time, several model of conceptual change have been proposed (e.g., Carey, 1999; Chi & Slotta, 1993; diSessa, 1993; Gopnik & Wellman, 1994; Hewson, Beeth, & Thorley, 1998; Ivarsson, Schoultz, & Saljo, 2002; Posner et al., 1982; Vosniadou, 1994). These models of conceptual change differ in terms of the researchers' assumptions about the nature of learners' naïve ideas and how the process of conceptual change occurs, and their point of views vary such as synthetic meaning (e.g., Vosniadou, 1994), alternative conception refinement (e.g., Chi & Slotta, 1993); knowledge in pieces (e.g., diSessa, 1993); and sociocultural perspective via artifact support (e.g., Ivarsson, et al., 2002). They also differ in the extent to which they advocate for the coherence or consistency of naive ideas. It can be illustrated that some researchers advocate the extreme theory-like naïve ideas (e.g, Gopnik & Wellman 1994) while others advocate the knowledge in pieces (e.g., Chi & Slotta, 1993; diSessa, 1988), and some researchers take positions in between these two extremes (e.g., Carey, 1999; Vosniadou, 1992).

Before giving the emphasis on conceptual change, the crucial questions are what the learning is and how this learning process occurs; because the nature of students' naïve ideas about science is still uncertain. Initially, learning can be defined as the result of self-organization and reorganization of existing ideas (Ausubel, 1968) or according to Hewson et al., (1998) learning is the increasing the status within the context of learner's conceptual ecology. In order to construct meaningful learning environment, it is better for learners to involve actively in the learning process. During this meaningful learning process, learners relate the new information to what they already know, which is known as a constructivist approach. However, what make this meaningful learning process difficult is students' alternative conceptions that are their naïve conceptions which are not often consistent with scientific phenomena.

Students' alternative conceptions about science that may be developed via interactions with parents, peers, teachers or objects in everyday life and are not considered correct from the scientific point of view are often resistant to change. In other words, students' naïve ideas based on experience often prevent scientific understanding. These students' alternative conceptions in science have shown themselves to be useful especially in everyday life, and if they are coherent and consistent, it is so hard to change them. Students who possess alternative conceptions, it is very difficult for them to achieve further understandings in science. In order to deal with alternative conceptions many issues have been stated. One of the strongest theories which deal with these students' alternative conceptions is the conceptual change. Although the importance of students' alternative conceptions is emphasized, teachers are not usually aware of their prior conceptions. Posner et al., stated that "teachers can spend a substantial portion of their time diagnosing errors in thinking and identifying defensive moves used by students to resist accommodation" (p. 226). Teachers' responsibility in teaching for conceptual change is to help students create the dissatisfaction with their own ideas about the topic being studied. Teachers also have the responsibility to guide students to grapple with the new conception so that it becomes intelligible, plausible, and fruitful.

In the early 1980s, Posner, Strike, Hewson, & Gertzog (1982) developed a theory which is based on Kuhn's and Lakatos's philosophical approach and Piaget's notions of assimilation and accommodation and provided a model of how learners might come to change their beliefs about a subject matter. Posner et al., (1982) drew an analogy between Piaget's concepts of assimilation and accommodation, a philosopher Kuhn's concept of scientific revolution and ideas of paradigms, and Lakatos's concept of research programs and notion of theoretical hard core ideas. This model takes into considerations of both existing knowledge and the content and characteristics of new information. Two types of conceptual change were stated by Posner et al. (1982) assimilation and accommodation. Assimilation was described as "where students use existing concepts to deal with new phenomena" and accommodation was described as "the student must replace or reorganize his central concepts". In order accommodation to occur in science education, there are four fundamental conditions to be fulfilled; which are (1) must be dissatisfaction with existing conceptions, (2) a new conception must be intelligible, (3) a new conception must appear initially plausible, and (4) a new concept should suggest the possibility of a fruitful research program (Posner et al., 1982, p. 214).

The conceptual change model illustrates learning as the interaction that takes place between an individual's experiences and his/her current conceptions and viewed conceptual change as a replacement of theory-like existing conceptions with new conceptions. Similarly, Gopnik and Wellman (1994) explained conceptual change on the grounds of scientific theory change in line with the ideas proposed by Kuhn's (1970). According to Gopnik and Wellman, if children have ideas that differ with those of the scientific community, they are interpreting fundamental facts and experiences about the natural world different from how the scientific community sees the world. Gopnik and Wellman referred to this position as "theory theory" and posited that naïve ideas are coherent, unitary, and theory-like.

A decade later, the initial theory was revised (Strike & Posner, 1992); according to original model, the process of conceptual change theory was replacement of theory-like existing conceptions with new conceptions, but this was much more logical than was likely true of individual conceptual change; this view was revised and the importance of affective and social issues for conceptual change were emphasized in the revised version. Additionally, the authors underlined that the initial version was not appropriate for direct application to the classrooms and the importance of facilitating conceptual change learning was emphasized.

Although the conceptual change model has been a useful and productive model for both researches and instructional interventions and received great attention in the science education literature, the theory has also been subjected to some criticisms. It is assumed that students' conceptual knowledge is more coherent than some researchers have suggested (e.g., diSessa, 1993) and the assumption of conceptual replacement has been questioned. diSessa proposed that there would not be theory change but rather theory formation from existing fragments and mentioned on the "knowledge in pieces" and made a distinction between novice and expert's knowledge structures, in that novices use "phenomenological primitives (p-prims)" which are developed from everyday experiences while the knowledge of experts is structured, organized, coherent and systematic. He maintained that conceptual change occurred when novices' self-explanatory, isolated and fragmented knowledge structures became organized and internally coherent, coming closer to the knowledge structure of experts. On the other hand, Chi & Slotta (1993) advocated that the knowledge is more structured that diSessa suggested. It was implied that alternative conceptions provide difficulty for the new conceptions to be embedded and refinement is done for the new scientific correct conceptions.

When the conceptual chance theory is considered like a theory, everything makes sense and it is very logical; therefore, there could not be any reason for conceptual understanding not to be occurred if it is implemented as how it should be. However, in the classroom environment during the application process no theory really works, because students interact with their peers, teachers, family, and even with their environment. For this reason, besides considering students' prior knowledge, learners' affective issues such as attitudes toward a subject, motivation to learn a subject, learning strategies, self-regulations, etc. should be also taken into account. Pintrich, Marx, & Boyle (1993) criticize the "cold" view of conceptual change model and gave the emphasis on the role of students' intentions in bringing about changes. According to Pintrich et al., motivational factors are an integral and critical aspect of learning. Therefore, the process of conceptual change in the classroom is influences by individual students' motivational beliefs and by peer and teacher interactions. The researchers mentioned that personal, motivational, social, and historical factors cannot be apart from the process of conceptual change (Pintrich, et al., 1993; Pintrich, 1999). An individual student's goal for learning and classroom life, his/her self-efficacy beliefs, and his/her interest have a significant impact on the conceptual change process.

There are some critiquing studies on the coherence of naïve ideas side (e.g., Carey, 1999; Vosniadou 1992; Vosniadou et al., 2008). For example, Carey (1999) approached conceptual change from a cognitive developmental perspective, indicating that radical conceptual change involved enrichment types of mechanisms and considerable re-organization of concepts. She identified several forms of conceptual change such as differentiation and coalescence, and supported the notion of "local incommensurability" by criticizing "radical incommensurability". Framework theory approach is another theoretical approach in understanding the process of conceptual change (Vosniadou, 1992; Vosniadou et al., 2008). Vosniadou et al. (2008) endorsed that naïve ideas were not fragmented instead they formed explanatory coherence. According to Vosniadou, using enrichment types of learning mechanisms, students could form "synthetic models" causing fragmentation, internal inconsistency and misconceptions. She assumed that concepts were embedded in framework theories and she viewed conceptual change as gradual lifting of the presuppositions of the framework theory allowing the more sophisticated synthetic models.

On the other hand, there is a sociocultural perspective (Ivarsson, et al., 2002). Ivarsson et al. gave emphasis on the artifact mediation based on Vygotsky's socio-constructivism, which advocates that learners learn how to use the appropriate artifacts during learning process and they view conceptual change as using the mediator artifacts in communicating with people. Metacognition which is defined as "one's knowledge and control of own cognitive system" (Brown, 1987, p. 66) also plays a crucial role in conceptual change through helping learners to recognize the inconsistencies between their alternative ideas and the scientific concepts (Pintrich et al. 1993; Vosniadou, 1994, 2007; Vosniaodu & Ioannides, 1998). Since metacognition provides awareness of students' thinking, this awareness can be helpful for students' alternative conceptions which can promote dissatisfaction; therefore, students can conceptualize their understanding via metacognitive strategies.

Lately, intentional conceptual change has been focused on, which emphasizes on the assumption that in order to change students' alternative conceptions, students should be deliberated to change their conceptions (Sinatra & Pintrich, 2003). Additionally, another sociocultural form of conceptual change which is called "instruction-based conceptual change" is introduced by Hatano and Inagaki (2003) considering conceptual change as consciously reducing incongruity process. They emphasized that conceptual change often occurred as theory change since concepts were embedded in theories and if students are intended to review their conceptual knowledge, instruction-based conceptual change can be persuaded.

Nevertheless, obviously with some revisions the Posner et al. (1982) model still remains extremely useful; because, the conceptual change gives emphasis on the constructivist view of learning, which is believed that students always interpret what is presented to them using their pre-existing knowledge, histories, and typical ways of perceiving and acting and mentioned on conceptual ecology. Over the years, based on the researches it has been implied that the conceptual change theory helps meaningful learning via giving emphasize on intelligence, plausibility and fruitfulness of a new concepts; I think, that's why, this model has become so popular in last three decades and still is an enduring subject in science education.

There is much research about conceptual change, conceptual change research, how to implement this model, but the other important idea what make this theory enduring is that generally gives the idea of how learning may occur in learners' mind and take the consideration of learners' conceptual ecology. Many instructional strategies which create the conditions that promote the conceptual change such as conceptual change texts (e.g. Chambers and Andre, 1997), concept mapping (e.g. Uzuntiryaki & Geban, 2005), analogies (e.g. Calik, Ayas, & Coll, 2008), cognitive conflict (e.g. Jaesool, Youngjick, & Beeth, 2000), argumentation (e.g. Niaz, Aguilera, Maza, & Liendo, 2002), metacognitive strategies (e.g. Yuruk, 2007) etc. have been used in the past three decades and the results of these studies imply that most of these instructional strategies are mainly successful in promoting conceptual change theory although there are still disagreements about theoretical explanations for what changes in the conceptual change process (Chi & Slotta, 1993; diSessa, 1993; Ivarsson, et al., 2002; Vosniadou, 1994). Posner et al. (1982)'s initial conceptual change theory has evolved through itself since it had been published; in other words, it has not broken down and has formed itself and it is not "cold" anymore, additionally has more awareness, regulation, sociality and even intention in it. One of the other reasons for the conceptual change theory of being enduring can be that this theory stands over the time because it is very apt for alterations and every critic make this theory stronger.

Consequently, more recently conceptual change literature focuses on a need for comprehensive learning model that takes cognitive, affective, and metacognitive variables into account, which also involves intentional attempt. In addition, there is a need for literature how motivational beliefs work on knowledge and intentional process.

2.2.2 Constructivist Teaching Strategies

Constructivist teaching strategies are students-centered, give emphasis to the applicability of science knowledge in situations in which students are interested, give emphasis in teaching nature of science concepts as well as basic ideas, replace scientific concepts to students' minds while changing students' alternative conceptions, and classroom interaction is essential in science learning.

Driver, Guene, & Tiberghien (1985, p.198) stated that conceptual change may occur, but this process is a long-term and slow. Students make connections between new knowledge and prior conceptions. During making these connections, some misinterpretations may occur because of student prior conception in case they are not scientifically correct. In other words, in learning process students can come across with conflictions due to their prior knowledge and these conflicts may create difficulties in learning. In terms of students, in order to integrate new concepts, meaningful connections may be encouraged. Promoting for reorganization of conceptions is not easy process; students may take part in learning process actively over an extended period of time.

When students are given opportunities to discuss their own ideas with their peers in small groups, students are come to realize that they have inconsistent ideas and lack of knowledge, which promote them to reconstruct their ideas in a more coherent way. This process is known as Socratic questioning (Driver, et al., 1985). Minner, Levy and Century (2010) investigated in their meta-analysis study that students' active involvement in learning process and discovering knowledge from activities enhance more understanding of scientific concepts and conceptual learning comparing to passive techniques.

Traditional teaching strategies usually do not recognize students' conceptions and often fail in meaningful learning. Constructivist teaching strategies take into consideration students' prior knowledge, mediate the learning process, and lead to student understanding. Learning cycle model was used in this current study in order to apply constructivist approach for developing student understanding of acids and bases concepts.

2.2.2.1 Learning Cycle Model (5E)

Constructivist theory emphasizes for meaningful understanding that it is crucial to develop multiple representation of ideas such as texting, symbolizing, graphing, or manipulating materials since different students can respond to different way of learning consistent with their individual strength. Such representations are translation of students' understanding, in which students could make connections between these representations; therefore, students integrate their understandings to apply into new situations.

Learning cycle is supported by constructivist approach since students explore and experience concepts and construct their own understanding using daily life events. Learning cycle model was developed by Robert Karplus, a professor from the University of California at Berkeley, gave emphasis to student exploration for a concept using concrete materials, then the teacher invents the concept and enables students to apply the concept to a new situations (Carin & Bass, 2001; Krajcik, Czerniak, & Berger, 1999; Hammerman, 2006). Students encounter scientific concepts that do not make any sense to them, and somehow they develop unscientific explanations to these concepts. In the *exploration* stage of learning cycle, students are given opportunities to explore the concepts to construct knowledge and develop understanding of them by inquiring, doing hands-on activities, and discovering. Therefore, students can integrate real meaning to concepts by exploring and engaging in learning process. For students to understand scientific concept conceptually, it is crucial for them to have prior experiences with concepts in real life; the conceptual invention stage of learning cycle enable students to construct knowledge and assimilate new concepts into their prior knowledge. Hence, the next stage is *concept invention* step of a learning cycle; in this stage the teacher discusses the scientific concepts and introduces the scientific explanations of the concepts to students by using their prior knowledge to make the concepts understandable. Since students experience the related concepts in the previous stage, the scientific explanations could be less confused for them and could accommodate the concepts more easily into their mental structure. The exploration and concept invention stages are useful for assimilation and accommodation of the new concepts, in the following *concept application* stage the teacher enables students to recognize the importance of knowledge and expand their understanding by engaging them to new situations (Krajcik, Czerniak, Berger, 1999). This stage thus gives opportunities to students construct more meaningful knowledge from their previous learning by exploring and inventing concepts (Carin & Bass, 2001).

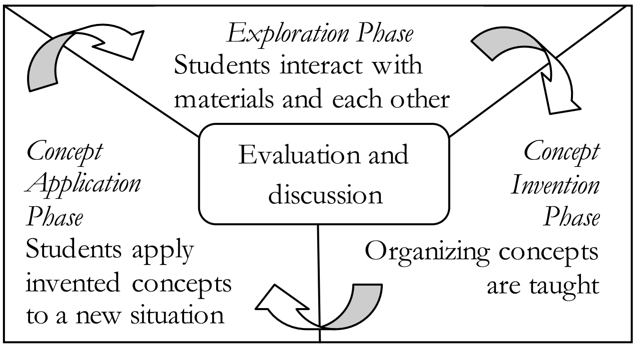

Figure 2.1 The learning cycle model by Karplus (Carin & Bass, 2001, p.117)

The proposed learning cycle model has been expanded to 5-E model including the stages of engagement, exploration, explanation, elaboration, and evaluation. In the *engagement* stage, teacher seeks for students' prior knowledge related to the concepts, which aims to give opportunities to students to think about the concepts to be learned by using analogy, telling a story, reading an article, or recalling their prior experiences and knowledge. Discrepant events can also be conducted in the engagement stage or beginning of the topic to capture the attention of the students since the unexpected events can stimulate student curiosity and interest, which would promote student motivation to learn. Additionally, discrepant events are more likely to be remembered for a long time because of intellectual engagement because engaging students in learning makes learning meaningful and improve student ability to recall knowledge. In this stage, students' alternative conceptions could also be identified. The teacher's role is to create interest and generate curiosity and the students' role is to find out what they know about the topic and find answers for questions.

In the *exploration* stage, as mentioned in the learning cycle, students develop their own understanding by exploring. The teacher's role is to encourage students to find answer to questions, observe and listen to students while interacting, direct probe questions, and act as a consultant for students. The students' role is to test predictions and form new ones based on activities, and discuss results with peers.

In the *explanation* stage, the teacher gives scientific explanations for the related concepts by creating meaning through reflection and discussion, which is similar to concept invention stage in the learning cycle. In addition, students are allowed to explain what they discovered and learned, in which students' possible alternative conceptions and discrepancies could be identified. The teacher's role is to encourage students to explain concepts and definitions in their own words, ask students' evidences, provide definitions and explanations by using students' prior knowledge and experiences. The students' role is to explain possible solutions using their observations from conducted activities, pay attention to peer's explanations, and try to comprehend explanations.

In the *elaboration* stage, students develop their understanding of the concepts by engaging in new situations such as telling a story, creative drama, production creation, demonstration, or model building; which is similar to concept application in the learning cycle. Students find more opportunities to learn through further investigation and research for making connections to student lives and interests, such as personal, family, community, national, or global issues. The teacher's role is to encourage students to apply the concepts and skills in new situations and expect students to use scientific definitions. The students' role is to apply new concepts, definitions, and explanations in new situations by using previous information, draw reasonable conclusions from evidence, and check for understanding among peers.

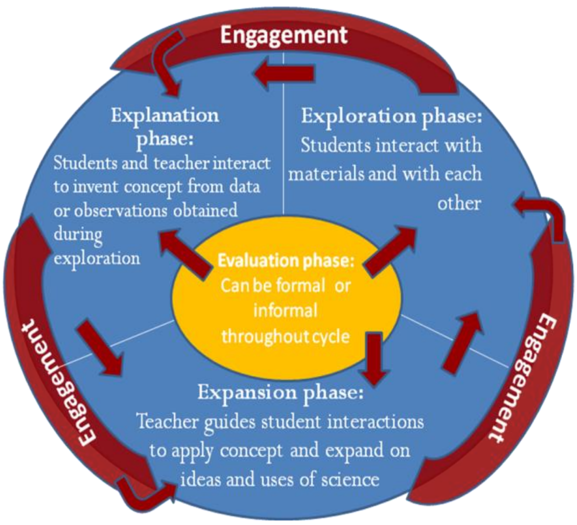

Figure 2.2 The 5E learning cycle model

In the *evaluation* stage, students are evaluated from the given concepts through reflective writing, applications of knowledge, sharing ideas and insight. The teacher's role is to observe students through applying new concepts and skills, assess students' knowledge and skills by asking open-ended questions, and look for evidence whether students have changed their thinking. The students' role is to answer open-ended questions by using their observations, demonstrate an understanding of concepts, and evaluate their own progress (Carin & Bass, 2001; Hammerman, 2006; Krajcik, Czerniak, & Berger, 1999). The general view and stage interaction of 5E learning cycle model is given in the Figure 2.2.

Learning cycle model supports Vygotsky's (1986) social constructivist theory emphasizing on scaffolding and student's ZPD for development as well as Ausubel's (1963) meaningful learning theory emphasizing on student activity in learning process through meaningful learning strategies (Marek, Gerber & Cavallo, 1999). The studies conducted on learning cycle model revealed that the learning cycle model was effective instruction on students' conceptual understanding than teacher centered traditional instruction (e.g. Akar, 2005; Bektas, 2011; Campbell, 2000; Ceylan, 2008; Cavallo, McNeely, & Marek, 2003; Garcia, 2005; Hanuscin & Lee, 2007; Lindgren & Bleicher, 2005; Musheno & Lawson, 1999; Pabuccu, 2008). Some of these studies were detailed as the following. Bektas (2011) applied 5E learning cycle model instruction with analogy, role playing and concept mapping over traditional instruction in order to investigate whether there was any significant difference on student understanding in the matter concepts on tenth grade students and the quantitative and qualitative results revealed that there was a significant conceptual understanding in favor of students in learning cycle group. Similar results were stated in the study of Ceylan (2008) for matter and solubility concepts and Akar (2005) for acids and bases concepts.

Another study, which investigated the effect of learning cycle model, was the study of Cavallo et al. (2003) and the researchers studied ninth grade students' understanding of chemical reactions. The qualitative results of open-ended questions indicated that students instructed through learning cycle revealed significant understanding of concepts. In another study by Hanuscin and Lee (2007), pre-service elementary teachers were taught the learning cycle model using a learning cycle and pre-service teachers' ideas about teaching and learning changed as developing understanding of usage of the instruction. Musheno and Lawson (1999) tested the student comprehension of science concepts through the learning cycle and traditional text and they found that the restructuring the text based on the learning cycle was more efficient and comprehensible for high school students in term of reasoning ability.

2.3 Motivation

It is obvious that when students are lectured on a subject, they are overloaded with facts. However, at the end of the lesson most of the students learn very few things or may be nothing. The important thing is to find the way that by which students learn more effectively and endure the knowledge. Learning is fun and exciting, at least when the curriculum is well matched to students' interests and abilities. Learners are motivated when they have the background and the desire to learn. Motivation is one of the most important components of learning in any educational environment (Maehr, 1984). Because everyone has different needs, goals, and different personalities, motivation is not the same for everyone. Students, in a same course of instruction, can be even motivated differently at different times.

The field of motivation in education is so broad and rich; many definitions of motivation have emerged from the various theoretical approaches to motivation. Behavioral theories describe motivation "as a change in the rate, frequency of occurrence, or form of behavior (response) as a function of environmental events and stimuli" (Schunk et al., 2008, pg.20). Motivation is viewed more like the frequency of behaviors; more motivated students are more likely to engage in tasks then less motivated students. In terms of implication, according to behavioral theories teachers should arrange the classroom environment as the way that students can respond properly to stimuli. Reinforcing the behavior makes it more likely to occur in the future, but punishing the behavior makes it less likely to occur. In contrast, cognitive theories describe motivation "is internal; we do not observe it directly but rather its products (behaviors)" (Schunk et al., 2008, pg.21). Motivation is the role of mental structures and the process of information and beliefs; in addition, different cognitive theories give emphasize on different processes such as attributions, perceptions of competence, values, affects, goals, and social comparisons. In view of the implication process, the cognitive theorists say that teachers should do instruction considering students' mental process and taking into account variables that affect their thoughts and behaviors.

The humanistic theory, Maslow's needs hierarchy theory, developed by psychologist Abraham Maslow (1954) reported that people have an innate desire to satisfy a given set of needs and these needs are arranged in a hierarchy of importance, with the most basic needs at the foundation of the hierarchy. There are five levels in this hierarchy: (1) Physiological (lower level) (2) Safety (lower level) (3) Love and belongings (higher needs) (4) Esteem (higher need) (5) Self-Actualization (higher need). Maslow emphasize that to be able to get upper level, the lower level should be first satisfied. Students will not be ready to learn if they have not had their lower level needs met. Children, who are sent to school hungry or tired or feel unsafe or cold in school, are not able to learn or are less creative when working on classroom activities. Based upon Maslow's theory, humanists currently investigate self-determination which "is the ability to have choices and some degree of control in what we do and how we do it" (Deci & Ryan, 1985). When people are in charge of something and achieve to do it, they feel happy.

According to Dweck & Elliot (1983) motivation directs individuals toward certain goals. In addition, according to Maehr (1984), motivation increases individuals' energy and activity levels. Furthermore, Eccles and Wigfield (1985) found that motivation affects the learning strategies and cognitive processes individuals employ. Afterwards, according to Stipek (1988) motivation also promotes initiation of certain activities and persistence in those activities. In the goal setting theory perspective, there are two types of goals of students, learning goals and performance goals (Meece, Blumenfeld, & Hoyle, 1988). Students with learning goals are mainly interested in mastering the task and they are not interested in how many mistakes they made. On the other hand, students with performance goals mainly compare their grades with others and choose tasks that are easy in order to maximize their grades.

It has been found that the term of motivation has many definitions based on different approaches. Mainly, it can be defined as "an internal state that arouses, directs, and sustains students' behavior" (Glynn & Koballa, 2006). From the educational perspective, motivation can be defined as any process that activates and maintains learning behavior. If the behavior is done by person's own desire, interest, and curiosity is intrinsic motivation; if the behavior is done to get an end or reward is extrinsic motivation. In addition, goal orientation, self-efficacy, self-determination, and anxiety are the other components of the motivation (Pintrich and Schunk, 1996). Additionally, Pintrich and Schunk advocate that these motivational components are influenced by classroom environment. Therefore, classroom strategies play a vital role in a student's motivation to learn.

2.3.1 The history of motivational studies in science education

The motivation concept in education literature has a long history. Questions about why students engage in, pursue, and accomplish certain goals or tasks, or why they avoid others, have been the subject of scholarly inquiry since the writings of 5th-century BC Greek philosophers such as Plato and Aristotle. The motivation concept was usually a topic under psychology until the beginning of the twentieth century; but, nowadays it is a separate topic of study. The studies on motivation can be found from the distant past, which are mainly about a state of mind considering the human psychology. The studies publishes in those years did not really mention about the educational psychology, instead they gave emphasizes on human psychology such as individual's will, volition, and instincts. One of the earliest studies on motivation in education is McDougall's study (1926, as cited in Schunk, Pintrich, & Meece, 2008) that made emphasizes on students' curiosity and mentioned the importance of linking the school activities to students' curiosity.

The intermediate past motivational studies in science education (from 1930 to 1954), motivation construct has been started to be thought as one of the proponents of learning. Hull (1943), advocated that motivation as an arousal state did not really guide or control the behavior but can be instinctive. There are still studies on psychological theories of motivation; but some theories such as reinforcement theories and need and cognitive theories made some contributions to education literature. Maslow (1954) proposed a hierarchy of needs, these needs imply that the lower needs are deficiency needs such as hunger or safety and the higher needs are growth needs such as need to achieve or need to realize one's potential. However, no empirical studies related to science education were conducted.

The recent past motivational studies in science education (from 1955to 1980), motivational studies in psychology has gained momentum. McClelland (1955) studied on thoughts, feeling and behaviors. The researcher advocated that the thoughts, feeling or behaviors were described like guided, goal-oriented, or persistent. Cognitive dissonance theory which is in some respects similar to disequilibrium in Piaget's theory of cognitive development was developed by Leon Festinger (1957). Festinger suggested that if the appropriate amount of disequilibrium can be created, this will in turn lead to the individual changing his or her behavior which in turn will lead to a change in thought patterns which in turn leads to more change in behavior. Based on the intrinsic motivation theory (White, 1959) when a learner learns something new or succeeds in a challenging task, she/he feels satisfaction; therefore, in future the learners can be more willingly to engage activities. It was reported that intrinsic motivation theory would be one of the most researchable subjects that promote effective learning and achievement environment. The other theory developed during this time period was expectancy theory (Vroom, 1964). This theory proposed that in order to motivation to occur, expectancy, instrumentality, and valance components must be present. Another cognitive approach which was developed during this time period was attribution theory (Weiner, 1974). This theory proposes that every individual tries to explain success or failure of self and others by offering certain "attributions." This theory proposes that the motivational determinants of a person's behavior are causal explanations of prior action outcomes. On the other hand, there were also some criticisms related to these theories. Maslow's (1954) hierarchy theory was based on need theories of motivation and a helpful motivational model, but some studies reported that students did not always act like Maslow's hierarchy. Wahba & Bridwell (1976) reviewed 17 studies and reported that there was little evidence for the ranking of needs like Maslow described or no clear evidence that human needs are classified into five distinct categories. Conversely, there have not any studies related to science education published in this time period, but intrinsic and extrinsic motivation, attribution, and expectancy theories has broadened and has been applied in educational settings.

The recent motivational studies in science education (from 1980 to present), studies on cognitive and psychological science has become common place in recent years. There were studies solely on cognitive science and psychology before 1980s, but psychological science studies that consider both cognitive and affective domains in science education are not so old. The studies mainly all influenced by the work of previous researchers. The theoretical studies have made an influence on educational studies and psychological studies integrated into cognitive science literature. More recently, studies integrated cognition and motivation and have been started to an integrative study instead of solely studying cognition and motivation. During this time period, some other theories were also developed such as Deci and Ryan (1985) self-determination theory advocates that students in particular need to feel competent and independent. More self-determined students are more likely to achieve at a high level than less self-determined motivation and if students are less self-determined motivation, it is hard for them to feel intrinsically motivated. In addition, if students believe they will fail, they do not even try to achieve the task. Furthermore, Bandura (1986) highlights self-efficacy that refers to beliefs concerning one's capabilities to learn or perform behaviors at designated levels. Based on Bandura, high self-efficacy beliefs are related to choosing desired goals, applying string effort to achieve these goals, and enduring these goals even there are difficult. When science teachers use the term self-efficacy, they are referring to the evaluation that a student makes about his/her personal competence to succeed in a field of science. Students' judgments of their self-efficacy in particular areas of science have been found to predict their performance in these areas. In terms of need theories, Neher (1991) critiqued Maslow's hierarchy theory and mentioned that students may deny themselves of sleep in order to study for a test or become so engaged in an activity that they forget about their fatigue, hunger, or personal problems.

Therefore, hypothetically it can be concluded that motivation can have several effects on how students learn science and their behaviors; such as motivation can direct behavior toward particular goals, lead to increase effort and energy, increase persistency of activities, determine what consequences are reinforcing, and lead to improve performance. In science education, qualitative and quantitative studies have been conducted to observe classroom environments on student motivations to learn science based on different motivational theories. More recently, theories have broadened and have been applied to educational settings and in science education field. In the 1980s motivational studies has been started to integrate into science education, which were mainly about motivational factors that affect on students achievement and classroom environment. For example, Nussbaum & Novick (1982) studied on curiosity construct in science classrooms and advocated that students are more interested in solving the conflicts as the curiosity of students increased. Ames & Archer (1988) made emphasize that there had been some research on classroom climate but much of these studies studied student achievement as the outcome measure. The researchers implied that students' perceptions of classroom climate were related to specific motivational variables such as interest and self-regulated learning.

At the beginning of the 1990s some theoretical studies have been published that mentioning about it was not proper to study just on cognitive domain in instructional studies, affective domains such as motivation and attitude should be taken into consideration. For example, Allen and Dietrich (1991) examined the student differences in attributions and motivation toward Earth Science. The results revealed that there was a shift in attributions and motivation toward effort of low achieving students; especially female students made more shifts in attributions toward effort than males. The researchers suggested improving the level and quality of science understanding for a broader ability range of high school students. In addition, Ames (1992) advocated that student motivation and related outcomes were sensitive to characteristics of the learning context, including teachers' instructional practices as well as school and classroom climate. Furthermore, Ames suggested that classroom tasks should be meaningful and relevant to students' lives; therefore, students can relate their lives to classroom content and they can understand the content more meaningfully. Pintrich, Marx and Boyle (1993) mentioned on the relationship between motivation, cognition, and classroom environment; afterwards, motivational studies have momentum in science education literature. Pintrich et al. made contributions to the literature on conceptual change which takes an important role in science education literature. They argued that the conceptual change process is not just cold process; instead that process is hot which is influenced by factors such as the choice to engage in the task, the level of engagement in the task, and the willingness to persist at the task which are all components of motivation. Pintrich and his colleagues made emphasize on the relationship between cognition and motivation and this study is one of the fundamental studies that advocate the relations of cognition and motivation and how these relations operate in educational contexts. Afterwards, many researchers support this view. Pintrich, Smith, García, and McKeachie, (1993) developed a questionnaire that measure several motivational constructs such as intrinsic value of learning, self-efficacy, text anxiety, students' strategy use, and self-regulation. The Motivated Strategies for Learning Questionnaire (MSLQ) has been used with different level students (from late elementary to secondary school) and become one of the most widely used measures of motivation and self-regulation in studies around the world.

Moreover, Anderman and Young (1994) studied the individual and classroom-level differences in motivation and strategy usage in middle school science based on self-efficacy, goal orientation, expectancy, value, and self-concept of ability concepts in science. Their results revealed that the usage of ability-focused instructional practices was not effective learning strategy. House (1994) made emphasize on the importance of students' initial motivation and their results reveal that the predictors of overall grade performance in chemistry are students' academic self-concept and achievement expectancies. Roach and Wandersee (1995) conducted a study for teaching science via historical vignettes. The results revealed that the usage of interactive historical vignettes link primal and contemporary science by doing emphasize on nature of science and students were more motivated to learn science. Czerniak (1996) researched the relationships between success in a science fair and self-concept, parental influences, motivation, and anxiety. The results reveal that parental influences had significant effect on students' success. However, this parental pressure did not motivate students intrinsically. Smist and Barkman (1996) studied the effectiveness of a middle school science curriculum designed to motivate students to learn science by studying the patterns of human. Their results revealed that the ability to recognize patterns was not equal for all learners that can be improved through instruction and they found gender difference that female students were more interested in science. Howard and Boone (1997) conducted a study to enhance students and enjoyment of experimental science. The results reveal that when students were aware of the class science is connected to real science; they were more motivated to learn science.

Afterwards, theoretical motivational constructs such as interest, intrinsic and extrinsic motivation, self-efficacy, interest, goal-directed behaviors have been studied and how these constructs affect on student learning have been investigated. For example, DeBacker and Nelson (2000) explored the relationships among motivational variables based on goal-setting theory and reported that students who value science have high perceived ability in science. In other words, higher achieving students reported higher learning goals scores than did lower achieving students in both physical and biological sciences. The gender difference was also analyzed and in both physical and biological sciences, female had more future goals than boys did. One of the other components of self-determination has been researched and it has been reported that students are more motivated when they feel in charge of control of their behaviors. For example, Black and Deci (2000) reported that college chemistry students' performance was influenced of their perceptions of self-determination.

Until present, many qualitative and quantitative studies have been conducted how motivational constructs affect on science learning, and about changing the classroom environment based on motivational strategies and how these changes effect on students motivation to learn science. For example, Mazlo, Dormedy, and Niemoth-Anderson (2002) conducted a study in the lab and examined four types of motivational methods. The authors advocated that the quiz group made more significant and positive progress than scheduled presentation group, unscheduled presentation group, or control group and imply that the students in quiz group put effort into understanding the lab before the class to improve their quiz scores. In addition, Sinatra and Pintrich (2003) advocated that the studies mainly stressed on cognitive and developmental factors, but maintained that the conceptual change researches have been experienced a warming trend. The authors advocated that motivation is an important factor in the conceptual change process and introduced "intentional conceptual change". The differences between intentional conceptual change process and the traditional conceptual change are that the intentional conceptual change is goal-directed and under the student's control and in order to bring a change in knowledge has regulation of cognitive, metacognitive, and motivational process. Pintrich (2003) also advocated for the importance of scientific motivation and using motivation perspective in educational context would advance the field. Additionally, Pintrich conclude that in order to facilitate motivation, cognition and learning in science classrooms the understanding of student motivation should be improved. According to student and classroom environment instructional design can be developed or adapted considering students' self-efficacy, interest, values, and goals.

Similarly, Flowerday, Schraw, and Stevens (2004) studied on interest component and advocated that because while emphasizing on interest, it gives attention to classroom events, students' engagement and their use of deep learning strategies have been increased.

The process of motivating students, individually or in groups, means that a teacher takes into consideration students' feelings, values, experiences, and their needs; because, motivation to learn is something that a teacher does with students, it is not something that a teacher does to students. In terms of behavioral theories, the studies are mainly on concepts such as incentive and reinforcement in science education. Koballa and Glynn (2007) gave an example on incentive and reinforcement; the promise of a field trip to a quarry to study rock strata could serve as an incentive for students to perform well on a geology test. Participation in the trip itself could be the reinforcement. On the other hand, some potential problems with the use of incentives and reinforcements have been reported. One major problem was that the students may not develop intrinsic motivation to learn. In some conditions, when students were offered incentives for doing tasks they naturally find motivating, their desire to perform the tasks can decrease (Cameron & Pierce, 2002; Deci, Koestner, & Ryan, 1999).

More recently, many studies were conducted to analyze students' motivation to learn science in different levels (elementary, high school, or college) based on different motivational theories (goal-setting theory, Maslow's need hierarchy theory, expectancy theory, reinforcement theory, or attribution theory) considering different motivational constructs (anxiety, intrinsic and extrinsic motivation, goal-directed behaviors, self-regulation, self-efficacy). The studies have revealed that understanding students' motivation to learn science would be possible as much as it is determined about their source of motivation to learn science. Hence, besides doing the quantitative studies, the qualitative studies are important to analyze the students' sources of motivation. Additionally, the factors such as anxiety, curiosity, intrinsic and extrinsic motivation, self-efficacy, attitude, self-determination, goal-directed behaviors, self-regulation, and needs that influence students' motivation have also been analyzed in science educational studies.

2.3.2 Motivation to Learn

It has been recognized that motivation can be one of the many causes of learning based on the researches on learning; considering from this point of view motivation is causation of affective and cognitive domains. The components of learning have also been analyzed and this issue is still an enduring subject searching the questions such as how the learner learns, what factors affect this learning, and what factors affect the achievement. Many different factors such as student profile, teacher profile, climate of school buildings, authorization and management in school affect student motivation (Pintrich & Schunk, 2002). However, the scope of this study covers solely student motivation to learn chemistry.

Classroom environment is important in motivation to learn science and motivation has a vital role in student learning and achievement. Many different tasks that are challenging but achievable can be fostered in class in order to increase student motivation to learn science. Relevance also promotes motivation, as does "contextualizing" learning, which is, helping students to see how skills can be applied in the real world. Tasks that involve "a moderate amount of discrepancy or incongruity" are beneficial because they stimulate students' curiosity, an intrinsic motivator. In addition, defining tasks in terms of specific, short-term goals can assist students to associate effort with success. Extrinsic rewards, on the other hand, should be used with caution, for they have the potential for decreasing existing intrinsic motivation.

Learning is inherently a social activity according to Pintrich and Schunk (2002). Students are intrinsically motivated when they engage in activities (Wigfield, Eccles, & Rodriguez, 1998). Jerome Bruner, cognitive psychologist, stated that natural world was interesting for children; hence, they were willingly to learn about everyday phenomena and children expressed intrinsic motivation when they were engaged in learning process by doing and discovering, which enhance meaningful learning (Carin & Bass, 2001). Carin and Bass (2001) underlined teachers' role of enhancing opportunities for students to realize how to use the knowledge and skills they have learned in daily life.

In studies it is stated that using learning cycle is effective method in student conceptual understanding and meaningful learning; additionally, it has been often implied that learning cycle can improve student motivation to learn. The studies based on the constructivist learning have suggested that the constructivist learning environment help to improve student motivation to learn (Ames, 1992; Anderson, 2003; Fosnot, 1996; Kim, 2005; Lawson, 2002; Pintrich, Marx, & Boyle, 1993); Pintrich & Schunk, 1996; Palmer, 2005; Turk, 2008). Therefore, it is expected that the learning cycle model promotes motivation to learn since learning cycle is based on the constructivist learning and connected to conceptual change; however, a few empirical studies have been found which investigated for the effect of learning cycle on student motivation to learn (Atay, 2006; Ceylan, 2009). Specifically, the engagement stage of 5E learning cycle is meant to improve student motivation to learn via discrepant events, real world applications about which students are familiar and presenting scientific concepts in the context of real world events, or encouraging group and class discussions.

2.3.2.1 Determination of Student Motivation to Learn

Student motivation can be determined using both qualitative and quantitative techniques. Interview with students is one of the frequent qualitative techniques that can be used to determine student motivation. Students can also be asked to write a self-report on their motivation. Questionnaire is one of the quantitative techniques that can be used to determine student motivation.

2.4 Gender Differences

Recently, gender differences in science education constitute issues of considerable interest. Studies on gender differences in education have been generally conducted in a threefold purpose, psychologically (researched have been done to analyze whether students are educated unequal regarding affective domain), schooling (researches have been done to find out whether there is any gender inequality on school aspect), and sociologically (research have been done to examine whether there is any gender inequality in society). This study focuses on the gender difference in science education in terms of affective domain; specifically, whether student motivation differs in terms of brain-type despite of a descriptive variable gender.

It has always been a concern in science education research whether girls and boys differ in achievement. Although gender equity is aimed in science education, science-related fields have stereotypically been considered as a masculine domain. This traditional attitude might not be dominant in recent years; however, gender differences issue is still popular in science education literature. Studies in science literature are inconsistent in gender differences in terms of achievement. Most studies, which found significant gender differences, reported that boys performed better than girls in science courses, particularly in physical science (Brynes, 1996; Lee & Burkam, 1996; Linn & Hyde, 1989; Steinkamp & Maehr, 1984); however, there are also studies which reported that the gender differences are in favor of girls (Anderman & Young, 1994; Britner, 2008; Britner & Pajares, 2006). Walding, Fogliani, Over & Bain (1994) made a research on how high school students gave response to chemistry question and they found that in some question, especially in computational ones, boys gave more correct answers. Besides, Weinburgh (1995) made a research on gender differences in student attitudes towards science from 1970 to 1991 and found that student attitude was correlated with student achievement in favor of boys. Interestingly, the later studies often address the gender difference was in favor of girls compared to the previous research which often pointed out the difference was in favor of boys. In other words, it is seen that the gender gap in achievement against girls has decreased. However, it is clear that the gender difference in science education still exists. Consequently, researchers argued that the important point was not reporting the gender difference instead further studies should be done in order to investigate the ideas behind this gender difference, such as gender bias within science classroom, student attitudes towards science, student motivation to learn, experience in childhood, or student ability.

Studies also emphasized, besides educational achievement, it is possible to observe the gender differences in occupation selection. The importance of role models has been noted, especially when students are in the situation of a career choice (Jacobs & Bleeker, 2004; Simpson & Oliver, 1990). Research reveals that girls are still less likely to choose a career in science than boys and are still holding negative attitudes toward science (Jones, Howe, & Rua, 2000; Weinburgh, 1995). Lau and Roeser (2002) argued that the lack of participation of females in male-dominated careers was due to their low self-efficacy. Likewise, other studies have also reported the effect of self-efficacy beliefs in career choice. Their findings reveal that self-efficacy beliefs of students influence or limited their occupational interest (Ji, Lapan, & Tate 2002; Lau & Roeser, 2002; Zeldin, Britner, Pajares, 2008), especially girls were affected in career choice by their family, teachers, or peer (Zeldin & Pajares, 2000). Steinkamp and Maehr (1984) reviewed refereed journal articles, books, unpublished reports, and dissertations and concluded that gender differences varied among countries of the world. Unexpectedly, gender differences favored boys in developed countries (Australia, Japan, Sweden, and US); however, in favor of girls in Israel.

Hence, students differ in science achievement, which also affect their career choice and student motivation is efficient factor on student achievement. When motivation to learn science is taken into account, some studies also reported gender differences favoring boys (Meece, Glienke, & Burg, 2006) and particularly, in favor of boys in physical sciences and in favor of girls in biological science and chemistry (Steinkamp & Maehr, 1984). Eccles et al. (1983, as cited in Meece et al., 2006) reported that gender difference in motivation occurs because of students' parents and teachers attitudes and categorized these attitudes in three sections as "(a) modeling sex-typed behavior, (b) communicating different expectations and goals for boys and girls, and (c) encouraging different activities and skills" (p. 361). The studies conducted (for example, Jacobs & Bleeker, 2004; Jacobs & Eccles, 2000) on the same purpose also reported the similar results that parental influence was effective on gender differences. In addition, teacher expectations sometimes differ when they think about whether boys and girls are successful in science; studies such as by Benz, Pfeiffer, and Newman (1981, as cited in Kahle, Parker, Rennie, & Riley, 1993) and Worrall and Tsarna (1987, as cited in Kahle et. al., 1993) found that teachers expected less success than girls. In terms of science education aspect, gender differences are often dominated in favor of masculine features. For instance, Mason, Kahle, & Gardner (1991) conducted a study and asked to draw a scientist to students from all ages; they found that students have stereotypic images of a male domain in science. There were other studies (such as; Boylan, Hill, Wallace, & Wheeler, 1992; Chambers, 1983 as cited in Kahle et al., 1993; Kahle & Meece, 1994) also reported the similar results about students' male image in science.

Beyond these general motivational differences, it is beneficial to analyze gender differences in terms of motivational dimensions. In science education literature within any given level, gender differences can be found in motivational dimensions; such as self-efficacy, intrinsic and extrinsic motivation, goal-orientations, self-determination, and test anxiety. In the following, some studies which reported statistical significant differences on motivational dimensions are given regarding gender differences.

Self-efficacy is important factor in motivation to learn. Bandura (1997) emphasized that self-efficacy beliefs play a significant role in learning and students with high self-efficacy perform better and eagerly participate in challenging tasks; in other words students who believe that they can be successful in scientific activities scored higher grades in science classes. Studies also mentioned that students' science self-efficacy beliefs are positively correlated with academic achievement (Britner, 2008; Britner & Pajares, 2001; Britner & Pajares, 2006; Bryan, Glynn, & Kittleson, in press; Eccles & Wigfield, 2002; Lau, & Roeser, 2002; Pajares, 1996; Schunk & Pajares, 2002). Gender difference has also been found in terms of self-efficacy beliefs' of students. Girls tend to have stronger self-efficacy in earth and environmental science classes (Britner, 2008); however, some studies reported this gender difference in favor of boys (Anderman & Young, 1994; Glynn, Brickman, Armstrong, & Taasoobshirazi, in press; Glynn, Taasoobshirazi, & Brickman, 2009; Lau & Roeser, 2002; Pajares, 1996; Pintrich & DeGroot, 1990). In addition, studies emphasized that girls feel more confident in succeeding scientific tasks (Britner & Pajares, 2006), but there is also studies which report that boys feel confident in science, as well (Kahle, et.al., 1993; Linn & Hyde, 1989). Girls tend to attribute their failure to low ability and boys tend to attribute their success to high ability (Brynes, 1996; Kahle & Meece, 1994). Besides, Linn and Hyde (1989) expressed that the greater confidence of boys in science achievement could affect their career choice.

Intrinsic and extrinsic motivations are other essential factors on student motivation. The more intrinsically motivated students feel more internal enjoyment and interest while doing the task or learning science and eagerly to participate in challenging tasks (Eccles & Wigfield, 2002); this would contribute positively to achievement (Eccles & Wigfield, 2002; Hanrahan, 1998). Gender differences in science mainly can be seen in terms of point of interest; girls are generally more interested in biology and chemistry and boys are generally more interested in physical sciences (Kahle et al., 1993). Studies reported boys were more interested in science than girls (Linn & Hyde, 1989); particularly, boys in high schools have higher interest and participation in physical sciences competitions and girls in biological sciences (Jones, Howe, & Rua 2000).

However, it was argued that this gender differences might be due to teacher or parental influence on students (Jones, 1991) or because of different experiences in childhood. For instance, DeBacker and Nelson (1999) reported that females were more extrinsically motivated than males.

Intrinsic motivation is highly correlated with self-determination and intrinsically motivated students express more competence and self-determination (Eccles & Wigfield, 2002). The more self-determined students tend to have more intention to pursue scientific studies. Vallerand, Fortier & Guay (1997) in their studies found that more self-determinated high school students were not likely to dropout the semester. Similar findings were found by Blach & Deci (2000) for organic chemistry courses. In terms of gender differences, girls had higher self-determination scores than boys (Glynn et al., in press; Glynn et al., 2009; Vallerand et al., 1997).

Setting difficult, proximal and specific goals affect student motivation to learn (Schunk, 1990) and goal-orientations are correlated with student academic achievement (Britner, 2008; Brynes, 1996); students with learning goals focus on learning and prefer challenging tasks whereas students with performance goals are more concerned with others (Eccles & Wigfield, 2002). Anderman and Young (1994) reported that there was gender difference on performance goals in favor of boys whereas learning goals in favor of girls (see also Guvercin, Tekkaya, & Sungur, 2010). On the other hand, the vice versa gender difference was also reported as higher learning goals in high school students (DeBacker & Nelson, 1999) and in low-ability students with stronger learning goals favoring boys (Meece & Jones, 1996) whereas higher performance goals favoring girls (Guvercin, Tekkaya, & Sungur, 2010), such as females receive higher grades in order to pleasure their teacher (DeBacker & Nelson, 1999). In addition, it was mentioned that students who have learning goals tend to be more successful regardless of their gender (Anderman & Young, 1994; Brynes, 1996; DeBacker & Nelson, 1999).

Another factor which influences student motivation is anxiety. Some studies reported girls are more anxious in science tests (Britner, 2008; Britner & Pajares, 2006; Glynn et al., 2009; Pintrich & DeGroot, 1990) compared to boys. Students' test anxiety is usually negatively correlated with their grades, but girls sometimes scored higher grades in spite of their high anxiety (Britner, 2008).

Taken together, the research on gender differences issues in science education reveals no clear pattern in student motivation to learn; therefore, these contradictory gender differences findings in motivation need further examination. Therefore, the main purpose of this study is to examine the motivational differences in different aspect such as ability or brain-type regardless gender since the literature review reveal that the contradictory differences are somehow related to different factors.

CHAPTER III

METHOD

This chapter provides an account of the study's research design and its features. The methodology of this study was presented in twelve main sections, which are population and sample of the study, variables and description of variables, instruments, instructional materials, design of the study, procedure for experimental and traditional groups, implementation for groups, treatment fidelity and verification, data collection, data analysis, power analysis, threads to internal validity, and assumptions and limitations.

3.1 Population and Sample

Ankara is the capital city of Republic of Turkiye. There are 75 Public High Schools, 75 Anatolian High Schools, two Science High Schools, two Fine Arts and Sports High Schools, and one Social Science High School considering 22 regions in Ankara (Ortaogretim Genel Mudurlugu, 2011). All eleventh grade students from public high schools in Çankaya region of Ankara were identified as the target population of the study, which was determined for the researcher's convenience. In Çankaya region, there are 16 Public High Schools, 15 Anatolian High Schools, 15 Technical and Vocational Schools, one Science High School, one Fine Arts and Sports High School, one Social Science High School, and one Anatolian Teacher High School (Cankaya Ilce Milli Egitim Mudurlugu, 2011). Since the target population is not much easy to access, the accessible population is determined as all eleventh grade students in public high schools located at the center of Çankaya district. Therefore, results of the study could be generalized to the selected accessible population. There are 16 public high schools in this district and the sample of this study was selected from this accessible population. One of these high schools which is more convenient was included into the present study. Therefore, a convenience sampling method which is a type of nonrandom sampling method was chosen for this study; which is defined as a sample which is conveniently available for the study (Fraenkel and Wallen, 2003, p.103). On the other hand, the researcher was aware of the limitations of nonrandom sampling method such as representativeness problems.

The selected school had three chemistry teachers, but only two of them were enrolling the eleventh grade classes. The purpose of the study was explained and how to achieve these aims were clarified to both teachers; however, only one chemistry teacher was enthusiastic to take part into the present study. The teacher was female and middle-aged; she had teaching experience in chemistry education and has been teaching nearly for twenty years. Additionally, into regular instruction of the teacher, she tried to use chemistry laboratory and demonstrations as much as possible, but rarely had students do experiments because of lack of time. Before the implementation, the teacher accepted to come together with the researcher in order to clarify the details of the implementation. During this meetings, the researcher gave details and purpose of the study to the teacher and explained to her what she was supposed to do and how the procedure would proceed during the implementation. The researcher strongly emphasized the instructional differences in experimental and traditional group to the teacher.

Two classes taught by the same teacher took part into the study. These two intact classes were randomly assigned as an experimental and a traditional group. Since classes were formed before the implementation, it was not possible to randomly select students to groups. Therefore, the same teacher instructed both in experimental and traditional groups. The sample of the present study consisted of 78 eleventh grade students from two classes, 40 (52.5% girl, 47.5% boy) students in the experimental group and 38 (50% girl, 50% boy) students in the traditional group.

The students participated in the study were mainly born at the year 1992 or 1993. The socioeconomic status of students in the school is in average. In other words, students were not much different in terms of the education level of their parents, income, or living standards. Most of the students in both classes took additional support for their courses. The number of students in experimental and traditional groups and gender distribution are given in Table 3.1.

Table 3.1 The number and gender distribution of students for experimental and traditional groups

	Experimental Group		Traditional Group		Total
	Female	Male	Female	Male	
Class A	21	19	---	---	40
Class B	---	---	19	19	38
Total	40		38		78

The distribution of students 2009-2010 first semester chemistry course grades are given at the Figure 3.1. The graph presents that students' achievement in chemistry courses was in average and there were not many high-achiever students in chemistry course. The chemistry course average scores are for Class A, which was the experimental group, was 2.55 and for Class B, which was the traditional group, was 2.68.

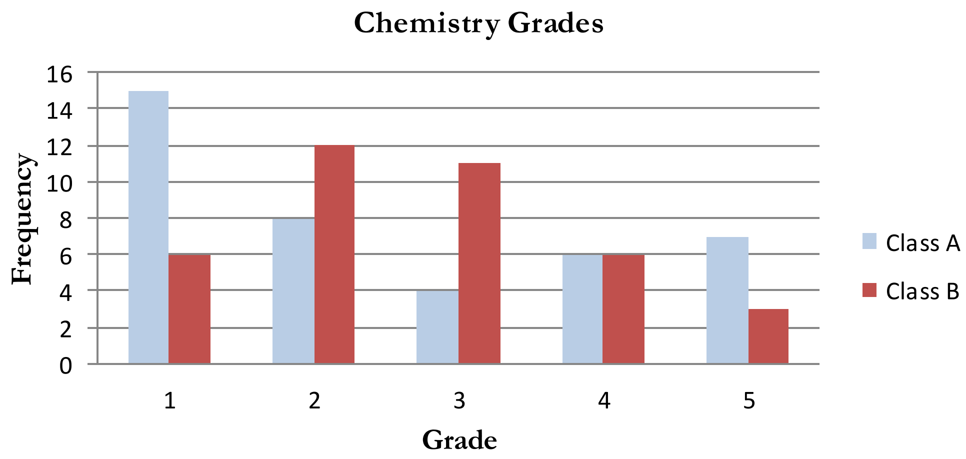

Figure 3.1 The distribution of students' previous semester grades in chemistry course for each class

The sample of interviews was selected in terms of purposeful sampling (Patton, 1990, p.230) in order to get information-rich cases for the present study. Eight students from both groups were interviewed, 4 students were from the experimental and 4 students from the traditional group were randomly selected; in this selection academic achievement variability was focused and gender was considered to be equal (See details in Table 3.2). The interviews were done both before the implementation and after the implementation in order to get pre- and post- ideas of students regarding acids and bases and their motivation to learn chemistry.

Table 3.2 The number and gender distributions of students for interviews

	Experimental Group		Traditional Group		
	Female	Male	Female	Male	Total
Class A	2	2	-	-	4
Class B	-	-	2	2	4
Total	2	2	2	2	8

3.2 Variables

There are two types of variables in this study; these variables are independent and dependent variables. Independent variables are not affected by other variables and they affect dependent variables (Fraenkel & Wallen, 2003). The following two sections gave the descriptive information about these variables.

3.2.1 Independent Variables

The five independent variables of the study are methods of teaching (MOT) which indicates two levels: 5E learning cycle oriented chemistry teaching instruction (LC) and traditional chemistry teaching instruction (TR), gender, the students' 2009-2010 first semester chemistry course grades (grade), pre-test scores of students on three-tier Acids and Bases Test (pre-TABT), and pre-test scores of student Chemistry Motivation Questionnaire (pre-CMQ). See Table 3.3 for the detailed characteristics of the independent variables used in the present study.

Table 3.3 The characteristics of the variables in the study

Variable Name	Variable	Continuous/Categorical	Scale
MOT	Independent Variable	Categorical	Nominal
Gender	Independent Variable	Categorical	Nominal
Pre-TABT	Independent Variable	Continuous	Interval
Pre-CMQ	Independent Variable	Continuous	Interval
Post-TABT	Dependent Variable	Continuous	Interval
Post-CMQ	Dependent Variable	Continuous	Interval

3.2.2 Dependent Variables

The two dependent variables of the study are the post-test scores of students on Three-tier Acids and Bases Test (post-TABT) and the post-test scores of students on Chemistry Motivation Questionnaire (post-CMQ). See Table 3.3 for the detailed characteristics of the dependent variables used in the study.

3.3 Instruments

The measuring tools used in the study were: Three-tier Acids and Bases Test (TABT), Chemistry Motivation Questionnaire (CMQ), Interviews, and Classroom Observation Checklist (COC). The following sections gave detailed information about these instruments.

3.3.1 Three-tier Acids and Bases Test

The Three-tier Acids and Bases Test (TABT) was developed by the researcher and the purpose of this test was to measure students' understanding of acids and bases concepts and identify their alternative conceptions. The test covers the definition of acids and bases, the characteristics of acids and bases, strong and weak acids and bases, pH and pOH concepts, neutralization reactions, and titrations. The test consists of 18 three-tier questions (Appendix B-3). The first-tier is a conventional multiple-choice question, the second-tier seeks for the reasoning behind the previous answer which holds possible alternative conceptions with one correct reason, and the last tier asks for student confidence about their answers for the first two-tiers.

Developing a three-tier test is a three-stepped process, which includes firstly interview step, secondly open-ended questions step, and lastly three-tier test step. There are many studies in science education that report students have alternative conceptions and these alternative conceptions affect students' learning and understanding in science and chemistry (Anderson, 1986; Palmer, 2001; Ross & Munby, 1991, see details for alternative conceptions in the Chapter 2).

Different types of assessments are used in science education in order to identify students' alternative conceptions such as interviews (Boo, 1998; Montfort, Brown, & Findley, 2008; Osborne & Gilbert, 1980; Thompson & Logue, 2006), open-ended questions (Calik & Ayas, 2005; Chou, 2002; Tsaparlis & Papaphotis, 2002), concept maps (Goh & Chia, 1991), and multiple-choice questions (Schmidt, 1997; Uzuntiryaki & Geban, 2005), which both have advantages and disadvantages in practical usage (Osborne & Gilbert, 1980; Tsai & Chou, 2002). Multiple-choice tests are often more preferable in science classes since they are easy to apply and evaluate students' understanding of the related subject; however, multiple-choice tests have some limitations in applying such as determining whether a student gives a correct response to a test consciously or just by a chance. On the other hand, interviews can give more detailed information about students' alternative conceptions and their understanding on a particular concept, but a large amount of time is needed to conduct interviews with many students for generalizing their alternative conceptions. Because of aforementioned techniques have some limitations for practical use in classes, two tier tests are proposed to identify students' alternative conceptions (Treagust, 1986; Treagust, 1995). In order to strengthen the advantages of multiple-choice tests two-tier tests were developed (Tan, Goh, Chia, & Treagust, 2002). First-tier of each question is a conventional multiple-choice question and second-tier of the question includes possible alternatives for the response in the first-tier. Two-tier tests are such as assessment tools that can make available for teachers or researchers to determine students alternative conceptions and whether a student gives a correct response to a question by understanding the related subject since the second-tier of a test asks for a reason for the response in the first-tier. Therefore, this type of tests differentiates student responses from lack of knowledge as well as chance factor. Treagust (1995) also suggests that when diagnostic tests are used either at the beginning or at the end of a topic, an instructor can identify students' alternative conceptions on a related topic and based on these detected alternative conceptions the instructor can modify the related lesson plan in order to remedy students' alternative conceptions. There are some studies on the development of three-tier test in physics (Eryilmaz & Surmeli, 2002; Pesman & Eryilmaz, 2009) and chemistry (Costu, Ayas, Niaz, Unal, & Calik, 2007; Kirbulut, Geban, & Beeth, 2010), in which as an addition to two-tiers the last third tier is added to ask for whether students are sure about their responses to the previous two tiers. Therefore, in order to develop a valid and reliable three-tier diagnostic test to assess students' understanding of acids and bases concepts threefold process was used.

The first step was to interview with students, then to apply open-ended questions, and lastly to distribute three-tier test. For this steps, there sample was needed. In order to get high rate correct response from students, the questions were distributed to 12th grade students who were more familiar than other grade levels to acids and bases concepts from the previous semester. The development of three-tier test process was done at the beginning of the 2009 – 2010 Fall semester. Three-different groups were selected from the target population: i) first group was needed to conduct interviews, 12 high school students (6 female and 6 male) were interviewed; ii) the second group was used to complete open-ended questions, 111 high school students (65 female and 46 male) completed open-ended questions; iii) the three-tier test was administered to the last group, 156 high school students (92 female and 64 male) completed the three-tier test.

In order to develop the three-tier acids and bases test three different instruments were administered. First of all, semi-structured interviews with high school students were conducted to determine whether there were any alternative conceptions that did not appear in the literature. The 12 interviewees were selected from 12th grade high school students based on their gender (girls and boys) and knowledge level (high-medium-low) from two different high schools. The interview consisted of 10 questions and their follow-up probes and adapted from the literature about high school students difficulties in acids and bases concepts in chemistry. The pilot study of the interview questions were administered before the study and the face validity of the questions were tested as well (see Appendix B-1 for the interview questions).

Secondly, the interviews findings and the related literature were used to construct open-ended questions. The open-ended questions were also composed of 10 questions and were conceptual questions covering the acids and bases concepts (see Appendix B-2 for the open-ended questions). In order to check the content validity of questions four chemistry education experts analyzed the open-ended questions in terms of appropriateness to high school students' level, alternative conceptions, and objectives. After administering the open-ended questions to 111 (58.56% girls and 41.44% boys) high school students, students' responses were categorized to form distracters of the three-tier test.

Lastly, after analyzing the responses of the open-ended questions, higher frequencies of categories and meaningful ones were selected as the distracters. These distracters included both one correct and alternative conceptions options. Hence, 18 three-tier questions were constructed; the first tier is the conventional multiple choice step, the second tier is the possible reasons of the given answer for the first tier, and the third tier is the confidence step for the first two tiers. In order to check the content validity of the three-tier acids and bases test three chemistry education experts and two chemistry teachers analyzed the test in terms of consistencies within first and second tier, appropriateness to high school students' level, alternative conceptions, and objectives. After the revision, the three-tier test was administered to 156 high school students (59% girls and 41% boys) in one class hour (Appendix B-3).

In the light of this development process the Three-tier Acids and Bases Test was developed. The TABT covers acids and bases theory, the dissociation of strong acids and bases, the dissociation of weak acids and bases, the reaction of acids and bases, pH, and titrations. Table 3.4 represents the alternative conceptions stated in the test.

Table 3.4 Alternative Conceptions in the TABT

Alternative Conceptions	Items
1. Proton donor substances have basic characteristics	1.2.b, 5.2.d
2. All substances including OH in their formulas have basic characteristics	1.2.c, 5.1.a, 5.2.a, 7.1.a, 7.2.e
3. The strength of acids/bases is related to concentration	2.2.a, 8.2.c, 10.2.b
4. The strength of acids/bases is related to pH	2.2.b, 3.2.a, 3.2.b, 8.2.d, 13.2.a, 13.2.b
5. The strength of acids/bases is related to mole number	2.2.c, 8.2.a
6. The pH value is positively correlated with the number of hydronium ion concentration in the solution	3.2.d
7. Mixing an acid with a base (without regard to quantities) neutralizes the base resulting in a neutral salt solution	4.2.a
8. Acids are stronger and more dangerous than bases	4.2.b , 7.1.e
9. In neutralization all the H and OH ions are cancelled	4.2.c, 7.1.c, 7.2.a

(Table 3.4 continued)

Alternative Conceptions	Items
10. Mixing equal molar quantities of H_3O^+ and OH^- to distilled water results in neutral water	4.2.d, 7.1.b, 7.2.d
11. Metallic compounds have basic properties	5.2.f
12. The strength concept in acids/bases is related with ion interactions	6.2.a
13. Liquid phase of acids/bases do not differ in solution environment in terms of particulate level	6.2.b, 18.2.a
14. Strong acids do not dissociate because they have strong bonds	6.2.d
15. Some acids/bases dissociate partially, which is based on the concentration of a solution	6.2.e
16. The strength of acids/bases is based on the rate of color change in litmus paper	8.2.e
17. As the number of hydrogen atoms increases in the formula of acids/bases, their acidity/basicity becomes stronger	8.2.f
18. Calculating the pH value of a solutions would not differ either using H_3O^+ or OH^-	9.2.a
19. The pH value of a solution is only related to acidic solutions, not about basic solutions (or OH^- ions)	9.2.c, 13.2.e, 13.2.f
20. Strong acids/bases eat materials away faster than weak acids/bases	102.a, 10.2.e
21. Bubbles or bubbling is a sign of chemical reaction or strength	10.2.c
22. Metals react only with strong acids	10.2.d
23. Only bases conduct electricity	11.2.a
24. Only strong acids conduct electricity	11.2.b
25. As the number of hydrogen atoms increases in the formula of an acid, its acidity becomes stronger	11.2.c
26. Any acidic or basic solution since including ion particles conducts electricity in same power regardless of its strength	11.2.e
27. pOH is just related with bases	12.2.a
28. Acids are more dangerous than bases	12.2.b
29. Only acids react with metals	12.2.c, 14.2.a
30. Acids react with all substances and H_2 gas is produced	14.2.a

(Table 3.4 continued)

Alternative Conceptions	Items
31. Bases react with all substances and H_2 gas is produced	14.2.b
32. Bases react with carbonate and CO_2 gas is produced	14.2.d, 14.2.e
33. Acids react with carbonate and H_2 gas is produced	14.2.a
34. Bases react with carbonate and H_2 gas is produced	14.2.b
35. Acids turn red litmus paper into blue	15
36. Bases turn blue litmus paper into red	15.2.d
37. Indicators are used to test whether an acid is strong or weak	16.2.a
38. In a titration reaction, a reaction does not occur unless there is an indicator	16.2.a, 16.2.c
39. A neutralization reaction always ends with a neutral solution, without regard to strength of acids or bases	16.2.c, 16.2.d, 17.2.f
40. Weak acids/bases dissociate easily since they have weak bonds	18.2.b, 18.2.c

Four types of variables were used to analyze the data: i) first-tier scores (only the conventional multiple choice step was taken into account), ii) two-tier scores (the first two tiers, the question and the reason of that question, was taken into account), iii) three-tier scores (the all tiers were taken into account), and iv) confidence tiers (only the third confidence tier was taken into account). In addition, the Cronbach alpha reliability was calculated for the first, second and three tier scores. This categorization was done as indicated by Pesman and Eryilmaz (2009). Based on this categorization students' responses can be analyzed into different level of understanding and patterns: a student's response can give an idea whether that the student responded to the first tier consciously since the second tier sought for its reason and the confidence tier presented whether the student was sure about the responses for the first two tiers, which actually sought for whether the student's errors were because of lack of knowledge or not. If a student answered incorrectly for the first and second tiers and finally sure about the answers for the first two tiers, it could be determined as the student has misconception on that particular concept.

The reliability (Cronbach alpha coefficient) for the first tier scores was found to be .58, for the two-tier scores was .59, and for the three-tier scores was .72. In addition, the relationship between two-tier scores and confidence tiers was investigated by using Pearson product-moment correlation coefficient. The high school students who scored higher in the test were more confident than lower scorers. There was a medium, positive and significant correlation between the two-tier scores and confidence tiers [$r=.45$, $n=156$, $p<.000$], with high scores of two-tiers with high level of confidence (see Figure 3.2).

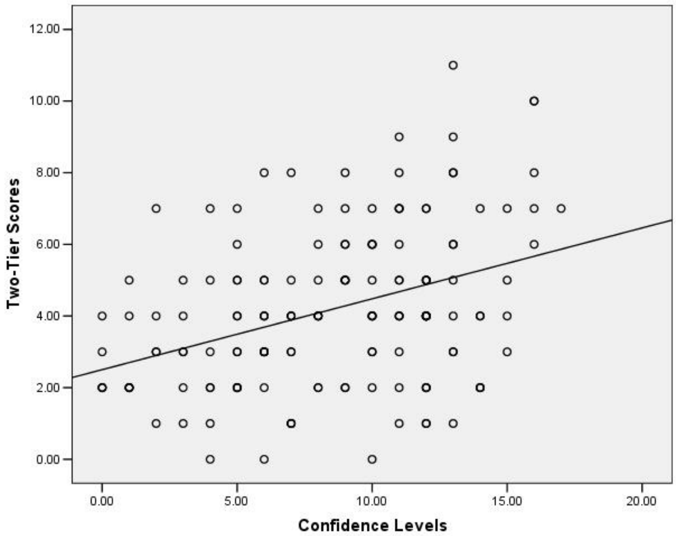

Figure 3.2 Scattergram of two-tier scores vs. confidence levels

The Figure 3.2 shows that there are some students scored low with high confidence, which indicates that these students are pretty confident about their responses at the test and probably have misconceptions on acids and bases concepts in chemistry.

The reliable and validated results of the developed TABT were found appropriate to be used in this present study; therefore, this test was distributed to as pre- and post-tests during the implementation. Since students were mostly unfamiliar with acids and bases questions before the implementation on the pre-test, only post-test scores details are presented here.

The item analysis was conducted for the post-TABT in threefold: one-tier scores, two-tier scores, and three-tier scores respectively. The Cronbach's alpha reliability coefficients were found as 0.767, 0.794, and 0.810 respectively. These results presents also that the three-tier tests are more reliable than conventional multiple-choice tests, which indicates one-tier test in this situation. Table 3.5 gives the results of the analysis. In the table, proportion of correct responses (labeled as Prop. Correct in the table) indicates the difficulty level of the items. In addition, point biserial (labeled as Point Biser. in the table) indicates the item discrimination, which is the correlation between correct or incorrect responses to each item. The difficulty levels in this present study were 0.128 and 0.667 with an average of 0.387 based on the three-tier test scores item analysis.

Table 3.5 Item analysis results for the post-TABT

One-tier Test Scores			Two-tier Test Scores			Three-tier Test Scores		
Item #	Prop. Correct	Point Biser.	Item #	Prop. Correct	Point Biser.	Item #	Prop. Correct	Point Biser.
1	0.423	0.328	1	0.295	0.354	1	0.269	0.443
2	0.397	0.310	2	0.346	0.309	2	0.308	0.372
3	0.551	0.200	3	0.500	0.238	3	0.462	0.252
4	0.718	0.411	4	0.603	0.498	4	0.564	0.552
5	0.526	0.353	5	0.154	0.297	5	0.128	0.313
6	0.846	0.237	6	0.641	0.448	6	0.538	0.454
7	0.590	0.680	7	0.385	0.520	7	0.359	0.529
8	0.500	0.365	8	0.449	0.417	8	0.397	0.468
9	0.590	0.251	9	0.474	0.388	9	0.462	0.416
10	0.590	0.632	10	0.513	0.619	10	0.449	0.593
11	0.667	0.583	11	0.551	0.662	11	0.538	0.606
12	0.244	0.396	12	0.179	0.352	12	0.154	0.334
13	0.564	0.762	13	0.423	0.656	13	0.333	0.564
14	0.526	0.427	14	0.346	0.525	14	0.346	0.533
15	0.782	0.449	15	0.705	0.548	15	0.667	0.596
16	0.308	0.508	16	0.192	0.517	16	0.192	0.529
17	0.449	0.562	17	0.397	0.579	17	0.372	0.636
18	0.692	0.603	18	0.487	0.518	18	0.436	0.519
Alpha		0.767	Alpha		0.794	Alpha		0.810
Mean P		0.553	Mean P		0.425	Mean P		0.387
Mean Item-Tot.		0.448	Mean Item-Tot.		0.469	Mean Item-Tot.		0.484

These results indicate that the items were quite difficult for the high school students and only 38.7% of the participants gave correct answers for the post-TABT. The item discrimination levels were 0.252 and 0.636 with an average of 0.484. Crocker & Algina (1986, p.315) suggested that item discrimination indexes below 0.19 should be eliminated or completely revised; as given in the table there were not any indexes below the criteria. The lowest index, which was 0.252, was in the range that needed revision (indexes between 0.20 and 0.29 need revision) and the item 3 was examined but no modification was done. The rest of items were in the satisfactory ranges and quite discriminative.

The mean proportion of correct responses of tests differed in terms of tiers, which is also a sign of the power of three-tier tests. The mean of item difficulty index is the highest for the one-tier test scores. In other words, 55.3% of the participants gave corrects answers for the one-tier questions; however, this index decreases to 42.5% for two-tiers and similarly to 38.7% for three-tier tests. The difference among the correct response of the one-, two-, and three-tier questions illustrated that students answered the questions by guessing or chance. When students are asked for an explanation for questions, the chance factor of answering a question correctly is reduced. In addition, a confidence-tier enables more reliable and valid results for test scores.

3.3.2 Chemistry Motivation Questionnaire

In order to assess student motivation to learn chemistry "Chemistry Motivation Questionnaire" (CMQ) was used. The CMQ was adapted from Science Motivation Questionnaire (SMQ) developed by Glynn and Koballa (2006) into Turkish by researcher. The SMQ aims to measure high school students' motivation to learn science. There were 30 items on a 5-point Likert-type scale and consisting of six factors which were *intrinsically motivated science learning*, *extrinsically motivated science learning*, *relevance of learning science to personal goals*, *responsibility (self-determination) for learning science*, *confidence (self-efficacy) in learning science*, and *anxiety about science assessment* (see Table 3.6 for item distribution into factors). The ranging of the items was "never", "rarely", "sometimes", "usually", and "always". The positive statements were scaled from 1 to 5 and the anxiety about science assessment factor consisting of negative statements was scaled from 5 to 1. Therefore, the maximum possible score was 150 and the minimum score was 30. The reliability coefficient estimated by Cronbach's alpha score was found 0.93 (Glynn and Koballa, 2006).

Table 3.6 Factors underlying in the SMQ

Factors	Item #
Intrinsically motivated science learning	1, 16, 22, 27, 30
Extrinsically motivated science learning	3, 7, 10, 15, 17
Relevance of learning science to personal goals	2, 11, 19, 23, 25
Responsibility (self-determination) for learning science	5, 8, 9, 20, 26
Confidence (self-efficacy) in learning science	12, 21, 24, 28, 29
Anxiety about science assessment	4, 6, 13, 14, 18

The adaptation process of SMQ into Turkish and chemistry was conducted during the spring semester of 2007-2008. The back-translation procedure was used during the adaptation process, in which a questionnaire is translated to target language than translated questionnaire is translated to original language by different bilingual researchers. Therefore, three bilingual researchers, studying chemistry education, individually translated the original questionnaire into Turkish. The consistencies and inconsistencies were compared between the translated questionnaires and the draft translated questionnaire was given to another bilingual two chemistry educators who have no knowledge of the questionnaire in order to translate the draft questionnaire into English. The purpose of this back translation was to find out whether there were any ambiguities in the items. In the light of these translations, the second draft of the questionnaire was formed. This second draft questionnaire was distributed to 27 high school students and they were pronounced that they were free to write any comments about items such as unclear items or grammatical errors at the blank spaces under each item. This procedure was done in order to check face validity of the questionnaire. Based on the students' feedbacks, the second draft of the questionnaire was revised and a final version was formed. The final CMQ was distributed to 1612 high school students. The 30 items of the CMQ were subjected to principal components analysis (PCA). Prior to performing PCA the suitability of data for factor analysis were assessed. Inspection of the correlation matrix revealed the presence of many coefficients of .30 and above. The Kaiser-Meyer-Olkin value was .947, exceeding the recommended value of .50 and falls into the range of being superb, indicating sample size was adequate for analysis (Field, 2009). In addition, the Barlett's Test of Sphericity reached statistical significance (χ^2 (435) = 19675.486, p<.001), supporting the factorability of the correlation matrix (Table 3.7).

Table 3.7 The KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.947
Bartlett's Test of Sphericity	Approx. Chi-Square	19675.486
	df	435
	Sig.	.000

The analysis of the CMQ via PCA with Direct Oblimin rotation gave five components with eigenvalues exceeding criterion of 1, explaining 31.68 per cent, 10.87 per cent, 5.94 per cent, 3.73 per cent, and 3.39 per cent of variance respectively (see Table 3.8 gives the pattern matrix for item loadings). The components were labeled as *self-efficacy in learning chemistry* (eight items), *anxiety about chemistry assessment* (five items), *relevance of learning science to personal goals* (seven items), *intrinsically motivated chemistry learning* (five items), and *self-determination for learning chemistry* (five items) respectively. This labeling process was done considering the item meanings which were closely related to each other and the factor loadings under the component. In the five components solution, total variance explained was 55.62%. The interpretation of the five components was quite consistent with previous research on the SMQ (Glynn & Koballa, 2006); the result of Glynn and Koballa (2006) study support the use of six components, however, the adaptation of this questionnaire is more suitable to the use of five components in Turkish education system and culture.

In addition, the reliability coefficient estimated by Cronbach's alpha was found to be 0.902. Furthermore, each factor's reliability coefficient was examined; self-efficacy in learning chemistry, anxiety about chemistry assessment, relevance of learning chemistry to personal goals, intrinsically motivated chemistry learning, and self-determination for learning chemistry were the factors and the reliability coefficients for these factors were 0.851, 0.754, 0.878, 0.691, and 0.755 respectively (see Table 3.9 for detail).

Table 3.8 Loading of items to the components in the CMQ

	Component				
	1	2	3	4	5
Q29	.738	.152			
Q21	.733		.119	.103	-.109
Q28	.728	.217			.160
Q12	.596				.271
Q24	.571		.137		.164
Q3	.448	-.308	-.119		.229
Q26	.331	-.112	.134		.266
Q30	.321	-.197		-.203	.293
Q6	.197	.799			
Q4	.144	.776			
Q13		.775			-.126
Q14	-.233	.634			
Q18		.461		-.406	.186
Q10			.855		
Q17			.821		
Q11			.799		.152
Q19			.719		
Q23	.190		.465	-.394	-.183
Q2	.226		.425	-.200	
Q25	.316		.358	-.328	
Q20	-.206	-.137		-.687	.133
Q16			.248	-.557	
Q22	.365	-.115	.148	-.410	-.154
Q27	.371	.108	.137	-.409	
Q1	.321	.103		-.356	.295
Q8	.124				.698
Q7	.178	-.259	-.133	-.141	.601
Q5			.205	-.114	.590
Q9		.139	.274		.560
Q15		-.317	.172	.127	.490

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalization. Rotation converged in 13 iterations.

Table 3.9 Summary for components found in the CMQ

Components	Item #	Eigenvalues	% of variance	α
Self-efficacy in learning chemistry	3, 12, 21, 24, 26, 28, 29, 30	9.50	31.68	0.85
Anxiety about chemistry assessment	4, 6, 13, 14, 18	3.26	10.87	0.75
Relevance of learning chemistry to personal goals	2, 10, 11, 17, 19, 23, 25	1.78	5.94	0.88
Intrinsically motivated chemistry learning	1, 16, 20, 22, 27	1.12	3.73	0.69
Self-determination for learning chemistry	5, 7, 8, 9, 15	1.02	3.39	0.75

The original SMQ consisted of six components whereas the adapted questionnaire consisted of five components into the case of Turkey. The extrinsically motivated science learning factor was distributed to other factors in the adapted version. On the other hand, the anxiety about chemistry assessment factor was composed of exactly the same items as defined in the original study. Additionally, the other four factors gave similar results with the original questionnaire. It was expected that the discrepancies would be found between the questionnaires; these differences could be because of cultural and educational differences. Based on these results, a valid and a reliable CMQ was adapted into Turkish.

The adapted version of CMQ was given to the sample (78 high school students) in this present study (see Appendix C for CMQ). The questionnaire consisted of two parts; the first part included demographic questions concerning gender, age, previous semester chemistry grade, education level of father and mother, number of siblings, expected grade at the end of the semester, and a couple of questions about socioeconomic status. The second part included 30 items concerning motivation to learn chemistry.

Confirmatory Factor Analysis (CFA) using LISREL was used in order to validate the adapted version's components of the CMQ proposed. Based on the analysis, the quite reasonable values were found for post-CMQ (see Appendix C for detail). Chi square and degree of freedom ratio (χ^2/df), which is less dependent to sample size, is checked for model fit (Joreskog & Sorbom, 1993). This ratio (χ^2/df) was found to be 2.11 indicating a good fit to the proposed model. Smaller values of Root-Mean-Square Error of Approximation (RMSEA) indicate a better fit and values below 0.05 indicate a very good fit (Byrne, 2010). The RMSEA value was found to be 0.077, indicating a moderate fit. 90-percent confidence interval for RMSEA ranged from 0.063 to 0.091. The Expected Cross-Validation Index (ECVI) is "a measure of the discrepancy between the fitted covariance matrix in the analyzed sample and the expected covariance matrix that would be obtained in another sample of the same size." This index can take any value but lower bound is 0 (Joreskog & Sorbom, 1993). The ECVI was found to be 9.304, ranging from 8.524 to 10.188. The Normed Fit Index (NFI) measures the model fit over the baseline independence model, having a lower bound 0 and an upper bound of 1, with the values exceeding 0.90 indicating a good fit to the data (Joreskog & Sorbom, 1993). The NFI was found to be 0.87, indicating that the proposed model was 87% better fitting than the null model. The Comparative Fit Index (CFI) is on the basis of noncentral χ^2 distribution, ranging from 0 to 1, with the values exceeding 0.90 indicating a good fit to the data. The CFI was found to be 0.955. The Root-Mean-Square Residual (RMR) is average residual value and Standardized RMR is average value across all standardized residuals, ranging from 0 to 1, with the values less than 0.05 indicating a good fit to the data (Byrne, 2010). The RMR was found to be 0.137 and SRMR was found to be 0.124, indicating a low model fit. The Goodness-of-Fit Index (GFI) is "a measure of the relative amount of variance and covariance in S that is jointly explained by Σ", ranging from 0 to 1 (Byrne, 2010), with values exceeding 0.9 indicates a good fit to the data. The GFI was found to be 0.633 and adjusted GFI was found to be 0.568. As the overall indices were taken into account for the post-CMQ, it could be inferred that the proposed model fit moderately to the present data. The path diagram, showing the components structure of post-CMQ, is given in Figure 3.3.

The reliability coefficient estimated by Cronbach's alpha was found to be 0.905 for post-CMQ. Furthermore, each factor's reliability coefficient was examined; self-efficacy in learning chemistry, anxiety about chemistry assessment, relevance of learning chemistry to personal goals, intrinsically motivated chemistry learning, and self-determination for learning chemistry were the factors and the reliability coefficients for these factors were 0.840, 0.754, 0.906, 0.654, and 0.783 respectively.

The CFA was applied to pre-CMQ as well. The indices presented here are for the pre-CMQ data. Based on this analysis, acceptable values were found (χ^2/df =2.14; RMSEA=0.071, ranging from 0.055 to 0.084; ECVI=8.911, ranging from 8.165 to 9.761; NFI=0.848; CFI=0.952; RMR=0.133; GFI=0.640, and AGFI=0.576). Hence, as the overall indices were taken into account for the pre-CMQ, it could be stated that the proposed model fit moderately to the present data. The path diagram, showing the components structure of pre-CMQ, is given in Figure 3.4.

The reliability coefficient estimated by Cronbach's alpha was found to be 0.873. Furthermore, each factor's reliability coefficient was examined; self-efficacy in learning chemistry, anxiety about chemistry assessment, relevance of learning chemistry to personal goals, intrinsically motivated chemistry learning, and self-determination for learning chemistry were the factors and the reliability coefficients for these factors were 0.796, 0.723, 0.878, 0.640, and 0.726 respectively.

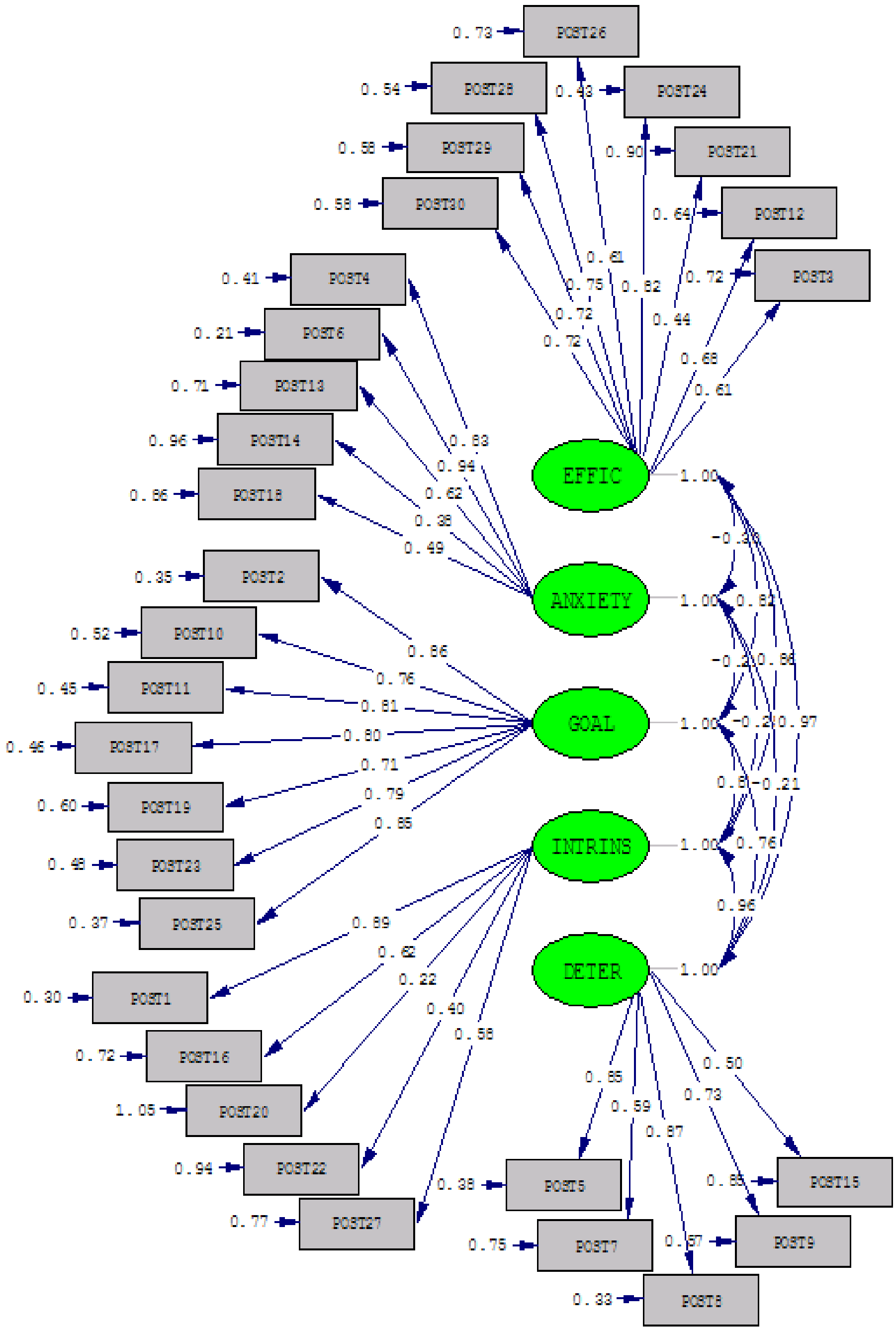

Figure 3.3 Path diagram for post-CMQ

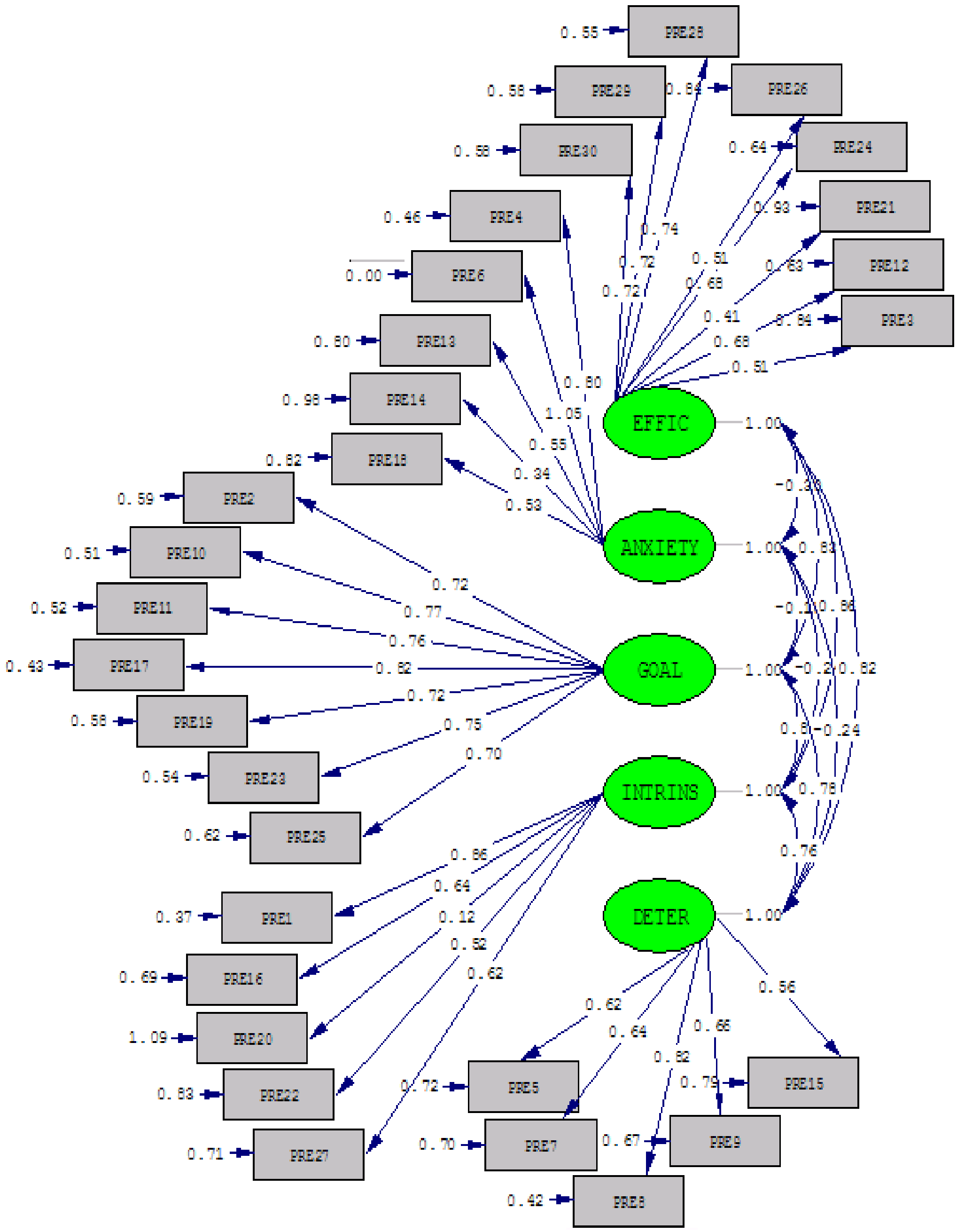

Figure 3.4 Path diagram for pre-CMQ

To sum up, the purpose of conducting CFA to CMQ was to present an evidence to construct related validity. Although the moderate fit was found for the proposed model in either case (pre- and post-CMQ), the results of both analysis reasonably supported the five component version of adapted CMQ.

3.3.3 Interviews

Twofold, consisting of cognitive and affective connections in learning, interview process was conducted with high school students during the study, which were done before and after the implementation. The purpose of these interviews was to find out students' ideas on acids and bases concepts and to bring out their perceptions on motivation to learn chemistry. The post-interviews also searched for what student ideas were about the implemented chemistry teaching method. Interview questions were formed in semi-structured version and probe questions were also embedded in case students had difficulties in answering the questions. These acids and bases interview questions were prepared by the researcher based on the literature review (Furio-Mas, Calatayud, & Barcenas, 2007; Nakhleh, 1994; Sheppard, 2006; Smith & Metz, 1996; Toplis, 1998; Vidyapati, & Seetharamappa, 1995) and taking acids and bases unit objectives into account. The interview questions were given to three chemistry educators and one chemistry teacher to check whether there were any unclear statements or inconsistencies with objectives. Some grammatical errors and inverted statements were declared by experts. Based on their feedbacks the final form of interviews was constructed (see Table 3.10 for interview schedule).

Eight students were interviewed before and after the implementation. These interviews were all audio-taped and transcribed verbatim for data analysis. All interviews were done in chemistry laboratory because of being quite and not disturbing place when students and the laboratory were available. Beforehand the interviews, students were informed that they would not be evaluated according to their responses and the purpose of the interview was to take their sincere ideas on acids and bases and learning chemistry. During the interviews students were encouraged to answer all questions in a friendly environment and told that there were no right or wrong responses as the main point was to truthfully express their ideas on learning chemistry.

Table 3.10 Interview Schedule for Acids and Bases

Big idea	Main Question	Purpose
Definition of acids and bases	What come to your mind when you are told about acids and bases?	To determine which theoretical definition (Arrhenious, Bronsted-Lowry, and Lewis acid-base definitions) students utilize, what properties they know about acids and bases, and which first three examples come up their mind.
Acids and bases in a daily life	Have you ever come across to an acid or a base in your daily life?	Elicit students' ideas about acids and bases in their everyday life, or how they know substances are acids or bases.
Defining of acids and bases	Students are shown some examples of acids and bases (chemical formulas of substances) and asked how they made up their minds that the substances are acids or bases.	Elicit students' ideas about how they determine a substance is an acid or a base when they are shown. A student strategy in determining of acids and bases could validate the underlying theoretical perspective that a student uses in defining acids and bases.
Identify acids and bases, pH and pOH concepts	Students are shown two erlenmeyers, one having of a pH 4 and the other having of a pOH 4, and asked how they can determine which beaker contains pH 4 solution. Students draw microscopic representations of each solution.	Elicit students' ideas about acids and bases, how they determine a substance is an acid or a base when they are able to test, indicators, litmus paper, and pH and pOH concepts. Microscopic representations of acids and bases could illustrate student models on acids and bases.
Strong and weak acids and bases	Show students a drawing of two erlenmeyers, one containing a strong acid and the other containing a weak acid solution. Ask students what the differences there are between two solutions in microscopic representations.	Elicit students' ideas about strong and weak acids and bases, student drawings of microscopic representations of a strong and a weak acid could illustrate student models on related concepts.
Neutralization	Students are demonstrated mixing an acid and a base in equal amounts in two conditions, in presence of phenolphthalein and not.	Elicit student ideas about acids and bases reactions, a neutralization concept, and indicators. Students' models of neutralization are determined.

Pre-interviews on acids and bases were done in order to get more detail about students' prior ideas on acids and bases concepts and learning chemistry. Before the interviews, some materials and instruments were prepared by the researcher; such as diluted strong and weak acid solutions, a sheet for identification of acids or bases, and materials for a neutralization activity. Post-interviews were done in order to get more details about students' post ideas on acids and bases and learning chemistry by the same interview questions as the pre-interview. In addition to pre-interview questions students were also asked about their ideas on the method in learning acids and bases; such as what they thought about the implementation, whether the method was effective and efficient for them, or what and how they felt about when they were in charge of doing activities.

In addition, afterwards the implementation the teacher was interviewed as well. The purpose of this interview was to find out the teacher's ideas on teaching approach. The interview questions cover what differences and difficulties that the teacher faced with during the process comparing the traditional chemistry teaching approach (see interview questions for both students and teacher in Appendix D).

3.3.4 Classroom Observation Checklist

Classroom Observation Checklist (COC) was used in order to ensure treatment verification in 5E learning cycle and traditional teacher-centered chemistry instruction. This COC was developed by the researcher; in this process previous studies were taken into consideration (Gurcay, 2003; Serin, 2009). Three aspects were considered while developing the COC, the physical conditions of a classroom and a chemistry laboratory, student's role in learning, and teacher's role in teaching for experimental and traditional groups. There are 32 items in this checklist, covering the main properties of the implemented chemistry instructions both for learning cycle and traditional instructions (see Appendix E). Observers had four alternatives in checking the related items; these alternatives are: yes, partially, no, and not applicable. Observers were expected to mark one of the three alternatives (yes, partially, and no) for related particular situations; but if an item included unrelated occasion for that particular observation, not applicable option was supposed to be marked.

All implementation sections were observed by the researcher in both groups. More than one observer enables to get more reliable results in implementation process; however, it was not possible to make another researcher observe the process. There were totally 49 classroom observations coded by the researcher; 26 class hours in the experimental group and 23 class hours in the traditional group.

3.4 Instructional Materials for the Experimental Group

This section gave the instructional materials used in the present study. The materials used in experimental groups and were developed by the researcher based on the literature research, objectives (See Appendix A), and daily life events related to acids and bases. In the subsections the details of these instructional materials are given.

3.4.1 Activities

The activities performed during the implementation were explained in this section. All activities were designed by the researcher and related contributory sources were emphasized. The developed activities were organized based on the big ideas, which were introduction to acids and bases, history of definition of acids and bases, determining acids and bases, strong and weak acids and bases, neutralization, and titration. The activities are given as the presented in the implementation.

3.4.1.1 Acids and bases

This activity was designed for motivational purposes; at the beginning of the unit students were supposed to write their ideas about what they knew about acids and bases. Students were free to write anything they want to express about acids and bases. The second question in this activity was about what they want to learn about acids and bases and this part was also was completed at the beginning of the unit (See Appendix F-1). The second question would express students' opinion about acids and bases, such as students might express their interest in acids and bases in their daily life or might state some subjects on acids and bases which they were anxious to learn about. The last question was about what students learn about during the implementation, in which students were supposed to express the subjects they had learned about. This third question would be distributed to the students at the end of the each activity. Students would be free to write anything that came to their mind about their previous learning; therefore, students were made to think about their understandings and learning.

3.4.1.2 A day with Melis

This was an introduction activity designed for students to make them aware of how they often interact with acidic and basic substances in their daily life and introduce them some acidic and bases substances that they often come across in their daily life. There were two version of this activity sheet; the first version was designed to be distributed in the first class of acids and bases concepts (See Appendix F-2A) and the second version was designed to be distributed to student to the next lesson (See Appendix F-2C). The purpose of the first version was to get student ideas about what substances they thought to be acidic or basic in their everyday life. The first version of this activity took about one-class hour. After the first class, students' results were categorized in order to detect their ideas about acidic and basic substances and their explanations of what they think; therefore, specifically, the false ideas about acidic and basic substances could be discuss in the next lesson (see the next chapter for results).

The second version was a brief activity designed for informational purposes. Students could find much more information about acidic and basic properties of many daily life substances. A teacher could lead the discussion on the acidic and basic properties of daily life substances; to begin with, students' false ideas could be stated. After discussion teacher informed students that they were going to also test acidity or basicity of some the substances they read in the text or other substances they were curious about in everyday life for coming classes. The second version of this activity took about 15-20 minutes.

In addition, this activity aimed to motivate students to learn about acids and bases concepts. Some basic knowledge (such as what materials in a daily life are acidic or basic), explanations of daily events (such as why statues get deformed), practical knowledge or key points (such as not to use acidic detergents with basic ones), and open-ended queries (such as how a cake rise) related to acids and bases were given in the activity to interest student to the subject and make them curious and anxious (see the next chapter for the results). This second version was not only designed for this section of the class, it was also designed to make attributions for the following class hours.

3.4.1.3 The History of the Definition of Acids and Bases

Since there are many definition of acids and bases student may feel complicated and exhausted in learning these definitions. The aim of this activity was to illustrate students why these definitions are needed and how these definition emerged during the history (see Appendix F-3A). Only Arrhenius, Bronsted-Lowry, and Lewis Acid-Base Theories were applied into the activity, as it is mentioned in the Chemistry Curriculum. The activity was consisted of the three main sections (Arrhenius Asit-Base Theory, Bronsted-Lowry Asid-Base Theory, and Lewis Acid-Base Theory); these sections have three sub-sections (Who Proposes the Theory, What is the Theory, and The Deficiencies in the Theory). This was a conceptual activity and students will discuss the theories, the properties of the theories, and the deficiencies of the theories. The average number of students in a group is four. At the beginning of the activity students study the theories; students were free to study individually or with group members. After 10 minutes, the students in each group pull out a paper from a bag, the student who gets "C" (stands for "Cevapla", which means answer) answers the questions and the student who gets "S" (stands for "Sor", which means ask) asks the questions to her/his team members. The Questioner asked the equal number of questions to team members (See Appendix F-3B). These were the questions for each theory to be asked;

- In what order did the definition of Acid-Base Theories emerge?
- Who proposed the Arrhenius/Bronsted-Lowry/Lewis Acid-Base Theory?
- What is an acid according to Arrhenius/Bronsted-Lowry/Lewis? What is a base according to Arrhenius/Bronsted-Lowry/Lewis?
- Could you give an example of the Arrhenius/Bronsted-Lowry/Lewis Acid-Base Theory?
- What are the deficiencies of the Arrhenius/Bronsted-Lowry Acid-Base Theory?

Group members, except the questioner, sit in order and the questioner directed the questions in that order. Students who answer the questions were not allowed to check the History of the Definition of Acids and Bases Text during questioning part. If a student did not know the right answer of the question, the turn passes to the next student. If no student gave the correct answer of the question, the questioner let them open the text and discuss the question. If still the group could not find the correct answer of the question, they could ask help from their teacher. Students get one point for each correct answer and a student who got the highest score got rewards, which were a METU emblem pen and a notebook. This activity took about one class hour.

At the end of the activity, the teacher mentioned that science was a subject that evolves every day. At the time of Arrhenius, his acid-base theory was valid, however, meanwhile it was observed that the theory had limitations and could not explain some acid-base reactions. This necessity had caused Bronsted and Lowry to propose another theory at the same time and even they were unaware of each other. Later, Lewis proposed the broadest theory of acids and bases. Both Arrhenius and Bronsted-Lowry theories are still valid, but have limitations in defining acids and bases.

Although this is a conceptual activity, it is also motivational since this activity includes a game and at the end of it they can get a reward. Another feature of this activity is that it is emphasized on the nature of science that science we know today may be invalid tomorrow and there is no one truth. Studies and developing technology enhance science to change.

3.4.1.4 Which Acid-Base Definition?

This activity designed to assess students understanding on acids and bases definitions. The activity covers Arrhenius, Bronsted-Lowry, and Lewis acid-base definitions. Five reactions were given in the activity sheet and students were supposed to complete the activity with their group members (See Appendix F-3C). This activity was designed to be distributed to the students afterwards the "The History of the Definition of Acids and Bases" activity, both activities could be used in a same class period, in case of shortage of time this activity could be used at the beginning of the next class in order to evaluate student understanding of acids and bases definition. The important part in the activity was that to make students were aware of the discrepancy within definitions and the number of species that can be considered acids or bases differed based on which aspects were considered. For example, if a reaction could be explained by the Arrhenius definition, that reaction could also be explained by the Bronsted-Lowry and Lewis definition but visa versa was not valid. In other words, if a reaction could be explained by the Lewis acid-base definition, that reaction could not be explained either by the Arrhenius or Bronsted-Lowry acid-base definition.

3.4.1.5 Let's do Magic!

This activity was designed for students to take their attention to indicators concept (Rohrig, 2002, p.140). Every groups gets two blank papers and liquid sprays, one of which containing an acidic and the other containing a basic solution. Students need to spray the liquid on the paper, as an outcome each group gets one word. Then, every group writes the word on a board and they construct a sentence, which is "Today's topic is to learn about indicators that help us to determine acidic and basic materials" ("Bugünkü – dersimizin – konusu – asidik ve bazik – maddeleri – belirlememizi – sağlayan – indikatörleri – yakından – tanımaktır.").

There were 10 groups in the classroom; therefore, the sentence was arranged as 10 parts. The papers were prepared before class and phenolphthalein was used to write the words. Phenolphthalein is a colorless indicator and when paper gets dried, no word can be read on the paper. The liquid spray containing diluted sodium hydroxide and the other liquid spray containing vinegar were prepared. As each group got two papers holding the same word, the groups were divided into two parts one of them spraying acidic solution and the other spraying the basic solution. As the basic solution was sprayed on the paper, the word turned to pink; in other words, phenolphthalein turned to pink in the basic solution. However, as phenolphthalein was exposed to the acidic solution, it remained colorless. This activity was used as an introductory activity on determining acids and bases to the class and took about 10 minutes.

3.4.1.6 Magic of Red Cabbage

In this activity students will learn that red cabbage juice turns into different colors in acidic and basic solutions (Rohrig, 2002, p.130. In addition, they comprehend that indicators are substances that help determining acidity or basicity of substances and they will apply what they have learnt from indicators and test acidity or basicity of substances via using litmus paper, red cabbage pH paper, and universal indicator. Additionally, students will learn about how to read and interpret the color of indicators. This activity makes emphasize on red cabbage juice; however, in order to extend student vision about indicators, litmus paper and universal paper is added to the activity. Therefore, students will comprehend there are many kinds of indicators, some them they are familiar with.

Students usually know about litmus paper from previous levels and often do not experience other indicators in a class. Students may feel anxiety when they hear the name of "indicators"; this anxiety can be because of hearing unusual name and then feel complexity in learning the details. Red cabbage is a vegetable that students often come across in everyday life. The color of red cabbage turns into many colors depending on acidity or basicity of a solution. Beforehand the activity was done in the class; the red cabbage pH papers were prepared. Red cabbage was boiled in a pan with sufficient amount of water. Filter papers were soaked into the red cabbage solution and let them absorb the solution. Then, filter papers were dried and cut in stripes (See teacher handouts below for detail).

At the beginning of the activity the teacher demonstrated the pH scale of red cabbage juice. Then, every group picked up at least three substances from the desk which they wonder about its acidity or basicity. Afterwards, students tested the materials via litmus paper, red cabbage pH paper, and universal indicator paper; and write down the results on the activity sheet (see Appendix F-4) and the common poster hanged on the wall. This activity takes about 20 minutes.

In addition, this activity aims to motivate students to learn about acids and bases, since students do tests and learn about everyday materials that they are familiar with in their everyday life.

3.4.1.7 The Strength of Acids

In this activity, students will observe the difference between a strong acid and a weak acid. Students often have difficulties in understanding the strengths of acids and bases. In addition in everyday language, students use “strong” and “weak” words in different meaning and they try to relate that meaning with acids or bases; such as strong acids have strong bonds and weak acids have weak bonds (See Alternative Conceptions in Acids and Bases Section).

A strong and a weak acid solutions can be at the same molarity; however, the molarity of hydronium ion will differ in dissociation process. In this kind of situation, students often think that since both solutions have the same molarity, the hydronium ions concentration in the solutions should be the same. In order to prove that this situation differs in strong and weak acids and bases, this activity is developed. Students will able to observe that even the solutions have the same molarity, the products can differ. In addition, students will observe one of the properties of acids, which is metals react with acidic solutions and hydrogen gas is liberated.

For the activity, each group had two erlenmeyers having two different solutions in them on their desks; these solutions were in the same volume and molarity; one erlenmeyer has 100 ml 0.5M acetic acid and the other has 100 ml 0.5M hydrochloric acid solution. The equal amount of magnesium metal was placed into the balloons and the balloon was put at the top of erlenmeyer. At the same time, magnesium metal particles were dropped into the Erlenmeyer (See Appendix F-5).

This activity took about 20 minutes, developed as a prerequisite acidity for the strength of acids and bases, and made the distinction between strong and weak acids. Afterwards this activity, “What are the differences between strong and weak acids?” activity is designed. This activity, labeled as “The strength of acids”, gave emphasis to students’ macroscopic level and the following activity, labeled as “What are the differences between strong and weak acids?”, aimed to emphasize on students’ microscopic level regarding the strength of acids and bases and students could be aware of the changes that take place on the particle level in strong and weak acids.

3.4.1.8 What are the differences between Strong and Weak Acids?

This activity aims to investigate students’ microscopic ideas on strong and weak acids/bases. High school students have many alternative conceptions about strong and weak acids/bases as mentioned in the previous sections; in order to determine whether students’ have alternative conceptions such as strong acids/bases are strong because of having strong bonds; weak acids/bases are weak because of having weak bonds; concentration acids/bases are strong; or diluted acids/bases are weak; this activity is designed (See Appendix F-6).

Students in a group discussed the four situations given in the activity and draw related drawings considering particles. This activity took about 20 minutes. This activity also integrates the students' ideas about strong and weak acids and bases as well as their ideas about concentrated and diluted solutions. Students discuss their representations with their group members. The purpose of this activity is to assess students' understandings about strong and weak acids as well as their understandings about concentrated and diluted concepts, and how they integrate these concepts.

3.4.1.9 What is Neutralization?

This brief activity is developed for students to comprehend about neutralization reactions. This activity is designed to be used as an introductory activity for the neutralization concept. Red cabbage is a perfect indicator for this activity, since its color vary in acidic and basic solutions. When the red cabbage juice is used, students will observe that as an acidic solution is added to the solution, the color turns into reddish colors and as a basic solution is added to the solution, the color of the solution turns into greenish colors. The neutral color of the red cabbage juice is purplish color. This activity will enhance student to realize that neutralization reaction occurs and based on the hydronium ions in the solution the color of red cabbage juice changes. In addition, the activity will make students think about what happen in particle level as neutralization occurs (See Appendix F-8).

Students had two droppers, one containing acidic solution (which was diluted hydrochloric acid) and the other containing basic solution (which was diluted sodium hydroxide). Each group also had a red cabbage juice solution and they added the acidic solution drop by drop and observe the color change; then, the basic solution was added drop by drop into the same solution and students observed how the solution turns back to its previous color and then color changing based on the basic solution. After that, students drew their models about what occurred in particulate level during the neutralization process.

During the implementation, this activity is back up with simulation which makes emphasize on the microscopic level and show how neutralization occurs on the particle level.

3.4.1.10 What causes a cake to rise?

This activity aims to cover the neutralization concepts and developed by the researcher. This activity enables students to comprehend the neutralization event with household materials used in their everyday life. Students also have opportunity to observe that there are some acids and bases that are not dangerous and their reactions with each other are not hazardous. Students have alternative concepts that only strong acids and bases react with each other and salt and water are produced; this activity could enhance students to observe weak acids and weak bases reactions. This is also motivational activity since not only girls but also boys may curious about what kind of reaction occurs that causes a cake to rise (See Appendix F-9).

Baking soda (sodium hydrogen carbonate) is usually needed when there is yogurt or lemon juice in cake recipes. Since baking soda is basic and lemon and yogurt is acidic, a neutralization reaction takes place and carbon dioxide gas is produced; this gas causes batter to rise during baking. On the other hand, baking powder includes sodium hydrogen carbonate as well as tartaric acid; therefore, there is no need to use additional acidic substances when using baking powder since its containing both.

In the activity, there were two steps; at the first step students were allowed to observe the differences between baking soda and baking powder. They add some water onto powders and observed the bubbles just in the baking powder case. The second step was using baking soda as a basic substance and vinegar as an acidic substance. Vinegar was used instead of yogurt in order to observe bubbles well enough. In the previous step, students observed that water did not affect on baking soda; however, in this step, they observed that vinegar affected on baking soda and bubbles came out. Since baking soda, in other words sodium hydrogen carbonate, is a carbonate compound, carbon dioxide gas was produced. Students were told that when baking a cake, the similar reaction took place and carbon dioxide gas got trapped in the batter and causes it to rise. This activity took about 20 minutes.

3.4.2 Teacher Handouts

This part provided explanations for teachers about the activities used during the implementation and were developed for the teacher so that the teacher can used them during the implementation and follow the instructions in using the activities These handouts guide teachers during the activities, most activities are student-centered, but teacher will always be there to guide them when they need. However, in some activities teacher does the action because of hazardous materials or for completing the interval steps quicker. These handouts were developed by the researcher considering objectives stated in the curriculum (See Appendix A for the objectives and G teacher handouts).

3.4.2.1 Acids and Bases in Our Daily Life

This teacher handout gives the detail about the introduction of acids and bases concepts. The teacher will seek students ideas about acids and bases such as whether they come across to any acids or bases during their daily life or what an acid or a base conjure up in their minds (See Appendix G-1A). The two-stepped activity labeled as "A day with Melis" was distributed in the context of this handout. The purpose of this section was to make students aware that not all acids or bases were dangerous or hazardous some of which were directly in our daily life in our food or surrounding.

3.4.2.2 The Definitions of Acids and Bases

This teacher handout gives directions about how to present acid-base definitions. This handout covers the Arrhenius acid-base definition, the Bronsted-Lowry acid-base definition, and the Lewis acid-base definition (See Appendix G-2). In order to give the differences within definitions students understandings and ideas were aimed to inquired during the process, specifically the limitations of the definitions were addressed. Two student activities, which were "The Definition of Acids and Bases" and "Which Acid-Base Definition?" were distributed in the context of this teacher handout.

3.4.2.3 Let's do Magic!

This activity aims to motivate students to learn about indicators. In order to take students' attention to indicators concept "Let's do Magic!" activity will be done (See Teacher Handouts in Appendix G-3). Before the class the teacher prepares the materials; the writing is done with phenolphthalein and a sentence with ten words is arranged since there are ten groups. This sentence is: "Today's topic is to learn about indicators that help us to determine acidic and basic materials" ("Bugünkü – dersimizin – konusu – asidik ve bazik – maddeleri – belirlememizi – sağlayan – indikatörleri – yakından – tanımaktır.").

3.4.2.4 Magic of Red Cabbage

This activity aims to teach what students should understand from indicators and learn about the properties of indicators (see Appendix G-4). This activity is leaded by teacher demonstration which is determining the pH scale of red cabbage; then student will test acidity or basicity of some substances via using litmus paper, red cabbage paper, and universal indicator and write down the results on the activity sheet and the common poster hanged on the wall.

In order to safe time it is better to prepare the red cabbage juice and red cabbage pH papers before the class. In order to prepare red cabbage pH papers, put some water and sliced red cabbage in a pot and boil. Turn off the heat after half an hour and filter the juice in a container. Put some filter papers in a container and let them soak the juice. After a while remove the filter papers from the juice and let them dry. These red cabbage pH papers can be in good conditions for weeks, longer in a closed envelope. Keep the red cabbage juice in a refrigerator to use in this activity. Before the class, students are told that they are free to bring any kind of substances they want from their houses to test whether they are acidic or basic. The teacher also obtains some substances such as lemon, vinegar, coke, yogurt, milk, baking soda, mineral water, baking powder, soap, shampoo, or detergent to class in case students forget to bring materials.

There are two parts in this activity. The teacher demonstrates the first part of this activity, which is determining the pH scale of red cabbage juice. In order to determine the color scale of red cabbage juice, the teacher ranges the tubes filled with hydrochloric acid solution, lemon juice, vinegar, distilled water, baking soda solution, ammonia solution, and sodium hydroxide solution according to their increasing pH; then places a few drops of red cabbage juice and let students observe the change. Afterwards determining the pH scale of red cabbage juice from red to yellow, students are let free to test their materials (See Figure 3.5).

Figure 3.5 The pH scale of red cabbage juice obtained in the experimental class (from left to right HCl solution, lemon juice, vinegar, water, carbonate solution, ammonia, NaOH solution)

In the second part, students will test the materials they bring from their home and this will let students determine acidity or basicity of many materials they are familiar in their everyday life. Teacher allows students to take at least three different substances from the desk and let them apply the acidity and basicity test. Teacher reminds students to write their results down both on their activity sheet and the common poster hanged on the wall (See Student version of this activity in 3.4.1.4 section).

3.4.2.5 Concentrated-Diluted Solutions

It is often difficult for students to understand what is occurring at the particulate level. A lemon contains citric acid, one of the weak acids. Students have alternative conceptions that weak acids/bases are diluted solutions or strong acids/bases are concentrated solutions (See Alternative Conceptions in Acids and Bases); therefore, it is difficult for students to comprehend strength concept in acids/bases. In order to eliminate or not to create such alternative conceptions, this activity is developed

(Appendix G-5). Concentrated or diluted weak acid solution can be set up in order to make students observe that it is possible to form concentrated solution from a weak acid. Preparing a glass of lemonade activity is designed in order to emphasize the difference in concentrated and diluted acids/bases. The teacher squeezes a lemon in a beaker (See I in Figure 3.6), add 10 ml water (II), add 10 ml water again (III), and lastly add 10 ml water (IV). Adding each time some water in the lemonade causes dilution and students could infer the taste difference as well. The teacher asks about students' ideas about how they can visualize these dilution events on the board. Taken into students responses into consideration, teacher uses the drawing below to illustrate the situation in the particulate level. Students are explained that when the same size fraction of the solutions is taken, as it is seen from the drawing, there is decreasing number of particles in the fractions from concentrated to diluted solution.

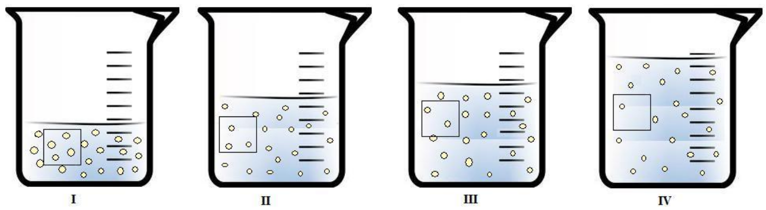

Figure 3.6 The particulate level illustration of dilution of lemonade

This representation helps students conceptualize dilution of a concentrated acidic or basic solution. A lemon has high concentration of citric acid which is a weak acid. Students have an alternation conception that a weak acid is always diluted (See the alternative conceptions section), in this illustration students could realize that concentration is not related to strength of acids or bases.

3.4.2.6 pH and pOH concepts

This activity will enhance students' understanding of pH and pOH concepts via experimenting different solutions or the same solutions in different concentrations relating the colour of redcabbage or litmus paper with pH and pOH concepts. Students usually relate pH and pOH concepts with the strength of acids or bases; such as, if a solution's pH value is close to 1, students consider the solution as a strong acid.

Students should illustrate that an acidic or basic solution with different concentrations have various pH or pOH values because of the difference in hydronium or hydroxide ion concentration. Another difficulty of students is that students may think that acidic solutions do not have hydroxide ions in solutions or visa versa for bases or neutral solutions with pH 7 do not have any ions in solutions. Therefore, this is activity mainly focused students' such alternative conceptions for not creating new ones or remeding the existing ones via emphasizing the concentration of hydronium or hydroxide ions, the derivation of pH and pOH values considering self-ionization of water, and the representations of acidic and basic solutions in different pH or pOH values using daily life examples.

3.4.2.7 Strong and Weak Acids

This activity will enhance students to differentiate the discrepancy between strong and weak acids and bases. In order to illustrate strong and weak concepts are related to dissociation the teacher will use a simulation, which shows the dissociation of HCl and HF in particle level (See Teacher Handouts in Appendix G-6). At the beginning of the activity the teacher inquiries about student ideas about strong acids and why some acids are called as strong or weak acids. The simulation progress is done step by step and students are let comprehend what is going on the particle level. Students have an alternative conception that strong acids have strong bonds and weak acids have weak bonds may be because of daily usage of these words. In order to overcome this kind of alternative conception, the teacher make emphasis on determining the strength of acids and bases is related to their dissociation in solutions and stresses the more dissociation, the stronger the acid. For further understanding, the teacher reminds students about electronegativity concepts from the previous semesters and recalls the periodic properties of F, Cl, Br, and I elements. The electronegavity values of H, F, Cl, Br, and I are given in order to compare the electronegativity difference in H–F, H–Cl, H–Br, H–I bonds. The teacher enables students to discuss which of them more easily give hydrogen into the solution relating the electronegativity difference in order to get the idea of the less electronegativity difference, the more easily dissociation.

In addition, conductivity of acids and bases were emphasized that a stronger acid is a better conductor of electricity since stronger acids dissociate more completely and more free ions are produced. The students are made to get a conclusion that a solution with high ion concentration will have a higher conductivity than one with a low ion concentration.

3.4.2.8 The Properties of Acids and Bases

This teacher handout covers the properties of acids and bases, such as taste, touch, reactions with metals, electrical conductivity, and neutralization. During the procedure demonstrations, videos and hands-on activities were used. Because of inconvenience of the chemistry laboratory air-conditions, an inquiry-based procedure was followed using videos. Attributions were arranged in the process to the second version of "A day with Melis", so that the real-life application of the properties of acids and bases would be illustrated. Students conducted two activities, which were "What is Neutralization?" and "How a Cake Rise?". Students could find interesting to learn some daily-life event related to acids and bases such as, the deformation of statues, acids rain, stomach sour, and baking a cake (Appendix G-8).

3.4.2.9 Titrations

This teacher handout was developed to illustrate titrations and enhance students to observe titration procedure both in macroscopic and microscopic level. The teacher does this activity in twofold, firstly does the demonstration and then shows the simulation of a titration considering particles. The teacher emphasizes that titrations can be used when there is a solution in unknown molarity to find out how much a substance is dissolved in a given volume of a solution.

In this particular situation, 60 ml HCl in unknown molarity is added to erlenmayer and 0.2 M NaOH solution is filled into a burette. In order to observe the change phenolphthalein indicator is used. This simulation is used since it shows titration process both in particle level and draws a graph step by step (Higher Education, 2009). Teacher enquires student ideas about what happens at each step in addition of sodium hydroxide taking into particle level and graph into account.

Students have an alternative conception that acid-base reactions occur in presence of indicators. In the simulation, a titration is demonstrated between a strong acid and s strong base as well as what happens at the particle level is highlighted. In every step of adding of sodium hydroxide into the erlenmeyer consisting hydrochloric acid, it is simulated what happens clearly step by step at the particle level (See Teacher Handouts in Appendix G-9 for the simulation steps in titration) as well as graphical presentation is available. During the titration simulation no indicator is used and no emphasize is done about it for the reaction occurrence, students can make aware of this (although this is a simulation); therefore, in order to get a reaction between an acid and a base, no indicator is needed idea is discussed with students. Hence, it is clearly stated that indicators just help us to observe when the end-point of a titration is reached.

3.5 Design of the Study

A quasi-experimental design that takes account of already existing groups (Fraenkel & Wallen, 2003, p. 278) is used as an experimental design in this study since it is not possible to do random selection of a student to a treatment group in Turkish school system. Because of the difficulty of a randomization of groups, random assignment was done between intact groups in order to control treatment groups. Therefore, the design of the study is the matching-only pre-posttest control group design as a type of quasi-experimental designs (Fraenkel & Wallen, 2003, p. 278).

Table 3.11 below summarizes the research design of the study, which expresses pre-tests were distributed before the implementation to both experimental and traditional groups. Afterwards the implementation process, post-tests were distributed to both groups.

Table 3.11 Research design

Groups	Pre-tests	Treatment	Post-tests
EG	TABT CMQ Semi-Structured Interview	5E Learning Cycle	TABT CMQ Semi-Structured Interview
TR	TABT CMQ Semi-Structured Interview	Traditional teacher-centered	TABT CMQ Semi-Structured Interview

This is a brief explanation for abbreviations in the Table 3.11: EG represents Experimental Groups which were implemented with 5E learning cycle model; TR represents Traditional Groups which were implemented traditional teacher-centered instruction. TABT was labeled for "Three-tier Acids and Bases Test" and CMQ was for "Chemistry Motivation Questionnaire".

3.6 Procedure

The section gives the procedure followed in this present study from the beginning to the end of the study. During the study process the following steps were carried out:

- ✓ The research problem was determined, which was studying on students understanding of acids and bases concept, determining student motivation to learn science, and developing activities to increase their motivation to learn chemistry.
- ✓ The key terms were determined, which were "acids", "bases", "alternative conceptions", "constructivism", "conceptual change", "inquiry", "constructivist teaching strategies", "learning cycle", "student-centered activities", "modeling", "motivation", "motivation to learn science", "real-life applications", and "hands-on activities".
- ✓ Literature review was done with the aforementioned key terms through Educational Resources Information Center (ERIC), Social Science Citation Index (SSCI), Ebscohost, Science Direct, JSTOR, Google Scholar, ProQuest Dissertation Abstracts International (DAI), ProQuest (UMI) Dissertations & Theses, METU Library Theses and Dissertations, Turkish Higher Education Council National Dissertation Center, TUBITAK-ULAKBIM Turkish Academic Network and Information Center, Hacettepe University Journal of Education, Education and Science (Eğitim ve Bilim), and Kuram ve Uygulamada Eğitim Bilimleri (KUYEB). Literature review process was done periodically to stay up to date.
- ✓ Sources were obtained and the readings were done. The literature review helped to construct the theoretical knowledge on the research problem. The similar previous studies lead the way, particularly alternative

conceptions on acids and bases. The results of research articles were examined and their implications and limitations were taken into consideration.

- ✓ Instruments used in the study were developed. The TABT was developed by the researcher. The CMQ was adapted into Turkish by the researcher. The pilot study of the TABT was done in 2008-2009 fall semester and the adaptation study of the CMW was done in 2007-2008 spring semester.
- ✓ Instructional materials for students and teachers were developed by the researcher based on the literature and revised based on the feedbacks from the chemistry educators.
- ✓ In order to conduct the study in high schools necessary permissions were gotten from the Ministry of National Education from two regions in Ankara, which were Cankaya and Etimesgut.
- ✓ Determining the sample size, Cohen, Cohen, West and Aiken (2003, p.177) was followed as a guideline for determining the sample size of the study. Similar to most educational studies, the significance level was determined as .05 in the present study, the power was set as .80, and the effect size of the study was set as a medium effect size (the proposed effect size values for f^2 were: small= .02, medium= .15, and large= .35). Therefore, the required sample size for this study was calculated as 56.
- ✓ Application of pre-tests, the TABT and the CMQ were administered to both experimental and traditional groups on the same day. These tests were administered two weeks before the study both by the researcher and the teacher. The semi-structured interviews were done when students were available. The students were informed that their results would be confidential and their names would not be used anywhere in the study.
- ✓ Main study was conducted in the 2009-2010 spring semester, this process lasted for nearly eight weeks for experimental group (23 class hours, 3 hours a week) and seven weeks for traditional group (21 class hours, 3 hour a week). The acids and bases unit was designed for approximately eight weeks (3 class hours a week) in former chemistry curriculum. During the implementation, the former chemistry curriculum had been

followed, the following semester the current chemistry curriculum was applied for 11th grades. Two intact classes were used in the implementation, one of them was the experimental and the other was the traditional group. In the experimental group 5E learning cycle and in the traditional group traditionally designed chemistry instruction was used.

- ✓ Application of post-tests; the TABT and the CMQ were administered to both experimental and traditional groups on the same day both by the researcher and the teacher. The semi-structured interviews were done when students were available.
- ✓ Data entering; the data gathered from the pre- and post-TABT and pre- and post-CMQ were entered into Microsoft Office Excel and then run in Iteman, SPSS, and Lisrel. The qualitative data gathered from the pre- and post-interviews were transcribed.
- ✓ Analysis of data; descriptive, inferential and confirmatory statistical analysis were done for the TABT and CMQ. The coding was done by the researcher.
- ✓ Writing the dissertation

3.7 Implementation for Groups

In this section, the implementation conducted in the experimental and traditional groups were given in two subsections. Constructivist teaching strategies (inquiry based hands-on activities, group discussions, and class discussions under the steps of 5E learning cycle model) were used in experimental group and traditional teacher-centered chemistry instruction was used in traditional group. The experimental group students were implemented in the chemistry laboratory; on the other hand, the traditional group students were implemented in the regular classroom (Figure 3.7).

Experimental Group (Chemistry Lab) Traditional Group (Regular Classroom)

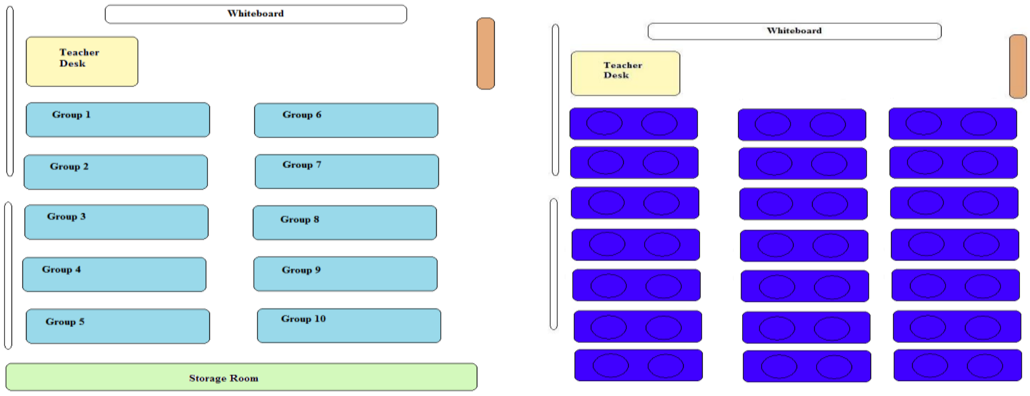

Figure 3.7 The view of class designs both in experimental and traditional groups

3.7.1 Treatment in the Experimental Group

The instruction was designed based on the learning cycle model considering five steps, which were Engagement, Exploration, Explanation, Elaboration, and Evaluation. Nine teacher handouts were designed and the teacher followed these handouts during the instruction. Ten student activities were designed for students to follow the procedure in the activities in which students were actively involved in learning procedure to get opportunities to develop manipulative and technical skills and the teacher acted as a facilitator. The teacher's role was a facilitator for students in discovering knowledge instead of providing knowledge. During the implementation, in order to encourage students the teacher asked leading questions and enhanced them to think and discuss the related questions in activities with their peers. The students' role was to discover knowledge with their peers by doing their activities and discussed the questions in activities or the teacher asked.

From elementary school curriculum, students were fairly aware of some basics of acids and bases. They knew that "Acids turns blue litmus to red and bases turns red litmus to blue.", "Acids taste sour and bases taste bitter.", "Acids release a hydrogen into water and bases release a hydroxide ion into water.". In order to determine what the students knew about acids and bases, the TABT (as a pre-test) was administered. This test also aimed to test students' alternative conceptions about acids and bases.

Before the treatment began, the teacher wanted from the students to create groups consisting of four pupils. In order to create groups, first of all the teachers let the students to create their own groups; afterwards, the teachers did rearrangement when there was imbalanced groups in terms of achievement. The teachers focused not to create groups only with low-achievers or with high-achievers. Because students can learn from each other, the groups were created balanced in terms of their achievement.

In order to identify students' general ideas about acids and bases and what want to learn about "Acids and Bases" unit an activity sheet was distributed at the end of the previous unit (See Appendix C), "Chemical Equilibrium", and 15 minutes were given to the students. Onto that sheet students were asked to give responses to two out of three questions. This activity is two stepped; at first students were questioned about what they know about acids and bases and what want to learn about acids and bases; during the unit they were going to be questioned about what they learned, as well. The purpose of this activity was to determine students' ideas about acids and bases and what they were striving to learn about for this unit. In other words, student expectations for "Acids and Bases" unit were inquired. The purpose of the last question was twofold, conceptually and motivationally. In a conceptual manner, it searched for student learning and whether they had any misunderstandings during the unit. In a motivational manner, this question managed students to think about their personal learning and since some students sometimes behave shy and could not ask questions or tell the teacher that they did not understand the subject, this activity could enable students to express difficulties in their learning and state their thoughts more easily by writing than face-to-face communication.

The next lesson in introducing the topic (this part corresponded to the engagement step of 5E), the teacher asked what images the word acid conjures up in their mind. The teacher listen students' responses and explained that she was going to distribute a paper set that wrote about a one day of a university girl. The teacher told the students that the aim of the activity was to determine what they thought about acids and bases in daily life. Therefore, an activity named "A day with Melis (see Appendix C, "Melis'in bir günü")" distributed to every student. First of all, each student read the activity individually and then tried to answer the related questions. Ten minutes were given to students to complete the reading activity and answering the questions. The questions were:

- What are the acids that Melis were faced with during the day?
- Why do you think that they are acids?
- What are the bases that Melis were faced with during the day?
- Why do you think that they are bases?

After each student finished the activity, the teacher enabled them to discuss the questions with their group members. In their discussions, students talked about the materials which could be acids or bases (this part corresponded to the exploration step of 5E). Ten minutes discussion time was given to students and they were asked to argue whether there were differences within each other in selecting the substances and their acid-base categorization. In addition, they try to convince their friends by supporting evidence why they thought that the substance is an acid or a base. After the discussion, they wrote the report which includes what substances they thought that were acids or bases in group agreement. If they lacked of consensus, they were told to write the differences they had discussed. The teacher collected all activity sheets and then asked whether they had difficulties in deciding what substance was an acid or a base. After getting students' reflection, the teacher explained that scientists also had difficulties in deciding what is an acid or a base. Then, the teacher expressed that the categorization of chemical substances as acids and bases helps in many ways; but just looking to the substance was not enough to understand the substance was an acid or a base (this part corresponded to the explanation step of 5E). The teacher also said that in many type of sciences this sort of categorization could be found; for example, she asked to the students what came to their mind when she said a dog. Students gave some descriptions of dogs such as furry, faithful, have long ears, act as a guard, have a good sense of smell, etc. the teachers stated that likewise the categorization of animals, the categorization of substances in chemistry helps in many ways such as when an acid or a base was called what should came to student mind would be discussed in the unit.; therefore, scientists made some generalizations for chemical substances. At the end of the lesson, the teacher told the students to check the description of some substances (at least three of them) at home in which they came across at the activity or about which they were curious about and they were free to bring them to class (this part corresponded to the exploration step of 5E). Therefore, for the next lesson, the students would check the descriptions of some substances written at the back they had read in the activity in order to determine whether these substances were acidic or basic.

For the next lesson, the collected activity sheets were analyzed by the researcher. The researcher categorized the students' answers (see Table 4.17 for the detail in Chapter 4). This categorization had four options: acidic, basic, neutral, and not sure. Based on student responses, the substances which were students not sure about their acidity or basicity or had false decision on their acidity or basicity were determined for the activities. These substances were going to be used by the students during the activities; therefore, the substances that were the students were not sure about whether they were acidic or basic were selected, such as aspirin, milk, mineral water, and toothpaste.

The following lesson the teacher started the lesson by asking whether they came across any acidic or basic materials in their daily life and got students responses. Then, the teacher asked the students what they found during their search on substances. The students expressed their search results such as one of the students stated carbonate included sodium bicarbonate and not sure still about its acidity or basicity but since it was used in food, it was probably an acidic substance; another student stated that bleach included sodium hydroxide and a basic substance as he thought about; and another student stated coke included water, sugar, carbon dioxide, coloring, phosphoric acid, and caffeine and since including phosphoric acid coke was an acidic substance. The teacher took students' findings into consideration and explained that the students themselves would tested those all materials whether they were acidic or basic. Then, the teacher continued by reporting the students' discussion group results and emphasized that although the students gave the similar responses, they had some discrepancies among each other in deciding whether substances were acidic or basic.

Afterwards, the teacher asked that how a material could be decided whether it was an acid or a base and listened students' responses. The teacher expected to get an answer that a litmus paper was used to test whether a material was acidic or base since the students were expected to know this knowledge from their middle school science courses. Then, teacher let students to test at least four materials with a litmus paper (See

Appendix F-2B); they were free to use the materials either they had brought from their homes or the teacher supported (this part corresponded to the exploration step of 5E). After finishing the activity, the students compare and discuss their results on the poster. Finally, the teacher distributed the second version of "A day with Melis" activity (see Appendix F-2C). The students were supposed to read the text and answer the question (this part corresponded to the evaluation step of 5E).

The following lesson, in order to both evaluate students' previous learning and get students' ideas on acid-base definitions the teacher asked to the students what they understood from the term of an acid and listened carefully the students' responses (this part corresponded to the explanation step of 5E). The students expressed their ideas what the word acids conjured up in their mind. The same questions were asked for bases. The teacher mainly paid attention to students' ideas, but she did not try to make corrections on students' responses. Then, the teacher explained that scientists use different approaches to determine what substances are acids or bases and it would be used to study them at the molecular level in order to understand the properties of acids and bases (this part corresponded to the elaboration step of 5E). The teacher gave some examples to students related with Arrhenius acids; such as HCl, H_2SO_4, HNO_3, HBr, HI and Arrhenius bases; such as NaOH, KOH, $Mg(OH)_2$, $Al(OH)_3$, $Ca(OH)_2$. The teacher told the students that stomach juice contains hydrochloric acid, cleaning materials also contains hydrochloric acid, power supply in cars contain sulfuric acid, soap contains sodium hydroxide, liquid soap and shampoos contain potassium hydroxide, stomach ache relief pills contain magnesium hydroxide or aluminum hydroxide, and limewater contains calcium hydroxide and then asked the students what were the common properties of these substances. The students responded such as "a substance which had hydrogen in its formula is an acid", "a substance that dissociate in water to produce hydrogen ions", "a substance that dissociate in water to produce hydroxide ions", or "a substance which had hydroxide in its formula is a base" were expressing. In this step, the teacher expressed that students' ideas were not so different with what Arrhenius said. The teacher mentioned the basics of the theory, how Arrhenius defined an acid and a base based on releasing ions when dissolving in water and asked from the students to show dissociation on the examples written on the board. In order to conflict the students, the teacher gave CH_4, NH_3 and CH_3COOH examples to students and asked them how they could determine these materials whether they were acidic or basic based on the Arrhenius Theory. The teacher explained that CH_4 was an Arrhenius acid based on his theory though not having the properties of an acid, NH_3 has the properties of a base but not recognized as a base based on the Arrhenius definition, and CH_3COOH has a properties of an acid though it was thought it contains OH group. Then, the teacher made a demonstration using NH_3 and HCl drops on two small pieces of cottons, and then placed these cottons into the two edges of glass tube. The students observed the occurrence of white smoke near the side of HCl cotton, and during this demonstration the teacher made the students remember their previous learning about the diffusion of gases. The teacher asked the students the reaction occurred and wanted them to explain this reaction based on the Arrhenius definition (this part corresponded to the evaluation step of 5E). The purpose was to make them aware of the deficiencies of Arrhenius definition such as restriction to water solutions, ambiguity of acid-base dissolution in water, and deficiency in definition in covering some compounds having the properties of a base; therefore, by this demonstration students attention were taken to the expansion of Arrhenius definition by Johannes Bronsted and Thomas Lowry independently as acid-base reactions can occur in the gas phase, as in the demonstration, no restriction to water solutions, and the definition of acids and bases behaviors based on the H^+ ions transfer (this part corresponded to the elaboration step of 5E). The teacher made emphasis on the expansion of the acid-base definition and the coverage of basic compounds which were excluded from the Arrhenius definition. The important point here was to underline that Arrhenius acid-base definition was not wrong but had some limitations and the Arrhenius definition was subject to change with the development of new knowledge. The teacher explained the Bronsted-Lowry definition using examples and gave explanation about conjugate acid-base pairs. In addition, in order to enhance comprehension on students about this subject the teacher gave various examples. In order to define Lewis acid-base definition the teacher asked students what Lewis reminded them; the aim was to make them remember electron-dot Lewis structure and N, O and Cl examples were given to be written. In terms of acid-base definition, it was emphasized that Lewis noticed the shared electron pair property in acids and bases reactions and defined acids and bases based on an electron-pair acceptor or donor. The teacher made the students aware that Lewis definition covered both Arrhenius and Bronsted-Lowry acid-base definitions and also increased the number of species that could be considered acids or bases. The reaction between NH_3 and BF_3 was given and shown that even not containing H, BF_3 was a Lewis acid. Afterwards, the activity labeled "The History of Acids and Bases Definitions" was distributed to the students (this part corresponded to the engagement step of 5E) and when there was enough time the next activity "Which Acid-Base Definition" was given (this part corresponded to the evaluation step of 5E).

This procedure was followed for the whole acids and bases unit, in order to save space only the introduction part of the unit was given but the rest of teacher handouts could be found at the Appendix G.

3.7.2 Treatment in the Traditional Group

In the traditional group, the teacher used the traditional teaching chemistry instruction. During the instruction in the traditional group, the teacher followed the traditional way what she used to do by directly giving the scientific concepts and the students were mostly passive, listened their teacher and took notes to their notebooks. The teacher sometimes did demonstrations in her traditional way of teaching and using demonstrations in traditional group did not change the traditional way of teaching at all. The same concepts were implemented in the traditional group using lecturing, demonstrations, and videos instead of inquiry based hands-on activities, group discussion, and class discussion. The students in this group did not complete the conceptual and motivational activities designed for experimental group; on the other hand, students followed their teachers doing the demonstrations and solved more algorithmic problems. Therefore, the same activities were used in both classes, just the procedure was different.

The introduction of acids and bases unit was started with student ideas about what they know about acids and bases and then the teacher explained that there were many acids and bases they were faced with in their daily life and gave examples such as battery acids, vinegar, lemon, apple, fruits as acids and soap, carbonate, toothpaste, and detergents as bases. The teacher distributed the students to read the second version of "A day with Melis" activity and told the students that they could find many examples and explanations about acids and bases from their daily life. The definition of acids and bases was the first topic to be explained and the teacher gave the detail on the

Arrhenius acid-base definition with related examples such as HCl, H_2SO_4, HNO_3, HBr, and HI for acids and NaOH, KOH, $Mg(OH)_2$, and $Ca(OH)_2$ for bases. Then, the teacher CH_4, NH_3 and CH_3COOH gave the aforementioned examples to students and asked whether those were acids or bases. The teacher wrote on the board the reaction between NH_3 and HCl, expressing at that reaction NH_3 was a base; then, explained the restrictions of the Arrhenius acid-base definition and gave the details about the Bronsted-Lowry definition illustrating examples and giving explanation about conjugate acid-base pairs. In addition, in order to enhance comprehension on students about this subject the teacher gave various examples on conjugate acids and bases, some of which solved by the teacher (especially the first examples) and some were solved by the students. Finally, the Lewis acid-base definition was explained by illustrating the restrictions of the Bronsted-Lowry acid-base definition and the students were given some examples on electron-dot Lewis structure. Then, the students were told that Lewis noticed the shared electron pair property in acids and bases reactions and defined acids and bases based on an electron-pair acceptor or donor. At the end of the topic the students were distributed the activity to read labeled as "The history of acids and bases definitions".

In this part, the comparable topic was just given for the treatment in the traditional group. Therefore, the teacher-centered instruction was conducted in the traditional group (See Appendix H for Sample Lesson Plan).

3.8 Treatment Fidelity and Verification

The developed instructional materials by the researcher were reviewed by experts in chemistry education. The supervisor of the study reviewed all instructional materials and gave feedbacks on them. Based all feedbacks the instructional materials were developed. During the implementation process, the classroom observation checklist was used by the researcher and the guest chemistry teacher both in experimental and traditional groups.

3.9 Data Analysis

Analysis of data was conducted using the SPSS and Iteman programs. The gathered data from pre-tests of TABT and CMQ and post-tests of TABT and CMQ were entered into Microsoft Excel. The TABT scores were calculated and then the scores were converted to the SPSS. At the first step, the missing data were checked and the descriptive data (which were the scores of experimental and traditional groups' mean, standard deviation, skewness, kurtosis, minimum, and maximum values) were calculated. These descriptive statistics gave a general view for the data and enlighten some assumptions for inferential statistics. In terms of inferential statistics, the analysis of which enhanced the generalizability of the sample data to the population, multivariate analysis of covariance (MANCOVA) was conducted with two dependent variables, which were post-TABT and post-CMQ; two independent variables, which were methods of teaching and gender; and two covariates, which were pre-TABT and pre-CMQ. Before conducting MANCOVA, the assumptions, which were normality, outliers, homogeneity of variances, multicollinearity, homogeneity of regression, and independence of observations, were checked and it was found that all assumptions were met.

In addition to quantitative data, there was also qualitative data gathered from pre- and post-interviews. The interviews were transcribed verbatim, the data was coded, and interpretations were done.

3.10 Power Analysis

Before conducting the study, the necessary sample size was calculated. The effect size values (f^2) stated by Cohen et al. (2003) were as small=.02, medium=.15, and large=.35. Based on the previous studies, the effect size of this present study was set to a medium effect size, the significance was set to .05, and the power was set to 0.80. The equation ($L = f^2(n - k - 1)$) mentioned by Cohen et al. (2003, p.181) was used to calculate the necessary sample size.

In this equation the symbols stands for: L is the function of k_B found in L tables (p.651), n is for sample size, and k is the sum of k_A (number of covariates) and k_B

(number of groups -1). Therefore, the necessary sample size was calculated as 56, see the calculation below:

$$L = f^2(n - k - 1) \quad \rightarrow \quad n = L/f^2 + k + 1$$

$$n=7.85/0.15 + 3 +1$$

$$n=56$$

This study was conducted with 78 students and the same equation was used for calculating L value and found as 11.1, see the calculation below:

$$L = f^2(n - k - 1) \quad \rightarrow \quad L = 0.15\ (78 - 3 - 1)$$

$$L= 11.1$$

Based on this calculated L value, the calculated power of the study was between in range of .90 (L=10.51) and .95 (L=13.00). Since the calculated L value is closer to .90, the calculated power was accepted as .90.

3.11 Threads to Internal Validity

Internal validity was defined as "observed differences on the dependent variable are directly related to the independent variable, and not due to some other unintended variable" by Fraenkel and Wallen (2003, p.178). There are possible threats to internal validity, which are: subject characteristics, mortality, location, instrumentation, testing, history, maturation, attitude of subjects, regression, and implementation. These possible treats to internal validity and minimization of these treats are discussed in this section.

- Subject characteristics: The group difference might affect the results of the study; therefore, random assignment was done in the study. In addition, the students' age, gender, socioeconomic status, motivation to learn chemistry, and prior knowledge of acids and bases concepts might be affective on the results and these variables were investigated. The students' age, gender and socioeconomic status were similar to each other. In order to equate groups, statistical techniques were also used as setting covariates at the analysis of MANCOVA.

- Mortality: Loss of subjects' threat is related about dropping out of the subjects from a study. In this present study, only one male student was excluded from the study since he did not participate to the pre-tests. He was a new registration from another school and came to class at the middle of the semester because of moving to the neighborhood.
- Location: This threat might occur when there are different conditions for groups. The classroom and laboratory conditions were similar in terms of size, lighting, and other conditions. The experimental group was in the laboratory in all classes, but the traditional group was generally in the regular class and sometimes in laboratory when there was a demonstration. The researcher collected more information to minimize the location threat for the groups.
- Instrumentation: This threat can be explained in three sections, which are instrument decay, data collector characteristics, and data collector bias. Instrument decay is changing the nature of the instrument. The instruments used in the present study for both experimental and traditional groups were the standard and same in terms of administration and scoring. Data collector characteristics such as gender, age, language patterns might effect on the nature of the data. The data collection procedure was the same for both groups and the researcher and the teachers were in class in all administration sections. Data collector bias is altering data to get certain outcomes. The teacher was trained to minimize this threat.
- Testing: This threat is about students might be alert or aware in the presence of pretests. In the study, there were two pre-tests and they were administered two weeks before the implementation. The implementation lasted for two month and this period is long enough to minimize the testing threat; additionally, this threat was valid for both experimental and traditional groups.
- History: Occurrence of unplanned events during implementation might affect the results of the study. The researcher existed in all classes in both experimental and traditional groups. During the implementation, the volcano named Eyyafyallayökül in Iceland erupted and it was told on

news that there was a risk of acid rains. In the activity, "A day with Melis" there is a part on acid rain and effects of acid rain. There was a discussion in both groups covering the questions: what acid rain was, the effects of acid rain, and why rain was called acid rain. Both experimental and traditional groups were affected by this history threat equally, this threat was controlled.

- Maturation: This threat was not possible threat for this study since the change in intervention was not because of passing of time.
- Attitude of subjects: There are three possible threats in terms of attitude of subjects: Hawthorne effect, John Henry effect, and demoralization effect. Hawthorne effect is positive effect on experimental group students due to increased attention and novelty of the treatment. The opposite effect is demoralization effect on control group students since not having any treatment. John Henry effect is another effect on control group students due to not having any treatment, students express more effort to better than experimental group students. These possible threats were assumed to be minimized in present study; the teacher told the students the instruction was not different and the same activities were conducted in both groups.
- Regression: This threat is possible when low or high achievers selected in a group. Random assignment was done in selecting the groups in this study; therefore, this threat was not a possible threat.
- Implementation: This threat is occurred when there are different individuals to implement the methods or the characteristics of individuals implementing the methods on the behalf of one of the treatments. The teacher implemented in both experimental and traditional groups and trained before the implementation. The classroom observation checklists were used to minimize this threat and treatment verification was provided.

3.12 Assumptions and Limitations

The assumptions of this present study were stated below:

- The instruments were completed by the students honestly, independently and seriously.
- The similar conditions were available during the administration of the instruments.
- No bias was done on the behalf of the either treatment.
- The teacher followed the teacher handouts.

The limitations of the study were stated below:

- The study was limited to 11th grade public high schools in the center of the city.
- The study was limited to the “Acids and Bases” unit.

CHAPTER IV

RESULTS AND CONCLUSIONS

The results of the study were presented in this chapter including the following eight sections: the descriptive statistics, the inferential statistics, the results on student activities, the results of three-tier acids and bases test and student interviews, the results of chemistry motivation questionnaire and student interviews, the results of the teacher interview, the results of classroom observation checklist, the summary of the results, and the conclusions of the study.

4.1 Descriptive Statistics

In order to carry out descriptive and inferential statistics, beforehand it is essential to check whether there were any missing values in the data. Therefore, missing analysis was done and it was observed that there were not any missing values in the data. However, there was an exclusion from the analysis; a student from another school was enrolled to Class B during the semester since this student had not completed the pre-tests was not included into the study.

Therefore, the descriptive statistics, given in the Table 4.1, shows the excluded scores. The descriptive statistics about pre-TABT, pre-CMQ, post-TABT, post-CMQ, grades, and gender were grouped in terms of implemented methods, experimental and traditional groups. The pre-TABT scores before implementation were almost the same for the both groups and the correct answer rate for this test was very low since most students were not sure for their responses, in other words because of the third tier of the questions which sought for whether students were sure in their responses. The possible maximum score for this test was 18, but the highest score was four for both groups. The first-tier of the test included conventional multiple-choice questions and when this first-tier was only analyzed, it was seen that the mean score of the first-tier questions was 4.05 for the experimental group and 3.53 for the traditional group in the pre-test (see Table 4.2 for details).

Table 4.1 Descriptive Statistics for the pre-TABT, pre-CMQ, post-TABT, post-CMQ, grades, and gender

	N	Mean	SD	Skewness	Kurtosis	Min	Max
Pre-TABT							
EG	40	1.10	1.01	.89	.58	0	4
TR	38	1.32	1.21	.70	-.15	0	4
Total	78	1.21	1.11	.81	.16	0	4
Pre-CMQ							
EG	40	102.78	14.99	.17	-.55	73	136
TR	38	105.03	16.41	-.57	-.11	62	127
Total	78	103.87	15.64	-.21	-.45	62	136
Post-TABT							
EG	40	8.90	3.89	.23	-.82	2	17
TR	38	4.95	3.30	1.08	.39	1	14
Total	78	6.97	4.11	.54	-.69	1	17
Post-CMQ							
EG	40	109.35	12.91	.13	-.19	86	141
TR	38	102.58	18.72	-.38	-.51	62	131
Total	78	106.05	16.26	-.46	.13	62	141
Grades							
EG	40	2.55	1.56	.47	-1.34	1	5
TR	38	2.68	1.17	.34	-.58	1	5
Total	78	2.62	1.37	.39	-1.07	1	5
Gender							
EG	40	1.48	.51	.10	-2.10	1	2
TR	38	1.50	.51	.00	-2.11	1	2
Total	78	1.49	.50	.05	-2.05	1	2

Note: Pre-TABT was labeled for the Three-Tier Acids and Bases Test scores before the implementation, and post- for after implementation; Pre-CMQ was labeled for the Chemistry Motivation Questionnaire scores before the implementation, and post- for after implementation. For instructional methods, EG stands for Experimental Group and TR stands for Traditional Group. Grades were labeled for students' chemistry grades in previous semester.

When the reason of the first tier of the questions was asked in the second tier, the correct response rate decreased as well; the mean score of two-tier questions was 2.05 for the experimental and 1.63 for the traditional group (giving correct responses for both first and second tiers). This inferred that students were not much able to give a correct explanation to first tier of the questions. This difference also revealed the possibility of the chance factor since when the third-tier, in other words confidence tier, was included to analysis, it was seen that the student scores decreased dramatically (giving correct responses for all three tiers, see Table 4.1).

Table 4.2 Descriptive Statistics for One-tier and Two-tier Questions

	N	Mean	SD	Skewness	Kurtosis	Min	Max
Pre-TABT							
One-tier							
EG	40	4.05	2.34	-.34	-.59	0	8
TR	38	3.53	1.81	.59	1.71	0	9
Two-tier							
EG	40	2.05	1.52	.37	-.51	0	6
TR	38	1.63	1.26	.50	-.46	0	4
Post-TABT							
One-tier							
EG	40	11.65	3.29	-.22	-.78	5	18
TR	38	8.19	3.62	.59	-.20	2	17
Two-tier							
EG	40	9.58	3.64	.02	-.56	2	17
TR	38	5.61	3.36	.86	-.03	1	14

Note: One-tier was labeled for the correct response rate of the first tier question, which was similar to conventional multiple-choice questions. Two-tier was labeled for the correct response rate of first and second tier questions, in other words a student should give a correct response for first tier and give a correct explanation for it in the second tier (both responses should be correct for scoring).

The similar decrease could also be observed for the post-TABT. The mean score for the three-tier questions were 8.90 for the experimental and 4.95 for the traditional group (see Table 4.1); on the other hand, the mean score for one-tier questions were 11.65 for the experimental and 8.19 for the traditional group (see Table

4.2). In addition, when students were asked for the explanation of their responses, students' the mean scores of two-tier questions decreased to 9.58 for the experimental and 5.61 for the traditional group. The mean of the post-TABT scores for the experimental group was higher than the one in the traditional group while there was not much difference in pre-TABT. The possible maximum score was 49.44% for the experimental and 27.5% for the traditional group in terms of the post-TABT. The possible maximum score was 5.61% for the experimental and 7.33% for the traditional group in terms of pre-TABT.

In terms of CMQ scores, there were slightly differences between the pre-CMQ and the post-CMQ scores (see Table 4.1). The mean of pre-CMQ scores are in favor of the traditional group students who revealed higher motivation to learn chemistry than the students in experimental group. On the other hand, this difference changed in post-CMQ scores in favor of the experimental group students who revealed higher motivation to learn chemistry than the students in control group. The possible maximum score of the CMQ is 150 and the possible minimum score is 30. The range in pre-CMQ scores was wider in traditional group than the experimental group, which stated that there was more variability in former one. The similar range variability was also acceptable for post-CMQ scores (see Figure 4.1 and Figure 4.2 for histograms of pre- and post-CMQs).

The gain scores on the TABT and CMQ is given in the Table 4.3 for both experimental and traditional group. In terms of TABT scores, both groups gained scores afterwards the implementation, but the traditional group could not gain as many scores as the experimental group.

Table 4.3 Gain scores for the experimental and the traditional group on the TABT and CMQ scores

Test	Group	Gain score (posttest - pretest)
TABT	LC	7.80
	TR	3.63
CMQ	LC	6.57
	TR	-2.45

In order to check whether the distribution of scores is normal, skewness and kurtosis values should be tested. The zero values of skewness and kurtosis reveal a normal distribution of scores (Field, 2009, p. 139). Since skewness and kurtosis values were in range between -2 and +2, it could be inferred that the pre-TABT, pre-CMQ, post-TABT, and post-CMQ scores were normally distributed for the experimental and traditional groups. Therefore, as an evidence of normal distribution, Figure 4.1 shows the histograms with normal curves for the pre-TABT and pre-CMQ, and Figure 4.2 shows the histograms with normal curves for the post-TABT and post-CMQ for both the experimental and traditional group.

LC TR

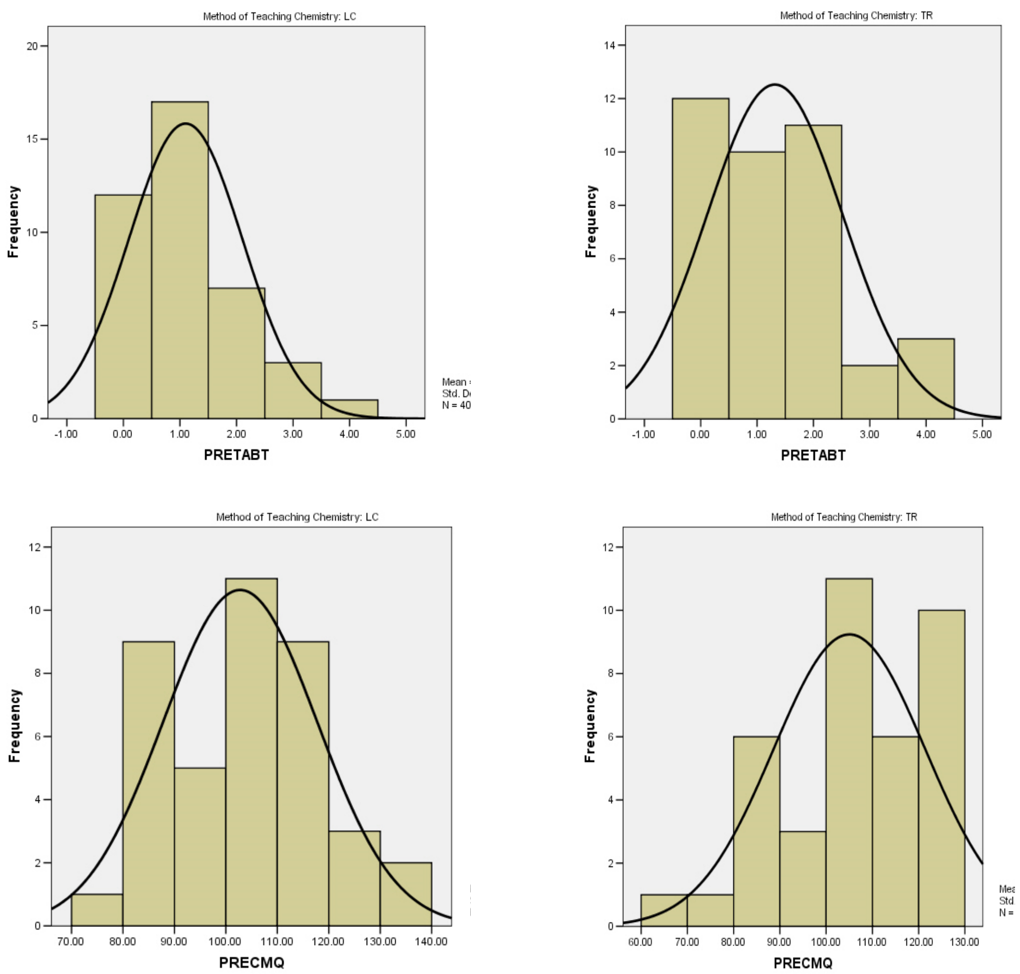

Figure 4.1 Histograms with normal curves for the pre-TABT and pre-CMQ for experimental and traditional group

LC TR

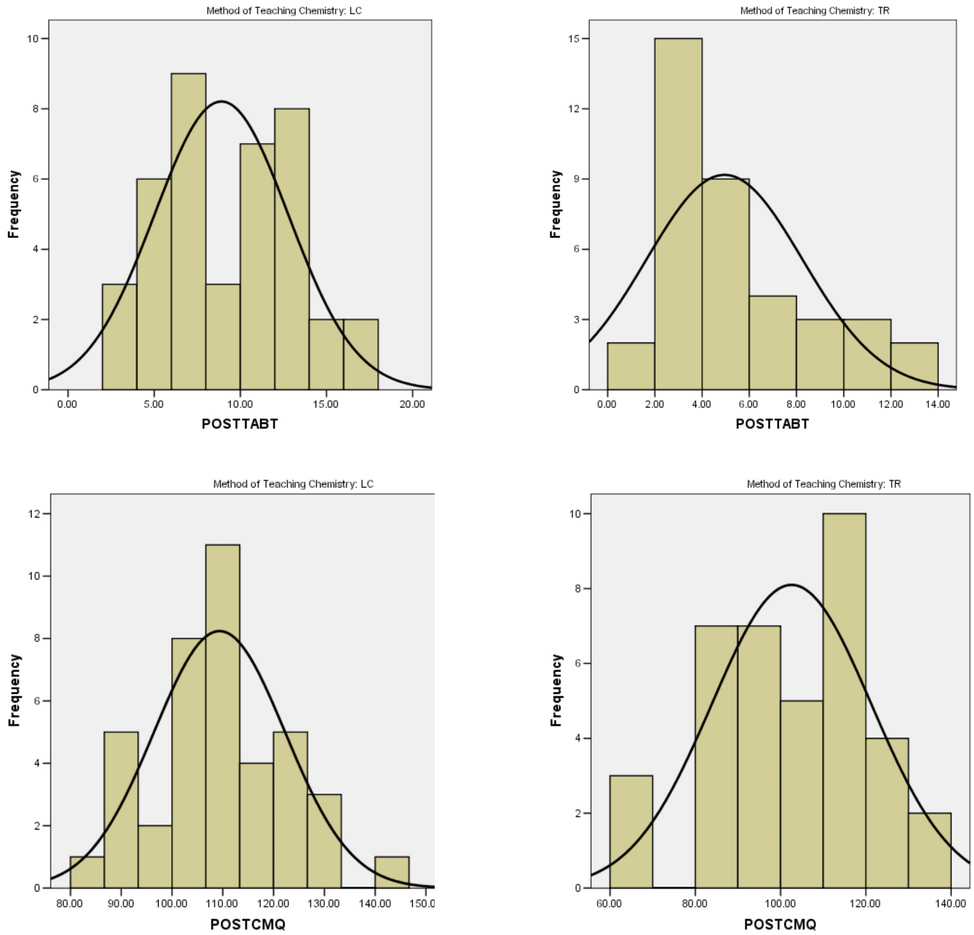

Figure 4.2 Histograms with normal curves for the post-TABT and post-CMQ for experimental and traditional group

It would be beneficial to show a general view of these aforementioned descriptive statistics in terms of experimental and traditional groups before running inferential statistics. Since gender was also investigated whether affected by instructional methods, this independent variable was also included into the composition. The Figure 4.3 reveals the big picture of two dependent variables scores categorized in terms of teaching methods and clustered by gender. The mean scores of the post-TABT and the post-CMQ were taken into consideration.

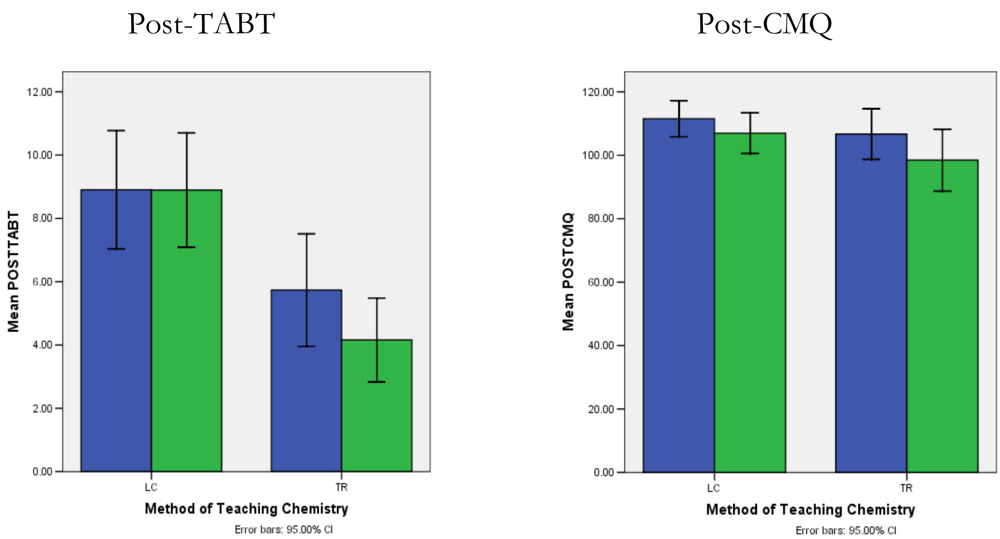

Figure 4.3 Graph of the descriptive statistics of post-TABT and post-CMQ categorized regarding teaching method and clustered by gender (blue=girls, green=boys)

4.2 Inferential Statistics

This section, as a first step, includes how covariates were determined and then assumptions of MANCOVA were tested. Lastly, results of MANCOVA were presented.

4.2.1 Determination of Covariates

Possible covariates were determined at the beginning of the study; these covariates were pre-TABT and pre-CMQ. Tabachnick and Fidell (2007, p. 212) suggested on covariates can be more than one and covariates could be used during analysis at the same time but they should be continuous variables, a small set and uncorrelated with each other. Additionally, covariates should be significantly correlated with dependent variables. Furthermore, Pallant (2001, p. 236) expressed that these correlations among each covariates should be mostly moderate correlations as well as covariates should be collected before implementation in order not to be influenced by it. The pre-TABT and pre-CMQ were administered to students before the implementation and it could be said that they were independent from the experimental effect. In order to test whether these variables were appropriate covariates, correlations among them was tested beforehand. The results of this correlation analyses could be seen in Table 4.4.

Table 4.4 Correlations among variables

Variables	Pre-TABT	Pre-CMQ	Post-TABT
Pre-CMQ	.443**		
Post-TABT	.258*	.289*	
Post-CMQ	.443**	.728**	.476**

* Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

The results revealed the potential covariates, which were students' pre-TABT and pre-CMQ, correlated significantly with the dependent variables, which were post-TABT and post-CMQ. The potential covariates correlated significantly with one another but these correlations were mostly small correlations except the one between pre-TABT and pre-CMQ with the value of .443, which was a medium correlation (Cohen, 1988). Consequently, these results revealed that pre-TABT and pre-CMQ could be used as covariates for MANCOVA.

4.2.2 Assumptions of MANCOVA

There are many assumptions in Multivariate Analysis of Covariance (MANCOVA); these are independence of observations, normality, outliers, homogeneity of variances, multicollinearity, and homogeneity of regression.

The first assumption is independence of observations. For verifying this assumption, the researcher observed all measurement sessions whether students did the instruments on their own. It was ensured that there was not any violation of the assumption since students completed the tests or questionnaires individually. Therefore, it could be said that this independence of observations assumption was met.

For assumption of normality, it is crucial to check both univariate and multivariate normality. The univariate normality is considered as the distribution of scores on dependent variables is normal, having a symmetrical, bell-shaped curve (Pallant, 2001, p.54). Skewness and kurtosis values give some information about the distribution of scores; skewness present some information on symmetry of the distribution and kurtosis present some information about the peakedness of the distribution. Ideally normal distribution gives zero values of skewness and kurtosis. Table 4.1 provide these information for this study and as the seen skewness and kurtosis values can be accepted as normal since the values were in acceptable range as mentioned in previous Section 4.1. Therefore, the univariate normality assumption was met. In addition, to check multivariate normality, Box's test of equality of covariance matrices can be used. Table 4.5 Box's test of the assumption of equality of covariance matrices with the hypothesis of the variance-covariance matrices are the same in groups. Since the statistics was not significant, the assumption of homogeneity was validated, which revealed the covariance matrices were roughly equal.

Table 4.5 Box's Test of Equality of Covariance Matrices

Box's M	14.86
F	1.570
df1	9
df2	60884.680
Sig.	.118

Outliers are risky for MANCOVA because this analysis is very sensitive to outliers. Univariate and multivariate outliers should be check before the analysis. Univariate outliers could be checked by examining the histograms on Figure 4.1 and 4.2. None extreme scores were detected and it could be said that there is no univariate outliers in the data. Mahalanobis distance is used for multivariate outliers and reveals that any cases have a strange pattern of scores across the two dependent variables. Since the Mahalanobis distance value, which was 7.347 (Table 4.6), is larger than critical value (13.82 for two dependent variables, see Table 19.1 in Pallant, 2001, p.221), there was not any multivariate outliers in the data. Consequently, the assumption of outliers was also met.

Table 4.6 Residuals statistics for Multivariate Normality

	Minimum	Maximum	Mean	Std. Deviation
Predicted Value	13.5201	54.5544	39.5000	10.41499
Std. Predicted Value	-2.494	1.445	.000	1.000
Std. Error of Predicted Value	2.334	6.709	3.849	1.094
Adjusted Predicted Value	13.9227	56.5062	39.4133	10.36613
Residual	-51.04169	43.17807	.00000	20.12531
Std. Residual	-2.503	2.117	.000	.987
Stud. Residual	-2.587	2.174	.002	1.006
Deleted Residual	-54.50621	45.51344	.08674	20.92614
Stud. Deleted Residual	-2.692	2.231	.001	1.019
Mahalanobis Distance	.022	7.347	1.974	1.759
Cook's Distance	.000	.151	.013	.023
Centered Leverage Value	.000	.095	.026	.023

The assumption of homogeneity of variances is tested via Levene's test with the hypothesis of the variances in scores are the same for each group. Table 4.7 shows the result of Levene's test and the post-CMQ value was larger than 0.05, which indicates the error variances across groups are equal. Consequently, the assumption of homogeneity of variances was satisfied for post-CMQ scores. However, the post-TABT value was smaller than 0.05, which indicates the null hypothesis was incorrect and the variances were significantly different; therefore the assumption of homogeneity of variances has been violated for post-TABT scores. Since this assumption was violated, a more conservative alpha level was set for determining significance for post-TABT in the follow-up ANCOVA.

Table 4.7 Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Post-TABT	2.916	3	74	.040
Post-CMQ	1.377	3	74	.257

The assumption of multicollinearity deals with correlations among independent variables. There should be no substantial correlations among dependent variables higher than .80. Table 4.4 shows the correlations among variables and all correlations are below .80; therefore, this assumption of multicollinearity was verified.

The assumption of homogeneity of regression was tested via Multivariate Regression Correlation (MRC) analysis. This assumption deals with the relationship between the covariate and the dependent variable for each of the groups. Dependent variables, post-TABT and post-CMQ, were used independently in this analysis. The covariates, which were pre-TABT and pre-CMQ, constituted the Set A. The independent variables, Method of Teaching, Gender, and Method of Teaching*Gender, formed the Set B. The other Set C was formed via multiplying Set A with Set B (pre-TABT * Method, pre-TABT * Gender, pre-TABT * Method * Gender, pre-CMQ * Method, pre-CMQ * Gender, pre-CMQ * Method * Gender). Table 4.8 and Table 4.9 show the results of MRC analysis which revealed that there is not any significant interaction between covariates and method of teaching for post-TABT and post-CMQ. Consequently, it could be implied that the homogeneity of regression assumption was verified.

Table 4.8 MRC results for Homogeneity of Regression for the post-TABT

Change statistics for post-TABT					
Model	R Square Change	F Change	df1	df2	Sig. F Change
Set A	.319	11.562	3	74	.000
Set B	.281	16.622	3	71	.000
Set C (Set A*Set B)	.053	1.056	9	62	.408

Table 4.9 MRC results for Homogeneity of Regression for the post-CMQ

Change statistics for post-CMQ					
Model	R Square Change	F Change	df1	df2	Sig. F Change
Set A	.564	31.922	3	74	.000
Set B	.086	5.775	3	71	.001
Set C (Set A*Set B)	.080	2.029	9	62	.051

This assumption could also be tested with customizing settings in MANCOVA in order to test whether there was interaction between the covariates and the treatment (Pallant, 2001, p.241; explained based on ANCOVA process and adapted to MANCOVA process). The procedure to evaluate this assumption is with the following steps: Analyze, General Linear Model, and Multivariate.

Table 4.10 Multivariate Tests for Homogeneity of Regression for the interaction between the covariates and the independent variables

Effect		Value	F	Hypothesis df	Error df	Sig.
Method * PRETABT	Pillai's Trace	.021	.684	2.000	65.000	.508
	Wilks' Lambda	.979	.684	2.000	65.000	.508
	Hotelling's Trace	.021	.684	2.000	65.000	.508
	Roy's Largest Root	.021	.684	2.000	65.000	.508
Method * PRECMQ	Pillai's Trace	.040	1.361	2.000	65.000	.264
	Wilks' Lambda	.960	1.361	2.000	65.000	.264
	Hotelling's Trace	.042	1.361	2.000	65.000	.264
	Roy's Largest Root	.042	1.361	2.000	65.000	.264
Gender * PRETABT	Pillai's Trace	.060	2.084	2.000	65.000	.133
	Wilks' Lambda	.940	2.084	2.000	65.000	.133
	Hotelling's Trace	.064	2.084	2.000	65.000	.133
	Roy's Largest Root	.064	2.084	2.000	65.000	.133
Gender * PRECMQ	Pillai's Trace	.033	1.117	2.000	65.000	.334
	Wilks' Lambda	.967	1.117	2.000	65.000	.334
	Hotelling's Trace	.034	1.117	2.000	65.000	.334
	Roy's Largest Root	.034	1.117	2.000	65.000	.334
Method * Gender * PRETABT	Pillai's Trace	.033	1.099	2.000	65.000	.339
	Wilks' Lambda	.967	1.099	2.000	65.000	.339
	Hotelling's Trace	.034	1.099	2.000	65.000	.339
	Roy's Largest Root	.034	1.099	2.000	65.000	.339
Method * Gender * PRECMQ	Pillai's Trace	.025	.822	2.000	65.000	.444
	Wilks' Lambda	.975	.822	2.000	65.000	.444
	Hotelling's Trace	.025	.822	2.000	65.000	.444
	Roy's Largest Root	.025	.822	2.000	65.000	.444

The dependent variables (post-TABT and post-CMQ) were put in the dependent variable box, the independent variables (Method and Gender) were put in the fixed factors box, and the covariates (pre-TABT and pre-CMQ) were put in the covariates box. Then, model and custom selections were operated. In the model box these variables were listed: Method, Gender, pre-TABT, and pre-CMQ as main effects and Gender * Method, Method * pre-TABT, Method * pre-CMQ, Gender * pre-TABT, Gender * pre-CMQ, Gender * Method * pre-TABT, Gender * Method * pre-CMQ as interactions. The significance level of the interactions terms were checked in the output

(See Table 4.10). Since the all significance values for the interactions were greater than 0.05, the assumption of homogeneity of regression was not violated. This result also supports the previous MRC results; therefore, it is safe to proceed with MANCOVA analysis as the assumption of homogeneity of regression double checked.

4.2.3 Results of MANCOVA

The main problem of the study was to investigate the effect of 5E learning cycle oriented instruction over traditional designed chemistry instruction and gender on student understanding of acids and bases concepts and motivation to learn chemistry. In order to get evidence for the main problem, it is worthwhile to analyze the following null hypothesis.

4.2.3.1 Null Hypothesis 1

The first null hypothesis was "There is no statistically significant overall effect of teaching methods taking into account 5E learning cycle oriented instruction and traditionally designed chemistry instruction on the population mean of the collective dependent variables of eleventh grade students' post-test scores of acids and bases concepts and motivation to learn chemistry when the pre-test scores of three-tier acids and bases concepts, the pre-test scores of motivation to learn science, and previous semester chemistry grades are controlled".

This null hypothesis was tested via MANCOVA, of which assumptions were already met. The results of MANCOVA are given in Table 4.11 and illustrated whether there is any statistical significant difference in methods of teaching on the post-TABT and post-CMQ scores. Based on the results in Table 4.11, the first null hypothesis was rejected, which express there was a statistically significant difference between 5E learning cycle oriented chemistry instruction and traditionally designed chemistry instruction on the collective dependent variables (Wilks' $\lambda=0.654$, $F(2,71)=18.741$, $p=0.000$) in favor of the experimental group. Partial eta square was found to be .346, in other words the effect size of the study indicates a large effect size (Cohen, 1988).

Table 4.11 Multivariate Tests results in MANCOVA

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Observed Power
Intercept	.833	7.110	2.000	71.000	.002	.167	.921
Pre-TABT	.943	2.157	2.000	71.000	.123	.057	.428
Pre-CMQ	.506	34.653	2.000	71.000	.000	.494	1.000
Method	.654	18.741	2.000	71.000	.000	.346	1.000
Gender	.984	.578	2.000	71.000	.563	.016	.143
Method* Gender	.991	.339	2.000	71.000	.714	.009	.102

The observed power of the study is 1.00 larger than calculated power. This result revealed that the students taught via 5E learning cycle oriented instruction compared to traditionally designed chemistry instruction had statistically different understanding of acids and bases concepts and motivation to learn chemistry, regardless gender.

4.2.3.2 Null Hypothesis 2

The second null hypothesis was: "There is no statistically significant mean difference between girls and boys on the population means of the collective dependent variables of eleventh grade students' post-test scores of acids and bases concepts and motivation to learn chemistry when the pre-test scores of three-tier acids and bases concepts, the pre-test scores of motivation to learn science, and previous semester chemistry grades are controlled".

This null hypothesis was also tested via MANCOVA and investigated whether there is any statistically significant difference in girls and boys on the post-TABT and post-CMQ scores. The results, in Table 4.11, infer that the null hypothesis was accepted. This means that there was not found any statistically significant difference in terms of gender and girls did not differ with boys on the post-TABT and post-CMQ scores (Wilks' λ=0.984, F(2,71)=0.578, p=0.563). This result revealed that girls and boys had roughly equal understanding of acids and bases concepts and motivation to learn chemistry regardless teaching method.

4.2.3.3 Null Hypothesis 3

The third null hypothesis was: "There is no statistically significant interaction between the methods of teaching and gender on the population means of collective dependent variables of eleventh grade students' acids and bases concepts post-test scores and motivation to learn chemistry post-test scores when the pre-test scores of three-tier acids and bases concepts, the pre-test scores of motivation to learn science, and previous semester chemistry grades are controlled".

The MANOVA results given in Table 4.11 reveal that there was not any statistically significant interaction between the methods of teaching chemistry and gender on the post-TABT and post-CMQ scores (Wilks' $\lambda=0.991$, $F(2,71)=0.339$, $p=0.714$). Therefore, the null hypothesis was accepted. This result revealed that 5E learning cycle method did not make any difference in girls and boys understanding of acids and bases concepts and motivation to learn chemistry over traditionally designed chemistry instruction.

4.2.3.4 Null Hypothesis 4

The fourth null hypothesis was: "There is no statistically significant difference between the post-test mean scores of students taught via 5E learning cycle model and who taught via traditionally designed chemistry instruction on the population means of acids and bases concepts post-test scores when the pre-test scores of three-tier acids and bases concepts, the pre-test scores of motivation to learn science, and previous semester chemistry grades are controlled".

A follow-up ANCOVA was conducted in order to test the effect of teaching methods on the stated dependent variable. Since the assumption of equality of variance was violated (see Table 4.7), more conservative alpha level was set for determining significance for post-TABT scores. An alpha of 0.025 was set since this is moderate violation as Tabachnick and Fidell (1996, p.86) suggested. Table 4.12 represents the result of this null hypothesis and there found to be there was a statistically significant difference on student understanding of acids and bases concepts depending on which method they were taught ($F(1,72)=30.938$, $p=0.000$) in favor of the experimental group. Therefore, the results inferred that the null hypothesis was rejected. The post-TABT mean score of students taught via 5E learning cycle was 8.90 and the other group's score was 4.95 (see Table 4.1), and this difference was found to be statistically significant.

Table 4.12 Follow-up ANCOVA for each dependent variable

Dependent Variable	Source	df	Mean Square	F	Sig.	Eta Squared	Observed Power
Post-TABT	Corrected Model	5	97.946	8.726	.000	.377	1.000
	Intercept	1	.551	.049	.825	.001	.055
	Pre-TABT	1	29.336	2.613	.110	.035	.358
	Pre-CMQ	1	61.629	5.490	.022	.071	.638
	Gender	1	.709	.063	.802	.001	.057
	Method	1	347.291	30.938	.000	.301	1.000
	Method*Gender	1	4.609	.411	.524	.006	.097
	Error	72	11.225				
	Corrected Total	77					
Post-CMQ	Corrected Model	5	2567.726	24.581	.000	.631	1.000
	Intercept	1	1399.707	13.399	.000	.157	.951
	Pre-TABT	1	279.626	2.677	.106	.036	.365
	Pre-CMQ	1	7303.386	69.915	.000	.493	1.000
	Gender	1	122.487	1.173	.282	.016	.188
	Method	1	1480.724	14.175	.000	.164	.960
	Method*Gender	1	43.994	.421	.518	.006	.098
	Error	72	104.461				
	Corrected Total	77					

The effect of covariates could be observed in the estimated mean scores in Table 4.13. The pure mean difference among groups was 3.95, but the estimated mean difference was 4.25. This difference occurred because of mean adjustment with the covariate effect. The partial eta squared was found 0.301 and eta squared was calculated as 0.215; which is indicated as a large effect size (see Tabachnick & Fidell, 2001, p.369 for eta squared calculations). Therefore, the method of teaching accounts for about 21.5% of the variability in student understanding of acids and bases concepts. The power to detect the effect was 1.000.

Table 4.13 Estimated Marginal Means for the post-TABT in terms of methods of teaching

Dependent variable	Group	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Post-TABT	LC	9.049	.532	7.988	10.109
	TR	4.799	.545	3.712	5.886

4.2.3.5 Null Hypothesis 5

The fifth null hypothesis was "There is no statistically significant difference on the post-test mean scores between girls and boys on students' understanding of acids and bases concepts when the pre-test scores of three-tier acids and bases concepts, the pre-test scores of motivation to learn science, and previous semester chemistry grades are controlled".

The conducted follow-up ANCOVA gave the result of this hypothesis as shown in Table 4.12. The null hypothesis was accepted based on this result ($F(1,72)=.063$, $p=0.802$). Therefore, it was implied from the result that girls and boys did not differ in understanding of acids and bases concepts. The methods of teaching implemented in the class did not make significant differences on student understanding of acids and bases concepts in terms of gender either the method is 5E learning cycle or traditionally designed chemistry instruction.

Table 4.14 Estimated Marginal Means for the post-TABT in terms of gender

Dependent variable	Gender	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Post-TABT	Girls	7.022	.539	5.947	8.097
	Boys	6.825	.552	5.726	7.925

The post-TABT scores were calculated as 7.40 for girls and 6.53 for boys; however, the covariates included to the model adjusted these values as 7.02 for girls and

6.83 for boys (see Table 4.14). The difference in these estimated mean scores was not statistically significant as the null hypothesis was accepted.

4.2.3.6 Null Hypothesis 6

The sixth null hypothesis was "There is no statistically significant interaction between methods of teaching and gender on students' understanding of acids and bases concepts when the pre-test scores of three-tier acids and bases concepts, the pre-test scores of motivation to learn science, and previous semester chemistry grades are controlled".

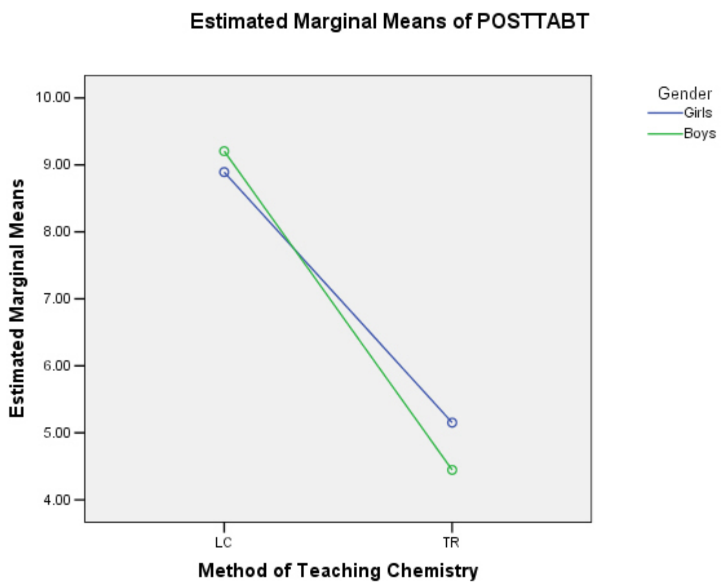

Figure 4.4 Graph of post-TABT scores in terms of gender as categorized in method of teaching chemistry

The performed follow-up ANCOVA investigated this null hypothesis (Table 4.12). There was not found any interaction between methods of teaching and gender on students' understanding of acids and bases concepts (F(1,72)=0.411, p=0.524). Therefore, this null hypothesis was accepted. Figure 4.4 gives an overview for post-TABT scores in terms of gender as categorized in method of teaching chemistry.

4.2.3.6 Null Hypothesis 7

The seventh null hypothesis was "There is no statistically significant difference between the post-test mean scores of students taught via 5E learning cycle model and who taught via traditionally designed chemistry instruction on the population means of motivation to learn chemistry post-test scores when the pre-test scores of three-tier acids and bases concepts, the pre-test scores of motivation to learn science, and previous semester chemistry grades are controlled".

The follow-up ANCOVA investigated methods of teaching in motivation to learn chemistry. There was a statistically significant difference between students' in experimental and traditional group on post-test scores in motivation to learn chemistry ($F(1.72)=14.175$, $p=0.000$) in favor of the experimental group. Therefore, the null hypothesis was rejected. The post-CMQ mean score of students in experimental group was 109.35 and in traditional group was 102.58 (Table 4.1). The estimated mean scores adjusted by covariates are 110.313 for experimental and 101.539 for traditional groups (Table 4.15); therefore, the difference in these mean scores was found statistically significant. This result implied that students taught using 5E learning cycle method in teaching chemistry were more motivated to learn chemistry than students taught using traditionally designed chemistry instruction. The partial eta squared was found 0.164 and eta squared was calculated as 0.162; which is indicated as a large effect size (see Tabachnick & Fidell, 2001, p.369 for eta squared calculations). Therefore, the method of teaching accounts for about 16.2% of the variability in student motivation to learn chemistry. The power to detect the effect was 0.960.

Table 4.15 Estimated Marginal Means for the post-CMQ in terms of methods of teaching

Dependent variable	Group	Mean	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Post-CMQ	LC	110.313	1.623	107.078	113.548
	TR	101.539	1.663	98.223	104.854

4.2.3.6 Null Hypothesis 8

The eighth null hypothesis was "There is no statistically significant difference on the post-test mean scores between girls and boys on students' motivation to learn chemistry when the pre-test scores of three-tier acids and bases concepts, the pre-test scores of motivation to learn science, and previous semester chemistry grades are controlled".

The conducted follow-up ANCOVA gave the result of this hypothesis as shown in Table 4.10. There was not found any statistically significant difference in the mean scores of post-CMQ in terms of gender ($F(1,72)=1.173$, $p=0.282$).

The post-CMQ scores were calculated as 109.225 for girls and 102.711 for boys regardless methods of teaching; however, these values were adjusted by the covariates included to the model (see Table 4.16). Girls scored higher in motivation to learn questionnaire than boys but this difference was not found statistically significant.

Table 4.16 Estimated Marginal Means for the post-CMQ in terms of gender

				95% Confidence Interval	
Dependent variable	Gender	Mean	Std. Error	Lower Bound	Upper Bound
Post-CMQ	Girls	107.219	1.645	103.941	110.498
	Boys	104.632	1.683	101.277	107.987

4.2.3.6 Null Hypothesis 9

The last hypothesis was "There is no statistically significant interaction between methods of teaching and gender on students' motivation to learn chemistry when the pre-test scores of three-tier acids and bases concepts, the pre-test scores of motivation to learn science, and previous semester chemistry grades are controlled".

The performed follow-up ANCOVA investigated this null hypothesis (Table 4.10). There was not found any interaction between methods of teaching and gender on student motivation to learn chemistry ($F(1,72)=0.421$, $p=0.518$). Therefore, this null hypothesis was accepted. Figure 4.5 gives an overview for post-CMQ scores in terms of gender as categorized in method of teaching chemistry

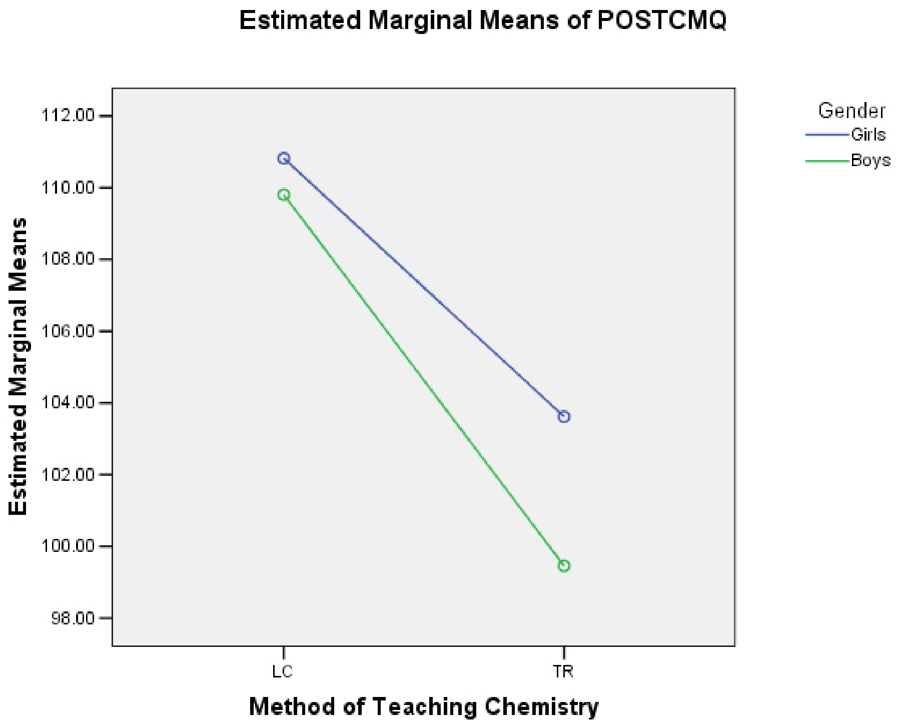

Figure 4.5 Graph of post-CMQ scores in terms of gender as categorized in method of teaching chemistry

4.3 Results on student activities conducted in the experimental group during the implementation

The results of activities conducted in the experimental group are given in this section. The results of three activities, which were 'Acids and Bases', 'A day with Melis' and 'What are the differences between Strong and Weak Acids?' were given in details at the following sections.

4.3.1 Acids and Bases

In the activity, "Acids and Bases" the students in the experimental group wrote about their opinions about acids and bases. This activity was threefold, what they knew about acids and bases, what they want to learn about acids and bases, and what they have learned about acids and bases. In terms of motivational perspective, the students had a chance to observe their own conceptual development, what they want to learn and what did they learn in the meantime.

This section gave details about all the students' ideas about acids and bases and what they want to learn about acids and bases (see Table 4.17 for student responses). Assessing students' understanding during the implementation was aimed; therefore, any student alternative conceptions or misunderstandings were planned to be determined. This activity was planned to be distributed to after each activity; however, because of lack of time just distributed three times: before the implementation, middle of the implementation, and after the implementation. This activity was useful to analyze student difficulties, misunderstandings, or alternative conceptions before and during the implementation, so that the teacher could make rearrangements in her lesson plans. The prior knowledge of students revealed that the students mainly used the Arrhenius acid-base definition in defining acids and bases (80% of the students used the Arrhenius definition and 20% did not write anything on definitions). In addition, students knew that acids turn litmus paper to red and bases turn litmus paper to blue. Additionally, they were aware of acids have a sour taste, bases have a bitter taste, and acids react with bases to form salt and water. On the other hand, few students gave everyday examples from acids and bases, which were lemon for acids and soap for bases.

Students' alternative conceptions were also determined in this activity such as; salts formed in neutralization reactions are always neutral, pH is a measurement of strength, only acids conductive, and a solution in neutralization reaction is always neutral. One student wrote that "in periodic table acids are at the range of 1-7 and bases are at the range of 7-14", this student probably messed up pH concept with periodic table.

When students were asked what they would want to learn about acids and bases, not many students (55%) specified any concepts in acids and bases just stated that what else acids and bases unit includes. It was interesting to determine that few students stated that they wanted to learn about questions related to university examination although many of them were focus on the university examination.

Table 4.17 Students' prior knowledge about acids and bases and their thoughts for learning about acids and bases

What students knew about acids and bases (frequency)	What they want to learn about acids and bases (frequency)
➢ Acid-base definitions	What else left (22)
Acids give H^+ ions into water (32)	The properties of acids and bases (4)
Bases give OH^- ions into water (32)	Daily life examples of acids and bases (5)
➢ Properties of acids-bases	
Acids have pH value between 0-7 (18)	What are acids and bases (2)
Bases have pH value between 7-14 (18)	Why acids and bases important (3)
pH 7 is a salt (3)	What are benefits and damages of acids and bases (2)
pH 7 is a neutral (1)	
In periodic table, acids are between 1-7 and bases are between 7-14 (1)	Want to do experiments related to acids and bases (2)
In acids, when pH gets smaller, acids get stronger (7)	Theories about acids and bases (3) Weak acids and weak bases (1)
In bases, when pH gets higher, bases get stronger (7)	Acids and bases reactions and their results (7)
Acids are caustic (1) and sour (20)	pH concept (3)
Bases are slippery (1) and bitter (20)	pH and pOH concepts (1)
Acids turn litmus paper to red (24)	Titrations (1)
Bases turn litmus paper to blue (24)	LYS and YGS questions on acids and bases (3)
Acids and bases turn litmus paper's color (1)	
Cleaning stuffs include bases (1)	
Lemon is acidic (3)	
Soap is basic (3)	
Only acids are conductive (9)	
Acids and bases react with each other (18), salt and water are formed (17); the salt precipitate (1) and the solution is neutral (7)	

During and after the implementation, students wrote their statements on acids and bases. At this third step, the students were declared that they were free to write their own understandings about acids and bases and they would not be graded based on their answers. Since the lack of time, the students did not have much time to think deeply on what they had learned, but they were asked to express their thoughts as much as possible. The students statements for during and after the implementation were given in the same Table 4.18 since the students were given the same sheet to fill. They were able to see their prior statements at the last step after the implementation and wrote further statements different from the prior ones.

Table 4.18 Categorization of students' statement after the implementation

What they have learned about acids and bases (f)
➢ Properties of acids and bases
It is dangerous to taste strong acids (5)
There are many acids and bases we faced with our everyday life (30)
Baking soda is basic (6)
There are some cleaning materials which are acidic especially used in kitchens (3)
Acid rain is harmful for environment (7)
Baking soda react with yogurt to rise cake (3)
Vinegar reacts with baking soda and carbon dioxide gas is formed (13)
Acids react with metals (16) and bases react only with amphoteric metals (9)
➢ Conductivity
Acids are conductive only when they dissociate in water (18)
Pure acids are not conductive (3)
Bases are conductive when they dissociate in water (17)
Ions are important for conductivity (11)
➢ Defining acids and bases
Acids are protons donors (15) and bases are proton acceptors (15)
Bases give OH^- ions into solutions (9)
Acids and bases have different definitions in terms of different aspects (14) such as Arrhenius (11), Bronsted-Lowry (11), and Lewis (10)
There are amphiprotic substances either behave as an acid or a base (13)
NH_3 has different dissociation than expected and it is a base (11)
➢ pH/pOH and indicators
Indicators are useful for testing acidity or basicity (22)
There are natural indicators such as red cabbage (7)
Red cabbage papers and phenolphthalein is similar to a litmus paper (2)
Red cabbage papers change its color in acidic and basic solutions, act as an indicator (24)
pH and pOH are convertible and valid for either acidic and basic solutions (8)
pH and pOH measure the molarity of H^+ and OH^- ions (21)
pOH is not just for basic solutions, acids have also have pOH (4)
➢ Neutralization
After a neutralization reaction, solution is not always neutral (11)
Phenolphthalein used in titrations helps to understand the neutralization (17)

The most specified feature by the students was they realized that they were very often faced with acids and bases during their everyday lives. The other point was that the students were aware of various definitions of acids and bases and they used Bronsted-Lowry and Lewis acid-base definitions besides the Arrhenius acid-base definition. Furthermore, 32.5% of the students mentioned on the amphiprotic substances that these substances acted as an acid or a base depending on the conditions. However, some students (22.5%) were still consistent in using the Arrhenius acid-base definition for bases and some of them used the Bronsted-Lowry acid-base definition (37.5%) in defining acids and bases.

During the implementation, the teacher made emphasize on pH and pOH concepts since students had alternative conceptions about pH was related to strength concept. Consequently, 52.5% of the students stated that pH and pOH measured the molarity of H^+ and OH^- ions. In addition, the students also address that acids and bases solutions conduct electricity and 27.5% of the students mentioned that conductivity was dependent on ions in solutions.

Students enjoyed very much doing activities during the implementation and they mainly expressed their understandings they got from these activities, as well. For instance, the students stated about the reaction between vinegar and baking soda, how a cake rise, acid rain, and red cabbage color change in acids and bases.

4.3.2 A day with Melis

The second activity that student done was “A day with Melis”. The first step in this activity was to determine students’ prior knowledge and their thoughts for substances of being acidic or basic. The students thought about substances acidity or basicity individually, and then they discussed their results with their peers. The all group’s results were given in Table 4.19. The students also wrote about some explanation for substances why they thought about they were acidic or basic. For instance, coke: “It is always told of being acid”, airan: “Since it is made of yogurt”, yogurt: “Since it is made of milk”, fruits: “We can eat them can’t be basic”, stomach: “I know stomach has an acid from the biology course”, rain: “I heard about acid rain”, mineral water: “It contains some gases like coke”, chocolate: “Something we can eat”, saliva: “Our biology teacher told us, saliva is basic”, tea: “When there is no sugar in it, its taste is bitter. Bases have a bitter taste". On the other hand, one group expressed that salt is a mixture of acids and bases.

Table 4.19 Categorization of the students' responses on the activity

	Acids	Bases	Neutral	Not sure
Substances	Vinegar* Milk* Rain Coke Airan Yogurt Apple Aspirin* Tear drops Fruits Stomachache Coffee* Rain Mineral water* Chocolate Lemon Onion* Salt* Deformation of a statue*	Soap Saliva Washing detergent Mineral water* Baking soda Tooth paste Onion* Aspirin* Deformation of a statue Vinegar* Tea Coffee*	Salt Water	Tooth paste Milk Onion Aspirin Mineral water

* The marked substances are both listed as an acid and a base

There were some substance which were the students were not sure about their acidity or basicity, they were toothpaste, milk, onion, aspirin, and mineral water. These substances were on purposely chosen for the second step for the students to test their acidity or basicity with litmus papers.

For the second step, the students brought whatever substances they would like to test into class to check their acidity or basicity with litmus paper. The substances that the students used were: vinegar, baking powder, tap water, lemon juice, tomato, mineral water, baking soda, coke, potato, orange, milk, soap, toothpaste, tea, egg, and yogurt (See Appendix H for the student posters). The students used litmus paper for testing and test whether their hypothesis were true or false. The students' potato, tomato, baking powder, egg predictions were different from their results. The most interesting result for them was to find out that egg yolk and egg white were the different in terms of acidity and basicity.

In the third part, the students found much more information about the acidic and basic substances and events related to acids and bases. The students answered the three questions, which were "What acidic or basic substances have you ever come across in your daily life?", What was the most interesting part in this activity?", and "What would you else like to mention about this activity?". The students' results were categorized for the first question in Table 4.20.

Table 4.20 The substances students mentioned from their daily life (frequency)

Acids	Bases
Lemon (11)	Wash my hand, Soap (17)
Coke (11)	Cleaning materials (12)
Milk (10)	Brush my teeth, Toothpaste (11)
Fruit juice (9)	Carbonate (7)
Tomato (9)	Egg white (6)
Orange (8)	
Aspirin (8)	
Airan (7)	
Fizzy drink (7)	
Apple (7)	
Vinegar (7)	
Yogurt (6)	

The students mentioned that they realized that they very often came across acidic and basic substances in their everyday life. Additionally, they gave examples on acidic and basic substances from their daily life such as fruit juice, lemon, apple, coke, airan, yogurt, egg yolk, vinegar, aspirin, milk, orange juice, and tomato for acids and soap, egg white, toothpaste, and carbonate for bases. The students also mentioned about what acids the substances include, such as vinegar contains acetic acid, aspirin contains acetylsalicylic acid, coke carbonic acid, and orange ascorbic acid.

For the second question, the students mentioned about the most interesting parts. Their responses are summarized in Table 4.21. Based on the students results, the most interesting sections were for them was to learn about why sugar was harmful for their teeth and the difference between baking powder and baking soda. Not only girls but also boys mentioned about the difference in baking powder and baking soda. One of the boys explained as the following (see Appendix H in Activity 2):

> The most interesting was using baking powder in some recipes and baking soda in some recipes. I knew that only baking powder was used. If there is not enough carbonate, there won't be enough CO_2 to rise the cake. Baking powder contains both an acid and a base. In fact, either baking powder or baking soda can be used based on the recipe. For example, carbonate is basic and if you do not mix with neither with yogurt nor with lemon, you will get a bitter taste. Baking powder does not have a bitter taste since including both an acid and a base. That's why can be used in cake recipes.

Students addressed their interesting subjects in the activity, but also they expressed their own reflections and took responsibilities such as they told that they are also responsible for acid rain and made reflection as the following:

> In the activity, in order to deal with stomach sour, the girl drank baking soda to relief the pain. When the exam time gets closer, I usually have stomach ache. Because of the exam stress, I usually don't have breakfast or just have a quick breakfast in order to safe time to study. In fact having a quick breakfast is not useful, it is instead harmful. I will try not to do this; it was good to learn this.

Another student explained that she always heard about that eating sugar was harmful for her teeth, but did not know the reason. She expressed that she felt pleasure to learn about this fact.

The students mainly mentioned for the third question that they learned practical information for their daily life, such as drinking carbonated water when having stomach ache, not to use acidic cleaning materials with basic ones, and practical usage of baking soda and baking powder. In addition, they expressed their pleasure to learn about this sort of information.

Table 4.21 Students' responses for the second question in Activity 2-C

The most interesting part for students (frequency)
Why sugar is harmful for teeth enamel (12)
The difference between baking powder and baking soda (12)
The erosion of statues because of acid rain (11)
Foods increase the acidity in our mouth (11)
Tooth enamel is as hard as diamond (9)
Baking soda is good for stomach sour (9)
The form of acid rain (9)
The effects of acid rain (9)
The reaction between bleach and acid contained cleaning materials and the risk of using both materials together (7)
Natural indicators (6)
Food contain acids (6)
The form of moisture (6)
Power supply in car contain acid (6)
The bite of ant contains acid (6)

4.3.3 What are the differences between Strong and Weak Acids?

This activity sought for the student understanding on the difference between a strong and a weak acid. The student did the activity which they observed the difference in balloons using acetic acid and hydrochloric acid and then they discussed this difference via simulation. In this activity, the students were supposed to draw the particles of the strong and weak acids considering both in concentrated and diluted solutions. The students thought about individually and then discussed with their peers. The students' individual results were given in Table 4.22. In the activity, 62.5% of the students gave correct responses in terms of the particles in strong and weak acid solutions and 87.5% of the students gave correct responses in terms of particles in concentrated and diluted solutions.

Table 4.22 Categorization of number of students considering correct and incorrect responses

	Correct	Incorrect
Strong –weak	25	15
Concentrated – Diluted	35	5

One of the student's drawings (Figure 4.6), who responded correctly both in terms of strong-weak acid and concentrated-diluted acid, is given below and she explained this drawing as the following:

> HCl is strong acid and dissociate nearly 100% and when this solution is diluted as our teacher showed in lemonade example less particles would be seen in diluted one. HF is a weak acid. Weak acids do not dissociate well. They have less H^+ ions in the solution and when the solution is diluted again less particles would be seen.

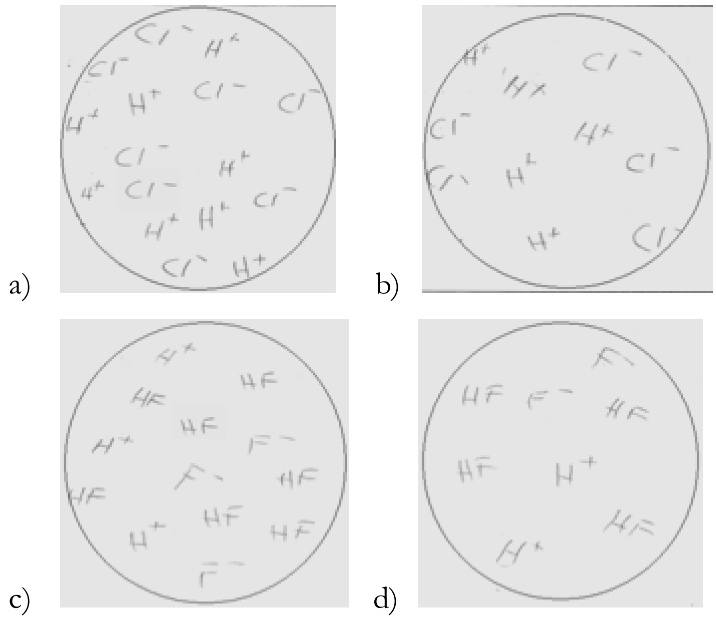

Figure 4.6 A student drawing: a) concentrated strong acid, b) diluted strong acid, c) concentrated weak acid, and d) diluted weak acid

Another student who responded correctly is also given below with his drawing (Figure 4.7) and explanation:

> Strong acids dissociate nearly 100%. HCl is a strong acid and its dissociation: $HCl \rightarrow H^+ + Cl^-$ Dilution affects the number of particles in a unit volume and not differs in terms of dissociation. Weak acids have a small dissociation percentage and have less H^+ ions in solutions. HF is a weak acid and its dissociation: $HF + H_2O \leftrightarrow H_3O^+ + F^-$ Dilution affects the number of particles in a unit volume and in terms of dissociation; dissociation of H^+ increases regarding LeChatalier's principle.

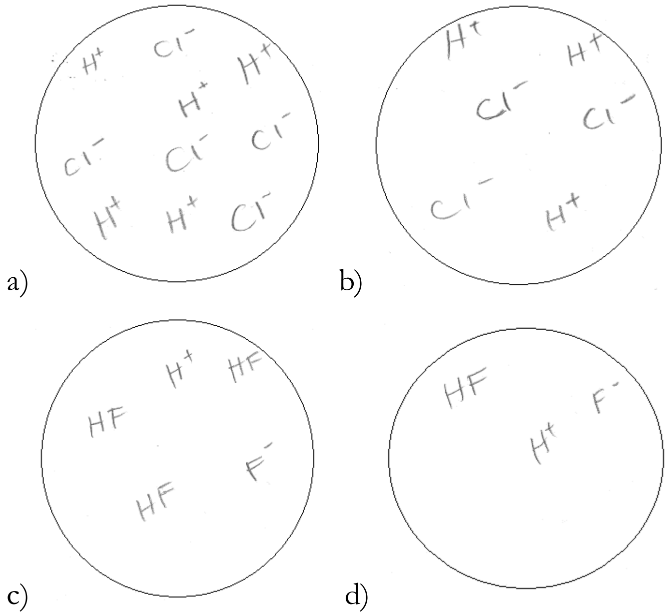

Figure 4.7 A student drawing: a) concentrated strong acid, b) diluted strong acid, c) concentrated weak acid, and d) diluted weak acid

4.4 Results of Three-tier Acids and Bases Test and Student Interviews

There are 18 three-tier questions in the TABT. The students in the present study completed the test prior the implementation and after it. The aim of this test was to determine students' alternative conceptions related to acids and bases concepts. Table 4.23 shows the percentages of the students who gave correct responses on pre- and post-TABT questions. In terms of pre-TABT scores, the easiest question was Item 15 both for experimental and traditional group students, with the percentage of correct responses 53 for the experimental and 34 for the traditional group. The most difficult question was Item 12 for the experimental group students, with no correct responses and Item 17 for the traditional group students, with no correct responses. In terms of post-TABT scores, the easiest question was Item 15 both for experimental and traditional group students, with the percentage of correct responses 88 for the experimental and 53 for the traditional group. The most difficult question was Item 17 for the experimental group students, with the percentage of correct responses 13 and Item 16 for the traditional group students, with the percentage of correct responses eight. In fact, the experimental group students gave correct responses (see first-tier responses 65% in Table 4.23) and correct explanation (see two-tier responses 63% in Table 4.23) for the Item 17, which was related to titration of weak acid and strong base;

however, the students in experimental group was not sure for their responses and they scored in low rate (with the percentage of 13).

Table 4.23 The percentages of student correct responses on pre- and post-TABT

	Pre-test (%)						Post-test (%)					
	Three-tier responses		Two-tier responses		One-tier responses		Three-tier responses		Two-tier responses		One-tier responses	
Items	EX	TR	EX	TR	EX	TR	EX	TR	EX	TR	EX	TR
Item 1	0	11	5	11	13	11	30	24	33	26	35	34
Item 2	0	11	3	11	0	42	30	21	38	29	43	50
Item 3	15	11	20	13	23	21	43	42	50	47	55	55
Item 4	0	8	10	8	13	16	68	42	70	50	80	66
Item 5	10	8	15	13	18	21	15	11	20	13	50	37
Item 6	0	3	0	3	15	21	75	29	83	45	98	29
Item 7	3	8	8	11	28	13	43	29	48	29	78	71
Item 8	5	3	10	3	18	3	58	18	68	21	70	39
Item 9	0	3	5	5	13	5	53	39	55	42	63	55
Item 10	5	18	28	18	45	29	63	24	73	29	83	53
Item 11	0	0	0	0	5	21	75	32	78	34	93	47
Item 12	0	0	0	0	0	11	60	39	68	58	75	71
Item 13	15	11	25	13	40	26	43	24	60	25	73	29
Item 14	0	0	0	3	20	16	50	18	50	18	53	39
Item 15	53	34	73	45	73	56	88	53	90	55	93	68
Item 16	0	3	0	3	20	16	30	8	30	8	40	63
Item 17	0	0	0	0	3	0	13	13	63	16	65	21
Item 18	5	3	5	5	23	26	58	29	63	34	80	50

Note: EX stands for the experimental group and TR stands for traditional group

The most significant difference among the scores on the post-TABT for the experimental and the traditional groups was on Item 6 with the value of 46; in other words, 46% of the experimental group students scored higher than the traditional group student for the Item 6. The smallest difference among the scores on the post-TABT for the experimental and the traditional groups was on the Item 3 with the value of 1; in other words, this question was responded nearly for the same rate either for the experimental and the traditional group students.

One of the interesting item was Item 7 since this item presented the power of three-tier tests; when the post-test responses was observed, it was clear to see that the one-tier responses for Item 7 was nearly equal for both the experimental and the traditional groups (with the percentages of 78 for the experimental and 71 for the traditional groups). However, the two-tier responses revealed that the students had difficulties in giving the correct explanation for the Item 7, with the decreasing percentages of 48 for the experimental and 29 for the traditional groups. Additionally, the last tier scores revealed that only percentages of 43 of the experimental group and 29 of the traditional group students were sure for their responses. Therefore, it was evident that students gave somehow correct responses by chance in conventional tests though they were not reveal conceptual understanding. The same situation could be observed in the Item 16 as well; even the traditional group students gave correct responses with the percentage of 63 for the first tier higher than the experimental group students with the percentage of 40, the three-tier responses revealed that the traditional group students did not give correct explanation for the question and were not sure in the responses since the percentage of correct responses decreased to eight for the traditional group and 30 for the experimental group students.

The change on scores is presented at the Table 4.24. These scores were calculated by subtracting the post-TABT scores with the pre-TABT scores. The most significant change was on the Item 6 and 11 for the experimental group. The Item 6 was about the dissociation of a strong acid on particulate level, sought for the students' alternative conceptions such as "Strong acids do not dissociate because they have strong bonds" or "The strength concept in acids/bases is related with ion interactions". The Item 11 was about conductivity considering the dissociation of acids or bases, sought for the students' alternative conceptions such as "As the number of hydrogen atoms increases in the formula of acids/bases, their acidity/basicity becomes stronger" or "Any acidic or basic solution since including ion particles conducts electricity in same power regardless of its strength". The highest progress for the experimental group students was determined for these questions illustrating that the experimental group students understood these concepts the most effectively.

Table 4.24 The change on percentage scores after the implementation

	Post-test score – Pre-test score					
	Three-tier responses		Two-tier responses		One-tier responses	
Items	EX (%)	TR (%)	EX (%)	TR (%)	EX (%)	TR (%)
Item 1	30	13	28	15	22	23
Item 2	30	20	35	18	43	8
Item 3	28	31	30	34	32	34
Item 4	68	34	60	42	67	70
Item 5	5	3	5	0	32	16
Item 6	75	26	83	42	83	8
Item 7	40	21	40	18	50	58
Item 8	53	15	58	18	52	36
Item 9	53	36	50	37	50	50
Item 10	58	6	45	11	38	24
Item 11	75	32	78	34	88	26
Item 12	60	39	68	58	75	60
Item 13	28	13	35	12	33	3
Item 14	50	18	50	15	33	23
Item 15	35	19	17	10	20	12
Item 16	30	5	30	5	20	47
Item 17	13	13	63	16	62	21
Item 18	53	26	58	29	57	24

Note: EX stands for the experimental group and TR stands for traditional group

In terms of traditional group, the most significant change was on the Item 12, which was about the properties of acids and bases, sought for the students' alternative conceptions such as "pOH is just related with bases" or "Only acids react with metals". Afterwards the implementation, the students in traditional group made the most significant change on the properties of acids and bases. While the significant difference in the experimental group was 75% with the average of 43.56, the change in the traditional group was 39% with the average of 20.56.

The smallest response change was on Item 5 both for experimental and traditional groups. Neither for the experimental group nor for the traditional group, did the implementation not make much difference on students understanding on acids and bases definitions. Half of the students in the experimental group responded correctly for the first-tier, but only 40% of them gave correct reasoning in the second tier and 25% of them were not sure for their responses. On the other hand, 37% of students in traditional group responded correctly for the first-tier, but only 35.1 of them gave correct reasoning in the second tier and 15.4% of them were not sure for their responses.

4.4.1 Student interviews on acids and bases concepts

Interviews were conducted before and after the implementation. The students in the traditional group follow their regular chemistry courses. The students in the experimental group conducted 10 activities which were developed on conceptual and motivational purposes and their teacher followed the developed lesson plans related to acid and bases. The activities and lesson plans were designed to overcome students' alternative conceptions and not to construct new ones during the implementation and construct conceptual understanding of acids and bases concepts.

Pre-interviews were done with eight students and they were asked the same questions (See Appendix D for interview questions). The interviewed students were labeled as IntTR1, IntTR2, IntTR3, and IntTR4 for the traditional group and IntEX1, IntEX2, IntEX3, and IntEX4 for the experimental group. The first question in student interviews was about what conjure up students' mind when it was called an acid or a base. Table 4.25 shows the student ideas for acids and bases; as it is seen from the coding all interviewed students used the Arrhenius definition in defining acids and bases. In addition, when they were asked to give examples for acids and bases, HCl and H_2SO_4 examples were given from all students and had difficulties in giving the third example. Three interviewees gave a lemon as the third example, two out of eight said HF, one of them said citric acid, and the other two interviewees told that noting came to their mind. In terms of bases, student had more difficulties in giving examples for bases; all of them gave NaOH as a first example, two of them gave KOH and two of them NH_3 as a second example. None of them could give a third example for bases. For properties of acids and bases, all interviewed students told that acids had a sour taste, turned litmus paper to red, and gave reactions with bases to form salts. Two of them added that acids had a corrosive property. Five of the interviewees told acids gave reactions with metals; in addition three of these added that acid did not react with nonmetals. Two of the interviewees said that acids were not good conductors. For the properties of bases all interviewees expressed that bases had a bitter taste, had a slippery property, turned litmus paper to blue, and gave reactions with acids to form salts. Four of them said bases conducted electric current but the rest told that they had no ideas for conductivity. Three of the students who expressed that acids gave reactions with metal and did not with nonmetals told that bases gave reactions with nonmetals and did not gave reactions with metals. These three students thought that the properties of acids and bases were adversely.

Table 4.25 Students' pre-responses for defining acids and bases

Students general ideas	# of students (out of eight)	
	Experimental	Traditional
Acids are dangerous	2	0
Acids have H in their formula	1	2
Acids give H^+ into solutions	4	4
Bases have OH in their formula	1	2
Bases give OH^- into solutions	4	4
Acids are substances below pH 7	4	4
Bases are substances above pH 7	4	4

After the implementation, the students differed in defining acids and bases considering the experimental and traditional group. The students in their post-interviews addressed that they had learned various acids and bases definitions different from their prior interviews. Table 4.26 summarizes the interviewees' post responses. The excerpt below belongs to a student, IntTR4, from the traditional group (I stands for interviewee and R stands for researcher):

> R: How can you define an acid or a base?
>
> I: The substances that contain H in their structures are acids and that contain OH in their structures are bases.
>
> R: What else can you say about acids and bases?
>
> I: Acids give H^+ ions into solutions and their pH is below 7, bases give OH^- into solutions and their pH is above 7.
>
> R: Would like to add something?
>
> I: No.
>
> R: What do Arrhenius, Bronsted-Lowry and Lewis acid-base definitions remind to you?

I: Conjugate acid-base, something like that? I don't remember exactly…NH_3 was a conjugate base?

The following excerpt belongs to a student, IntEX2, from the experimental group:

R: How can you define an acid or a base?

I: Substances that give protons are acids and that accepts are bases. In fact, there are different definitions but this is more practical for me.

R: What are the others?

I: There are the Arrhenius definition and the Lewis definition. But, I like the Bronsted-Lowry's definition since works for many acids and bases.

R: Why are there different definitions, what can you say about this?

I: During the time, it was understood that the Arrhenius acid-base definition is not enough in defining acids and bases, and then Bronsted and Lowry proposed proton transfers for acids and bases. Then, Lewis proposed electron-pair transfers for acids and bases.

R: Would like to add something?

I: Acids have pH below 7 and bases have pH above 7.

The statistical analyses between the experimental and the traditional group reveled that there was a significant difference between the groups and the first question of the post-interview supported this statistical findings. The interviewees stated the similar responses for the properties of acids and bases such as their pH values, the color change in litmus paper, conductivity of electricity, reaction with metals; however, there were some discrepancies in defining acids and bases. Three interviewees in the experimental group used the Bronsted-Lowry acid-base definition in defining acids and bases and the other one was also aware of various definitions but used the Arrhenius acid-base definition. On the other hand, three interviewees in the traditional group used the Arrhenius acid-base definition and only one of them was aware of various acid-base definitions; and the other interviewee used the Bronsted-Lowry acid-base definition and was also aware of the other definitions.

The experimental group interviewees were more confident in giving examples for acids and bases and could gave at least three examples for acids and bases; however, the traditional group interviewees were less confident in giving examples and could give at least three examples for acids but they were not successful in giving examples for bases just gave NaOH, KOH, and NH_3 as examples.

Table 4.26 Students' post-responses for defining acids and bases

Students general ideas	# of students (out of eight)	
	Experimental	Traditional
Acids are dangerous	0	1
Acids have H in their formula	0	1
Acids give H^+ into solutions	1	3
Bases have OH in their formula	0	3
Bases give OH^- into solutions	1	3
Acids donate protons	3	1
Bases accepts protons	3	1
Aware of different definitions	4	2
Acids are substances below pH 7	4	4
Bases are substances above pH 7	4	4

The second interview question was about acids and bases in our daily life. The students were asked that whether they came across to acids or bases in their everyday life. During the pre-interviews, all interviewees gave the same examples for acids which were lemon, coke and vinegar. One of them added stomach acid and another three students added some fruits as substances that they came across during their daily life. In terms of bases, all students told that soap was the material they most came across in their daily life and two of them added the other cleaning materials had also basic properties. The students then asked how they knew those substances were acidic or basic and their responses were they learnt from their teachers or books. One of the interviewee, IntEX3, explained as the following:

> Acids can be found in food and I understand it from its sour taste. Lemon has a sour taste and vinegar also... Coke, for example, has an acid. When I eat an orange, I get a sour taste. These sorts of things came to my mind from daily life.

In terms of bases, IntEX3 added: "The soap that we wash our hands is a basic substance and I guess some cleaning materials such as bleach is also a basic substance." Another student, IntTR2, expressed as the following for acids:

> I don't think that I come across to a strong acid in daily life. But, I guess, vinegar, lemon or some vegetables such as tomatoes have acids and so they are in our daily life. We drink coke and it is acidic.

And in terms of bases, IntTR2 said: "I know soap is a basic substance since the primary school, but nothing else comes to my mind now. I guess cleaning materials may be basic."

Afterwards the implementation, during the post-interviews the difference in giving examples from everyday life was also detected. The experimental group interviewees felt more confident in giving examples, but the traditional group interviewees did not feel the same confidence. For instance, an interviewee, IntEX2, from the experimental group stated as the following:

> I can give many examples for acids and bases such as lemon, vinegar, tomato, apple… many fruits are acidic, yogurt, sulfuric acid is used in car power supply are acidic… for basic ones baking soda can be used in cakes, window cleaners, soap, toothpaste, shampoo, and some detergents.

On the other hand, an interview, IntTR1, from the traditional group had some difficulties in giving examples as the following: "I can give lemon, vinegar for acids…what else...foods include acids in general…coke for example is acidic…for bases, soap is basic…what else…other cleaning detergents are all bases…these are the substance we know from daily life."

The third question was related to determining acids and bases and students were shown the drawings of six erlenmeyers and asked to determine which of them were acids or bases. During the pre-interviews, all students classified HCl as an acid and NaOH as a base correctly with the reasoning including H or OH in their formulas. IntEX3 expressed for the other substances:

> NH_3 is a base and I know that it is an exception although it has H in its formula. I've known that it is a base since primary school and there is an expression "Ammonia is a base the one who does not know is a goose." (Laughing) I remember from this expression and there are always exceptions. But I have no idea for BF_3, may be, it could be a base since it is similar to NH_3. I don't know. I guess, as I remember, CH_3COOH is also an exception; although it has OH in its formula, it is an acid. As far as I know, NaCl is a salt but I don't how it is related to acids and bases.

Similar to IntEX3's opinion another interviewee IntTR3 said NH_3 was a base but could not explain why it was a base just said he remembered that there was an exception for it and stated BF_3 could also be a base since having a similar structure. Another interviewee, IntTR1, strongly hold the Arrhenius definition and told that if there was H in formula, a substance was an acid and if there was OH in formula, then a substance was a base; therefore, he added HCl and NH_3 were acids, NaOH and CH_3COOH were bases, and expressed the other ones which were BF_3 and NaCl were neither an acid nor a base since not including H or OH. Consequently, BF_3 was the most difficult option for the students and none of them gave the correct response. Two students mentioned ammonia was a base explaining of being an exception although having H in formula. Three students determine CH_3COOH was a base since having OH in formula, two students said it was an acid of being an exception but could not explain the reason, and the other three students told that it was an acid giving dissociation of acetic acid. Seven of the interviewees stated NaCl was a salt and the other student stated nothing about being salt.

Afterwards the implementation, during the post interviews the interviewees used their understandings for determining acids and bases. The interviewees from the experimental group mentioned about the acid-base definitions and one them, IntEX1, explained as the following:

> In order to determine whether the substance is acid or a base, first I check whether there is H or OH in their formula. Here, HCl is an acid and NaOH is a base. CH_3COOH seems to have OH but its dissociation is different and it is a Bronsted-Lowry acid and NH_3 is a Bronsted-Lowry base. I am not sure for BF_3 but if there was a reaction, I can determine more easily. If it is a proton donor, it is an acid and it is a proton acceptor, it is a base. But also, there was a Lewis definition could be also considered as a Lewis acid if it is an electron acceptor or a Lewis base if it is an electron donor. The final one, NaCl, is a salt. I remember this from neutralization reactions.

Although, IntEX1 did not mention about electron pair instead used just 'electron', her logic was valid for determining acids and bases. The other interviewees from the experimental group gave the similar explanation; only one of them used the Arrhenius acid-base definition but also was aware of the other definitions. On the other hand, one of the interviewees, IntTR3, from the traditional group stated as the following:

> I: HCl is an acid since containing H and NaOH is a base since containing OH. CH_3COOH and NH_3 were exceptions and CH_3COOH is an acid and NH_3 is a base.
>
> R: How can you explain their acidity or basicity?
>
> I: They are exceptions as I said. There are always exceptions.
>
> R: Yes, but based on what they are accepted as an acid or a base?
>
> I: In science there are exceptions these are one of them.
>
> R: OK. What about the others?

I: I am not sure about BF_3 but similar to NH_3 and could be a base. NaCl is a salt.

This interviewee used the Arrhenius acid-base definition in determining acids and bases. Only one interviewee, IntTR2, used the Bronsted-Lowry definition in determining acids and bases and was aware of the other definitions. The other two interviewees gave the similar explanations to IntTR3 and hold the Arrhenius acid-base definition but one of them was aware of the other definitions. Similar to prior responses, the students in their post-interviews had difficulties in determining whether BF_3 was an acid or a base and somehow they determined the other substances acidity or basicity.

The fourth question sought for student ideas for indicators, particulate level of acids and bases, pH and pOH concepts. Firstly, students were shown two solutions one having pH value of 4 and the other having pOH value of 4 and asked what they thought about those solutions. During the pre-interviews, all interviewees stated that one solution was an acidic and the other was a basic. In order to determine which one was acidic or basic, six of them stated that they would use a litmus paper to test the solutions as litmus paper turned red the solution was an acidic or blue the solution was a basic. One of the students said he would add a piece of sodium element into solutions as acidic solutions gave reactions with metals, the acidic one could be determined. The other student told that he had no idea how to determine which solution was acidic or basic. The latter two students were also asked whether they heard about litmus paper and both of them stated that they knew about litmus paper, but one of them said litmus paper turned blue in acidic solutions. None of the students could give a reasonable answer for indicators. Afterwards, they were asked to draw these solutions in particle level. Five students showed the dissociation in acidic and basic solutions as IntTR2's drawing below (Figure 4.8):

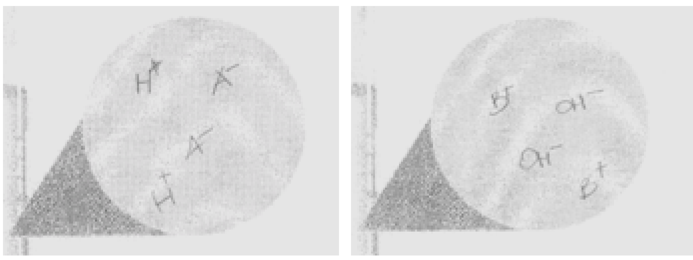

Figure 4.8 The pre-drawing of the dissociation in acidic and basic solutions by IntTR2

The other three students drew the similar drawings (Figure 4.9) as shown below which is belong to IntEX1 and her explanation:

I don't know exactly how acidic and basic solution could be seen, but they should be different in terms of ions. These ions are positive and negative charged and they will naturally stay close to each other since there is attraction with oppositely charged ions. The same situation happens for bases, as well. The oppositely charged ions stay closer.

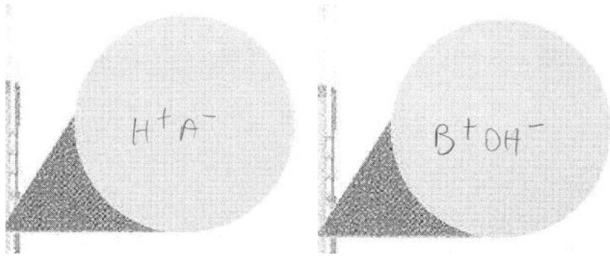

Figure 4.9 The pre-drawing of the dissociation in acidic and basic solutions by IntEX1

Afterwards, the students were posed about questions related to pH and pOH. Three students stated that pH was a value that measured acidity and pOH measured basicity, but added that pH was a valid for just acidic substances below the value of 7 and pOH was a valid for just basic substances above the value of 7. Another three students mentioned that pH measured the strength of acids and pOH measured the strength of bases with the explanation as pH decreased the acid was stronger. Two students explained that either pH or pOH value was valid for acids and bases since they could be converted to each other. Lastly, when the students were asked what would happen when those solutions were mixed, all interviewees stated that acids and bases react with each other.

After the implementation, during the post-interviews the students revealed the differences in their responses in terms of being in the experimental and the traditional group. This interview question also supported the statistical difference found in MANOVA findings. All interviewees stated that the solution with pH was an acid and the solution with pOH was a basic solution. Then, all interviews stated that they would used a litmus paper to test which solution was an acidic or a basic and explained correctly that acids turn litmus paper to red and bases turn litmus paper to blue. In addition to litmus paper, the all interviewees from the experimental group added that they could also use red cabbage juice in determining solutions acidity or basicity; however, no interviewee in the traditional group mentioned any alternative way in determining solutions acidity or basicity. In terms of representations in particle level, interviewees differed in their drawings. For instance, three interviewees in the experimental group drew the similar drawing given in Figure 4.10. The other interviewee in the experimental group did not mention about the existence of OH^- ions.

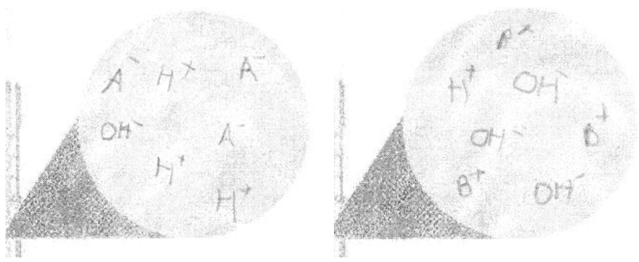

Figure 4.10 The post-drawing of the dissociation in acidic and basic solutions by IntEX2

The IntEX2 explained his drawing as the following:

> pH=4 is an acid solution. Although it is an acidic solution, it will also contain a small amount of OH^- ions because of the self-ionization of water. This amount will be 10^{-10}. I mean pOH is 10. pOH=4 is a base. This also contains a small amount of H^+ ions, 10^{-10}. pH here is 10.

On the other hand, the drawings of the interviewees from the traditional group did not address the existence of OH^- ions in acidic solution or H^+ ions in basic solution. When they were asked about pH and pOH, two of the interviewees stated that pOH of the acidic solution was 10 and pH of basic solution was 10 by stating the formula of pH + pOH = 14. The other two interviewees mentioned that pH was only valid for acidic solutions and pOH was only valid for basic solutions; although they made this explanation, they also stated that pOH of the acidic solution was 10 and pH of basic solution was 10 by stating the formula of pH + pOH = 14. These two students did not reveal understanding of pH and pOH concepts, they just made memorization.

The fifth question sought for students' ideas on strength of acids and what students thought about the differences between a strong and a weak acid. During the pre-interviews, three out of eight students stated that strong and weak acids differed in terms of bonding strength. One of the students who supported this idea was IntTR1, his drawing (Figure 4.11) and explanation is given below:

> A strong acid and a weak acid… both of them are acids… the strong one's molecules would be more closer to each other, I guess, since the bonds would be more stronger.

But in terms of a weak acid, I think the molecules would be more untidy around because of having weak bonds.

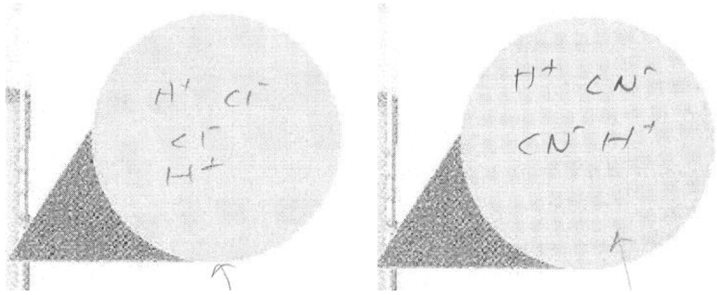

Figure 4.11 The pre-drawing of the strength of acids by IntTR1

The other three students stated that pH of these acids would be different, the stronger acid would had the lower value of pH; one of these students who supported this idea was IntEX4, see her drawing (Figure 4.12) and explanation below:

IntEX4: I don't know how I would have seen these solutions. May be like this… Really, I don't know.

Researcher: OK. Then, why do you think that these solutions are called as strong and weak? What is the difference among these solutions?

I: pH would be different. The stronger will have a lower pH value. For example, I know HCl is very strong acid. It is very dangerous. It is pH value is 1. I am not sure about HCN; but if it is a weak acid, it is pH value may be 6.

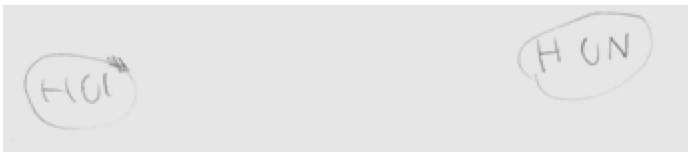

Figure 4.12 The pre-drawing of the strength of acids by IntEX4

The second part of the fifth question aimed to assess students' ideas on strength and molarity concepts. The HCl solutions were given in different molarities and students were asked to rank these solutions in terms of their strength. Six interviewees directly tried to find the pH values of the solutions and then made the ranking based on their solutions. One interviewee did not relate to pH concepts and thought about the molarity values and stated that the strength of the solutions could be from the highest to the lowest molarity. The other student, IntTR2, expressed that the all three solutions contained HCl solutions in different molarities but could not explain the correct answer and made ranking in terms of molarity.

After the implementation, the post-interviews also supported the findings of statistical analysis since the interviewees from the experimental group illustrated more conceptual understanding than the interviewees from the traditional group. All interviewees from the experimental group stated that the dissociation of a strong acid and a weak acid differed. For instance, one of the interviewees, IntEX1, drawing and is given in Figure 4.13 and her explanation are as the following:

> Strong acids dissociate nearly 100% and weak acids do not dissociate well. HCl is a strong acid and its dissociation is like this… HCN is a weak acid and it has a small dissociation percantage. Its dissociation could be like this… a small amount of H^+ ion and more HCN molecules.

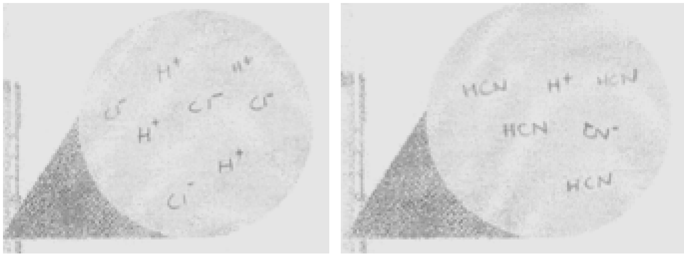

Figure 4.13 The post-drawing of the strength of acids by IntEX1

On the other hand, two interviewees, IntTR2 and IntTR3, from the traditional group mentioned about the dissociation difference and the other two mentioned about the bonding strength. IntTR2 stated the correct explanation for strong and weak acids but was unable to draw the correct representation of these solutions. His drawing is given in Figure 4.14 and explained that there would be less ions in the weak acid solution because of small dissociation percentage. The similar explanation was also done by IntTR3.

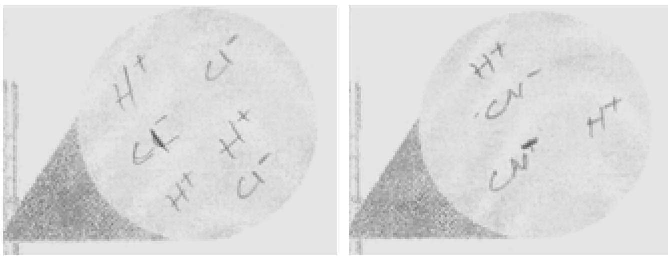

Figure 4.14 The post-drawing of the strength of acids by IntTR2

In terms of on the section of strength and molarity concepts, two interviewees from the experimental group firstly tried to find the pH values of the solution but then they realized that all solutions were HCl solution in different concentration and then concluded that the strength of these solutions would be the same. The other two interviewees from the experimental group directly stated that the strength of the solution was the same. On the other hand, three of the interviewees from the traditional group found the pH values of the solutions and ranged their strength based on their pH values and the other interviewee, IntTR2, stated that the strength of the solutions would be the same. The traditional group students did not reveal the understanding of the strength concept properly and they all had conflict with the concentration concept except one of the interviewee.

The sixth question sought for students' ideas on neutralization concept and the role of indicators. This was an active question that the students observe the mixing of an acid and a base in two conditions in presence of an indicator and not. At the fourth question when students were asked what would happen when mixing an acid and a base solutions, all students responded that there would be a reaction between an acid and a base. In this question, HCl and NaOH solutions were prepared and students observed the two different situations and there was a color change in an erlenmeyer with an indicator (phenolphthalein) and no color change in the other one which did not include an indicator. During the pre-interviews, four students were very confused with the results and they tried to explain the difference because of the presence of an indicator as the indicator was the agent to the reaction occurred and so no reaction occurred in the absence of indicator. Two of these four students wrote the reaction correctly but the other two students had a conflict in writing the reaction, one of them, IntEX3, stated as the following:

> …but I know that this reaction happens among HCl and NaOH, a neutralization reaction occurs and the products are salt and water. But, there was no change in the mixture when there is no indicator. I don't understand. Something should be wrong… most probably, indictor is the thing that made this reaction occur since there was a color change, but I don't know how to show in this reaction. I am confused.

The other three students mentioned that indicator enhanced to the reaction to happen faster and they explained that there was also a reaction in the other erlenmeyer where there was no indicator but this reaction happened more slowly. These three students made a connection with the previous topic and they thought that indicator acted as a catalyst. IntTR2, who supported this view, made the drawing (Figure 4.13) as below and his explanation was as the following:

> Hydrogen in acid and hydroxide in base come together and they neutralize each other and water is formed. This is a neutralization reaction. Salt is also formed. NaCl salt… salts precipitate and can be seen at the bottom of the erlenmeyer.

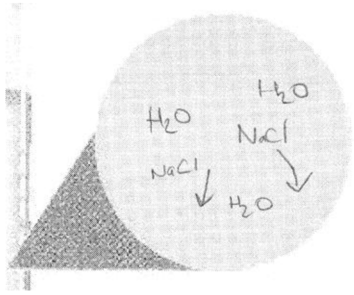

Figure 4.15 The pre-drawing of neutralization reaction by IntTR2

The other student, InEX1, could not explain the situation but expressed as the following and see her related drawing (Figure 4.14):

> I: …I can't explain the reason something related to indicator but I really don't know… but I can write the reaction. This is a neutralization reaction and salt is formed. I am not sure about the salt. Is this precipitate?
>
> R: What do you think?
>
> I: I am confused. Salts are soluble, cannot precipitate, I guess... for example, if I prepare salty water, I won't see any salt at the bottom when I stir it. But, I don't know whether these are close to each other or not. Should be something like this…

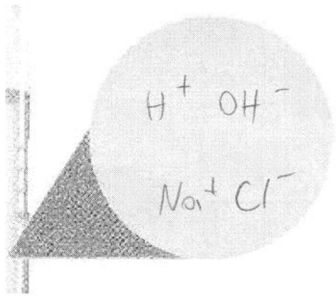

Figure 4.16 The pre-drawing of neutralization reaction by IntEX1

Lastly, all students wrote the neutralization reaction correctly and stated that the pH value of the solution was 7, but none of them gave the correct explanation for the role of indicators. In terms of particle level, three interviewees showed their drawing considering molecules (similar to IntTR2's drawing above) and five of them showed their drawing considering ions (similar to IntEX1's drawing above). Only two of them explained that the formed salt would not precipitate, the others stated that the salt would precipitate. When the students were asked, the condition of using a weak acid and a strong base, the students gave various responses. One of them, IntTR1, stated that acids and bases always gave a neutralization reaction with pH 7 either they were strong or weak, and the strength concept was related to bonds, which was not related to acids and bases reaction. The other interviewee, IntEX4, from the experimental group explained that the reaction was not a neutralization reaction since there was a weak acid and it was a regular chemistry reaction without any neutralization with pH above 7.

After the implementation, the interviewees' responses differed in terms of being in the experimental and the traditional group. As it is reported in MANCOVA results, the students in experimental group had more understanding in acids and bases concepts. This statistical result was also supported in this interview question that the interviewees' responses from the experimental group for this question were more reasonable and valid; however, the interviewees' responses from the traditional group were more invalid, having alternative conceptions and had confusions in concepts. After the demonstration, three interviewees from the experimental group stated that an indicator was used to observe the equivalence point and the other interviewee (IntEX4) stated that there was not enough neutralization to observe the color change. One of the interviewee (IntTR3) from the traditional group explained the correct response of usage of indicators. The others from the traditional group could not make any reasonable explanation for the situation. IntTR2 stated that an indicator acted as a catalyst and still in his post-interview he hold this idea and explained the same reasoning for the situation.

Considering the mixing of an acidic and basic solution, all the interviewees stated that the reaction was a neutralization reaction and wrote the correct reaction of HCl and NaOH. The interviewees' responses for neutralization reactions from both the experimental and the traditional group are summarized in Table 4.27.

The following excerpts of two interviewees revealed the understandings of the neutralization concept and illustrated the difference between the experimental and the traditional group. The excerpt of an interviewee, IntTR4, from the traditional group (see the related drawing in Figure 4.15):

> R: You say so when you mix these two erlenmeyers, the neutralization reaction occurs. What do you mean with the term of neutralization?
>
> I: The ions from acids and the ions from bases neutralize each other.

R: How does this neutralization occur? Can you clarify?

I: The ions from acids are H^+ ions and the ions from bases are OH^- ions; these ions form H_2O and since no ions remain in the solution, it is neutralization.

R: You mean no ions present in the mixed solution?

I: Yes. That's why; it is called a neutral solution. If there are H^+ ions, it is acid and if there are OH^- ions, it is base. No ions in solution, so it is neutral.

R: What about the pH value of the solution?

I: It is 7.

Table 4.27 The summary of responses of interviewees for the sixth question after the implementation

Coding for the sixth question	Number of interviewees	
	Experimental group	Traditional group
Strong acid and strong base		
The solution is neutral	4	4
The products are salt and water	4	4
No H^+ and OH^- ions in the solution	1	3
Na^+ and Cl^- ions in the solution	3	2
NaCl precipitate	1	2
pH is 7	4	4
Weak acid and strong base		
The solution is neutral	0	2
The solution is basic	4	2
The products are salt and water	4	4
No ions in the solution	0	2
Only OH^- ions in the solution	1	2
OH^- ions > H^+ ions	3	0
pH is 7	0	2
pH is above 7	4	2

The excerpt of an interviewee, IntEX3, from the experimental group (see the related drawing in Figure 4.16):

R: You say so when you mix these two erlenmeyers, the neutralization reaction occurs. What do you mean with the term of neutralization?

I: HCl solution contains H^+ ions and NaOH contains OH^- ions. When these solutions are mixed NaCl and H_2O are formed. The ions in solution are balanced.

R: Can you clarify what is this balance?

I: In a neutral solution, H^+ and OH^- ion concentration is equal and that's why in neutralization reactions the solution is neutral with pH 7.

R: So, you mean that there are H^+ and OH^- ions in the solution with the equal amount?

I: Yes.

Although there was a logic difference among these two thoughts, the students in the similar logics could get the true answers in case of strong acids and strong bases neutralization reactions; however, the students supporting the former logic could fail in case of weak acids and strong base neutralization reactions since they were not considering acidic solutions could contain not only H^+ ions, but also a small number of OH^- and vice versa situation is acceptable by the self-ionization of water.

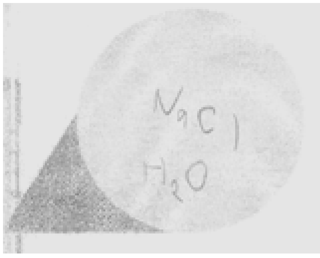

Figure 4.17 The post-drawing of neutralization reaction by IntTR4

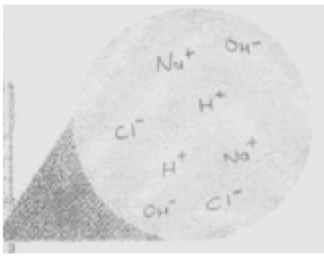

Figure 4.18 The post-drawing of neutralization reaction by IntEX3

When the students were asked, the condition of using a weak acid and a strong base, the interviewees from the experimental group stated the situation would differ because of fewer amounts of H^+ ions and added that the pH value of the solution would be above 7.

4.5 Results on Chemistry Motivation Questionnaire and Student Interviews

The CMQ had five components which were self-efficacy in learning chemistry, anxiety about chemistry assessment, relevance of learning chemistry to personal goals, intrinsically motivated chemistry learning, and self-determination for learning chemistry. In order to get more detailed information on student motivation to learn chemistry in terms of the experimental and traditional groups, multivariate analysis of covariance was conducted considering the aforementioned five components. Based on the adaptation of CMQ results on components pre- and post-CMQ scores were computed (see Table 3.9). The computed components' descriptive statistics were given in Table 4.28 for the experimental and Table 4.29 for the traditional group.

Table 4.28 Descriptive Statistics for the each component in terms of pre- and post-CMQ in the experimental group

	N	Mean	SD	Skewness	Kurtosis	Min	Max
Pre-CMQ							
Pre-Efficacy	40	27.98	5.35	-.02	-.61	16	38
Pre-Anxiety	40	16.45	4.38	-.25	-.84	7	23
Pre-Goals	40	22.05	5.82	.13	-.96	12	34
Pre-Intrinsic	40	16.70	3.72	.13	-.92	10	24
Pre-Determination	40	19.60	2.59	-.29	-.33	13	24
Post-CMQ							
Post-Efficacy	40	30.08	4.59	-.36	-.84	21	38
Post-Anxiety	40	16.85	4.90	-.02	-1.17	9	25
Post-Goals	40	24.78	5.23	-.10	-.72	15	35
Post-Intrinsic	40	17.33	3.34	-.12	-.45	10	24
Post-Determination	40	20.33	2.73	-.31	-.68	14	25

The pre-CMQ was administered to both the experimental and the traditional groups prior to the implementation; therefore, these values were not being influenced by the implementation. The post-CMQ was administered after the implementation; therefore these values were affected by the implementation. The difference between the experimental and the traditional groups' CMQ scores was analyzed by using MANCOVA. The scores on the pre-CMQ were treated as a covariate in order to control the differences between groups although no difference was found neither for the total pre-CMQ scores ($F(1,76)=0.401$, $p=0.529$; Table 4.30) nor for the collective aforementioned CMQ components (Wilks' $\lambda=0.944$, $F(5,72)=0.858$, $p=0.514$; Table 4.31). This result revealed that the students the experimental and the traditional group were roughly equally motivated to learn chemistry.

Table 4.29 Descriptive Statistics for the each component in terms of pre- and post-CMQ in the traditional group

	N	Mean	SD	Skewness	Kurtosis	Min	Max
Pre-CMQ							
Pre-Efficacy	38	29.68	5.99	-.04	-1.27	19	39
Pre-Anxiety	38	15.74	4.39	-.01	-.72	7	25
Pre-Goals	38	23.21	6.79	-.21	-1.02	11	34
Pre-Intrinsic	38	16.45	3.42	-.40	.62	7	23
Pre-Determination	38	19.95	3.65	-.65	.26	10	25
Post-CMQ							
Post-Efficacy	38	29.39	6.11	-.23	-.66	16	39
Post-Anxiety	38	14.74	3.45	-.02	-.54	7	21
Post-Goals	38	23.26	6.63	-.09	-.96	10	35
Post-Intrinsic	38	16.42	3.95	-.44	-.58	7	22
Post-Determination	38	18.76	4.30	-.34	-.93	10	25

Table 4.30 Univariate test results in ANOVA for pre-CMQ

Source	df	Mean Square	F	Sig.	Partial Eta Squared	Observed Power
Corrected Model	1	98.769	.401	.529	.005	.096
Intercept	1	841483.436	3413.371	.000	.978	1.000
Method	1	98.769	.401	.529	.005	.096
Error	76	246.526				
Total	78					
Corrected Total	77					

Table 4.31 Multivariate Test results in MANOVA for pre-CMQ components

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Observed Power
Intercept	.013	1111.936[b]	5.000	72.000	.000	.987	1.000
Method	.944	.858[b]	5.000	72.000	.514	.056	.290

The assumptions of MANCOVA were checked beforehand the analysis; which were independence of observations, normality, outliers, homogeneity of variances, multicollinearity, and homogeneity of regression.

Table 4.32 Box's Test of Equality of Covariance Matrices

Box's M	63.657
F	1.240
df1	45
df2	13370.998
Sig.	.131

In terms of independence of observations, it was ensured that there was not any violation of the assumption since students completed the questionnaire individually. The skewness and kurtosis values for each component can be found in Table 4.28 and Table 4.29; the values of which are in the acceptable range. In addition, the univariate normality was check in previous section 4.1 for the total pre- and post CMQ and there was no violation for this assumption. For multivariate normality, Box's test of equality of covariance matrices is given in Table 4.32. Since the statistics was not significant, the assumption of homogeneity was validated, which revealed the covariance matrices were roughly equal. Mahalanobis distance was checked for multivariate outliers by using the critical value of 20.52 (see Table 19.1 in Pallant, 2001, p.221). The Mahalanobis distance was found to be 16.447, which is smaller than the critical value (Table 4.33).

The Levene's test was used for checking the assumption of homogeneity of variances. Table 4.34 shows the result of Levene's test. All values for each motivation component was larger than 0.05, except the value of post-Intrinsic. This significant value indicated that the error variances across groups are not equal. In other words, the assumption of homogeneity of variances was satisfied for the four post-motivational component scores; however, the assumption of homogeneity of variances has been violated for post-Intrinsic scores. Therefore, a more conservative alpha level was set for determining significance for post-Intrinsic in the follow-up ANCOVA. The correlation analysis was done in order to check the assumption of multicollinearity. It was not found highly correlated dependent variables (higher than .8) and this assumption of multicollinearity was verified (Table 4.35).

Table 4.33 Residuals statistics for Multivariate Normality

	Minimum	Maximum	Mean	Std. Deviation
Predicted Value	15.7493	60.2349	39.5000	8.01237
Std. Predicted Value	-2.964	2.588	.000	1.000
Std Error of Predicted Value	3.236	10.431	5.894	1.501
Adjusted Predicted Value	8.9438	58.5928	39.4305	8.24155
Residual	-43.82441	45.48384	.00000	21.19674
Std. Residual	-1.999	2.075	.000	.967
Stud. Residual	-2.038	2.126	.001	1.003
Deleted Residual	-45.54019	47.76036	.06952	22.83242
Stud. Deleted Residual	-2.085	2.181	.000	1.011
Mahalanobis Distance	.691	16.447	4.936	3.134
Cook's Distance	.000	.071	.013	.015
Centered Leverage Value	.009	.214	.064	.041

Table 4.34 Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Post-Efficacy	.288	3	74	.834
Post-Anxiety	1.669	3	74	.181
Post-Goals	1.869	3	74	.142
Post-Intrinsic	2.827	3	74	.044
Post- Determination	.380	3	74	.767

Table 4.35 Correlations among variables

Variables	Post-Efficacy	Post-Anxiety	Post-Goal	Post-Intrinsic
Post-Anxiety	-.241*			
Post-Goals	.671**	-.146		
Post-Intrinsic	.607**	-.192	.661**	
Post-Determination	.559**	-.124	.663**	.525**

*Correlation is significant at the 0.05 level (2-tailed)
**Correlation is significant at the 0.01 level (2-tailed)

The assumption of homogeneity of regression was tested by customizing settings in MANCOVA and checked whether there was interaction between the covariates (pre-Efficacy, pre-Anxiety, pre-Goals, pre-Intrinsic, and pre-Determination) and the independent variables (method and gender). The significance level of the interactions terms were checked in the output (Table 4.36). Since the all significance values for the interactions were greater than 0.05, the assumption of homogeneity of regression was not violated.

Table 4.36 Multivariate Tests for Homogeneity of Regression for the interaction between the covariates and the independent variables

Effect	Wilks' Lambda Value	F	Hypothesis df	Error df	Sig.
Intercept	.871	1.476	5.000	50.000	.214
Method * pre-Efficacy	.929	.770	5.000	50.000	.576
Method * pre-Anxiety	.903	1.070	5.000	50.000	.388
Method * pre-Goals	.991	.089	5.000	50.000	.994
Method * pre-Intrinsic	.907	1.022	5.000	50.000	.415
Method * pre-Determin.	.922	.844	5.000	50.000	.525
Gender * pre-Efficacy	.927	.787	5.000	50.000	.564
Gender * pre-Anxiety	.831	2.038	5.000	50.000	.089
Gender * pre-Goals	.981	.192	5.000	50.000	.964
Gender * pre-Intrinsic	.947	.561	5.000	50.000	.729
Gender * pre-Determin.	.921	.856	5.000	50.000	.517
Method * Gender * pre-Efficacy	.969	.319	5.000	50.000	.899
Method * Gender * pre-Anxiety	.960	.421	5.000	50.000	.832
Method * Gender * pre-Goals	.893	1.202	5.000	50.000	.322
Method * Gender * pre-Intrinsic	.844	1.849	5.000	50.000	.120
Method * Gender * pre-Determination	.942	.620	5.000	50.000	.685
Method * Gender	.680	1.385	15.000	138.429	.163

Two-way multivariate analysis of covariance was conducted to explore method and gender differences in a set of dependent variables (post-Efficacy, post-Anxiety, post-Goals, post-Intrinsic, and post-Determination) after the preliminary assumption testing with no serious violations noted. The results are given in Table 4.37. It was found that there was a statistically significant difference between the experimental and traditional groups on the dependent variables (Wilks' λ=0.766, F(5,65)=3.969, p=0.003, partial eta squared=0.234). When the follow-up ANCOVAs considered separately, the differences to reach statistical significance using a Bonferroni adjusted alpha level of .01, were post-Goals (F(1,69)=7.603, p=0.007, partial eta squared=.099) and post-Determination (F(1.69)=12.137, p=0.001, partial eta squared=.150). The follow-up ANCOVA results are given in Table 4.38 for each dependent variable.

The main effect for gender (Wilks' λ=0.903, F(5,65)=1.401, p=0.236) and the interaction (Wilks' λ=0.894, F(5,65)=1.536, p=0.191) effect did not reach statistical significance. An inspection of the mean scores indicated that the students in the experimental group reported higher levels of relevance of personal goals (M=25.30) than the students in the traditional group (22.72). In addition, the students in the experimental group reported higher levels of self-determination (M=20.59) than the students in the traditional group (M=18.47). The estimated marginal means regarding teaching method for each dependent variable are given in Table 4.39. The estimated marginal means regarding gender (Table 4.40) and interaction (Table 4.41) for each dependent variable are given at the following.

Table 4.37 Multivariate Tests results in MANCOVA

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.	Partial Eta Squared	Observed Power
Intercept	.828	2.701	5.000	65.000	.028	.172	.785
Pre-Efficacy	.789	3.485	5.000	65.000	.007	.211	.890
Pre-Anxiety	.682	6.059	5.000	65.000	.000	.318	.992
Pre-Goals	.562	10.137	5.000	65.000	.000	.438	1.000
Pre-Intrinsic	.588	9.127	5.000	65.000	.000	.412	1.000
Pre-Determin.	.778	3.709	5.000	65.000	.005	.222	.911
Method	.766	3.969	5.000	65.000	.003	.234	.930
Gender	.903	1.401	5.000	65.000	.236	.097	.463
Method* Gender	.894	1.536	5.00	65.000	.191	.106	.505

Table 4.38 Follow-up ANCOVA for each dependent variable

Dependent Variable	Source	df	Mean Square	F	Sig.	Eta Squared	Observed Power
Post-Efficacy	Corrected Model	8	158.011	11.516	.000	.572	1.000
	Intercept	1	129.439	9.433	.003	.120	.857
	Pre-Efficacy	1	157.009	11.443	.001	.142	.915
	Pre-Anxiety	1	6.287	.458	.501	.007	.102
	Pre-Goals	1	125.834	9.171	.003	.117	.848
	Pre-Intrinsic	1	3.033	.221	.640	.003	.075
	Pre-Determinat.	1	5.021	.366	.545	.005	.092
	Method	1	60.034	4.375	.040	.060	.541
	Gender	1	24.276	1.769	.188	.025	.259
	Method*Gender	1	9.840	.717	.400	.010	.133
	Error	69	13.721				
	Corrected Total	77					
Post-Anxiety	Corrected Model	8	68.045	5.097	.000	.371	.998
	Intercept	1	43.004	3.221	.077	.045	.425
	Pre-Efficacy	1	.000	.000	.996	.000	.050
	Pre-Anxiety	1	361.270	27.062	.000	.282	.999
	Pre-Goals	1	27.608	2.068	.155	.029	.294
	Pre-Intrinsic	1	49.422	3.702	.058	.051	.475
	Pre- Determinat.	1	1.863	.140	.710	.002	.066
	Method	1	38.810	2.907	.093	.040	.390
	Gender	1	5.989	.449	.505	.006	.101
	Method*Gender	1	.525	.039	.843	.001	.054
	Error	69	13.350				
	Corrected Total	77					
Post-Goals	Corrected Model	8	203.143	12.631	.000	.594	1.000
	Intercept	1	67.526	4.199	.044	.057	.524
	Pre-Efficacy	1	.750	.047	.830	.001	.055
	Pre-Anxiety	1	1.180	.073	.787	.001	.058
	Pre-Goals	1	644.732	40.087	.000	.367	1.000
	Pre-Intrinsic	1	59.306	3.687	.059	.051	.474
	Pre- Determinat.	1	9.890	.615	.436	.009	.121
	Method	1	122.278	7.603	.007	.099	.776
	Gender	1	6.943	.432	.513	.006	.099
	Method*Gender	1	22.712	1.412	.239	.020	.216
	Error	69	16.083				
	Corrected Total	77					

Table 4.38 Follow-up ANCOVA for each dependent variable (continued)

Dependent Variable	Source	df	Mean Square	F	Sig.	Eta Squared	Observed Power
Post-Intrinsic	Corrected Model	8	74.305	11.826	.000	.578	1.000
	Intercept	1	17.787	2.831	.097	.039	.382
	Pre-Efficacy	1	16.969	2.701	.105	.038	.367
	Pre-Anxiety	1	6.359	1.012	.318	.014	.168
	Pre-Goals	1	5.835	.929	.339	.013	.158
	Pre-Intrinsic	1	105.745	16.830	.000	.196	.981
	Pre-Determinat.	1	.242	.039	.845	.001	.054
	Method	1	23.788	3.786	.056	.052	.484
	Gender	1	31.636	5.035	.028	.068	.600
	Method*Gender	1	38.169	6.075	.016	.081	.681
	Error	69	6.283				
	Corrected Total	77					
Post-Determination	Corrected Model	8	69.205	10.170	.000	.541	1.000
	Intercept	1	32.943	4.841	.031	.066	.583
	Pre-Efficacy	1	7.081	1.041	.311	.015	.172
	Pre-Anxiety	1	.260	.038	.845	.001	.054
	Pre-Goals	1	46.395	6.818	.011	.090	.731
	Pre-Intrinsic	1	6.171	.907	.344	.013	.156
	Pre-Determinat.	1	77.221	11.348	.001	.141	.913
	Method	1	82.594	12.137	.001	.150	.930
	Gender	1	1.979	.291	.591	.004	.083
	Method*Gender	1	.178	.026	.872	.000	.053
	Error	69	6.805				
	Corrected Total	77					

Table 4.39 Estimated Marginal Means in terms of Method

Dependent Variable	Method	Mean	Std. Error	95% Confidence Lower Bound	95% Confidence Upper Bound
Post-Efficacy	EX	30.619	.595	29.432	31.806
	TR	28.811	.610	27.594	30.028
Post-Anxiety	EX	16.534	.587	15.363	17.704
	TR	15.080	.602	13.880	16.281
Post-Goals	EX	25.302	.644	24.017	26.587
	TR	22.722	.660	21.405	24.040
Post-Intrinsic	EX	17.441	.403	16.638	18.244
	TR	16.303	.413	15.480	17.127
Post-Determination	EX	20.591	.419	19.756	21.427
	TR	18.471	.430	17.614	19.328

Table 4.40 Estimated Marginal Means in terms of Gender

Dependent Variable	Gender	Mean	Std. Error	95% Confidence Lower Bound	Upper Bound
Post-Efficacy	Girls	30.305	.604	29.101	31.509
	Boys	29.125	.618	27.892	30.358
Post-Anxiety	Girls	15.514	.595	14.326	16.702
	Boys	16.100	.610	14.884	17.316
Post-Goals	Girls	24.328	.653	23.024	25.631
	Boys	23.697	.669	22.362	25.032
Post-Intrinsic	Girls	17.546	.408	16.731	18.361
	Boys	16.199	.418	15.364	17.033
Post-Determination	Girls	19.700	.425	18.852	20.548
	Boys	19.373	.435	18.495	20.231

Table 4.41 Estimated Marginal Means in terms of Method and Gender Interaction

Dependent Variable	Method	Gender	Mean	Std. Error	95% Confidence Lower Bound	Upper Bound
Post-Efficacy	EX	Girls	30.824	.828	29.173	32.475
		Boys	30.414	.869	28.680	32.147
	TR	Girls	29.786	.904	27.982	31.590
		Boys	27.836	.898	26.044	29.628
Post-Anxiety	EX	Girls	16.330	.816	14.701	17.958
		Boys	16.738	.857	15.028	18.448
	TR	Girls	14.698	.892	12.919	16.478
		Boys	15.462	.886	13.695	17.230
Post-Goals	EX	Girls	25.033	.896	23.246	26.821
		Boys	25.571	.941	23.694	27.448
	TR	Girls	23.622	.979	21.669	25.576
		Boys	21.822	.972	19.882	23.762
Post-Intrinsic	EX	Girls	17.357	.560	16.240	18.474
		Boys	17.525	.588	16.352	18.698
	TR	Girls	17.735	.612	16.514	18.956
		Boys	14.872	.608	13.659	16.084
Post-Determination	EX	Girls	20.812	.583	19.649	21.974
		Boys	20.371	.612	19.150	21.592
	TR	Girls	18.588	.637	17.317	19.859
		Boys	18.354	.633	17.092	19.616

When the estimated marginal mean in terms of method (Table 4.39) were investigated, it is inspected that not only the statistically significant dependent variables, but also there were differences in other dependent variables in terms of method although they were not statistically significant. Preliminary scores in motivational components all increased after the implementation in the experimental group students; considering self-efficacy in learning chemistry, anxiety about chemistry assessment, relevance of learning chemistry to personal goals, intrinsically motivated chemistry learning, and self-determination for learning chemistry. On the other hand, preliminary scores in motivational components all decreased after the implementation in the traditional group students; considering the aforementioned motivation components. There were slightly differences in terms of gender in student motivation to learn chemistry, but these differences were not found statistically significant.

4.5.1 Student interviews on motivation to learn chemistry

Besides the statistical differences, the differences between the experimental and traditional group students were also detected in the student interviews. There were eight interviewees and they were interviewed both before and after the implementation. Four interviewees were from the experimental group (IntEX1, IntEX2, IntEX3, and IntEX4) and the other four were from the traditional group (IntTR1, IntTR2, IntTR3, and IntTR4). IntEX1, IntEX3, IntTR3, and IntTR4 were female and IntEX2, IntEX4, IntTR1, and IntTR2 were male students. All the interviewees stated that they took extra private courses; except IntEX2, he added that he was not willingly to take extra courses since what he learned at school was enough for him when he studied regularly.

During the interviews, the students expressed their thoughts about learning chemistry and based on their responses codings were constructed considering both pre- and post-interviews. None of the interviewee mentioned any thought about learning chemistry intrinsically during the pre-interviews, though some of them said that they enjoy learning chemistry putting conditions such as getting high grades or doing experiments. After the implementation, the interviewees from the experimental group revealed intrinsic motivation to learn chemistry such as relating chemistry learning to their real life and finding chemistry learning significant. All interviewees were aware of the university extrance examination and expressed that they had to learn chemistry to be successful in the exam, which shows that the students are somehow extrinsically to learn chemistry because of the education system both during the pre- and post-interviews. Some students also explained that learning chemistry was related to their goals such as becoming a doctor or an occupation related to chemistry requires chemistry learning. Consequently, based on the students' interviews the following codings were interpreted from both groups; throughout this categorization the students' both pre- and post-interviews were considered and based on their responses "more", "less", or "same" terms were used to differentiate the students' pre- and post-views of motivation to learn chemistry. Table 4.42 summarizes the students' view on learning chemistry. The patterns used for the categorization were given as below:

- Intrinsically motivated chemistry learning (Intrinsic)
- Self-efficacy in learning chemistry (Efficacy)
- Self-determination for learning chemistry (Determination)
- Anxiety about chemistry assessment (Anxiety)
- Relevance of learning chemistry to personal goals (Goals)

Table 4.42 The students' views considering pre- and post- interviews

	Intrinsic	Efficacy	Determination	Anxiety	Goals
IntEX1	More	Same	More	Same	More
IntEX2	More	More	More	Less	More
IntEX3	More	Same	Same	Same	More
IntEX4	Same	Same	More	Same	More
IntTR1	Same	Less	Same	More	Same
IntTR2	Same	Same	Same	Same	Same
IntTR3	Less	Same	More	Same	More
IntTR4	Less	Less	Less	More	Less

The students' detailed explaination on motivation to learn chemistry and some interview excerpt were given at the following part. There were six questions in order to determine students' motivation to learn chemistry. The first question was about whether students like to learn about chemistry. In the pre-interviews, five students (IntEX1, IntEX2, IntEX3, IntTR3, and IntTR2) stated that learning chemistry was enjoyable and pleasant. On the other hand, the students put some conditions for liking chemistry. For instance, IntEX1 and IntTR3 stated that they liked learning chemistry when they were able to do it and IntTR2 expressed that he liked the chemistry when he got high grades in chemistry. One of the interviewees, IntEX3, said that she liked learning chemistry when she was in laboratory doing experiments. IntEX3 expressed as the following:

> I: When the chemistry course is in laboratory, I enjoy learning chemistry more.
>
> R: You mean, when you do experiments in laboratory?
>
> I: No, we don't do experiments. Our teacher does but it is different place from the class and observing the teacher doing experiments is interesting.
>
> R: How often do you go to laboratory to do experiments?
>
> I: Not much and when we are in class, I don't enjoy much learning about chemistry.

Other three interviewees (IntTR1, IntTR4, and IntEX4) stated that learning chemistry was boring since they were not learning useful things. One of them, IntEX4, explained as the following:

> I don't know why we learn chemistry. I just need it for the university exam. I don't see my mother and father using chemistry in their everyday life. It is not like mathematics, math is useful for calculations. But chemistry is not useful. When I go to a market, I say give me a water, not give me H_2O.

When the post-interviews were investigated an interviewee, IntTR2, from the traditional group held his opinion about learning chemistry. He stated that he liked chemistry when he got high grades and during the acids and bases unit he was successful in doing algorithmic problems, but added that he did not like conceptual questions and during the acids and bases unit since there were not many conceptual questions, he liked to learn about acids and bases. Another interviewee, IntTR3, from the traditional group said similar thoughts to her pre-interview such as she liked chemistry when the subject was not too hard and she understood it; additionally, she explained from subject to subject the answer of this question could change. The acids and bases unit was not too tough for her and expressed that she liked learning about them. The other interviewee, IntTR4, for the experimental group also stated the similar thoughts that she usually got bored in chemistry classes but had to learn about it since she were supposed to answer some chemistry questions in the university exam. An interviewee, IntEX1, from the experimental groups stated some different thoughts for the first question such as she expressed that she enjoyed the classes lately more than before since they were at chemistry lab during all the chemistry classes and stated her learning was more concrete than being abstract by explaining:

> Of course, we were learning new subjects but they were just abstract and we forgot easily if we don't repeat our notes. We didn't observe anything and just solved the questions. But, in this unit we both observed many substances and made inferences to learn the subjects and I think the courses were more efficient and I still didn't forget what I have learned.

Another interviewee, IntEX4, from the experimental group had also some changes in his thoughts about learning chemistry and he explained as the following:

> I thought that chemistry was useless for our life, but there was a handout about a day of a university girl at the beginning of the acids and bases unit. Before that, I thought that I just learn about scientific things about chemistry to succeed in exams. But, I understand from that handout that everything that we drink and eat in our daily life is somehow related to chemistry and even the soap we used every day is a subject of chemistry. Therefore, I didn't get bored in this chemistry course. I started to think about chemistry during the day; for example, when I eat something, I think now whether that is acidic or basic.

The second question was about the importance of learning chemistry. During their pre-interviews, all interviewees stated that learning chemistry was important for them since they were supposed to answer chemistry questions in the university entrance examination and having a good grade at the end of the semester. Three students (IntTR2, IntTR3, and IntEX2) added that the chemistry was related to their life; therefore, learning about chemistry made them understood more easily about the life. IntTR2 also included that he wanted to be a doctor and for this reason learning biology and chemistry was more important for him; how better he learnt about chemistry, the more successful he would in the university exam. During their post-interviews, all interviewees stated their similar thoughts for the importance of learning chemistry. For instance, an interviewee, IntTR4, from the traditional group stated that chemistry out of school would not be useful for her except the university exam and she did not want any department related to chemistry. In addition, IntTR1 stated that he never understood the logic of chemistry and chemistry was not related to everyday life like biology or physics. On the other hand, interviews from the experimental groups put in extra thoughts for this question. IntEX4 added that the chemistry course enhance him to explain some cases occurred in daily life such as when he added a piece of lemon to his tea, the tea's color changed and he stated that he knew the reason of it since he learned about indicators. Another interviewee, IntEX2, from the experimental group included that:

> Chemistry is important for our lives since it enhance us to understand the life itself. But it was not easy for me to understand many things because some of them were very complicated. But I can say that although I am not a scientist, I can understand some events for example why an onion makes us cry or why some acids are dangerous some are not.

The third question was about whether chemistry knowledge they learned would be useful for the students. During the pre-interviews, four students (IntTR1, IntTR4, IntEX3, and IntEX4) stated that they would not need any chemistry knowledge after they graduate from the high school, learning chemistry was just important for passing the university examination. The other three students (IntTR2, IntTR3, and IntEX2) stated that learning chemistry made the life simpler since they understand the life when they learnt about it. For instance IntTR2 explained as the following:

> During the rate of reaction unit, I have learnt why we put our foods in refrigerators. The chemical reactions that occur in food get slower and food do not get spoiled. This kind of knowledge makes our lives more practical.

The other student, IntEX1, stated as the following "Of course, learning new things is important and useful, but nothing comes to mind now how chemistry could be useful for me in the future". After the implementation when the same question was asked to the students, the responses of the experimental and traditional group interviewees differed. For instance, IntTR4 still had the same thoughts that the chemistry she had learned was not useful for her; she explained that the knowledge she learned at school was just useful at school for exams and during daily life she did not use that knowledge since she did not have to think about that knowledge. IntEX3 and IntEX4 had expressed that they would not need any chemistry knowledge after their graduation; however, after the implementation, they stated that they could use the chemistry they learned for their daily lives. For instance, IntEX4 explained that he liked the handout about the girl who went to university and realized that chemistry was in everywhere in his life, giving an example the color change of a tea when adding lemon juice and felt pleased when he knows the answers of daily life events. Another interviewee, IntEX1, was unable to explain how chemistry knowledge could be useful for her in pre-interview; however, afterwards the implementation she stated that chemistry enabled her different point of view and explained as the following:

> In our daily life, we do many things but usually don't think the reason of the daily events. I sometimes have stomach sour and use antacid to relief the pain. In acids and bases unit, I learned this process is a neutralization reaction as excess acid is neutralized with the help of antacid. Also, I know that carbonate does the same. If I had stomach sour, I know that I should take something a base like carbonate. By means of chemistry I am aware of this.

The fourth question was related to significance of learning chemistry for students' real lives. For this aim it was asked what would be a difference among an individual who learnt chemistry and the one who did not. During the pre-interviews, this was the most difficult question for the students to answer. Similar to the third question the same four students (IntTR1, IntTR4, IntEX3, and IntEX4) stated that nothing would be different in terms of living. IntEX4 also added that the individual who did not learn chemistry could start a business life earlier and starts to make money. In addition, IntEX3 express as the following:

> Learning chemistry is difficult and that person should be happier for not learning chemistry. Nothing will differ among each other and I won't need chemistry anymore in my future life. I want to be a doctor and I will choose medicine in the university exam. I won't need any chemistry after the exam. I just need to learn about biology and organs. That's' why I just need chemistry for the exam.

The other two interviewees, IntTR2 and IntEX2, stated that they themselves would have better job opportunities since they would able to finish a university. The rest two students (IntEX1 and IntTR3) said that there should be differences among two individuals but they could not give any explanation about what they could be. IntEX1 just stated as the following:

> The chemistry I have learned is practical and makes us understand the life itself. But I don't know what to say about the differences… but there would be some differences of course.

During the post-interview, the interviewees in the experimental group could make more explanation for this question. IntEX2 stated in his first interview that there would be occupation differences, but in his later interview he also explained that he could explain and understand the events more scientifically when they came across the same cases in their real life. In addition, there were also differences in IntEX3's thoughts as her prior thought was that chemistry would not be useful for her even that she wanted to be a doctor; however, she explained in her post-interview that she would need chemistry even though she was not become a doctor. The similar ideas were also stated by IntEX4 as the following:

> I: I thought that we don't use chemistry in our daily life, but I realized that chemistry is used in daily life more than I think.
>
> R: What changed your ideas?
>
> I: There was an activity related to a university girl and mentioned about what she did during her day and there were explanations. I read that there are many events related to chemistry.
>
> R: So? What difference there would be for you?
>
> I: As I said, knowing chemistry would make my life more understandable and practical. I can make explanations for the event.
>
> R: Can you give examples?
>
> I: I gave tea example for example, squeezing lemon to tea changes tea's color. I know why this happens… tea is a natural indicator and changes its color in acids and bases. But the person who does not know anything about chemistry couldn't make any explanation to this situation, but I can.

The interviewees from the traditional group nearly gave the similar responses.

The fifth question was about the properties of chemistry course that the students like and dislike. During the pre-interviews, the students mainly focused on they liked chemistry of being enjoyable, related to their everyday life, and doing experiments in chemistry and disliked chemistry of being boring, difficult to learn, and hard to understand some topics. After the implementation, the interviewees from the traditional group stated the similar likes and dislikes; on the other hand, the ideas of the experimental group students emerged such as they expressed that doing activities on their own and stating the facts were so enjoyable for them. In addition, they expressed that they enjoyed learning the logic of the concepts and how those concepts were related to their everyday life.

The sixth question was about how the students would like to learn about chemistry. During the pre-interviews, the students mainly focus on the idea that chemistry should be learned by doing experiments since they did not forget easily when doing and they wished to learn chemistry by doing experiments. The students also addressed that they want to learn about why chemistry was important for their life, how it was related to their everyday life, and what to learn more interesting and daily life examples in their chemistry courses. After the interviews, the experimental group interviewees added that they liked the simulations and activities they had conducted related to acids and bases and they would like to learn the other topic in the similar way.

In terms of motivation to learn chemistry, the students' ideas in pre-interviews did not differ either they were in the experimental or traditional group. Their views' in learning chemistry was very similar to each other; all of them were focus on the university entrance examination which was not possible for them to ignore. Instead of learning chemistry they generally were focus on having a good performance in chemistry course. However, after the implementation the different ideas between the experimental and traditional group students mentioned. The interviewees from the traditional group still held the similar performance based ideas, however, the interviewees from the experimental group made emphasize on the relevance of chemistry to their real life.

4.6 Results of the Teacher Interview

Afterwards the implementation, a couple of questions were asked to the teacher; the focus of this interview was to get the teacher's ideas on the method used in the experimental group and what she thought about the effectiveness of the implementation. The first question was about the teacher's general ideas on the 5E learning cycle model and she replied that conducting activities with the students were enjoyable but also difficult in managing the whole classroom. She also added that during the implementation the students had opportunities to make connections with real world context; in her previous lectures she tried to solve as many as questions possible with the students since they wanted her to do. On the other hand, she expressed that the most frequent question that the students asked was why they needed to learn chemistry concepts and how they were going to use that knowledge in their future. She clarified that the implemented method gave answers to the students' questions and how chemistry was related to their real world. The next question was about the differences and similarities between the previous instructions. The teacher mentioned that she rarely had opportunities to demonstrate experiments to the students because of lack of time since she had to complete the curriculum in her traditional instructions and tried to give daily life examples related to concepts. She added that in order to teach chemistry concepts to the students; there should not be always complex chemistry experiments, materials or events from daily life could also be very explicable for students to learn chemistry concepts though there needed to be done much preparation before the instruction in terms of materials or lesson plans. On the other hand, she included that less arithmetical questions were solved with the students related to acids and bases concepts in the experimental group, which was also some students' complains in the experimental group. The third question was related to student behaviors in the classroom whether she had observed any differences in student motivation. The teacher explained that the students were very enthusiastic to be in chemistry laboratory and conducting activities in the experimental group, some students came to her and express that whether the following concepts would be implemented by the similar way in the chemistry laboratory since they enjoyed learning by doing. In addition, she gave details about a student who was not really interested in chemistry class, but revealed much progress and desire in doing activities related to acids and bases. The next question was asking about whether learning cycle model developed any student skills. The teacher said that the students were more anxious at the beginning of the implementation but meanwhile they got used to doing activities and expressing their ideas in group and class discussions and their anxiety decreased. She also stated that hands-on activities revealed positive impact on students since they were studying and doing the activities together and comprehended more understanding while learning with peers. The teacher explained her statement that although she tried to create friendly environment in the class, some students could be very shy and not willingly to ask questions to her; but, they could be more relaxed to ask questions to their friends. The fifth question was about the difficulties the teacher experienced during the implementation and the teacher said that she had to be more prepared for the class since the students were asking more conceptual questions and had to study on related lesson plans for conducting the instruction properly. The following question was about whether the students declared any opinion on the instruction; the teacher mentioned that some students made complains about not solving many arithmetical questions on acids and bases and some of them stated that they did not want to do activities; on the other hand some students asked her that whether the following chemistry units would be instructed in the chemistry laboratory by doing activities as well, some of them told her that they were pleased to learn that how chemistry was related to their life even they did not choose a career related to chemistry. The last question was about whether the teacher would prefer to use the 5E learning cycle model in the future instructions and she replied that she was glad and enjoyed to implement the 5E learning cycle of instruction and would like to use this method in her following intructions but she also stated that the developing lesson plans based on learning cycle and developing or finding hands-on activities were not easy tasks and needed time to construct. Additionally she expressed that the classes were very crowded and it was not much convenient to do activities with 40 students in the same time since it was difficult to manage them and answer their questions at the same time.

4.7 Results of the Classroom Observation Checklist

The classroom observation checklists (COC) completed both for the experimental and traditional group by the researcher for 49 class hours, 26 for the experimental class and 23 for the traditional class. They were examined whether they revealed evidence for implementation of 5E learning cycle model of instruction in the experimental group and traditional teacher-centered instruction in the traditional group. As stated in the limitations section, it would be more reliable to have at least one more observer during the implementation but it was not convenient or possible for any observer to sit in any class sections.

There were 32 items in this checklist, covering the main properties of the implemented chemistry instructions both for learning cycle and traditional instructions, considering the following aspects: the physical conditions of a classroom and a chemistry laboratory, student's role in learning, and teacher's role in teaching for both groups. Some items, related to activities in the COC, were only applicable to the experimental group (Item 5, 6, 7, 8, 9, 12, 23, 27, 29, and 30) and coded as NA in the traditional group (See Table 4.43 for checklist resulsts).

Table 4.43 Classroom observation checklist results

	Experimental Group				Traditional Group				
Item #	# of Obsv.	Yes (%)	Partially (%)	No (%)	# of Obsv.	Yes (%)	Partially (%)	No (%)	NA (%)
Item 1	26	100	-	-	23	100	-	-	-
Item 2	26	100	-	-	23	100	-	-	-
Item 3	26	81	19	-	23	-	70	30	-
Item 4	26	73	27	-	23	-	70	30	-
Item 5	26	85	15	-	23	-	-	-	100
Item 6	26	61	39	-	23	-	-	-	100
Item 7	26	69	31	-	23	-	-	-	100
Item 8	26	73	27	-	23	-	-	-	100
Item 9	26	69	31	-	23	-	-	-	100
Item 10	26	35	65	-	23	69	31	-	-
Item 11	26	-	27	73	23	100	-	-	-
Item 12	26	69	31	-	23	-	-	-	100
Item 13	26	85	15	-	23	-	-	100	-
Item 14	26	88	12	-	23	-	65	35	-
Item 15	26	65	35	-	23	22	39	39	-
Item 16	26	77	23	-	23	30	39	31	-
Item 17	26	100	-	-	23	100	-	-	-
Item 18	26	85	15	-	23	26	39	35	-
Item 19	26	77	23	-	23	22	-	78	-
Item 20	26	77	23	-	23	30	-	70	-
Item 21	26	88	12	-	23	-	39	61	-
Item 22	26	81	19	-	23	56	44	-	-
Item 23	26	73	27	-	23	-	-	-	100
Item 24	26	85	15	-	23	30	39	31	-
Item 25	26	-	27	73	23	87	13	-	-
Item 26	26	100	-	-	23	100	-	-	-
Item 27	26	81	19	-	23	-	-	-	100
Item 28	26	-	19	81	23	100	-	-	-
Item 29	26	100	-	-	23	-	-	-	100
Item 30	26	100	-	-	23	-	-	-	100
Item 31	26	73	27	-	23	39	30	31	-
Item 32	26	85	-	15	23	48	-	52	-

The COC was used to support treatment verification and get evidence for the implementations. Therefore, the treatment verification is ensured with the descriptive statistics obtained for each group.

4.8 Summary of the Results

The summary of the results could be summarized as the follwoing:

- The mean scores of the students in the experimental group (M=1.10) was lower than the students in the traditional group (M=1.32) in the pre-TABT.
- The mean scores of the students in the experimental group (M=102.78) was lower than the students in the traditional group (M=105.03) in the pre-CMQ.
- The mean scores of the students in the experimental group (M=8.90) was higher than the students in the traditional group (M=4.95) in the post-TABT.
- The mean scores of the students in the experimental group (M=109.35) was higher than the students in the traditional group (M=102.58) in the post-CMQ.
- The normal distribution was found for variables in the descriptive statistics.
- Pre-TABT and pre-CMQ were determined as covariates since these variables were continuous variables, significantly correlated with dependent variables, and revealed moderate correlation among each other.
- The assumptions of MANCOVA, independence of observations, normality, outliers, homogeneity of variances, multicollinearity, and homogeneity of regression, were met.
- There was a statistically significant difference between 5E learning cycle oriented chemistry instruction and traditionally designed chemistry instruction on the collective dependent variables (Wilks' λ=0.654, F(2,71)=18.741, p=0.000) in favor of the experimental group.
- There was not found any statistically significant difference in terms of gender and girls did not differ with boys on the collective dependent variables of the post-TABT and post-CMQ scores (Wilks' λ=0.984, F(2,71)=0.578, p=0.563).

- There was not any statistically significant interaction between the methods of teaching chemistry and gender on the post-TABT and post-CMQ scores (Wilks' $\lambda=0.991$, $F(2,71)=0.339$, $p=0.714$).
- There was a statistically significant difference on student understanding of acids and bases concepts depending on which method they were taught ($F(1,72)=30.938$, $p=0.000$) in favor of the experimental group.
- There was no statistically significant difference on the post-test mean scores between girls and boys on students' understanding of acids and bases concepts when the pre-test scores of three-tier acids and bases concepts, the pre-test scores of motivation to learn science, and previous semester chemistry grades are controlled ($F(1,72)=.063$, $p=0.802$).
- There was not found any interaction between methods of teaching and gender on students' understanding of acids and bases concepts ($F(1,72)=0.411$, $p=0.524$).
- There was a statistically significant difference between students' in experimental and traditional group on post-test scores in motivation to learn chemistry ($F(1.72)=14.175$, $p=0.000$) in favor of the experimental group.
- There was not found any statistically significant difference in the mean scores of post-CMQ in terms of gender ($F(1,72)=1.173$, $p=0.282$).
- There was not found any interaction between methods of teaching and gender on student motivation to learn chemistry ($F(1,72)=0.421$, $p=0.518$).
- The student post-interviews revealed that the interviewees from the experimental group showed more conceptual understanding of acids and bases concepts and higher motivation to learn chemistry than the interviewees from the traditional group.
- The teacher interview revealed that the teacher enjoyed implementing 5E model of instruction and found the instruction effective on student learning and motivation.
- The results of classroom observation checklist revealed evidence 5E learning cycle model of instruction for the experimental and traditional teacher-centered instruction for the traditional group.

4.9 Conclusions of the Study

The conclusions of the present study are as the following:

- 5E model of instruction is more effective compared to the traditional teacher-centered instruction in conceptual understanding of acids and bases concepts and practically significant (η^2=0.215).
- 5E model of instruction is more effective compared to the traditional teacher-centered instruction in increasing student motivation to learn chemistry and practically significant (η^2=0.162).
- 5E model of instruction or traditional teacher-centered instruction has no statistically significant effect on gender in conceptual understanding of acids and bases concepts.
- 5E model of instruction or traditional teacher-centered instruction has no statistically significant effect on gender in increasing student motivation to learn chemistry.
- Students enjoyed learning by doing on their own and expressed to learn the following concepts by the similar instruction.

CHAPTER V

DISCUSSION AND IMPLICATIONS

There are five sections in this chapter; these sections begin with a discussion and interpretations of the results. Secondly, the generalization of the study will be presented. Afterwards, conclusion and implications of the results will be given. Finally, suggestions of this study for future research will follow.

5.1 Discussion of the Results

The purpose of this study was twofold: (1) to investigate the effect of 5E learning cycle oriented instruction and gender on 11th grade high school student conceptual understanding of acids and bases concepts compared to traditional teacher-centered instruction and (2) to investigate the effect of 5E learning cycle oriented instruction and gender on 11th grade high school student motivation to learn chemistry compared to traditional teacher-centered instruction. In other words, the focus was to improve students' conceptual understanding in chemistry and lifelong learning skills, see chemistry's real world application, and motivate students to learn chemistry by using 5E model of instruction which allowed the students to engage in more hands-on and minds-on activities embedded with real world application instead of the traditional teacher-centered method. The students in the experimental group spent their classes in the chemistry laboratory doing guided inquiry based activities during the implementation process and the students in the traditional group solved more mathematical problems on acids and bases than the students in the experimental group.

The results indicate that the students in the experimental group scored significantly higher than the students in the traditional group with respect to understanding of acids and bases concepts. There was an increase in correct answers for both groups, but the traditional group could not gain as many scores as the experimental group. It seems evident that the students' conceptual understanding of acids and bases concepts was improved with the 5E model of instruction. Comparing results from the experimental and traditional group showed improvement in students' understanding of the concepts of the properties of acids and bases, pH, the representations of acids and bases, the strength of acids and bases, and the use of indicators. The most significant difference was on the representation of particles in a strong acid solution in post-TABT (Item 6 in the concept test). Students' understanding of what occurs at the particle level as related to solution of strong acids was investigated in the pre- and post-TABT. The question was about the particles in aqueous solutions of strong acids with the same molar concentration and the students from the experimental group answered correctly in a very high rate (75%) while the students from the traditional group answered correctly in a low rate (29%). Similar results were found to be for the representation of aqueous solutions of weak acids with the same molar concentration (Item 18 in the concept test) in favor of the experimental group students. From these results it can be illustrated that the 5E model of instruction was more effective in the implementation of strength concepts of acids and bases than the traditionally designed chemistry instruction. Another remarkable point was on the properties of acids related to dissociation concept (Item 11 in the concept test), in which there was a big gap in response rate in terms of the groups; the traditional group students were in contradiction with the alternative conceptions that "only strong acids conduct electricity" or "the conductivity of acids increases as the number hydrogen atoms increases"; therefore the correct response rate of the question was relatively low (32%) as compared to the experimental group students' response rate (75%). Therefore, the effectiveness of 5E model of instruction also provides further empirical support for the Biological Sciences Curriculum Study 5E instructional model and 21st century skills prepared by Bybee (2009) and request to encourage teachers to use learning cycle to help in the understanding of chemistry concepts. From a theoretical perspective, these findings are consistent with literature that the use of 5E model of instruction enhances conceptual understanding (e.g. Akar, 2005; Bektas, 2010; Cavallo et al., 2003; Ceylan, 2008; Guzzetti et al., 1993; Lawson, 1995; Pabuccu, 2008). Therefore, the 5E model of instruction may increase students' conceptual understanding of acids and bases concepts because of engaging students in observation, investigating facts, analyzing the data, interpreting the results as conducting inquiry based hands-on activities enriched with real world context. In addition, the findings of the current study are consistent with the constructivist view of science learning described by Driver and Scott (1996), Duit and Confrey (1996), and Yager (1991). Constructivism suggest to use inquiry based activities since inquiry based activities enhance students to construct understanding of nature (Chiappetta & Adams, 2004). In order to construct scientific knowledge and create meaningful learning for students, it is efficient for students to engage in learning process. Therefore, this present study is compatible with the studies in the literature.

The quantitative results of the present study were also supported by the qualitative results. Similarly, the interview results also showed the students in the experimental group were able to identify more substances which are acidic or basic and revealed more conceptual understanding on acids and bases concepts. The interview sampling group was comprised of equal numbers of students based on their academic achievement in chemistry during the previous semester and equal number interviewees were selected in terms of gender. The students from both groups used the Arrhenius definition in defining acids and bases in the pre-interview, similar with the findings of Cros et al., (1988) and Demerouti et al., (2004). After the implementation the students' responses on defining acids and bases revealed differences by the teaching method instructed; as Cros et al., (1988) concluded the students made progress in defining acids and bases but the experimental group interviewees were much aware of the various definitions and the differentiation between them. Schmidt (1995) proposed that students have difficulties in understanding Brønsted-Lowry acid-base model and Demerouti et al., (2004) reported that students prefer to use Arrhenius acid-base model in defining acids and bases though they are aware of Brønsted-Lowry acid-base model. Furthermore, Cros et al., (1986) reported that students are likely to use pH concepts in defining acids and bases; similarly, in the current study the students used this descriptive definition as pH is below 7 a substance is an acid or above 7 is a base. The students' understanding of what occurs at the particle level as related to solution of strong and weak acids were asked to them in pre- and post-TABT and interview questions; the similar results were found in picture depicting the particles in aqueous solutions of strong acids and weak acids as found in the concept test. The interviewees from the experimental group stated dissociation difference in strong and weak acids; however, the interviewees from the traditional group still had difficulties in explaining and drawing the differences between strong and weak acids. During the implementation in the experimental group, the students' prior belief on particles in aqueous solutions of strong acids and weak acids were investigated and the instruction of these concepts were given on the discrepancies among the concepts; since Nakhleh (1994) reported that students had difficulties in understanding of the particular nature of matter. Hence, as found in the present study, the students revealed difficulties in understanding the concepts which were highly related to conceptual understanding of particular nature of matter such as acids and bases concepts; particularly, these difficulties were found in the students in the traditional group in which prior knowledge and representation of particles did not much taken into consideration during the implementation process. Furthermore, thinking about the acids and bases concepts to access the prior knowledge, conducting interesting activities which were relevant to real life, finding coherent generalizations for concepts, and applying the understandings to new contexts may also develop students' conceptual understanding of acids and bases concept in the experimental group. Therefore, as the qualitative results illustrate, the 5E model of instruction was effective in improving in the conceptual understanding of acids and bases concepts than the traditional teacher-centered instruction.

Furthermore, follow-up ANCOVA results, which conducted to test the effect of teaching methods on the post-CMQ, indicated that the students in the experimental group scored significantly higher than the students in the traditional group in terms of student motivation to learn chemistry. There was not any statistically significant difference on the mean of the pre-CMQ scores for the experimental and the traditional group (the traditional group students scored a less higher than the experimental group students); however after implementation the mean of the post-CMQ scores for the experimental group was significantly higher than the one in the traditional group. There was an increase in the total mean scores of the CMQ in the experimental group while there was a decrease in the total mean score of the CMQ in the traditional group. While motivational components were taken into account, it was found that there were statistically significant differences on the components of relevance of learning chemistry to personal goals and self-determination for learning chemistry, in favor of the experimental group for both components. On the other hand, although there was not found any statistical significance between the pre- and post components, which were self-efficacy in learning chemistry, anxiety about chemistry assessment, and intrinsically motivated chemistry learning, there was an increase after the implementation for all the aforementioned components in the experimental group. Conversely, although there was not found any statistical significance between the pre- and post components, there was a decrease after the implementation for all the aforementioned components in the traditional group. Therefore, it seems evident that the student motivation to learn chemistry was increased with the 5E model of instruction as the current study provides further empirical support for the study of Schunk (1991) and Pintrich and Schunk (2002) who requested that students are more motivated to learn when they engage in activities and work in groups (Meece & Jones, 1996). It has been found in the studies (Ames, 1992; Black & Deci, 2000; DeBacker & Nelson, 2000; Guvercin, Tekkaya, & Sungur, 2010; Meece, 1991; Pintrich, 2003; Pintrich, & De Groot, 1990; Schunk, 1991) that motivation influence learning. Pintrich et al., (2003) made contributions to the literature on conceptual change which takes an important role in science education literature. They argued that the conceptual change process is not just cold process; instead the process is hot and is influenced by factors such as the choice to engage in the task, the level of engagement in the task, and the willingness to persist at the task which are all components of motivation. The present study gives an evidence for Pintrich et al.'s study that students are affected by motivational activities, which influence their understanding of concepts.

The quantitative results of the present study were also supported by the qualitative results. Similarly, the interview results also showed the students in the experimental group were more motivated to learn chemistry. The results of a study conducted by Howard and Boone (1997) revealed that when students were aware of the class science is connected to real science; they were more motivated to learn science. In addition, Ames (1992) suggested that classroom tasks should be meaningful and relevant to students' lives for meaningful understanding. Therefore, the findings of the present study are consistent with the studies such as Ames (1992), Howard and Boone (1997) the interviews of the students revealed that the students exhibited higher motivation since they stated that they enjoyed learning while doing hands-on activities and using real world context. Developing activities on real life events were time consuming, but it was challenging and enjoyable for students to scan the acidic and basic substances and addressing them. Some students were anxious because of being in charge of the activities and felt anxiety while doing the activities at the beginning of the implementation since the activities were inquiry based and the questions were conceptual and asked for explanations. However, meanwhile the students got used to doing the activities and their role, and felt more relaxed and comfortable through the implementation. In addition, the teacher was very helpful and encouraging during the implementation. The students' anxiety at the beginning of the implementation may be because of not being experienced of doing any activities in chemistry laboratory or they were usually told what and how to do not only in high school but also in elementary school and they felt inconvenience, which was expected. The interviewed students also indicated that the implementation was enjoyable and effective since they learned by doing and related the concepts to their everyday life, which made the concepts more relevant and interesting for them. Furthermore, the post-interviews revealed that the students were satisfied with the implementation of 5E model of instruction and stated that while answering questions related to acids and bases concepts remembering the activities helped them to answer the questions. In addition, the students in their post-interviews showed enthusiasm in doing hands-on activities for the following unit. The activities conducted by the students motivated them to explore and explain real world events related with acidic and basic concepts; during the interviews the students stated that they started to be curious about the acidity of basicity of many substances in their houses. When students conduct an activity and perform the task correctly, they really understand the concepts and are not just memorizing the facts or using memorized algorithms though they struggled with the activities. It was also illustrated from the students' post-interviews that working in groups (Brunning, Schraw, and Ronning, 1999) supported the students affectively and conceptually by scaffolding as described by Pintrich, Marx, and Boyle (1993). According to Bandura (1986), the development of self-efficacy beliefs directly affects achievement. Being successful and efficient in the activities had an efficient impact on the students' self-efficacy beliefs; the increased post-CMQ scores for the experimental group students were also evident for this finding. Ames and Archer (1988) stated that students' goals were related to characteristics of the learning environment. The students in the experimental group conducted activities which were meaningful, challenging and have apparent relevance to their lives, which made significant effect on student goals. In addition, Anderman and Young (1994) reported that learning goals affects meaningful cognitive engagement; the current study's findings revealed a significant difference on the student relevance of learning chemistry to personal goals regardless gender. Pintrich and Schunk (2002) explained that motivation is a process involving goals in requirement of physical and mental activities; during the development of the implementation these effects were taken into consideration. The students in the experimental group comprehend that they need to learn chemistry not only the school exams or the University Entrance Examination, but they also learn chemistry for their daily life since they got aware of the need of chemistry in their real life such as when they have a stomach sour, they should take something basic like baking soda and felt the joy of explaining the real life events. Therefore, this study suggests 5E model of instruction can be used to increase student motivation to learn. This method of using 5E model of instruction is also answering Koballa's (1992) request to using planned efforts in improving high school students' motivation to learn chemistry. Accordingly, since the conducted instructional activities enhance the students to explicit their ideas and involved them to learning process, the students became aware of their own learning, used their learning in daily context, and made interpretations from daily events. Encouraging the students to express their ideas in group or class discussion improved their confidence and involving into the learning process motivated students to learn chemistry.

Brophy (1998) emphasized that student willingness to learn is based on their expectancy and values. One of the activities implemented in the current study was investigating student expectations about the chemistry course aiming to understand their interests and values, and provide their expectations about the course. During the present study, it was though strategically about how each activity would effect on student motivation to learn; therefore, the teacher made emphasize to students why they need to learn chemistry and concepts related to acids and bases since students are more motivated to learn when they find something worthwhile to learn. Furthermore, students are more motivated to learn scientific concepts when the concepts include familiar situations to them, which also promote their interest in chemistry learning. The findings of this study also support the previous researches on student motivation (Ben Ari, 2003; Brophy, 1998; Fosnot, 1996; Marzano, 2001; Pintrich & Schunk, 1996). Furthermore, the students conducted activities on their own or in groups in the current study promoting to use higher-order thinking skills which focused the improvement in motivation to learn.

The traditional group students were less successful and less motivated to learn chemistry may be due to the fact that the traditional teacher-centered instruction did not provide learning environment to counteract the students' alternative conceptions to facilitate conceptual change and the students had difficulties in relating the conceptual concepts to their real world and had questions on why they need to learn chemistry. Conversely, the experimental group students exhibited higher motivation since they enjoyed learning concepts and had realized that the chemistry concepts were not only needed for the examinations, but also the facts they learned in school was also useful for their daily lives. Students usually seek the reason of why they learn chemistry concepts apart from examinations and whether scientific concept would be useful for them in their daily lives. In this study, the experimental group students conducted activities embedded with real world context and they realized that chemistry and science gave explanations for real world events corresponding also to the engagement phase of the learning cycle, which increased student motivation for learning chemistry. On the other hand, the students in the experimental group in the current study spontaneously wrote about what they had learnt about the acids and bases concepts two times on their own throughout the implementation; therefore, they evaluated their learning though it was planned to be each week such as a learning diary in order to take their reflections on their learning on acids and bases concepts and bring to their mind their learning to promote meaningful chemistry learning supporting the evaluation stage of 5E learning cycle. Throughout the learning cycle process, teachers have opportunities to evaluate students anytime formally or informally; however, in the teacher-centered methods teachers usually evaluate students at the end of the unit, which is disadvantage considering meaningful student learning. In the present study (considering post-CMQ scores), the students in the experimental group revealed more motivation on personal relevance of learning science after the implementation as supporting studies such as Ben Ari (2003), which found that as students having more mastery goal structure have more motivational beliefs. The students in the traditional group did not reveal much illumination of why they need to learn chemistry or how chemistry learning would be helpful in future to them; consequently, the teacher-centered instruction did not create much difference in student motivation to learn chemistry.

In terms of gender differences, there have been inconsistent results in gender literature regarding cognitively and affectively; the studies, which found significant gender differences, reported that boys performed better than girls in science courses, particularly in physical science (Brynes, 1996; Lee & Burkam, 1996; Linn & Hyde, 1989; Steinkamp & Maehr, 1984); however, there are also studies which reported that the gender differences are in favor of girls (Anderman & Young, 1994; Britner, 2008; Britner & Pajares, 2006). Walding, Fogliani, Over & Bain (1994) made a research on how high school students gave response to chemistry question and they found that in some question, especially in computational ones, boys gave more correct answers. When motivation to learn science is taken into account, some studies also reported gender differences favoring boys (Meece, Glienke, & Burg, 2006) and particularly, in favor of boys in physical sciences and in favor of girls in biological science and chemistry (Steinkamp & Maehr, 1984). Taken together, the research on gender differences issues in science education reveals no clear pattern in student motivation to learn; therefore, these contradictory gender differences findings in motivation need further examination. Findings from the present study illustrate that girls and boys did not differ in terms of conceptual understanding of acids and bases concepts and motivation to learn chemistry similar to the studies of Anderman & Young (1994), Bektas (2011), Ceylan (2008), DeBacker and Nelson (2001), Eccles et al. (1993), Pajares (1996) which found no gender differences. The results related to gender imply that the 5E model of instruction had no bias on gender; in other words, had equal effect on girls and boys' conceptual understanding of acids and bases concepts and motivation to learn chemistry. This study is also evidence for improving student motivation to learn and developing students' conceptual understanding regardless gender as Wigfield (1994) reported.

The current study on acids and bases concepts has also limitations. One of which was the experimental group students took the instruction in chemistry laboratory and the traditional group students took in their traditional classroom environment. The experimental group students conducted activities and these activities required everyday materials as well as chemical ones; therefore, a chemistry laboratory was more convenient for the students and the teacher to implement the acids and bases concepts. In addition, the students in the experimental group conducted an activity based on what they have learned about acids and bases; this activity was considered to be done each week to monitor student learning on acids and bases concepts however because of the lack of time the activity was done less than planned. It had been better to conduct this activity at the end of the week or at the end of the each concept learning to monitor student learning on every concepts; therefore, this is also a limitation of this current study. The other limitation was that the experimental group students studies on more real life context because of the nature of the study; however, after the implementation and the post-tests all materials distributed to the experimental groups students were also given to the traditional group students.

The medium effect size was set at the beginning of the study and based on the data analyses a large effect size was found as the observed effect size. This implies that the present study both had practical and statistical significance in terms of conceptual understanding and student motivation to learn. Furthermore, the observed power was found to 1.000 for the conceptual test and 0.960 for the motivation questionnaire, which were both higher than the calculated power.

5.2 External Validity

The findings of the study indicated that there were significant differences on overall the effect of teaching methods taking into account 5E learning cycle model oriented teaching and traditionally designed chemistry teaching on the population mean of the collective dependent variables of eleventh grade students' post-test scores of acids and bases concepts and motivation to learn chemistry in favor of 5E model of instruction. The number of students participated in the study (n=78) exceeds the 10% of the accessible population. Therefore, the findings of this present study can be generalized to the accessible population of the study.

5.3 Implications

In terms of practical applications, the present findings have clear implications for chemistry teaching and learning. The suggestions of the present study are as the following:

- Constructivist teaching strategies (such as 5E model of instruction, inquiry based activities) should be used in order to develop students' conceptual understanding of acids and bases concepts.
- Constructivist teaching strategies (such as 5E model of instruction, inquiry based activities) should be used in order to increase student motivation to learn chemistry.
- Student-centered activities should be used to increase students' behavioral skills to use equipments in a chemistry laboratory for testing scientific concepts.
- Students' pre-conceptions should be taken into account before the instruction.
- Students have difficulties in understanding various acids and bases definitions, teachers should emphasize the differences of the various definitions and discuss the strength and limitations of each definition.
- Students have difficulties in understanding the particulate nature of matter and consequently have difficulties in understanding in acids and bases concepts, teachers should make emphasis on the representations of acidic and basic solutions, specifically during instruction of strength concept.
- Real world context should be used in instruction to facilitate deep approaches to learning.
- The instructions enriched with real world context improve students' curiosity which in turn increases student motivation to learn chemistry.
- Three-tier test should be used to assess students' conceptual understanding and can also be generalized across the country.
- An importance should be given in the representation of particle level of the substances for understanding of acids and bases concepts.

- Teachers may hold alternative conceptions and their view can narrow students' view as well; teachers should given importance to their own development.
- Teacher-student interaction is essential on student motivation to learn, teachers should take into consideration students' feelings, values, experiences, and their needs.

5.4 Recommendations for Further Researches

The following recommendations can be stated from the result of the present study:

- The effectiveness of constructivist teaching strategies can also be tested with different chemistry topics
- Beforehand the main instruction, prior units should also be implemented with the focused instruction in order to eliminate the novelty effect
- Smaller groups should be constructed during the implementation
- Retention test should be given to test durability of the concepts; in the present study no retention test was distributed because of lack of time
- Longitudinal studies should be conducted in order to observe the effect of constructivist teaching strategies on student motivation to learn
- In order increase the generalization of the current study, the study should be replicated in various school types, grade levels and environmental conditions
- Teacher motivation to teach should be investigated and the studies related to increase their motivation should be conducted

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APPENDIX A

INSTRUCTIONAL OBJECTIVES

Students will able to

1. to define acids and bases according to Arrhenius Acid-Base Theory.
2. to define acids and bases according to Bronsted-Lowry Acid-Base Theory.
3. to define acids and bases according to Lewis Acid-Base Theory.
4. to compare the Arrhenius, Bronsted-Lowry, and Lewis definitions of acids and bases
5. to recognize acids and bases from names and formulas.
6. to explain the properties of acids and bases.
7. to distinguish the properties of acids and bases.
8. to describe the similarities and differences in physical and chemical properties of acids and bases
9. to give examples for acidic and basic substances in everyday life.
10. to define pH and pOH terms.
11. to describe the pH scale.
12. to state the relation between acids and bases.
13. to distinguish acids and bases according to pH values.
14. to explain that solutions with a pH less than 7 are acids and a solution with a pH more than 7 are bases.
15. to explain the relationship between pH and pOH.
16. to explain that a solution with pH=7 is a neutral solution at the particle level.
17. to define an indicator.
18. to clarify the importance of indicators.
19. to identify indicators from everyday life such as tea, red cabbage, red onion, etc.
20. to read the color of litmus, red cabbage, and universal pH papers in acidic and basic solutions.
21. to apply acids change blue litmus paper to pink and bases change pink litmus paper to blue.

22. to apply red cabbage juice turns into reddish color in acidic solution and greenish color in basic solution.
23. to solve problems related to acid-base reactions.
24. to explain the strength concept of acids and bases.
25. to describe the dissolution of strong acids and bases in water at the particle level
26. to clarify the strength of acid solutions increases with the amount of H_3O^+ ions in the solutions.
27. to clarify the strength of base solutions increases with the amount of OH^- ions in the solutions.
28. to give examples for strong acids and bases.
29. to describe the dissolution of weak acids and bases in water at the particle level
30. to distinguish concentration and strength concepts for acids and bases.
31. to describe what concentrated and diluted acids are in the particle level.
32. to define neutralization reactions.
33. to show how to write equations for neutralization reactions.
34. to describe neutralization reactions at the particle level.
35. to describe an acid-base titration.
36. to explain how indicators are used in titrations and how they are chosen.
37. to explain the purpose and the process of an acid-base titration.

APPENDIX B

THE DEVELOPMENT OF THREE-TIER ACIDS AND BASES TEST

B-1. INTERVIEW QUESTIONS FOR THE DEVELOPMENT OF THREE-TIER ACIDS AND BASES TEST

ASİTLER VE BAZLAR - MÜLAKAT SORULARI

1. Hiç asidik bir madde ile temasın oldu mu?
   1.1. Asit denince aklına ne geliyor?
   1.2. Asidik maddeler tehlikeli midir? Günlük hayatta asidik maddelerle karsılaşıyor muyuz?

2. Hiç bazik bir madde ile temasın oldu mu?
   2.1. Baz denince aklına ne geliyor?
   2.2. Bazik maddeler tehlikeli midir? Günlük hayatta bazik maddelerle karsılaşıyor muyuz?

3. Görüşü çok kuvvetli bir aletin olsaydı ve bu aletle maddeleri tanecik boyutunda görebilseydin, asidik ve bazik çözeltilere bu aletle baktığında ne görürdün? Asidik ve bazik çözeltiler arasında nasıl bir fark gözlemlerdin?
   3.1. Neden bir maddeye asit derken diğer bir maddeye baz diyoruz?
   3.2. Bir maddeyi asit yapan özellikler nelerdir?
   3.3. Bir maddeyi baz yapan özellikler nelerdir?

4. Kimya laboratuarında öğretmenin sana bir çözelti verdiğini düşün ve senden bu çözeltinin asidik mi bazik mi olduğunu tespit etmeni istese, asidik mi bazik mi olduğuna nasıl karar verirsin?
   4.1. İndikatör veya turnusol kağıdı kullanarak bir maddenin asit veya baz olduğunu nasıl tespit ederiz?
   4.2. İndikatörler asitlerin veya bazların kuvvetliliği hakkında bilgi verirler mi?
   4.3. Bildiğin indikatörler var mı? Günlük hayatta hiç indikatörlerle karsılaşıyor muyuz?

5. Aşağıda verilen asitleri kuvvetliliklerine göre sıralayınız.
   a) 0.1 M HCl   b) 0.01 M HCl   c) 0.001 M HCl

5.1. Bir asidin veya bazın kuvvetli olması ne demektir?

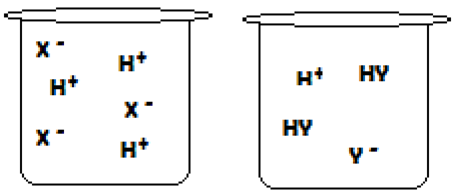
5.2. Kuvvetli bir asit demek aynı zamanda derişik bir asit mi demektir?

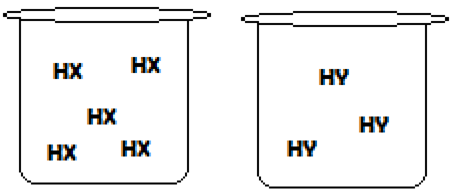
6. Görüşü çok kuvvetli bir aletin olsaydı ve bu aletle maddeleri tanecik boyutunda görebilseydin, aşağıda verilen HCl ve HCN çözeltilerini bu aletle nasıl görürdün?

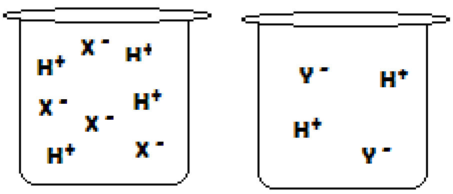
6.1. Zayıf asit veya zayıf baz denince ne anlıyorsun?

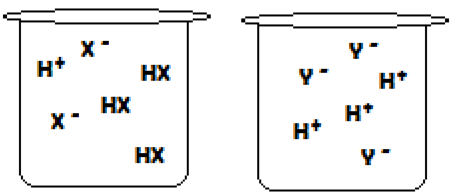
6.2. Zayıf bir baz ile kuvvetli bir baz arasındaki farklılıkları nasıl tanımlarsın?

7. Aşağıda verilen kuvvetli ve zayıf asit içeren beher çiftlerinden hangisi eşit derişimli çözeltilerdir? (HX ve HY asidik çözeltileri temsil etmektedir)

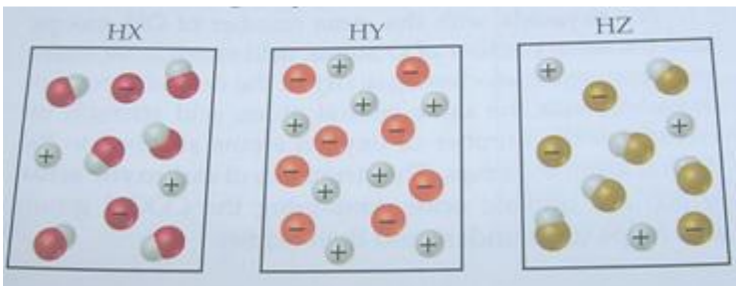
a) 

b) 

c) 

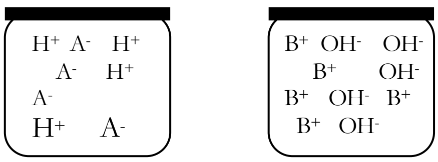
d) 

8. Aşağıdaki asidik çözeltilerden hangisi en yüksek pH değerine sahiptir? (Tüm çözeltiler aynı hacme sahiptirler ve HX, HY ve HZ asidik çözeltiyi temsil etmektedir)

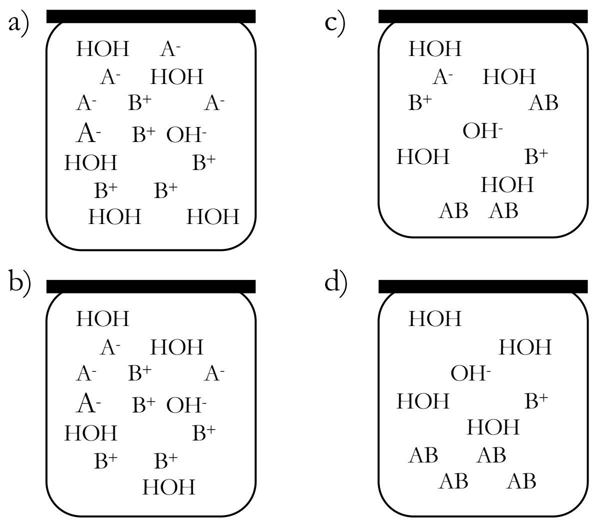


8.1. pH dediğimiz kavram nedir?
8.2. Sadece asidik çözeltilerin mi pH değerleri vardır?
8.3. Yukarıdaki üç asitten hangisi en kuvvetlidir?
8.4. Bir asidin veya bazın kuvvetliliğiyle pH arasında ilişki var mıdır?
8.5. pOH dediğimiz kavram nedir?
8.6. pH ile pOH arasında bir ilişki var mıdır?
8.7. pH veya pOH kavramlarını neden kullanıyoruz?

9. Elinde, aşağıda verilen gibi hacimleri eşit iki beherin olsa ve verilen bu beherler başka daha büyük bir beherde karıştırılsa sonuç olarak ne olmasını beklersin? (HA asidik çözeltiyi ve BOH da bazik çözeltiyi temsil ediyor).



Öğrenci çizim olarak bir şey çizemezse, aşağıda karışımı temsil eden şekiller gösterilerek öğrencinin şekillerden birisini seçmesi istenir:



9.1. Bir asit ve bir baz reaksiyona girdiğinde ne gözlemlemeyi beklersin?
9.2. Asitlerin bazlarla olan reaksiyonu sonucunda oluşan ürünler nelerdir?
9.3. Oluşan tuzun pH değeri nedir? (ya da nötrleşme tepkimesi sonucunda ortamın pH değeri nedir?)

10. Elinde derişimini bilmediğin bir asit çözeltisi var ve senin bu çözeltinin derişimini bulman gerekiyor. Bunun için sana aşağıdaki malzemeler veriliyor:

- fenolftalein indikatörü
- 0.1 M sodyum hidroksit çözeltisi

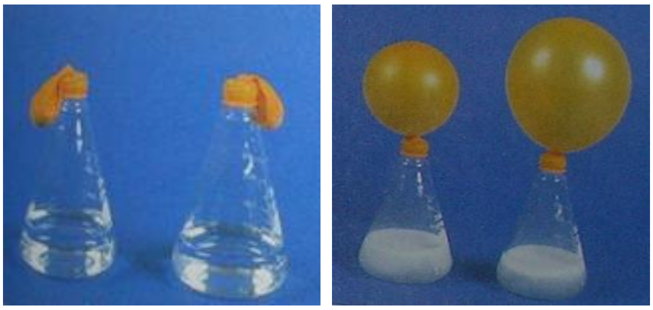
- pH kağıdı
- bir adet pil
- birkaç beher, erlen, dereceli silindir
- kati sodyum hidroksit NaOH
- kırmızı ve mavi turnusol kağıdı
- 2 adet büret
- bir termometre

Bu bilinmeyen asit çözeltisinin derişimini rapor etmen isteniyor. Verilen malzemelerden faydalanarak derişimi bilinmeyen asit çözeltisinin derişimini nasıl tepsi edersin? Bu işlemi nasıl yapacağını detaylı bir şekilde açıklar mısın? (Verilen bütün malzemelere ihtiyaç duymayabilirsin, deney düzeneğini resmederek de açıklayabilirsin).

10.1. Titrasyonlarda reaksiyonun olması için indikatör gerekli midir değil midir?

10.2. Titrasyonlarda indikatörü ne için kullanırız?

10. Aşağıdaki birinci şekilde 1M H CH_3COOH ve 1M HCl içeren eşit hacimli iki erlen görülmektedir. Iki balonda da aynı miktarda magnezyum metali bulunmaktadır. İkinci şekilde ise, magnezyum metali erlenlerin içine düşürüldüğünde balonların şiştiği görülmektedir. Bu olayı açıklayabilir misin?



11.1. Neden balonlarda şişkinlik görüldü? Nasıl bir reaksiyon oluşmuş olabilir?

11.2. Bir balonun daha şişkin diğerinin daha az şişkin olmasının nedeni sizce ne olabilir?

B-2. OPEN-ENDED QUESTIONS FOR THE DEVELOPMENT OF THREE-TIER ACIDS AND BASES TEST

ASİTLER VE BAZLAR – AÇIK UÇLU SORULAR

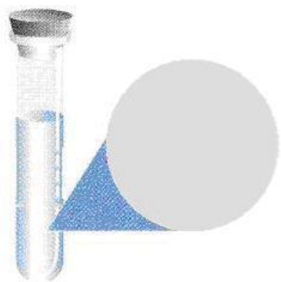
1.Asit ve baz denince aklınıza gelenleri aşağıda verilen tabloya yazınız (Asitlerin ve bazların yapısını, günlük hayatımızda karşılaşıyor muyuz, hangi maddelerde bulunabilirler, metallerle veya ametallerle reaksiyonlarını, tadını, elektrik iletkenliğini, pH değerlerini, turnusol kağıdının rengini değiştirirler mi gibi özellikleri düşünebilirsiniz. Aklınıza gelen herhangi başka özellikleri de belirtebilirsiniz).

Asit denince....	**Baz denince...**

2.Aşağıda tabloda verilen maddelerin asit mi baz mı olduğuna karar vererek nedenini açıklayınız.

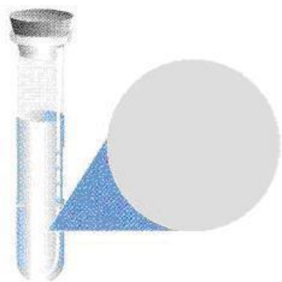
Madde	Asit? Baz?	Neden?
$Ca(OH)_2$		
CH_3NH_2		
H_2SO_4		
BF_3		
CO_2		
CH_3COOH		

3.Hayali bir mikroskobunun olduğunu düşün ve bu mikroskobun görüşü çok kuvvetli olduğundan maddeleri tanecik boyutunda görebiliyorsun. Bu mikroskopla maddeleri tanecik boyutunda görebildiğine göre zayıf bir asit olan HF çözeltisine ve kuvvetli bir asit olan HCl çözeltisine baktığında bu çözeltiler arasında nasıl farklılıklar görürdün? Her iki çözeltiyi aşağıda verilen alanlara çizerek ve zayıf asit-kuvvetli asit arasındaki farklılıkları açıklayınız (Çözeltilere baktığınızda su moleküllerini de göreceğinizi hatırlayınız ve çiziminizde su moleküllerini de dikkate alınız).



$HF_{(suda)}$ çözeltisi

Çiziminizi açıklayınız:



$HCl_{(suda)}$ çözeltisi

Çiziminizi açıklayınız:

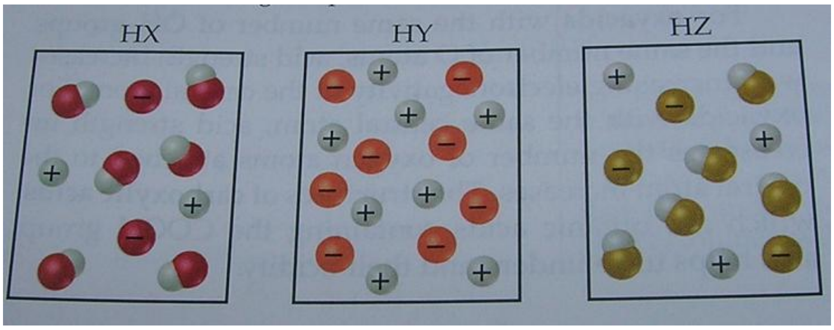
4.Aşağıda verilen bazik çözeltileri **kuvvetliliklerine** göre sıralayınız. Sıralama nedeninizi açıklayınız.

I. 0.1 M NaOH
II. 0.01 M NaOH
III. 0.001 M NaOH

a) Zayıf bir asit olan HF ve kuvvetli bir asit olan HCl maddelerinden **eşit hacim** ve **eşit derişimli** çözeltiler oluşturuluyor. Bu iki çözelti için hangi özellikler aynı olur (pH değerleri, iyonlaşma yüzdesi, H^+ iyonu molar derişimi, elektrik iletkenliği, nötrleştirmek için gerekli OH^- iyonu miktarı, metallerle açığa çıkardıkları gaz miktarı gibi özellikleri düşünebilirsiniz. Eşit olduğunu düşündüğünüz başka özellikler de olabilir, onları da belirtiniz)?

5.pH denince ne anlıyorsun? Asidik ve bazik çözeltileri düşündüğünde hangi çözeltilerin pH değeri vardır? Açıklayınız.

a) Aşağıdaki asidik çözeltilerden hangisi **en yüksek pH** değerine sahiptir (Tüm çözeltiler aynı hacme sahiptirler ve HX, HY ve HZ asidik çözeltiyi temsil etmektedir)? Nedenini açıklayınız.



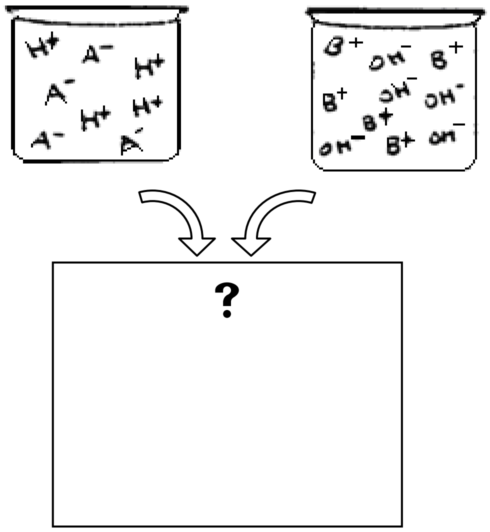
b) HX, HY ve HZ çözeltilerinin pOH değerleri var mıdır? Nedeninizi açıklayınız.

c) HX, HY ve HZ çözeltilerinden hangisi kuvvetli asit çözeltisi, hangisi zayıf asit çözeltisi olabilir? Yorumunuz nedir? Nedeninizi belirtiniz ve kuvvetli- zayıf asitlik durumuna nasıl karar verirsiniz açıklayınız.

Çözelti	**Kuvvetli asit? Zayıf asit?**	**Neden?**
HX		
HY		
HZ		

d) Kimya öğretmeninizin elinde farklı iki kapta eşit hacimlerde üzerinde etiketi olmayan iki çözelti bulunmaktadır. Öğretmeniniz bu çözeltilerden birinin **zayıf bir asit** olan HF çözeltisi, diğerinin de **kuvvetli bir asit** olan HCl çözeltisi olduğunu belirtiyor ve sizden hangisinin kuvvetli asit çözeltisi olduğunu belirlemek için ona soru sormanızı istiyor.
Bu amaçla öğretmeninize hangi soruları sormalısınız ki elde ettiğiniz bilgi sonucunda hangi çözeltinin kuvvetli asit çözeltisi hangisinin zayıf asit çözeltisi olduğunu anlayabilesiniz? Soruları sorma amacınızı açıklayınız. Elde ettiğiniz bilgi ile kuvvetli veya zayıf asidi nasıl tespit edersiniz belirtiniz?

6.Aşağıda olduğu gibi **asidik** ve **bazik** çözelti içeren iki ayrı kabın olduğunu düşün. Eğer bu kaplar başka bir kapta karıştırılırsa ne olmasını beklersiniz? Son durumda elde edeceğimiz kabı ve içinde bulunanları <u>çizerek</u> açıklayınız (HA asidik çözeltiyi ve BOH da bazik çözeltiyi temsil ediyor).
Ortamın pH değeri ile ilgili yorum yapınız ve oluşan tepkimeyi yazarak açıklayınız.

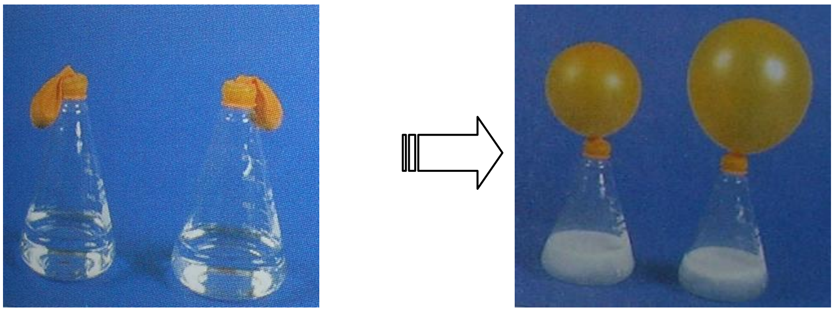


7.Öğretmeninizin elinde üzerinde etiketi olmayan bilinmeyen bir çözelti bulunmaktadır. Öğretmeninizin öncelikle bu çözeltinin asidik bir çözelti mi yoksa bazik bir çözelti mi onu belirlemesi gerekiyor. Daha sonra da bu çözeltinin derişimini tayin etmesi gerekiyor.

Siz öğretmeninizin yerinde olsanız bilinmeyen bu çözeltinin **<u>asitlik veya bazlığını</u>** ve daha sonra da **<u>derişimini</u>** tayin etmek için nasıl bir yol izlerdiniz? Tespit için ne tür maddelere veya malzemelere ihtiyacınız olur belirtiniz. Nedenleriyle açıklayınız.

Asitlik-Bazlık Tespiti	Derişim Tespiti

8. Aşağıda verilen resimlerden birinci resimde, içerisinde **aynı hacimde** ve **derişimde** X ve Y çözeltileri olan iki erlen görülmektedir. Her balonda da **aynı miktarda magnezyum metali** bulunmaktadır. İkinci şekilde ise, magnezyum metali erlenlerin içine düşürüldüğünde iki balonunun da şiştiği fakat balonlardan birinin diğerine göre biraz daha fazla şiştiği gözlenmiştir.
Balonlardaki şişkinlik farklılığı neden kaynaklanmış olabilir? Nedenlerinizi açıklayınız.



B-3. ÜÇ AŞAMALI ASITLER VE BAZLAR TESTI

ASITLER VE BAZLAR

Üç aşamalı test

Okul	:		
Ad Soyadı	:		
Sınıf	:		
Şube	:		
Cinsiyet	: ☐ Bayan	☐ Bay	
1. dönem kimya dersi karne notu	:		

Yönerge:

1. Sınava başlamadan önce yukarıda verilen kısmı doldurunuz.
2. "Asitler ve Bazlar" ile ilgili 18 tane üç aşamalı çoktan seçmeli soru bulunmaktadır.
3. Üç aşamalı çoktan seçmeli sorularda, ilk aşamada sorunun cevabı, ikinci aşamada o soruya verdiğiniz cevabın sebebi ve üçüncü aşamada ise verdiğiniz bu cevaplardan ne kadar emin olduğunuz ile ilgili işaretlemeniz gereken seçenekler bulunmaktadır.
4. İkinci aşamada verilen sebeplerden biri sizin fikrinizi yansıtmıyorsa boş bırakılan seçeneğe kendi cevabınızı belirtiniz.
5. Lütfen soruları dikkatle okuyunuz ve bütün sorulara cevap veriniz.

Başarılar!

Prof. Dr. Ömer GEBAN Aras. Gör. Ayla CETIN-DINDAR

ÜÇ AŞAMALI TEST

1.1 Aşağıdaki tepkimede verilenlerden hangisi Bronsted-Lowry asit-baz tanımına uyan bir baz gibi davranmıştır?

$$HCOOH + CN^{-} \leftrightarrow HCOO^{-} + HCN$$

(a) HCOOH
(b) CN^{-}

1.2 Yukarıda verdiğim cevabın sebebi;
(a) Proton (H^{+}) alan maddeler baziktir.
(b) Proton (H^{+}) veren maddeler baziktir.
(c) Yapısında OH içeren maddeler baziktir.
(d) Yapısında H içermeyen maddeler baziktir.
(e) ……………………………………………………………………………………………

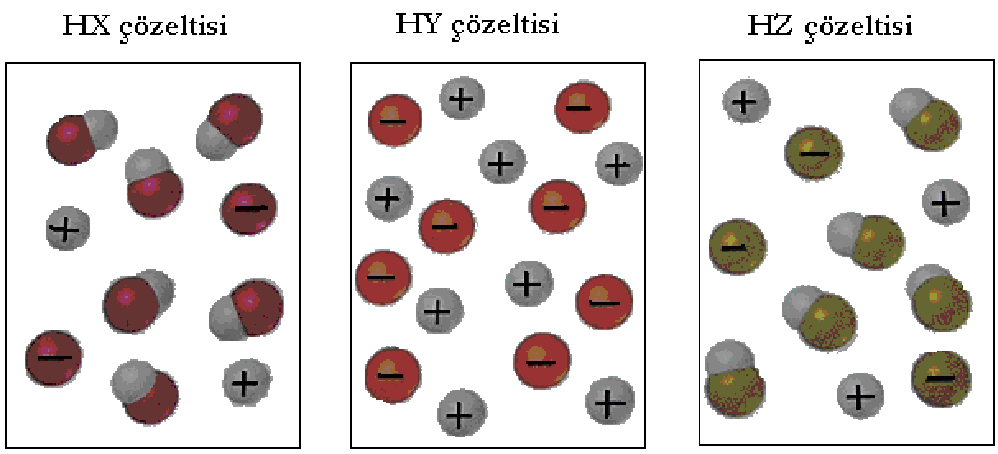
1.3 Yukarıdaki iki soruya verdiğim cevaptan;
(a) Eminim.
(b) Emin değilim.

2.1 Aşağıda verilen bazik çözeltileri kuvvetliliklerine göre sıralayınız.
I. 0.1 M NaOH
II. 0.01 M NaOH
III. 0.001 M NaOH
(a) I>II>III
(b) I=II=III
(c) III>II>I

2.2 Yukarıda verdiğim cevabın sebebi;
(a) Çözeltinin derişimi arttıkça bazlık değeri azalır.
(b) Çözeltinin pH değeri arttıkça bazlık değeri artar.
(c) Çözeltideki mol sayısı arttıkça bazlık değeri artar.
(d) Çözeltide iyonlaşan moleküllerin yüzdesi aynı olduğu için bazlık değeri aynıdır.
(e) Derişim ve kuvvetlilik aynı kavramlar olduğu için derişim arttıkça bazlık değeri artar.
(f) ……………………………………………………………………………………………

2.3 Yukarıdaki iki soruya verdiğim cevaptan;
(a) Eminim.
(b) Emin değilim.

3.1 Görüşü çok kuvvetli bir mikroskopla maddeleri tanecik boyutunda görebileceğinizi hayal edin ve üç tane farklı HX, HY ve HZ çözeltilerine bu mikroskopla baktığınızı düşünün. İyonlaşma yüzdeleri farklı olan bu çözeltileri aşağıda gösterildiği gibi görüyorsunuz. Sizce, bu asidik çözeltilerden hangisi **en yüksek pH değerine** sahiptir? *(* *ile gösterilen* H_3O^+ *ve*  *ile gösterilen* X^-, Y^- *veya* Z^- *iyonlarını,*  *veya*  *ile gösterilen HX veya HZ asitlerinin iyonlaşmamış molekülerini temsil etmektedir. Gösterimlerde şekillerin basitliği açısından su molekülleri ihmal edilmiştir.)*



(a) HX   **(b)** HY   **(c)** HZ

3.2 Yukarıda verdiğim cevabın sebebi;

(a) Zayıf bir asitten oluşan asidik çözeltinin pH değeri daima yüksektir.

(b) Kuvvetli bir asitten oluşan asidik çözeltinin pH değeri daima yüksektir.

(c) Ortamdaki H_3O^+ iyon derişiminin daha az olması pH değerinin daha yüksek olmasını sağlar.

(d) Ortamdaki H_3O^+ iyon derişiminin daha fazla olması pH değerinin daha yüksek olmasını sağlar.

(e) ....

3.3 Yukarıdaki iki soruya verdiğim cevaptan;

(a) Eminim.

(b) Emin değilim.

4.1 Ceyda kimya laboratuarında asitler ve bazlar ünitesi ile ilgili deney yapmaktadır. Normal şartlar altında, eşit hacim ve derişimdeki zayıf bir asit olan hidroflorik asit (HF) çözeltisi ile kuvvetli bir baz olan sodyum hidroksit (NaOH) çözeltisini karıştırırsa, oluşan çözelti nasıl bir özellik gösterir?

(a) Asidik **(b)** Bazik **(c)** Nötr

4.2 Yukarıda verdiğim cevabın sebebi;

(a) Asitlerin bazlarla tepkimesiyle nötrleşme meydana gelir ve tepkime sonucunda her zaman nötr tuz çözeltisi oluşur.
(b) Asitler her zaman bazlardan daha kuvvetli ve tehlikelidir. Dolayısıyla, tepkime sonucunda oluşan çözelti her zaman asidiktir.
(c) Verilen iki çözeltinin derişimleri eşit olduğundan, tepkime sırasında asidik çözeltiden gelen artı yüklü iyonlar (H^+) ile bazik çözeltiden gelen eksi yüklü iyonlar (OH^-) da eşit olacağından net yük sıfır olur ve çözelti nötr olur.
(d) Asitliği temsil eden hidrojen iyonları (H^+) ile bazlığı temsil eden hidroksit iyonları (OH^-) birebir tepkimeye girer ve saf su oluştuğundan çözelti nötr olur.
(e) Tepkime sonucunda sodyum flüorür ve su oluşur. Sodyum flüorürün su ile tepkimesinden sonra, ortamdaki hidroksit iyonları (OH^-) derişimi hidrojen iyonlarının (H^+) derişiminden daha fazla olduğundan çözelti baziktir.
(f) ....

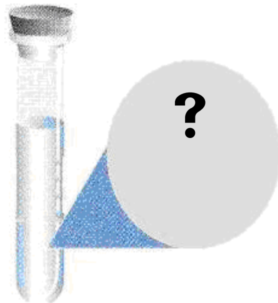
4.3 Yukarıdaki iki soruya verdiğim cevaptan;
(a) Eminim.
(b) Emin değilim.

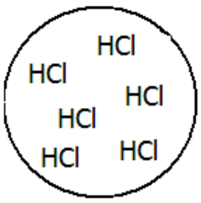
5.1 Aşağıda verilen maddelerin hangisi bazik özellik gösterir?
(a) CH_3COOH **(b)** CH_3NH_2 **(c)** BF_3

5.2 Yukarıda verdiğim cevabın sebebi;
(a) Molekül formülünde OH vardır.
(b) Sulu çözeltilerine OH^- iyonu verir.
(c) Elektron çifti alabilen bir maddedir.
(d) Suda çözündüğünde hidrojen verir.
(e) Suda çözündüğünde H^+ alan maddedir.
(f) Metalik bileşikler bazik özellik gösterir.
(g) ....

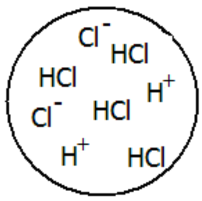
5.3 Yukarıdaki iki soruya verdiğim cevaptan;
(a) Eminim.
(b) Emin değilim.

6.1 Görüşü çok kuvvetli bir mikroskopla maddeleri tanecik boyutunda görebileceğinizi hayal edin ve yandaki şekildeki gibi bir tüpün içerisine baktığınızı düşünün. Bu tüpün içerisinde <u>kuvvetli bir asit</u> olan ve tuz ruhu olarak da bilinen 0.1 M hidroklorik asit (HCl) çözeltisi bulunmaktadır. Bu mikroskobu kullanarak hidroklorik asit çözeltisine baktığında bu çözeltiyi nasıl görürdün? (Ortamdaki su moleküllerini göz ardı ediniz.)

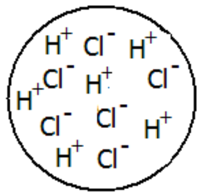




(a)



(b)



(c)

6.2 Yukarıda verdiğim cevabın sebebi;

(a) Kuvvetli bir asit olan HCl çözeltisinde artı ve eksi yükler arasında etkileşim fazladır; dolayısıyla kısmen iyonlaşır.

(b) Kuvvetli bir asit olan HCl çözeltisi sıvı fazında olduğu gibi tamamen moleküler olarak bulunur.

(c) Kuvvetli bir asit olan HCl çözeltisinin tamamına yakını iyonlarına ayrışarak suda artı ve eksi yüklü iyonlar olarak bulunur.

(d) Kuvvetli bir asit olan HCl çözeltisinde moleküler arası çekim kuvvetleri çok güçlü olduğundan suda hiç iyonlaşmazlar.

(e) Kuvvetli bir asit olan HCl çözeltisi kısmen iyonlaşarak artı ve eksi yüklü iyonlar olarak bulunur; moleküllerin iyonlaşması çözeltinin derişimine göre değişir.

(f) ………………………………………………………………………………………

6.3 Yukarıdaki iki soruya verdiğim cevaptan;

(a) Eminim.

(b) Emin değilim.

7.1 Esen kimya dersindeki projesi için araştırma yapmaktadır. Kimya laboratuarında öğretmeninin onun için hazırladığı iki çözeltiyi bulmuştur. Birinin üzerinde 1M CH_3COOH çözeltisi yazmakta, diğerinin üzerinde de 1M KOH çözeltisi yazmaktadır. Aynı hacimlerde olan bu iki çözeltiyi daha büyük bir beherde karıştıran Esen'in elde ettiği son çözelti için aşağıdakilerden hangisi doğrudur?

(a) Çözelti sadece OH^- iyonlarını içerir.

(b) Çözelti OH^- iyonları kadar H_3O^+ iyonlarını içerir.

(c) Çözelti ne H_3O^+ iyonlarını ne de OH^- iyonlarını içerir.

(d) Çözelti H_3O^+ iyonlarına göre OH^- iyonlarını daha çok içerir.

(e) Çözelti OH^- iyonlarına göre H_3O^+ iyonlarını daha çok içerir.

7.2 Yukarıda verdiğim cevabın sebebi;

(a) Çözeltideki (+) ve (-) iyonlar birbirlerini çeker ve çözeltide hiç yüklü iyon bulunmaz.

(b) Kuvvetlilik farkından dolayı H_3O^+ iyonlarını nötrleyecek kadar OH^- iyonu bulunmaz.

(c) Kuvvetlilik farkından dolayı OH^- iyonları ile nötr ortam yaratacak kadar H_3O^+ iyonları bulunmaz.

(d) Molariteleri aynı olduğu için ortamda eşit oranda hem H_3O^+ iyonları hem de OH^- iyonları bulunur.

(e) İki çözelti de bazik çözelti olduğu için ortamda sadece OH^- iyonları bulunur.

(f) ....

7.3 Yukarıdaki iki soruya verdiğim cevaptan;

(a) Eminim.

(b) Emin değilim.

8.1 Kimya öğretmeninizin elinde iki adet beher ve beherlerin içerisinde hacimleri eşit olan iki çözelti bulunmaktadır. Öğretmeniniz bu çözeltilerden birinin zayıf bir asit olan X çözeltisi, diğerinin de kuvvetli bir asit olan Y çözeltisi olduğunu belirtiyor. Hangi beherin kuvvetli asit çözeltisini içerdiğini belirleyebilmeniz için öğretmeninizin hangi bilgiyi tek başına vermesi sizin için yeterli olacaktır?

(a) Çözeltilerin derişimleri

(b) Çözeltilerin pH değerleri

(c) Yapısındaki hidrojen sayısı

(d) Çözünenin iyonlaşma yüzdeleri

(e) Turnusol kağıdının rengini değiştirme hızı

8.2 Yukarıda verdiğim cevabın sebebi;

(a) Çözeltideki iyon sayısı arttıkça kuvveti de artar.

(b) Asidin iyonlaşma yüzdesi arttıkça kuvveti de artar.

(c) Çözeltideki asidin derişimi arttıkça kuvveti de artar.

(d) Çözeltinin pH değeri arttıkça asitliğin kuvveti azalır.

(e) Kuvvetli asitler turnusol kağıdının rengini daha hızlı değiştirirler.

(f) Bir asidin yapısındaki hidrojen sayısı arttıkça asitlik kuvveti de artar.

(g) ………………………………………………………………………………..

8.3 Yukarıdaki iki soruya verdiğim cevaptan;

(a) Eminim.

(b) Emin değilim.

9.1 Ömer okulda "Asitler ve Bazlar" ünitesini görmekte ve öğretmeninin verdiği alıştırma sorularını çözmektedir. Sorulardan birisi şöyledir:

"Sulu bir çözeltinin $[OH^-]$ iyonu derişimi 1.10^{-12}'dir. Çözeltinin pH değeri nedir?"

Sizce, Ömer çözeltinin pH değerini kaç hesaplamıştır?

(a) pH=2 **(b)** pH = 12 **(c)** Yorum yapılamaz

9.2 Yukarıda verdiğim cevabın sebebi;

(a) Çözeltinin pH değerini hesaplamak için verilen OH^- iyon derişiminin eksi logaritması alınır.

(b) Suyun otoiyonizasyonu dikkate alınarak H_3O^+ iyon derişimi bulunur ve bulunan iyon derişiminin eksi logaritması alınarak pH değeri hesaplanır.

(c) Sulu çözeltide OH^- iyonları verildiği için pH değerinden söz edilemez; çünkü pH değeri H_3O^+ iyon derişimi ile hesaplandığından sadece asitler için geçerlidir.

(d) ………………………………………………………………………………………………………

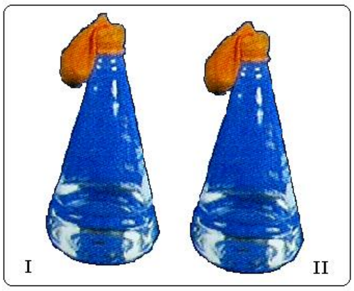
9.3 Yukarıdaki iki soruya verdiğim cevaptan;

(a) Eminim.

(b) Emin değilim.

10.1 Yanda verilen resim içerisinde **aynı hacimde ve derişimde** iki çözelti bulunmaktadır.

- I numaralı erlende sirkede bulunan ve *zayıf bir asit* olan asetik asit çözeltisi
- II numaralı erlende ise mide özsuyunda bulunan ve *kuvvetli bir asit* olan hidroklorik asit çözeltisi vardır.



Her balonun içinde de **aynı** miktarda magnezyum metali bulunmaktadır. Aynı anda balonlarda bulunan magnezyum metali çözelti içerisine atılırsa aynı süre zarfında aşağıdakilerden hangisi gözlemlenir?

(a) İki balonda da aynı miktarda şişme gözlemlenir.

(b) Balonlarda herhangi bir değişiklik gözlemlenmez.

(c) Sadece hidroklorik asit bulunan erlende (II) şişkinlik gözlemlenir.

(d) Hidroklorik asit bulunan erlende (II) daha fazla şişkinlik gözlemlenir.

10.2 Yukarıda verdiğim cevabın sebebi;

(a) Metaller asitlerin içerisinde erirler ve gaz çıkışı olmaz.

(b) İki çözelti de aynı derişimde olduğu için, tepkime sonucu aynı miktarda gaz çıkışı olur.

(c) Kuvvetli asidin magnezyum metali ile tepkimesinde zayıf aside göre daha fazla baloncuk çıkar; bu yüzden hidroklorik asidin olduğu balonda daha fazla şişme gözlenir.

(d) Metaller sadece kuvvetli asitlerle tepkimeye girdiklerinden sadece hidroklorik asidin olduğu balonda şişme gözlenir.

(e) Kuvvetli asit çözeltisi magnezyum metalini daha hızlı aşındıracağından hidroklorik asidin olduğu balonda daha fazla şişme gözlenir.

(f) Kuvvetli asit çözeltisinde magnezyum metali ile tepkimeye girecek daha çok iyon bulunduğundan gaz çıkışı hidroklorik asit çözeltisinde daha fazla olur.

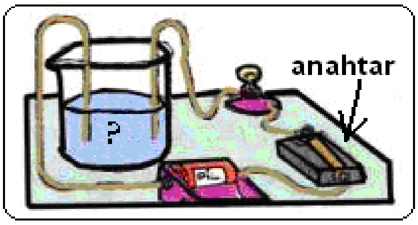
(h) ……………………………………………………………………………………..

10.3 Yukarıdaki iki soruya verdiğim cevaptan;

(a) Eminim.

(b) Emin değilim.

11.1 Ahmet çözeltilerin elektrik akımını iletmeleriyle ilgili bir araştırma yapmaktadır. Farklı çözeltiler kullanarak hangi tür çözeltilerin elektriği daha iyi ilettiği ile ilgili yanda gösterildiği gibi bir deney düzeneği hazırlamıştır. Behere farklı çözeltiler koyarak devredeki anahtara bastığında ampulün parlaklık şiddetine göre araştırma sonuçlarını yazacaktır. Ahmet'in elinde aşağıda verilen çözeltiler bulunmaktadır; bu çözeltilerden hangisi elektrik akımını daha iyi ileterek ampulün daha parlak olmasına sebep olur?



(a) 100 ml 1 M HCl çözeltisi

(b) 100 ml 1 M H_2S çözeltisi

(c) 100 ml 1 M NH_3 çözeltisi

(d) 100 ml 1 M CH_3COOH çözeltisi

(e) Hepsi

11.2 Yukarıda verdiğim cevabın sebebi;

(a) Sadece bazik çözeltiler elektrik akımını iyi iletirler.

(b) Sadece kuvvetli asidik çözeltiler elektrik akımını iyi iletirler.

(c) Asitlerin yapısındaki hidrojen sayısı arttıkça asidin kuvveti artar ve elektrik akımını daha iyi iletirler.

(d) Çözelti içerisinde daha fazla iyon oluşturan maddeler elektrik akımını daha iyi iletirler.

(e) Hem asidik hem de bazik çözeltiler, iyon tanecikleri içerdiklerinden asit veya bazın kuvvetine bakılmaksızın hepsi aynı şiddette elektrik akımını iletirler.

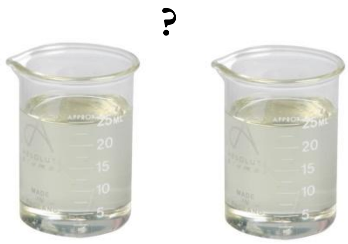
(f) ....

11.3 Yukarıdaki iki soruya verdiğim cevaptan;

(a) Eminim.

(b) Emin değilim.

12.1 Öğretmeni Mete'ye farklı çözeltiler içeren iki adet beher vermiştir; bunlardan birisinde asidik bir çözelti diğerinde ise bazik bir çözelti olduğunu belirtmiştir. Mete'nin hangi çözeltinin bazik çözelti olduğunu belirlemesi gerekiyor.



Sizce aşağıda verilenlerden hangisi **tek başına** Mete'nin bazik çözeltiyi belirlemesine yardımcı olur?

(a) Zn metali ile tepkimesini test etmesi

(b) İyonlaşma yüzdesinin bilmesi

(c) pOH değerini bilmesi

(d) Hiçbiri

12.2 Yukarıda verdiğim cevabın sebebi;

(a) Sadece bazik çözeltiler OH^- iyonları içerdiği için, çözeltilerin pOH değerini bilmek bazik çözeltiyi tayin etmeyi sağlar.

(b) Asitler daha kuvvetli oldukları için daha fazla iyonlaşırlar, iyonlaşma yüzdesi düşük olan çözelti bazik çözeltidir.

(c) Sadece asitler metallerle tepkime verdikleri için, Zn metalini çözeltilerin içine attığında tepkime vermeyen çözelti baziktir.

(d) Çözeltilerin pOH değerinin bilinmesi, suyun iyonlaşmasından faydalanarak, çözeltilerin H+ ve OH- iyonlarını tespit ederek bazik çözeltiyi tayin etmeyi sağlar.

(e) ....

12.3 Yukarıdaki iki soruya verdiğim cevaptan;

(a) Eminim.

(b) Emin değilim.

13.1 Kenan laboratuarda bir deney için öğretmenin verdiği iki ayrı çözeltinin pH değerini ölçerek, A çözeltisini pH değerini 9.6 ve B çözeltisinin pH değerini de 12.7 olarak buluyor. B çözeltisinin asitlik veya bazlık özelliği hakkında ne söyleyebilirsiniz?

(a) Zayıf Asit

(b) Zayıf Baz

(c) Kuvvetli Asit

(d) Kuvvetli Baz

13.2 Yukarıda verdiğim cevabın sebebi;

(a) pH arttıkça bazik çözeltinin kuvveti artar.

(b) pH arttıkça bazik çözeltinin kuvveti azalır.

(c) B çözeltisinde, A çözeltisine kıyasla ortamda daha fazla H^+ iyonu bulunur.

(d) B çözeltisinde, A çözeltisine kıyasla ortamda daha fazla OH^- iyonu bulunur.

(e) pH sadece asitliğin ölçüsüdür; bazik maddeler için geçerli değildir. Dolayısıyla pH arttıkça asidik özellik artar.

(f) pH sadece asitliğin ölçüsüdür; bazik maddeler için geçerli değildir. Dolayısıyla, pH arttıkça asidik özellik azalır.

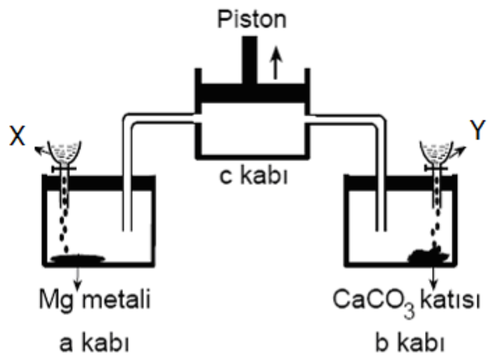
(g) …………………………………………………………………………………………………

13.3 Yukarıdaki iki soruya verdiğim cevaptan;

(a) Eminim.

(b) Emin değilim.

14.1 Yandaki şekilde **eşit kütlelerde** magnezyum (Mg) metalinin bulunduğu "a kabı" ve kireç taşı olarak bilinen kalsiyum karbonat ($CaCO_3$) katısının bulunduğu "b kabı" pistonlu c kabına bağlanmıştır. a ve b kaplarına, uygun derişimdeki X ve Y çözeltilerinden yeterli miktarda eklendiğinde her bir kapta oluşan tepkimede gaz çıkışının olduğu ve bir süre sonra pistonun ok yönünde yükseldiği gözlenmiştir. X ve Y çözeltileri için ne söyleyebilirsiniz?



(a) İki çözeltide bazik

(b) İki çözeltide asidik

(c) X asidik ve Y bazik çözelti

(d) X bazik ve Y asidik çözelti

(e) Çözeltilerin asitliği veya bazlığı hakkında yorum yapılamaz.

14.2 Yukarıda verdiğim cevabın sebebi;

(a) Asitlerin metal ve karbonatlarla etkileşmesi sonucu H_2 gazı açığa çıkar.

(b) Bazların metal ve karbonatlarla etkileşmesi sonucu H_2 gazı açığa çıkar.

(c) Asitlerin metallerle etkileşmesi sonucu H_2 gazı ve karbonatlarla etkileşmesi sonucu CO_2 gazı açığa çıkar.

(d) Bazların metallerle etkileşmesi sonucu H_2 gazı ve karbonatlarla etkileşmesi sonucu CO_2 gazı açığa çıkar.

(e) Asitlerin metallerle etkileşmesi sonucu H_2 gazı ve bazların karbonatlarla etkileşmesi sonucu CO_2 gazı açığa çıkar.

(f) Bazların metallerle etkileşmesi sonucu H_2 gazı ve asitlerin karbonatlarla etkileşmesi sonucu CO_2 gazı açığa çıkar.

(g) Hem asitler hem de bazlar metaller ve karbonatlarla tepkimeye girerler ve giren maddelerin özelliklerine göre açığa çıkan gazlar da değişir.

(h) ……………………………………………………………………………………..

14.3 Yukarıdaki iki soruya verdiğim cevaptan;

(a) Eminim.

(b) Emin değilim.

Ece kimya laboratuarında öğretmenin verdiği malzemelerle aşağıda verilen üç adımda Deney A' yı yapıyor. Ece'nin deney adımlarını ve yaptığı gözlemleri dikkate alarak aşağıda verilen **15**, **16** ve **17.** soruları alt basamaklarıyla cevaplayınız.

Deney A		
Adım	İşlem	Gözlem
I.	Ece'nin elinde asidik veya bazik olan bir çözelti vardır. Ece'ye bu çözeltinin zayıf özellikle ve hacminin 100 ml olduğu belirtiliyor. Ece bu çözeltiye turnusol kağıdı batırıyor.	Kırmızı turnusol kağıdında bir değişme olmadığını, mavi turnusol kağıdının renginin ise kırmızı olduğunu gözlemliyor.
II.	Bilinmeyen bu çözeltiye birkaç damla uygun bir indikatör damlatarak, kuvvetli olduğu bilinen 0.1 M Y çözeltisini büret yardımıyla yavaş yavaş ilave ederek titre ediyor.	Çözeltinin renk değiştirdiği anda harcanan Y çözeltisinin miktarının 150 ml olduğu tespit ediyor.
III.	Bilinmeyen X çözeltisine, 0.1M'lık Y çözeltisi ilave etmeye devam ediyor ve bu çözeltiye turnusol kağıdını batırıyor.	Kırmızı turnusol kağıdının renginin mavi olduğunu, mavi turnusol kağıdının ise renginin değişmediğini gözlemliyor.

15.1 Ece'nin yaptığı **yukarıdaki Deney A**'da, I. adımdaki bilinmeyen çözelti sizce nedir?

(a) Asidik çözelti **(b)** Bazik çözelti **(c)** Nötr çözelti

15.2 Yukarıda verdiğim cevabın sebebi;

(a) Kırmızı turnusol kağıdında bir değişme gözlenmediği için bazik bir çözeltidir.
(b) Kırmızı turnusol kağıdında bir değişme gözlenmediği için nötr bir çözeltidir.
(c) Mavi turnusol kağıdının rengini kırmızıya çevirdiği için asidik bir çözeltidir.
(d) Mavi turnusol kağıdının rengini kırmızıya çevirdiği için bazik bir çözeltidir.
(e) Mavi turnusol kağıdının rengini kırmızıya çevirdiği için nötr bir çözeltidir.
(f) ....

15.3 Yukarıdaki iki soruya verdiğim cevaptan;

(a) Eminim.
(b) Emin değilim.

16.1 Ece'nin yaptığı **yukarıdaki Deney A**'da, II. adımdaki titrasyon işlemi için aşağıda verilen ifadelerden hangisi ya da hangileri doğrudur?

I. Renk değişiminin olduğu anda çözeltinin pH değeri 7'dir.

II. İndikatör kullanılmasaydı titrasyon olayı gerçekleşmezdi.

(a) Yalnız I

(b) Yalnız II

(c) İki ifade de doğru

(d) İki ifade de yanlış

16.2 Yukarıda verdiğim cevabın sebebi;

(a) İndikatörler, asit-baz titrasyonlarında tepkimenin gerçekleşmesini sağlarlar ve tepkimeye giren asit veya bazın kuvvetine göre de eşdeğerlik noktası değişir.

(b) İndikatörlerin kendine özgü renk değiştirme aralığı vardır, bu özelliği ile asit-baz titrasyonlarında kullanılan asit veya bazın kuvvetine göre değişiklik gösteren eşdeğerlik noktasının saptanmasına yardımcı olurlar.

(c) İndikatörler asit-baz titrasyon tepkimelerinde tepkimenin gerçekleşmesini sağlarlar ve nötrleşme tepkimelerinde asidik veya bazik çözeltilerinin kuvvetliliği önemli değildir, tepkime sonucunda oluşan çözelti her zaman nötr olur.

(d) İndikatörler kendilerine özgü renk değiştirme aralıkları vardır; bu özellikleriyle eşdeğerlik noktasının saptanmasına yardımcı olurlar. Nötrleşme tepkimelerinde asit veya bazın kuvvetliliği önemli değildir, tepkime sonucunda oluşan çözelti her zaman nötr olur.

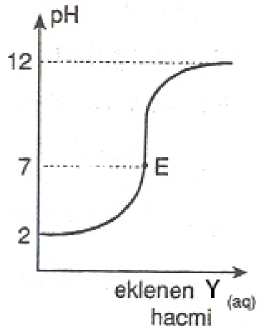
(e) ....

16.3 Yukarıdaki iki soruya verdiğim cevaptan;

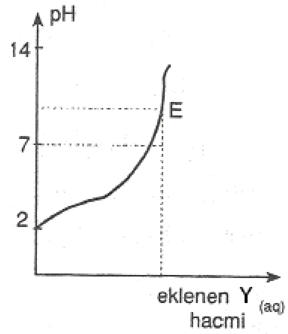
(a) Eminim.

(b) Emin değilim.

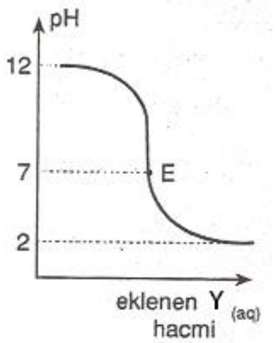
17.1 Ece'nin yaptığı **yukarıdaki Deney A**'da, III. aşamanın sonunda deneyin grafiğini çizmek istersek elde edilecek titrasyon eğrisi aşağıdakilerden hangisi olur? (E ile ifade edilen eşdeğerlik noktasıdır.)



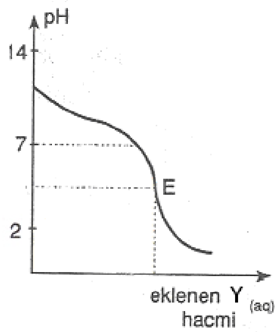
(a)



(c)



(b)



(d)

17.2 Yukarıda verdiğim cevabın sebebi;

(a) Asit-baz tepkimelerinde asidin veya bazın kuvveti etkili değildir, nötrleşme nedeniyle eşdeğerlik noktası her zaman 7 olur.

(b) Zayıf asit-kuvvetli baz titrasyonlarında eşdeğerlik noktası ortamda yeteri kadar H^+ iyonları bulunmadığından 7'den büyük olur.

(c) Zayıf asit-kuvvetli baz titrasyonlarında eşdeğerlik noktası ortamda yeteri kadar H^+ iyonları bulunmadığından 7'den küçük olur.

(d) Zayıf baz-kuvvetli asit titrasyonlarında eşdeğerlik noktası ortamda yeteri kadar OH^- iyonları bulunmadığından 7'den büyük olur.

(e) Zayıf baz-kuvvetli asit titrasyonlarında eşdeğerlik noktası ortamda yeteri kadar OH^- iyonları bulunmadığından 7'den küçük olur.

(f) Kuvvetli asit-kuvvetli baz titrasyonlarında nötrleşme nedeniyle eşdeğerlik noktası 7 olur.

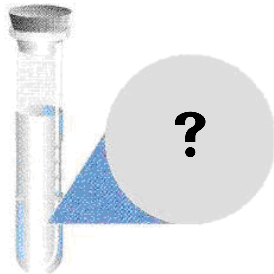
(g) ....

17.3 Yukarıdaki iki soruya verdiğim cevaptan;

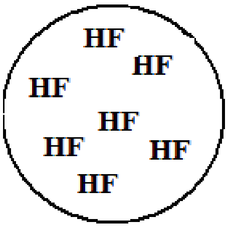
(a) Eminim.

(b) Emin değilim.

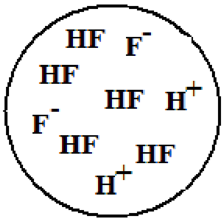
18.1 Görüşü çok kuvvetli bir mikroskopla maddeleri tanecik boyutunda görebileceğinizi hayal edin ve yandaki şekildeki gibi bir tüpün içerisine baktığınızı düşünün. Bu tüpün içerisinde <u>zayıf bir asit</u> olan 0.1 M hidroflorik asit (HF) çözeltisi bulunmaktadır. Bu mikroskobu kullanarak hidroflorik asit çözeltisine baktığında bu çözeltiyi nasıl görürdün? (Ortamdaki su moleküllerini göz ardı ediniz.)



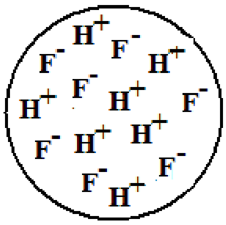
(a)



(b)



(c)



18.2 Yukarıda verdiğim cevabın sebebi;

(a) Zayıf bir asit olan HF çözeltisine bakıldığında sıvı fazında olduğu gibi tamamen moleküler olarak görünür.

(b) Zayıf bir asit olan HF çözeltisinde artı ve eksi yükler arasında etkileşim zayıf olduğundan kısmen iyonlaşır; fakat moleküllerinin sayısı iyonların sayısının yanında oldukça azdır.

(c) Zayıf bir asit olan HF çözeltisinde moleküler arası çekim kuvvetleri zayıf olduğundan suda tamamen iyonlaşırlar.

(d) Zayıf bir asit olan HF çözeltisi kısmen iyonlaşarak artı ve eksi yükü iyonlar olarak bulunur; fakat iyonların sayısı molekülerin sayısının yanında oldukça azdır.

(e) ………………………………………………………………………………………..

18.3 Yukarıdaki iki soruya verdiğim cevaptan;

(a) Eminim.

(b) Emin değilim

APPENDIX C

KİMYA MOTİVASYON ANKETİ

Sevgili Öğrenciler,

Aşağıdaki ankette kimya dersine yönelik motivasyonunuzu belirlemeye yönelik ifadeler yer almaktadır. Her cümleyi dikkatle okuduktan sonra size uygun olan tek bir yanıtı işaretleyiniz. Yapmanız gereken sizi en iyi tanımlayacak durumu kursun kalem ile yuvarlayarak içini doldurmanızdır. Verdiğiniz bilgiler yalnızca araştırma amaçlı kullanılacak olup kesinlikle gizli tutulacaktır. Araştırmanın geçerliliği açısından cevaplarınızın doğru ve eksiksiz olması gereklidir. Katkılarınız için şimdiden çok teşekkür ederiz.Kimya derslerini hakkında ne düşündüğünüzü ve nasıl hissettiğinizi anlamak için, lütfen aşağıdaki ifadeleri verilen cümleyi dikkate alarak değerlendiriniz:

Kimya dersinde olduğum zaman…	Hiç bir zaman	Ara sıra	Bazen	Genellikle	Her zaman
1. Kimyayı öğrenmekten hoşlanırım.	(1)	(2)	(3)	(4)	(5)
2. Öğrendiğim kimya bilgisi kendimin kişisel hedeflerimle ilişkilidir.	(1)	(2)	(3)	(4)	(5)
3. Kimya sınavlarında diğer öğrencilerden daha başarılı olmak isterim.	(1)	(2)	(3)	(4)	(5)
4. Kimya sınavlarının nasıl geçeceğini düşünmek beni endişelendirir.	(1)	(2)	(3)	(4)	(5)
5. Eğer kimya öğrenirken zorluk çekersem nedenini bulmaya çalışırım.	(1)	(2)	(3)	(4)	(5)
6. Kimya sınavı zamanı geldiğinde endişelenirim.	(1)	(2)	(3)	(4)	(5)
7. Kimya dersinden iyi bir not almak benim için önemlidir.	(1)	(2)	(3)	(4)	(5)
8. Kimya dersinde öğretilenleri öğrenmek için gerekli çabayı gösteririm.	(1)	(2)	(3)	(4)	(5)
9. Kimyayı iyi öğrenmemi sağlayacak stratejiler kullanırım.	(1)	(2)	(3)	(4)	(5)
10. Kimyayı öğrenmenin iyi bir iş bulmada bana nasıl yardımcı olacağını düşünürüm.	(1)	(2)	(3)	(4)	(5)

Kimya dersinde olduğum zaman…	Hiç bir zaman	Ara sıra	Bazen	Genellikle	Her zaman
11. Öğrendiğim kimya bilgisinin bana nasıl faydası olacağını düşünürüm.	(1)	(2)	(3)	(4)	(5)
12. Kimya dersi başarımın diğer öğrenciler kadar veya daha iyi olacağını düşünürüm.	(1)	(2)	(3)	(4)	(5)
13. Kimya sınavlarında başarısız olmaktan endişelenirim.	(1)	(2)	(3)	(4)	(5)
14. Kimyada diğer öğrencilerin daha başarılı olduğunu düşünmek beni kaygılandırır.	(1)	(2)	(3)	(4)	(5)
15. Kimya ders notumun genel not ortalamamı nasıl etkileyeceğini düşünürüm.	(1)	(2)	(3)	(4)	(5)
16. Benim için kimya hakkında bilgiler öğrenmek aldığım nottan daha önemlidir.	(1)	(2)	(3)	(4)	(5)
17. Kimya hakkında bilgiler öğrenmenin kariyerime nasıl faydası olacağını düşünürüm.	(1)	(2)	(3)	(4)	(5)
18. Kimya sınavlarına girmekten hoşlanmam.	(1)	(2)	(3)	(4)	(5)
19. Öğrendiğim kimya bilgilerini nasıl kullanacağımı düşünürüm.	(1)	(2)	(3)	(4)	(5)
20. Kimya ile ilgili bilgileri anlayamıyorsam bu benim hatamdır.	(1)	(2)	(3)	(4)	(5)
21. Kimya laboratuarında ve projelerinde başarılı olacağımdan eminim.	(1)	(2)	(3)	(4)	(5)
22. Kimya öğrenmeyi ilginç bulurum.	(1)	(2)	(3)	(4)	(5)
23. Öğrendiğim kimya bilgileri hayatımla ilişkilidir.	(1)	(2)	(3)	(4)	(5)
24. Kimya dersindeki bilgi ve becerileri tam olarak öğrenebileceğime inanırım.	(1)	(2)	(3)	(4)	(5)
25. Öğrendiğim kimya bilgilerinin benim için pratik değeri vardır.	(1)	(2)	(3)	(4)	(5)
26. Kimya sınavları ve laboratuarları için iyi hazırlanırım.	(1)	(2)	(3)	(4)	(5)
27. Beni zorlayan kimya hoşuma gider.	(1)	(2)	(3)	(4)	(5)
28. Kimya sınavlarında başarılı olacağıma eminim.	(1)	(2)	(3)	(4)	(5)
29. Kimya dersinden en yüksek notu alabileceğime inanırım.	(1)	(2)	(3)	(4)	(5)
30. Kimya ile ilgili bilgileri anlamak bana başarı hissiyatı verir.	(1)	(2)	(3)	(4)	(5)

APPENDIX D

Interview Questions

Öğrenci Görüşme Soruları

Asitler ve Bazlar

1. Asit ve baz denince aklına ne geliyor?
    - Öğrenci tanım yapmazsa:

      Asitleri tanımla desem nasıl bir tanım yaparsın?

      Bazları tanımla desem nasıl bir tanım yaparsın?

   Üç tane asit örneği verebilir misin?

   Üç tane baz örneği verebilir misin?

   Asitlerin ve bazların özellikleri hakkında ne söyleyebilirsin?
    - Öğrenci cevap veremezse:

      Asitlerin genel özellikleri nelerdir? Örneğin, asitlerin pH özellikleri nelerdir?, Turnusol kağıdında nasıl bir değişiklik yaparlar?, Başka maddelerle tepkimeye girerler mi?, Elektriği iletirler mi?.

      Bazların genel özellikleri nelerdir? Örneğin, bazların pH özellikleri nelerdir?, Turnusol kağıdında nasıl bir değişiklik yaparlar?, Başka maddelerle tepkimeye girerler mi?, Elektriği iletirler mi?.

      Ne biliyorsun başka asitler ve bazlar hakkında?

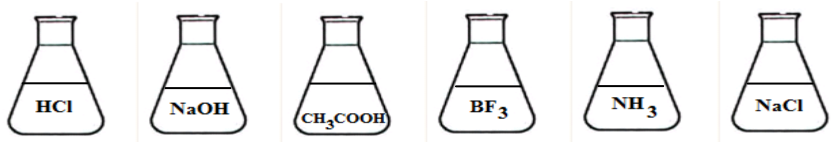
2. Sence günlük hayatımızda asidik veya bazik maddelerle karşılaşıyor muyuz? Bu maddelerin asidik veya bazik olduğunu nasıl biliyorsun?
    - Öğrenci örnek veremezse:

      Sence bulaşık deterjanı, sirke, kola, limon ve sabun asidik mi bazik mi?

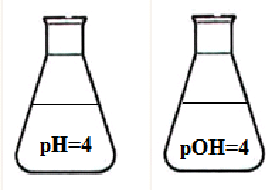
      Bunların asidik veya bazik olduğuna nasıl karar veriyorsun?

3. (Öğrenciye HCl, $NaOH$, CH_3COOH, BF_3, NH_3 ve $NaCl$ çözelti şekilleri örnekleri gösterilir)

   Buradaki erlenleri düşündüğünde çözeltilerin asitliği veya bazlığı hakkında ne düşünüyorsun? Bu çözeltilerin asidik veya bazik olduğuna nasıl karar veriyorsun?



4. (Öğrenciye şekildeki gibi iki tane yarısına kadar dolu erlen gösterilir. İki erlen de renksiz çözelti içermektedir. Çizim için HA ve BOH örnekleri verilebilir.)



Bu beherlerden birinde pH değeri 4 olan bir çözelti diğerinde de pOH değeri 4 olan bir çözelti vardır. Buradaki çözeltiler için ne söyleyebilirsin?

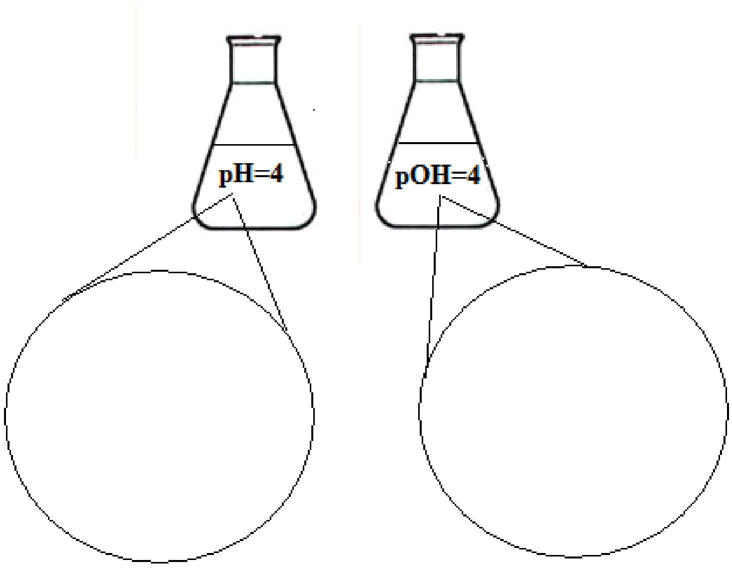
pH değeri 4 olan çözeltiyi tespit etmeni istersem nasıl bir yol izlersin? Her hangi bir malzemeye ihtiyacın olabilir mi?

- Öğrenci cevap veremezse:

  İndikatör denince aklında bir şey çağrışıyor mu?

  Turnusol kağıdı hakkında bir fikrin var mı?

Görüşü çok kuvvetli bir cihaz olsa elinde, maddeleri tanecik boyutunda görebildiğini düşün, bu cihazla bu çözeltilere baktığında ne görürdün resmeder misin?



pH veya pOH denince aklına ne geliyor?

- Öğrenci cevap veremezse:

Sadece asidik çözeltiler için mi pH değerinden söz ederiz?

Bazik çözeltilerin pH değeri var mıdır?

pH ile pOH arasında bir ilişki var mıdır?

Bu iki erlendeki çözeltileri başka bir erlende karıştırsak ne gözlemleriz?

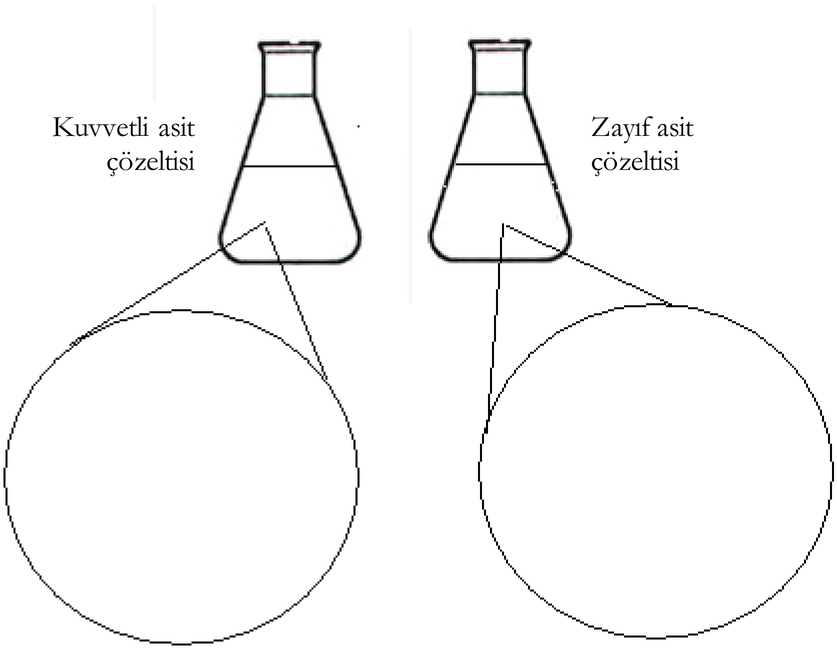
Tepkime oluşur mu?

5. (Öğrenciye şekildeki gibi iki erlen gösterilir, birisinin kuvvetli bir asit çözeltisi diğerinin de zayıf bir asit çözeltisi olduğu belirtilir. HCl ve HCN örnekleri verilerek öğrenciler bu maddeleri kullanarak resmedebilirler.)

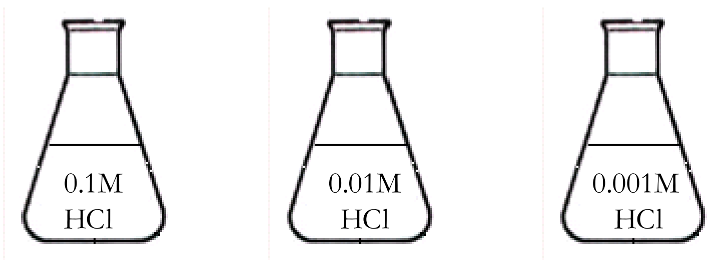
   Kuvvetli veya zayıf asit çözeltisi denince aklına ne geliyor?

   Ne fark vardır sence bu çözeltiler arasında?

   Görüşü çok kuvvetli bir cihaz olsa elinde, maddeleri tanecik boyutunda görebildiğini düşün, kuvvetli ve zayıf asit içeren bu çözeltilere bu cihazla baktığında ne görürdün?



Aşağıda verilen asit çözeltilerini kuvvetliliklerine göre nasıl sıralarsın?



a) 0.1 M HCl b) 0.01 M HCl c) 0.001 M HCl

6. (Öğrenciye kabaca nötrleşme etkinliği gösterisi yapılır. İki tane farklı erlen gösterilir, birisinin içerisinde bir miktar fenolftalein indikatörü olduğu belirtilir, diğerinin içerisinde ise bir şey olmadığı gösterilir. Elimizdeki asidik çözeltiden eşit miktarda bu iki erlene ilave edilir. Daha sonra, bazik çözeltiden de eşit miktarda alınarak içerisinde asidik çözelti olan erlene ilave edilir. Öğrencinin indikatör olan erlende renk değişimini gözlemlemesi sağlanır. Diğer erlen için de aynı işlem tekrarlanır, fakat burada renk değişimi gözlenmez.)

   Aynı maddeleri ilave etmemize rağmen, iki erlende farklı durum gözlendi. Bu iki farklı durum için ne düşünüyorsun?

   Neden fenolftalein indikatörü bulunan erlende renk değişimi gözlendi?

   İki çözeltiyi karıştırdığımıza herhangi bir tepkime oluşur mu?

   - Öğrenci cevap veremezse:

     Nötrleşme denince aklına ne geliyor?

     Tepkimeye giren ve oluşan ürünler nelerdir?

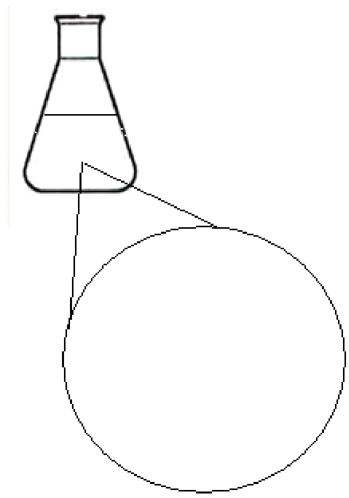
     İndikatör nedir? Nasıl bir fonksiyonu vardır?

   Karıştığımız bu asit çözeltisinin 100ml 0.1M HCl çözeltisi ve baz çözeltisinin 100ml 0.1M NaOH çözeltisi olduğunu göz önüne aldığında, verilen tepkimeyi nasıl tamamlarsın?

   Elde ettiğimiz bu son çözeltiyi aşağıdaki şekle nasıl resmedersin?

   Bu son çözeltinin pH değeri hakkında ne söyleyebilirsin?

$$HCl + NaOH \rightarrow$$



Bu örnekte, kuvvetli bir asit ve kuvvetli bir baz kullandık. Eğer ki, çözeltilerden birisi zayıf bir çözelti olsaydı açıklamalarında herhangi bir değişiklik olur muydu? Örneğin, elinde zayıf bir asit çözeltisi ve kuvvetli bir baz çözeltisi bulunuyor ve sen bunları başka bir beherde karıştırıyorsun. Bu durum için ne düşünüyorsun?

- Öğrenci cevap veremezse:

  Bu durumda yine nötrleşme olayı olur mu?

  Tepkime sonucunda oluşan ürünler nelerdir?

  Çözeltinin pH değeri için ne söyleyebilirsin?

Kimyayı Öğrenmeye yönelik Motivasyonla ilgili Görüşme Soruları

1. Kimya hakkında bir şeyler öğrenmek hoşuna gidiyor mu?
   Neden böyle düşünüyorsun?
2. Kimya öğrenmek senin için önemli mi?
   Kimya hakkında bilgi sahibi olmak sana ne kazandırır?
3. Kimya dersinde öğrendiğin bilgilerin senin için faydalı olduğunu düşünüyor musun?
4. Kimya dersine hiç girmemiş biri ile kendini kıyasladığında aranızda herhangi bir fark olduğunu düşünüyor musun?
   Bugüne kadar öğrendiğin kimya bilgisi senin nasıl işine yaradı?
5. Kimya dersiyle ilgili hoşuna giden veya gitmeyen özellikler nelerdir?
6. Kimya dersini nasıl öğrenmek isterdin?

Uygulama sonrası görüşme sorularına ilave edilen sorular

1. Asitler ve bazlar ünitesini öğrenirken önceki ünitelerdeki öğrenmelerini kıyasladığında benzerlikler veya farklılıklar hissettin mi?
2. Asitler ve bazlar ünitesini öğrenirken genelde siz grubunuzla beraber etkinlikleri yaptınız. Bu şekildeki öğrenme hakkında ne düşünüyorsun?
3. Etkinliklerin kontrollünün sizin üzerinizde olması sizde bir problem yarattı mı?
4. Zorlandığın veya hoşlanmadığın bir etkinlik oldu mu?
5. Yaptığınız etkinliklerle ilgili söylemek istediklerin var mı?
6. Sence bu yöntemle öğrenmek etkili veya verimli oldu mu? Olumlu veya olumsuz belirtmek istediğin düşünceler var mı?
7. Kimya dersine yönelik düşüncelerinde değişiklik oldu mu?

8. Bu tarz öğrenme ile ilgili başka eklemek istediklerin var mı?

Öğretmen Görüşme Soruları

1. Asitler ve bazlar ünitesinin öğretiminde uyguladığınız öğrenme döngüsü yaklaşımı için neler söylemek istersiniz?
2. Önceki konu anlatımlarınız ile kıyaslarsanız asitler ve bazlar ünitesinin anlatımında ne tür benzerlikler ve farklılar gerçekleştirdiniz?
3. Uygulama esnasında sınıf içinde öğrencilerin derse yönelik davranışlarında farklılıklar gözlemlediniz mi? Gözlemlediyseniz bunlar nelerdir?
4. Öğrenme döngüsü yaklaşımına göre hazırlanmış asitler ve bazlar ünitesi öğretiminin, öğrencilerin hangi yönlerini geliştirdiğini düşünüyorsunuz?
5. Asitler ve bazlar ünitesinin öğretiminde herhangi zorluklarla karsılaştınız?
6. Öğrenciler, size uygulama esnasında dersin isleyişiyle ilgili herhangi bir olumlu veya olumsuz görüş ilettiler mi?
7. Daha sonraki anlatımlarınız için öğrenme döngüsü yaklaşımını ileriki ders planlarınıza uygulamayı düşünür müsünüz?

APPENDIX E

CLASSROOM OBSERVATION CHECKLIST

Sınıf Gözlem Formu	Evet	Kısmen	Hayır	NA
1. Sınıf/Laboratuar ortamı ders yapmaya elverişli mi?				
2. Sınıfta/Laboratuarda öğrenciler için yeterli sıra/banko var mı?				
3. Öğrenciler derse katılmaya istekli mi?				
4. Öğrenciler yeni bilgiler öğrenmeye hevesli mi?				
5. Öğrenciler sınıf içi etkinlik tartışmalarına katılıyorlar mı?				
6. Öğrenciler grup içi etkinlik tartışmalarına katılıyorlar mı?				
7. Öğrenciler, etkinlikleri grup halinde beraber gerçekleştiriyorlar mı?				
8. Öğrenciler, etkinlikten faydalanarak kavramları anlamaya çalışıyor mu?				
9. Öğrenciler gruplar halinde etkili bir şekilde çalışıyorlar mı?				
10. Öğrenciler, öğretmen konu hakkında bilgi verirken not tutuyorlar mı?				
11. Öğrenciler, sürekli bilgi alan konumunda mıdır?				
12. Öğrenciler, öğrenmek için sorgulayıcı etkinlikler gerçekleştiriyorlar mı?				
13. Öğrenciler, aktif olarak derse katılıyorlar mı?				
14. Öğrenciler, bilgiye ulaşmak için gayret ediyorlar mı?				
15. Öğrenciler, ders sonunda neler öğrendiklerini değerlendirdiler mi?				
16. Öğretmen, öğrencilerin ilgisini çekebiliyor mu?				
17. Öğretmen, öğrencilerin rahat hissedebileceği bir ortam sağlıyor mu?				
18. Öğretmen, öğrencilerin önceki dersle ilgili öğrenmelerini sorguluyor mu?				

Sınıf Gözlem Formu	Evet	Kısmen	Hayır	NA
19. Öğretmen, öğrencilere kavramsal sorular soruyor mu?				
20. Öğretmen, öğrencilere merak uyandıran sorular soruyor mu?				
21. Öğretmen, öğretimi günlük hayat örnekleriyle şekillendiriyor mu?				
22. Öğretmen, öğrencilerin konu ile ilgili öğrenmelerini sorguluyor mu?				
23. Öğretmen, öğrencilerin etkinliklerle ilgili tahminlerini sorguluyor mu?				
24. Öğretmen, öğrencilere düşünmelerini sevk eden sorular soruyor mu?				
25. Öğretmen, kavram öğretimini doğrudan öğrencilere veriyor mu?				
26. Öğretmen, ders esnasında öğrencilerin soru sormasına izin veriyor mu?				
27. Kavramların öğrenilmesi amacıyla etkinlikler yapılıyor mu?				
28. Öğretmen, sürekli bilgi veren konumunda mıdır?				
29. Öğretmen, grup içi ve sınıf içi etkinliklerde öğrencileri cesaretlendiriyor mu?				
30. Öğretmen, grup içi ve sınıf içi etkinliklerde öğrencilere rehberlik ediyor mu?				
31. Öğretmen, konu öğretiminde öğrencilerin kavram yanılgıları gidermeye çalışıyor mu?				
32. Öğretmen, ders sonunda öğrencilerin öğrenmelerini sorguluyor mu?				

Sınıf: ……………………………

Tarih: …………………….…….

Ders süresi: …………………….

Değerlendiren: …………………

APPENDIX F

STUDENT HANDOUTS

F–1. ACIDS AND BASES

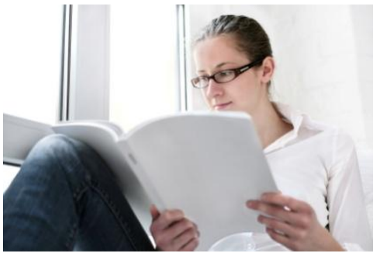
Asitler ve Bazlar

Ne biliyorum?	Ne Öğrenmek İstiyorum?
Ne Öğrendim?	

F-2A. A DAY WITH MELIS (MELİS'İN BİR GÜNÜ)

Sınıfınız: **Grup Numaranız:**
Adınız Soyadınız:

Asitler ve Bazlar



Melis üniversite birinci sınıf öğrencisi ve kimya mühendisliğinde okuyor. Melis'in bugün önemli bir dersten sınavı var ve sınavına biraz daha çalışmak için erkenden kalktı. Kahvaltısını yapmayarak sınav ile ilgili okumalarını tekrar ederken bir şeyler atıştırmayı tercih etti, kahve ve çikolata sevdiği bir ikiliydi. Melis çikolata yemenin sağlıklı olmadığını bilse de, çikolatanın tadı çok hoşuna gidiyordu. Diğer yandan, uyanık olabilmek için sütsüz kahvesinden bol bir yudum alarak ders notlarını tekrar etmeye devam etti. Ders notlarının tekrarını bitirdikten sonra bardağını bulaşık deterjanıyla yıkadı.

Melis'in sınav yaklaştıkça stresi daha da artıyordu ve midesinde yanma hissetti ve birkaç kaşık yemek sodasını su ile karıştırıp içti ve üniversiteye gitmek için hazırlanmaya başladı. Üzerini değiştirdi, dersleri için gerekli kitap ve defterlerini çantasına yerleştirdi. Dişlerini fırçalamak için banyoya gitti. Önceki gün banyonun temizliğinde ev arkadaşı çamaşır suyu kullandığı için banyonun içi hala hiç sevmediği keskin çamaşır suyu kokuyordu. Dişlerini fırçalarken banyodaki çamaşır suyu kokusundan yine rahatsız oldu. Diş fırçasına fındık büyüklüğünde diş macunu koydu ve dikkatli bir şekilde dişlerini fırçaladı. Artik üniversiteye gitmeye hazırdı, evden çıkmadan acele ile çantasına da bir elma attı.

Evden dışarı çıktığında hafiften yağmur çiseliyordu, hızlı adımlarla otobüs durağında gitti ve onu okula götürecek otobüsü beklemeye başladı. Melis'in otobüsü beklerken durağı karşısındaki mermerden yapılmış bir heykele gözü ilişti. Heykeldeki aşınmalar daha önce dikkatini çekmemişti. Yağmura rağmen otobüs zamanında geldi ve hemen otobüse bindi. Beklerken montu ve çantası ıslanmıştı ve burnuna nem kokusu geliyordu.

Sınavı iyi geçen Melis, sınavdan sonra kendini mutlu ve rahatlamış hissetti. Sabah çantasına koyduğu elmayı zevkle yedi. Sınav stresini üzerinden atmak için Melis ve arkadaşları bir yerlere gitmeye karar verdiler. Öncelikle bir şeyler yemek istiyorlardı. Mekâna gittiklerinde yemeğine başlamadan önce Melis ellerini sabunla yıkadı. Arkadaşları ne yiyeceklerine karar vermişlerdi hızlıca menüye göz attı. Sabahki sağlıksız kahvaltıdan sonra hamburger ve kızartılmış patates gibi sağlıksız şeyler yemek istemiyordu. Tavuklu salata yiyerek onu dengelemek istedi ve içecek olarak da kola yerine ayran siparişi verdi. Siparişleri beklerken sınav sorularını tartışmaktan alıkoyamadılar kendilerini. Salatası geldiğinde tuz ve sirke ilavesi yaptı. Melis afiyetle salatasını yerken bir yandan da ayranını yudumluyordu. Yemekten sonra Melis ve arkadaşları çimlerin üzerine oturup çay içmeye karar verdiler. Çayın yanına bir parça kek de aldılar, Melis'in aklına annesinin yaptığı nefis kekler geldi. Annesini özlemişti sınav haftası biter bitmez ailesinin yanına gitmeye karar verdi. Melis çimlerde uzanırken çimlere düşen kek kırıntısını sırtına yüklemiş karıncayı seyre daldı.

Melis arkadaşlarıyla vakit geçirmekten keyif alıyordu ama eve dönüp diğer sınavlarına hazırlanması gerekiyordu. Arkadaşlarıyla vedalaşıp evin yolunu tuttu. Eve döndüğünde ev arkadaşını ağlarken buldu, ona neden üzüldüğünü sordu. Ev arkadaşı ise ona gülüyordu çünkü gözyaşlarının nedeni üzüntü değil yemek için doğradığı soğandı. Melis de salata yaparak ev arkadaşına akşam yemeğini hazırlamasına yardım etti. Maydanoz, domates, yeşilbiber, salatalık ve kırmızılâhanayı dikkatlice yıkayarak salatayı hazırladı ve beraber keyifli bir yemek yediler. Yemek sonrası bulaşıkları yıkadıktan sonra da odalarına ders çalışmaya gittiler. İlerleyen saatlerde Melis'in ev arkadaşı elma, uzum, şeftali gibi meyvelerden hazırladığı bir meyve tabağını getirdi, beraber sohbet ederek meyve yediler.

Günün temposundan mı bilinmez Melis başında bir ağrı hissetti, her ne kadar sıklıkla ilaç içmemeye çalışsa da bir ağrı kesici onun baş ağrısını hafifletebilirdi. Biraz daha ders çalıştı. Aldığı ağrı kesici yavaş yavaş etkisini göstermeye başladı, baş ağrısı hafifliyordu. Saat epey ilerlemişti artık yatması gerekiyordu, yatmadan önce her zaman yaptığı gibi bir bardak ılık sütünü içti ve dişlerini fırçaladı. Yatakta biraz kitap okuduktan sonra uykuya daldı.

- ❖ Okuduğunuz metinde, Melis'in günlük hayatta karşılaştığı asidik ve bazik maddeleri tahmin ediniz. Neden asidik veya bazik olduklarını düşünüyorsunuz?
- ❖ Grup arkadaşlarınızla asidik veya bazik olarak tahmin ettiğiniz maddeler arasında benzer maddeler var mı? Farklı cevap verdiğiniz maddeleri tartışınız.

Senin Kişisel Görüşlerin:
Grup Arkadaşlarınızla Görüşleriniz:

F-2B. AN ACID OR A BASE ?

ASİT Mİ? BAZ MI?

Evden getirdiğiniz veya öğretmeninizden aldığınız en az 4 malzemeyi turnusol kağıdı ile test ederek asidik mi yoksa bazik bir madde mi olduğuna arkadaşlarınızla tartışarak karar veriniz?

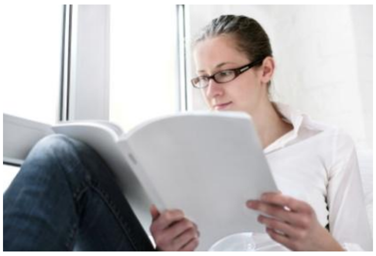
Elde ettiğiniz sonuçları tahtadaki postere grup numaranızı belirterek not ediniz.

Kullandığınız Madde	**Tahmin Asit ? Baz ?**	**Turnusol Kağıdı**		**Sonuç**
		Kırmızı	**Mavi**	

F-2C. A DAY WITH MELIS

MELİS'İN BİR GÜNÜ

Asitler ve Bazlar



Melis üniversite birinci sınıf öğrencisi ve kimya mühendisliğinde okuyor. Melis'in bugün önemli bir dersten sınavı var ve sınavına biraz daha çalışmak için erkenden kalktı. Kahvaltısını yapmayarak sınav ile ilgili okumalarını tekrar ederken bir şeyler atıştırmayı tercih etti, kahve ve çikolata sevdiği bir ikiliydi. Melis çikolata yemenin sağlıklı olmadığını bilse de, çikolatanın tadı çok hoşuna gidiyordu [Tükürük karmaşık bir salgıdır; pH değeri nötre yakın olup 7,4 civarındadır. Melis yediği çikolata azı dişlerine yapışıp ağzındaki bakteriler için de kahvaltı niteliğini taşımaktadır. Ağzımızdaki çikolata, şekerleme gibi tatlı yiyeceklerden gelen şeker aside dönüşür ve diş minesini çözer. Diş minesi %98 oranında hidroksiapatitten ($Ca_5(PO_4)_3OH$) oluşup dişin en dış tabakası olup şeffaflığını verir ve doğada elmastan sonraki en sert maddedir. Her iyonik katı gibi sulu ortamda hidroksiapatit de devamlı olarak çözünür ve çökelir. Çözünme ve çökelme dengesi sürecinde tükürüğümüz çok asidik olmadığı sürece kalsiyum, fosfat ve hidroksit iyonlarını içerir ve bu denge tepkime denklemi aşağıdaki gibidir:

$$Ca_5(PO_4)_3OH_{(k)} \rightleftharpoons 5Ca^{+2}_{(suda)} + 3PO_4^{-3}{}_{(suda)} + OH^-_{(suda)}$$

Bu dengeden dolayı, diş minemizde bir değişiklik gözlenmez. Fakat bazı yiyecekler bu dengeyi bozarlar. Ağzımızdaki bakteriler yediğimiz yiyecekleri parçalar, özellikle yiyeceklerdeki yüksek şeker miktarından, laktik asit ve asetik asit gibi asitler oluşur. Bu asitler, tükürükteki hidroksit iyonlarını nötrler ve çökelme tepkimesi yavaşlar. $Ca_5(PO_4)_3OH$ çözünmeye devam eder; dolayısıyla dişlerin koruyucu kaplamasında net bir azalma gözlenir. İçtiğimiz sulardaki ve diş macunumuzdaki flor bu bahsettiğimiz hasarın azaltmamıza yardımcı olur. Flor iyonu, çökelme tepkimesindeki hidroksit iyonunun (OH^-) yerini alır ve orijinal diş minesine benzer florapatitt, $Ca_5(PO_4)_3F$, çökelir. Çökelme ve çözünme denge tepkime denklemi aşağıdaki gibidir:

$$5Ca^{+2}_{(suda)} + 3PO_4^{-3}{}_{(suda)} + F^-_{(suda)} \rightleftharpoons Ca_5(PO_4)_3F_{(k)}$$

Florapatit, hidroksiapatite göre 100 kat daha az çözünürdür; dolayısıyla asidik maddelerden daha az etkilenir. Bu nedenle dişlerimizi düzenli olarak fırçalamamız diş minesinin sağlığı açısından

önemlidir.].

Melis diğer yandan, uyanık olabilmek için sütsüz kahvesinden bol bir yudum alarak ders notlarını tekrar etmeye devam etti [Kahve hafif asidik bir içecektir, pH değeri 5 civarındadır.]. Ders notlarının tekrarını bitirdikten sonra bardağını bulaşık deterjanıyla yıkadı [Deterjanlar genelde bazik maddeler içerir. Fakat tuvalet temizleyiciler gibi fosforik asit (H_3PO_4) veya hidrojen sülfat (HSO_4^-) gibi asitleri içeren temizlik malzemeleri de vardır. Ev temizliğinde veya çamaşır yıkamada kullanılan çamaşır suyu sodyumhipoklorit (NaClO) çözeltisidir ve hipoklorit iyonu (OCl^-) bazik bir çözeltinin klor gazı ile tepkimesinden oluşur. Denge tepkime denklemi aşağıdaki gibidir:

$$Cl_{2(g)} + 2OH^-_{(suda)} \rightleftharpoons OCl^-_{(suda)} + Cl^-_{(suda)} + H_2O_{(s)}$$

Bu tepkimede klor atomları Cl_2'dan OCl^-'ye devamlı olarak birbirine dönüşür. Bazik bir çözeltide, ileri yönlü tepkimenin hızı klor gazının büyük bir kısmını şişe içerisinde OCl^- formunda tutacak kadar hızlıdır. Fakat çamaşır suyu bir asit çözeltine ilave edilirse, bazik çamaşır suyundaki hidroksit iyonları asitteki H^+ iyonları ile su oluşturmak için tepkimeye girer. Ortamdaki hidroksit iyonlarının azlığından dolayı, Cl_2 ve OH^- arasındaki tepkime yavaşlarken ters yöndeki tepkime aynı hızda gerçekleşmeye devam eder. Bu durum klor gazının tehlikeli düzeye gelmesine neden olur. Bundan dolayıdır ki, çamaşır suyu şişelerinin etiketlerinin üzerine tuvalet temizleyiciler gibi asidik maddeler içerikli temizlik malzemeleri ile birlikte kullanmayın uyarısı yazılıdır. Annenizi bu konu hakkında uyarınız].

Melis'in sınav yaklaştıkça stresi daha çok artıyordu ve midesinde yanma hissetti ve birkaç kaşık karbonatı su ile karıştırıp içti ve üniversiteye gitmek için hazırlanmaya başladı [Melis'in ayaküstü abur-cubur kahvaltısı ve sınav öncesi stresi midesinde hazımsızlığa yol açtı ve karbonat-su karışımı midedeki fazla asidi nötrleştirmeye yardımcı oldu. Çünkü karbonat midedeki asit fazlasını nötrleyecek sodyum bikarbonat ($NaHCO_3$) içerir]. Melis üzerini değiştirdi, gerekli kitap ve defterleri çantasına yerleştirdi. Dişlerini fırçalamak için banyoya gitti. Önceki gün banyonun temizliğinde ev arkadaşı çamaşır suyu kullandığı için banyo hiç hoşlanmadığı keskin çamaşır suyu kokuyordu. Diş fırçasına fındık büyüklüğünde diş macunu koydu ve dikkatli bir şekilde dişlerini fırçaladı. [Diş macunları genellikle bazik maddeler içermektedir ve pH değerleri 8 civarındadır. Ağız

içerisinde biriken şeker ve yemek artıklarından oluşan bakterin yok edilmesinde yardımcı olurlar] Artik üniversiteye gitmeye hazırdı, evden çıkmadan acele ile çantasına da bir elma attı [Malik asit, elma öncelikli olmak üzere, birçok meyve ve sebzede doğal olarak bulunan bir asittir. 1785 yılında ilk kez Carl Wilhelm Scheele tarafından elmadan izole edilmiştir. 1787'de ise, bu aside Antoine Lavoisier Latincede elma anlamına gelen "malik asit" adını vermiştir.].

Melis, evden dışarı çıktığında yağmur hafifçe çiseliyordu, hızlı adımlarla otobüs durağında gitti ve onu okula götürecek otobüsü beklemeye başladı [Asitlerin sulu çözeltileri suda iyonlar oluştururlar. İyonlaşmış sıvılara elektrolit denir. Bu sıvılar elektrik akımını iletirler. Asitlerin suya verdiği bu özelliğinden faydalanılarak kimyasal piller yapılır. Aküler kimyasal pillerdir, bir sonraki ünitede kimyasal piller ile ilgili detaylı bilgi verilecektir]. Melis'in otobüsü beklerken durağın karşısındaki mermerden yapılmış bir heykele gözü ilişti. Heykeldeki aşınmalar daha önce dikkatini çekmemişti [Doğal yağmurun pH değeri 5,6 civarındadır; bu değerden daha az olan yağmurlar asit yağmurları olarak adlandırılırlar. Doğal yağmur atmosferdeki karbondioksiti, azot dioksiti ve kükürt trioksiti çözdüğü için biraz asidiktir. Kükürt dioksit de volkanik patlamalar ve orman yangınları sonucunda oluşur. Havadaki azot dioksitle etkileşmesi sonucu kükürt trioksite dönüşür, SO_3:

$$SO_2(g) + NO_2(g) \rightarrow SO_3(g) + NO(g)$$

Doğal yollardan oluşan havadaki $NO_2(g)$ ve $SO_{2(g)}$ seviyelerini aynı zamanda biz insanlar da yükseltiyoruz ve böylece yağmurun asitliğini de arttırmış oluyoruz. Örneğin, kömür oldukça yüksek oranda kükürt içerir; kömür yandığında kükürt, kükürt dioksite, $SO_2(g)$ dönüşür. Kükürt dioksit de havada kükürt trioksite dönüşür ve yağmur suyunda çözünmesiyle sülfürik asit, H_2SO_4(suda) oluşur. Her kullanılan taşıt da asit yağmurlarının oluşmasına katkısı olur. Azot ve oksijen içeren hava, arabanın silindirlerinde ısındığında iki gazın tepkimesiyle azot monoksit, NO(g) oluşur; bu gaz da daha sonra havada azot dioksite, $NO_2(g)$ dönüşür. Azot dioksit yağmur suyuyla bir araya gelerek nitrik asidi, HNO_3(suda) oluşturur. Özellikle sanayileşmenin yoğun olduğu bölgelerde yüksek miktarlarda oluşan kükürt oksit ve azot oksitlerin yağmur suyunda çözünmesiyle, sülfürik asit (H_2SO_4), nitrik asit (HNO_3) ve hidroklorik asit (HCl) oluşur. Asit yağmurları, sadece bitkilerin, ormanların ve balıkların yaşamlarını etkilemekle (göllerdeki pH seviyelerini değiştirdiği için) kalmaz, yapısında kalsiyum

karbonat ($CaCO_3$) bulunan heykelleri bile zamanla bozunmaya ve aşınmaya uğratır. Yağmurdaki asit kalsiyum karbonatla tepkimeye girerek mermer heykellerin ve binaların çözünmesine neden olur:

$$CaCO_3(k) + 2HNO_3(suda) \rightarrow Ca(NO_3)_2(suda) + CO_2(g) + H_2O(s)$$

Evlerimizde çaydanlıklarda, su borularında kireçlenme olayını sıklıkla gözlemleriz. Eğer ki kireçlenmiş malzemeler asidik çözeltiler ile temizlenirse yukarıda verdiğimiz tepkime gerçekleşir ve kalsiyum karbonat çözünmüş olur.]. Yağmura rağmen otobüs zamanında geldi ve hemen otobüse bindi. Beklerken montu ve çantası ıslanmıştı ve burnuna nem kokusu geliyordu [Islak giysiler ve kirli spor giysilerinin karakteristik kokusu monoprotik bir asit olan hekzanoik asitten kaynaklanır, $CH_3CH_2CH_2CH_2CH_2CO_2H$]. Sınavı iyi geçen Melis, sınavdan sonra kendini mutlu ve rahatlamış hissetti. Sabah çantasına koyduğu elmayı zevkle yedi. Sınav stresini üzerinden atmak için Melis ve arkadaşları bir yerlere gitmeye karar verdiler. Öncelikle bir şeyler yemek istiyorlardı. Mekâna gittiklerinde yemeğine başlamadan önce Melis ellerini sabunla yıkadı [Klasik sabunlar içerdikleri bazik maddelerden (sabun, kuvvetli bir bazın hayvansal yağların tepkimesi sonucundan elde edilir) dolayı deride kayganlık hissi verirler ve pH değerleri genelde 8–10 arasında değişiklik gösterir. Cildimizin normal pH değeri 4,5–6,5 arasında değişir; ellerimizi klasik sabunlarla yıkadığımızda cildimizin pH değeri yükselir. Kuruluk hissi verir ama sağlıklı bir cilt kısa sürede tekrar gerekli nem ve pH dengesine kavuşur]. Arkadaşları ne yiyeceklerine karar vermişlerdi hızlıca menüye göz attı. Sabahki sağlıksız kahvaltıdan sonra hamburger ve kızartılmış patates gibi sağlıksız şeyler yemek istemiyordu. Tavuklu salata yiyerek onu dengelemek istedi ve içecek olarak da kola [Kolanın tam olarak formülü bilinmese de içerisinde sitrik asitle beraber şeker, tatlandırıcı, karamel, vanilya özütü, su gibi maddelerin olduğu bilinmektedir ve pH değeri 2,5 civarındadır] yerine ayran siparişi verdi. Siparişleri beklerken sınav sorularını tartışmaktan alıkoyamadılar kendilerini. Salatası geldiğinde tuz ve sirke ilavesi yaptı [Sirke asidik özellik gösterir ve pH değeri 2,4 – 3,4 arasında olabilir. Bütün asitler gibi sirke de ekşi bir tada sahiptir. Asetik asit, CH_3COOH sirkeye ekşi tadını ve keskin kokusunu vermesiyle bilinir. Sirke genelde %4–8 oranında asetik asit içerir ama turşu kurmak için kullanılan sirkelerde bu oran %18'e varır. Sirkenin oluşturduğu asitli ortam gıdaların bozulmasına neden olacak çoğu mikroorganizmanın büyümesini engeller. Bu yüzden turşuluma sebzelerin ömrünü uzatmak için etkili bir yöntemdir.]. Melis afiyetle salatasını yerken [Melis'in midesi, tavuk etinin içerdiği proteini

sindirime başlamak için bir miktar asit üretir. Normal bir insanda, midedeki asidin pH değeri 1 ile 2 arasında değişebildiği gibi, mide özsuyunda %0,3 oranında hidroklorik asit yer almaktadır. Hidroklorik asit, kendi başına, mideyi delebilecek güçte bir asittir. Ancak midede yer alan kalın mukus tabakası, asidin mide epitellerine zarar vermesini engeller. Ancak, eğer mukus tabakası çok ince olursa veya asit çok düşük bir pH değerine sahipse, bunun sonucunda mide ekşimesi, ülser veya reflü gibi mide rahatsızlıkları görülebilmektedir] bir yandan da ayranını yudumluyordu [Ayran, yoğurdun içine su katılarak elde edilen bir tür içecektir. Yoğurt ise, süt şekerinin (laktozun), yoğurt mayasının etkisiyle kısmen laktik asit haline gelmesinden meydana gelen bir nevi pıhtılaşmış süttür. Baksa bir ifadeyle, sütten (inek sütünün pH değeri 6,4 ila 6,8 arasında farklılık gösterir) yoğurt üretiminde laktik asit (5,5 saat suresince mayalanan yoğurdun pH değeri 4,65 civarındadır) oranı artmaktadır. Laktik asit, 1780 yılında Carl Wilhelm Scheele tarafından keşfedilen, formülü CH_3CHOH-$COOH$ olan bir organik hidroksiasittir. 1881'de ticari olarak büyük ölçüde ekşimiş sütten elde edildi; bu yüzden süt asidi de denir. Laktik asit başlı başına yoğurt, ayran, kefir ve bazı peynirler gibi ekşi süt ürünlerinde mevcuttur.].

Yemekten sonra Melis ve arkadaşları çimlerin üzerine oturup çay içmeye karar verdiler [Çay doğal bir pH belirteci (indikatör)dir. Çaydan başka kırmızılâhana, gül yaprağı, kırmızı soğan kabuğu, çilek, kuşburnu, kiraz gibi doğal pH belirteçleri de çözeltinin pH değerine bağlı olarak renk değiştirme özelliğine sahiptirler. Turnusol kağıdı da pH belirtecidir ve belirteçleri ile ilgili detaylar ilerideki derslerde tartışılacaktır]. Çayın yanına bir parça kek de aldılar, Melis'in aklına annesinin yaptığı nefis kekler geldi [Kek nasıl kabarır? Neden bazı tariflerde kabartma tozu bazılarında ise karbonat kullanılır? Bu iki sorunun da cevabı asitlerin ve bazların özellikleri ve tepkimelerinde saklıdır. İyi kabarmış kek yapabilmenin sırrı ilerleyen derslerde tartışılacaktır.]. Annesini özlemişti sınav haftası biter bitmez ailesinin yanına gitmeye karar verdi. Melis çimlerde uzanırken çimlere düşen kek kırıntısını sırtına yüklemiş karıncayı seyre daldı [Formik Asit, karıncada bulunan asittir ('Formica' kelimesi Latincede karınca anlamına gelir). Doğada ilk olarak karıncaların salgılarında rastlanmış ve buradan çekilerek elde edilmiştir. Isırgan otunu da bilirsiniz, yapraklarına dokunduğunuzda eliniz bir süre sızlar; ısırgan otundaki bu yakıcı madde de formik asittir.].

Melis arkadaşlarıyla vakit geçirmekten keyif alıyordu ama eve dönüp diğer sınavlarına hazırlanması gerekiyordu. Arkadaşlarıyla vedalaşıp evin yolunu tuttu. Eve döndüğünde ev arkadaşını ağlarken buldu, ona neden üzüldüğünü sordu. Ev arkadaşı ise ona gülüyordu çünkü gözyaşlarının nedeni üzüntü değil yemek için doğradığı soğandı [Soğan doğrandığında, onu oluşturan hücreler parçalanır. Soğan hücreleri, iki bölümden oluşur; allinazlar olarak adlandırılan enzimleri ve sülfit bileşiklerinden oluşan aminoasitleri içerir. Allinazlar, sülfitleri parçalayarak sülfenik aside dönüştürür. Sülfenik asit ise, kararsız bir yapıya sahiptir ve kısa sürede uçucu bir kükürt bileşiğine dönüşür. Bu gaz, havada hızla yayılır. Bu gazı, "soğan kokusu" olarak algılarız ve bu madde gözümüze ulaştığında gözü yakan bir aside dönüşür. Başka bir ifadeyle, gözümüzü yakan bu gazın kendisi değil, onun gözyaşımızla tepkimeye girmesi sonucu ortaya çıkan sülfürik asittir. Gözümüzü nemli tutan bu gözyaşı sıvısında oluşan küçük miktardaki sülfürik asit, çok duyarlı olan göz sinirlerini uyarır. Gözümüzün bu kadar duyarlı olması, onun göze kaçan yabancı maddeleri uzaklaştırmasına yardımcı olur. Sülfürik asit de gözü tahriş eden, zararlı bir madde olduğundan, gözümüzdeki sinirlerin aldığı uyarıların tetiklemesiyle, gözyaşı bezleri daha fazla gözyaşı salgılayarak yabancı maddeleri uzaklaştırmaya çalışır. Yani, bir bakıma gözümüzü yıkayarak temizler. Gözümüze, toz ya da başka bir yabancı madde kaçtığında da benzer tepkiler ortaya çıkar. Soğan doğrarken gözümüzün yanmasını önlemek için bazı basit önlemler alabiliriz.

Yapılacak şey, tahriş edici gazın gözümüze ulaşmasını olabildiğince önlemek. Bunun için soğan doğrarken ondan olabildiğince uzak durmak alınacak en basit önlem; açık alanda veya havadar bir yerde doğramak, doğramadan önce soğanı buzdolabında soğutmak veya suda doğramak gibi önlemler alınabilir.]. Melis de salata yaparak ev arkadaşına akşam yemeğini hazırlamasına yardım etti. Maydanoz, domates, yeşilbiber, havuç, salatalık ve kırmızılâhanayı dikkatlice yıkayarak salatayı hazırladı ve beraber keyifli bir yemek yediler [Maydanoz, domates, yeşil sivri biber, ıspanak, lahana, taze fasulye, karnabahar ve patates gibi sebzelerde *askorbik asit*; limonda *sitrik asit*; alabalık, ıspanak, maydanoz, piliç eti, brokoli, lahana, böbrek, marul, muz, yumurta gibi gıdalarda *folik asit* bulunur]. Yemek sonrası bulaşıkları yıkadıktan sonra da odalarına ders çalışmaya gittiler.

İlerleyen saatlerde, Melis ev arkadaşı ile beraber elma, uzum, şeftali gibi meyvelerden oluşan bir meyve tabağını hazırladılar ve birlikte sohbet ederek yediler [Elma ve kavunda *malik asit*; limonda *sitrik asit*; üzümde *tartarik asit*; portakal, greyfurt ve mandalina gibi turunçgillerde ve şeftali, ahududu, çilek, kivi, kızılcık, böğürtlen gibi meyvelerde C vitamini olarak da bilinen *askorbik asit* bulunur.].

Günün temposundan mı bilinmez Melis başında bir ağrı hissetti, her ne kadar sıklıkla ilaç içmemeye çalışsa da bir aspirin içmesi onun baş ağrısını hafifletebilirdi [Asetilsalisilik asit, bilinen adıyla aspirinin etken maddesidir, genellikle ufak ağrı ve sızılar için kullanılan ağrıkesici ve ateş düşürücü bir ilaçtır. Aspirinin ortaya çıkması, kimyager Felix Hoffmann'ın 1897'de saf asetilsalisilik asit üretmesiyle mümkün olmuştur. Kaynağı ise dünyanın her yerinde yetişen söğüt ağacıdır. Soğut ağacının yaprak ve kabuklarından doğal olarak üretilen bitkisel ilaçlar eski çağlarda da ağrı kesici ve ateş düşürücü olarak kullanılıyordu. Hipokrat, salisilik asidin farkında olan ilk hekimlerden biridir. Bazı rahatsızlıkların tedavisi için reçetesine söğüt ağacı kabuğundan sağlanan suyu ilaç olarak yazmıştır. Suda bulunan ve ağrıyı hafifleten madde bugün bildiğimiz tanımıyla salisilik asittir. Maddenin adı ile kökeni arasında bir bağ vardır. 'Salix' kelimesi Latincede söğüt anlamına gelir.]. Melis biraz daha ders çalışmaya devam etti. Aldığı ağrı kesici yavaş yavaş etkisini göstermeye başladı, baş ağrısı hafifliyordu. Saat epey ilerlemişti artık yatması gerekiyordu, yatmadan önce her zaman yaptığı gibi bir bardak ılık sütünü içti ve dişlerini fırçaladı [İnek sütünün pH değeri 6,4 ila 6,8 arasında farklılık gösterir. Laktik asit daha çok ekşimiş sütte bulunur, sütun asitliğinin artması demek laktik asit oranının artması demek ve bu olay da sütun ekşimesidir. Süt içerdiği bol kalsiyum ve vitaminlerle birçok hastalığı önler, hatta tedavi eder. Bu yüzden uzmanlar, sağlık açısından bol miktarda süt tüketilmesini öneriyorlar. Süt, başta protein olmak üzere, içerdiği fosfor, B grubu vitaminleri ve diğer bileşikleri sayesinde kanser oluşumunu da engellemektedir.]. Melis biraz kitap okuduktan sonra uykuya daldı.

Siz gün içerisinde hangi asidik veya bazik maddelerle karşılaşıyorsunuz? Belirtiniz.
Melis'in bir günü etkinliğinde ilginizi çeken en çok ne oldu? Nedenini açıklayınız.
Etkinlik hakkında başka belirtmek istedikleriniz var mı?

F-3A. THE HISTORY OF ACID-BASE DEFINITIONS

ASİT-BAZ TANIMLARININ TARİHÇESİ

Kim Önermiştir?

Svante August Arrhenius, (1859–1927), İsveçli kimyacı ve fiziksel kimya biliminin kurucularındandır. Elektrolitlerin iletkenlikleri üzerine yaptığı çalışmalarını doktora derecesi için sundu. Profesörleri tatmin etmeyen ve en düşük notu alan bu çalışmasıyla daha sonra Nobel Kimya Ödülü'nü alacaktı. Tezinin en önemli yanı, saf tuzların veya saf suyun iletken olmadığını, oysa sudaki tuz çözeltilerinin iletken olduklarını açıklamasıydı. Arrhenius'un açıklamasına göre tuzlar, çözelti oluşturduklarında, yüklü parçacıklara parçalanıyorlardı. Faraday bunlara iyon adını vererek iyonların elektroliz prosesi sonucu ortaya çıkacaklarını düşünmesine rağmen, Arrhenius, elektrik akımı olmadan da tuz çözeltilerinin iyon içerebileceğini öneriyordu. Bu nedenle, çözeltilerdeki kimyasal reaksiyonların, iyonlar arasındaki reaksiyonlar olduğunu ileri sürüyordu. Bu teori, zayıf elektrolitler için bugün hala geçerlidir, fakat kuvvetli elektrolitlerin davranışlarını da bu teori kapsamına almak için Peter J. W. Debye ve Erich Hückel'in teoride bazı değişiklikler yapması gerekmiştir.

Asit-Baz Tanımı

Arrhenius Asit-Baz Tanımı

1887'de Svante Arrhenius, sulu bir çözeltide iyonun var olduğu kuramını açıklarken, asit çözeltilerinin H^+ iyonları, baz çözeltilerinin de OH^- iyonlarını içerdiğini belirtmişti.
Bu teoriye göre:

ASIT: Suya H^+ iyonu veren maddeler.
BAZ: Suya OH^- iyonu veren maddeler.

Örnekler:

$$HCl_{(aq)} \rightarrow H^+ + Cl^-$$
Suya H^+ iyonu verir

$$H_2S_{(aq)} \rightarrow H^+ + Cl^-$$
Suya H^+ iyonu verir

$$NaOH_{(s)} \rightarrow Na^+ + OH^-$$
Suya OH^- iyonu verir

$$NH_{3(aq)} \rightarrow NH_4^+ + OH^-$$
Suya OH^- iyonu verir

Arrhenius Asit-Baz Tanımının Yetersiz Kaldığı Durum:

Üç Asit-Baz tanımları içerisinde en sınırlı olandır; çünkü tepkimelerin suda gerçekleşmesi ve suya H^+ veya OH^- iyonu vermeleri gerekmektedir.

Hidroklorik asit hem sodyum hidroksit çözeltisi (NaOH) ile hem de amonyak (NH_3) çözeltisi ile nötrleşme tepkimesi verir. Her iki durumda da, renksiz bir çözelti elde edilir ve iki çözeltiden de kristalleşme sonucunda beyaz bir tuz olan sodyum klorür veya amonyum klorür elde edilir. Bu iki tepkime de benzer tepkimelerdir:

$$NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

$$NH_{3(aq)} + HCl_{(aq)} \rightarrow NH_4Cl_{(aq)}$$

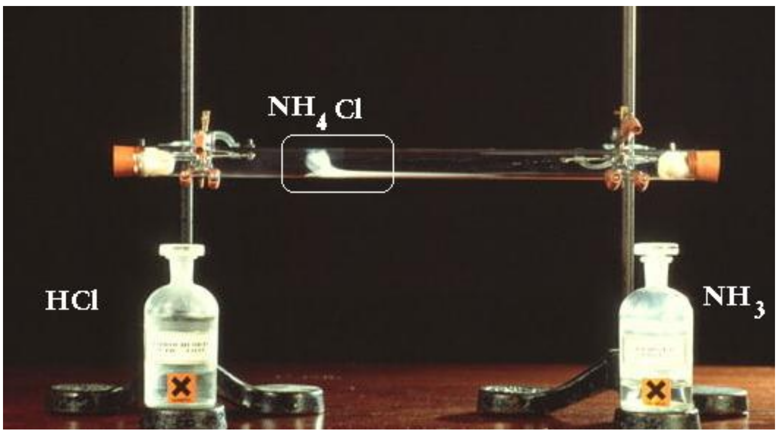
- Sodyum hidroksit (NaOH) ile olan tepkimede, hidroklorik asitten gelen hidrojen iyonları ile sodyum hidroksitten gelen hidroksit iyonları ile tepkimeye girer ve Arrhenius'un teorisini doğrular.
- Fakat amonyak (NH_3) ile gerçekleşen tepkimede, ortamda hidroksit iyonları bulunmamaktadır! Bu durumda amonyak'ın su ile tepkimesinden amonyum iyonlarını veya hidroksit iyonlarını oluşturduğunu düşünebilirsiniz:

$$NH_{3(aq)} + H_2O_{(l)} \leftrightarrow NH_4^+{}_{(aq)} + OH^-{}_{(aq)}$$

Bu tersinir (çift yönlü) bir tepkimedir ve tipik bir amonyak çözeltisinde, amonyak %99 oranında amonyak molekülleri olarak bulunur. Buna rağmen, ortamda bulunan hidroksit iyonlarından (OH-) dolayı Arrhenius teorisini destekler diyebilirsiniz. Fakat aynı tepkime, amonyak gazı ve hidroklorik asit gazı arasında susuz ortamda da gerçekleşir:

$$NH_{3(g)} + HCl_{(g)} \rightarrow NH_4Cl_{(g)}$$

Aşağıdaki resimde büretin sol ucunda HCl damlatılmış pamuk, sağ ucunda ise NH_3 damlatılmış pamuk görüyorsunuz. Susuz ortamda gerçekleşen bu tepkimenin ürünü NH_4Cl dikdörtgen içine alınmıştır.



Bu tepkimede, ortamda ne hidrojen iyonları ne de hidroksit iyonları vardır, çünkü tepkime çözelti içerisinde gerçekleşmez. Arrhenius'un teorisine göre bu tepkime asit – baz tepkimesi değildir. Fakat iki madde de çözelti içerisinde olduğunda aynı ürünü oluşturduğunu biliyoruz.

Aynı yıl içerisinde Johannes Bronsted ve Thomas Lowry birbirlerinden bağımsız olarak bu ihtiyaca bir öneri sunmuşlardır.

Kim Önermiştir?

1923 yılında Danimarkalı **Johannes Bronsted** (1879–1947) ve İngiliz **Thomas Lowry** (1874–1936) birbirlerinden haberleri olmadan aynı konu üzerinde bağımsız makaleler yayımladılar. Asit ve bazların davranışlarına ilişkin daha genel bir tanım önerdiler.
Bronted – Lowry, Arrhenuis'un teorisine karşı çıkmamışlardır sadece onun tanımına ilave yapmışlardır.

Asit-Baz Tanımı

Bronsted/Lowry Asit-Baz Tanımı

Arrhenius'un teorisinden farklı olarak, Bronsted ve Lowry'nin yaptıkları asit-baz tanımı sadece sulu çözeltileri içermemektedir, sulu çözeltilere ilaveten proton içeren bütün sistemleri kapsamaktadır.
Bu teoriye göre:

ASIT: Proton (H^+) veren maddedir.
BAZ: Proton alan maddedir.

Asitler çözeltide hidrojen iyonu oluştururlar çünkü verdikleri protonlar su molekülleri ile tepkimeye girer.

$$H_2O_{(s)} + HCl_{(aq)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$$

baz asit
(proton alır) (proton verir)

Proton vericinin olduğu ortamda mutlaka proton alıcı bir maddede eşlik etmelidir. Bir asit protonunu verdiği zaman **konjuge baz**, bir baz protonu aldığı zaman da **konjuge asit** olur.
Arrhenius asit-baz tepkimelerinde de hidrojen iyonu transferi olduğu için bütün Arrhenuis asit-baz tepkimeleri aynı zamanda Bronsted/Lowry asit-baz tepkimeleridir.
Çözelti ortamında gerçekleşen tepkimede, amonyak sudaki protonu alır:

$$NH_{3(aq)} + H_2O_{(l)} \leftrightarrow NH_4^+{}_{(aq)} + OH^-_{(aq)}$$

baz asit konjuge asit konjuge baz

Yukarıda verilen iki tepkime de su (H_2O) ile gerçekleşmiştir, su HCl ile olan tepkimesinde *baz*, NH_3 ile olan tepkimesinde ise *asit* olarak davranmıştır. Böylelikle, asit – baz tepkimelerinde maddeler karşısındaki maddeye göre farklı davranış gösterebilirler. Bu şekilde hem asit hem de baz olarak davranan maddelere anfoter denir.

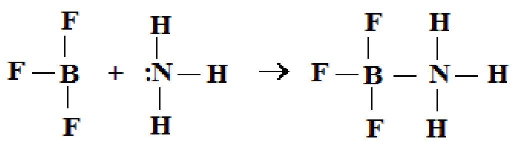
Fakat tepkimeler susuz ortamda gerçekleşiyorsa (yukarıda resmedilen deney örneğinde olduğu gibi) Arrhenius'un asit–baz teorisi yerine Bronsted/Lowry asit–baz teorisiyle açıklanır:
Örneğin, hidroklorik asit ve amonyak tepkimesinin gaz ortamında oluşmasında amonyak hidrojen klorürdeki protonu alır:

$$HCl_{(g)} + NH_{3(g)} \rightarrow NH_4^+ + Cl^-$$

asit	baz	konjuge asit	konjuge baz

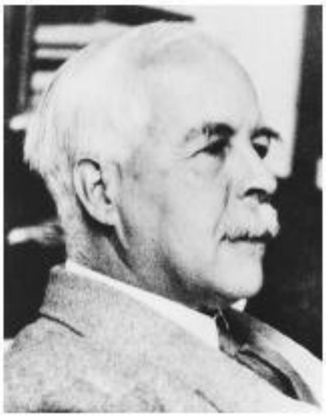
Böylelikle, Bronsted/Lowry, Arrhenuis'un asit-baz tanımını proton (H^+) transferi olarak genişletmiştir (Bu tanım sulu ortam gerektirmemektedir).

<u>Bronsted/Lowry Asit-Baz Tanımının Yetersiz Kaldığı Durum:</u>
Arrhenuis'un asit-baz teorisi asit-bazların susuz ortamdaki davranışlarını açıklayamadığı gibi, Bronsted-Lowry'nin asit-baz teorisi de **ortamda proton transferinde bulunmayan sistemleri açıklayamamaktadır.**
Örneğin, amonyak (NH_3) bortriflorür (BF_3) ile tepkimeye girer ve bir ürün oluşur. Ne Arrhenius'un asit-baz teorisi ne de Bronsted-Lowry'nin asit-baz teorisi aşağıda verilen tepkimeyi açıklayabilmektedir:



Gilbert Lewis bu ihtiyaca başka bir öneri sunmuştur.

Kim Önermiştir?



Gilbert Lewis (1875-1946), Amerikalı kimyagerin kimyasal bağlar hakkında çalışmaları bulunmaktadır. Lewis, yaşamının büyük bir kısmını, moleküllerin yapısı ve kimyasal değişmelerdeki enerji değişmelerini anlamak için harcamıştır. Zamanına göre ileri bir düşünce tarzına sahiptir ve kimya bilimine derin katkıları olmuştur. Kimyasal bağlar hakkındaki modern düşünceleri, bu konunun kapsamını büyük ölçüde etkilemiştir. Lewis, enerji değişiminin, bir kimyasal tepkimenin olup olmayacağını önceden bilmeye olanak tanıdığını ilk anlayanlardandır.

Asit-Baz Tanımı

Lewis Asit-Baz Tanımı

Lewis daha önceki asit-baz teorilerine karşı çıkmamış desteklemiştir; başka bir ifadeyle var olan Arrhenius ve Bronsted/Lowry teorilerini daha da genişletmiştir. Genişletmekten kasıt ise, bütün Arrhenius asit-baz tepkimeleri ve Bronsted/Lowry asit-baz tepkimeleri aynı zamanda Lewis asit-baz teorisiyle de açıklanabilmektedir.
Bu teoriye göre:

ASIT: Yeni bir bağ oluşturmak için başka bir atomdan elektron çifti alan maddedir.
BAZ: Yeni bir bağ oluşturmak için başka bir atoma elektron çifti veren maddedir.

Aşağıda verilen amonyak tepkimesi ne Arrhenius ne de Bronsted-Lowry asit-baz teorileri ile açıklanabilmektedir. Fakat Lewis asit–baz tanımını genişleterek, yapılarında hidrojen olmasa bile birçok maddenin tepkimesini asit-baz tepkimesi olarak açıklayabilmiştir:

F_3B + $:NH_3$ $\rightarrow$ $F_3B:NH_3$
asit baz
(e^- çifti alan) (e^-çifti veren)

Diğer örnekler:

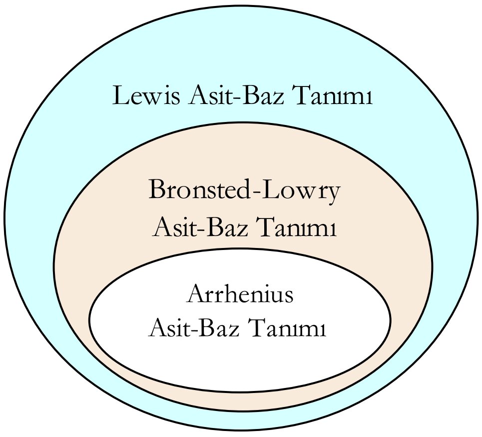
$\mathbf{H^+ + :\ddot{\underset{..}{O}}H^- \rightarrow H\text{-}O\text{-}H}$
asit baz

$SnCl_4 + Cl^- \rightarrow SnCl_6^{-2}$
asit baz

Lewis Asit-Baz Tanımının Özelliği

En kapsamlı asit-baz tanımıdır.

Lewis asit-baz teorisi, hem Arhenius asit-baz tanımını hem de Bronsted-Lowry asit-baz tanımını kapsamaktadır.
Bu üç asit-baz teorilerini şematik gösterimi yandaki gibi olabilir:



F-3B. THE GAME OF THE HISTORY OF ACID-BASE DEFINITIONS

Asit – Baz Tanımlarının Tarihçesi Oyunu

Asit-Baz tanımlarının tarihçesini anlatan metin ile ilgili aşağıda 12 adet soru bulunmaktadır. Arkadaşların ellerindeki metinlere göz atmadan senin sorduğun sorulara cevap vereceklerdir. Belirli bir düzende oturan arkadaşlarına aşağıdaki soruları yöneltecek ve herkese eşit soru soracaksın. Sorusunu bilemeyen grup arkadaşının sorusunu diğer grup arkadaşlarına sırasıyla sorabilirsin, soruyu bilen puan kazanır. Hiç kimse o sorunun yanıtını doğru bir şekilde veremezse sorular bitiminde grup arkadaşlarınızla beraber elinizdeki metne göz gezdirerek doğru cevabı bulmaya çalışın; eğer ki doğru cevabı bulmada problem yaşarsanız öğretmeninizden yardım isteyiniz.

Sorduğun soruyu bilen her arkadaşınıza bir puan veriniz. En yüksek puan alan grup arkadaşınız ODTÜ amblemli bir kalem ve bir not defteri kazanacaktır.

Kolay gelsin! Başarılar!

Sorulacak Sorular	**Cevaplayan Kişi**	**Aldığı Puan**
▪ Asit – Baz Teorilerinin tarihsel gelişim sırası nasıldır?		
▪ Arrhenius Asit – Baz Teorisini kim önermiştir?		
▪ Bronsted-Lowry Asit – Baz Teorisini kim önermiştir?		
▪ Lewis Acid-Base Teorisini Asit – Baz Teorisini kim önermiştir?		

▪ Arrhenius'a göre asit ve baz nedir?	
▪ Bronsted-Lowry'e göre asit ve baz nedir?	
▪ Lewis'e göre asit ve baz nedir?	
▪ Arrhenius Asit – Baz Teorisinin desteklediği bir asit-baz tepkimesi örnek vererek açıklayabilir misin?	
▪ Bronsted-Lowry Asit – Baz Teorisinin desteklediği bir asit-baz tepkimesi örnek vererek açıklayabilir misin?	
▪ Lewis Asit – Baz Teorisinin desteklediği bir asit-baz tepkimesi örnek vererek açıklayabilir misin?	
▪ Arrhenius Asit – Baz Teorisi neden bütün asit-baz tepkimelerini kapsamaz?	
▪ Bronsted-Lowry Asit – Baz Teorisi neden bütün asit-baz tepkimelerini kapsamaz?	
Toplam	

F-3C. WHICH ACID-BASE DEFINITION?

HANGİ ASİT-BAZ TANIMI?

Aşağıda verilen tepkimeler hangi asit-baz tanımı/tanımları ile açıklanabilir? Grup arkadaşlarınızla tartışarak nedenleriyle beraber açıklayınız.

Tepkime	**Açıklayan Tanım**	**Neden?**
$HI + H_2O \rightarrow H_3O^+ + I^-$		
$HI + NH_3 \rightarrow NH_4^+ + I^-$		
$H_2O \rightarrow H^+ + OH^-$		
$H^+ + NH_3 \rightarrow NH_4^+$		
$I_2 + NH_3 \rightarrow NH_3I^+ + I^-$		

F-4. THE MAGIC OF RED CABBAGE

KIRMIZI LAHANANIN SIHRI

Evinizden getirdiğiniz ve istediğiniz en az üç malzemeyi seçiniz. Malzemenin asidik veya bazikliğini test etmeden önce tahmininizi aşağıdaki tabloya yazınız. Her bir malzemeyi turnusol, kırmızı lahana ve indikatör kağıdı ile test ediniz. Test sonuçlarına göre malzemenizin asidik veya bazikliğini tartışarak not ediniz. Mor lahana ve indikatör kağıdının renklerini yorumlamak için kırmızı lahana pH skalasını ve indikatör kağıdı pH skalasını dikkatlice inceleyiniz.

Bütün malzemelerinizi test ettikten sonra tahtaya asılmış olan postere grup sonuçlarınızı yazmayı unutmayın ve sizinle aynı malzemeleri kullanmış olan grup arkadaşlarınızla sonuçlarınızı karsılaştırın.

Madde	Tahmin	Turnusol Kağıdı	Kırmızılahana Kağıdı	İndikatör Kağıdı	Asidik? Bazik?

F-5. THE STRENGHT OF ACIDS

ASITLERIN KUVVETI

Etkinliğin Amacı:

Aynı derişime sahip iki farklı asidik çözeltinin kuvvetliliklerini incelemek.

Aynı derişimdeki iki farklı asidik çözeltinin aynı miktar magnezyum metali ile tepkimesi sonucunda oluşan ürün miktarlarında değişiklik gözlenir mi?

Etkinliğin gerçekleştirilmesi:

Elinizdeki malzemelerle asidik çözeltilerin özelliklerini incelemek amacıyla aşağıdaki deneyi grup arkadaşlarınızla gerçekleştiriniz. Arkadaşlarınızla tablodaki soruları tartışarak gözlem ve sonuçlarınızı yazınız.

- Magnezyum metalinden eşit miktarlarda olacak şekilde balonlara yerleştiriniz.
- Elinizde iki adet erlen bulunmaktadır. Bu iki erlende aynı derişim ve hacimde iki farklı çözelti bulunmaktadır; çözeltilerden biri hidroklorik asit diğeri de asetik asit çözeltisidir. Balonlardan birini asetik asit (CH_3COOH) çözeltisinin, diğerini de hidroklorik asit (HCl) çözeltisinin bulunduğu erlenin ağzına tutturunuz.
- Aşağıdaki soru-cevap tablosuna tepkimeleri başlatmadan önce erlenlerdeki maddeleri göz önüne alarak deney öncesi düşüncelerinizi belirtiniz.
- Aynı anda magnezyum metalinin çözeltinin içerisine düşmesini sağlayarak tepkimeyi başlatınız ve gözlemleyiniz.

Sorular	Cevaplar
<u>Tepkimeyi başlatmadan önce:</u> Balonlarda bir değişiklik olacağını düşünüyor musunuz? Açıklayınız. Gerçekleşecek tepkimelerde iki erlen arasında bir fark gözlemeyi bekliyor musunuz? Nedenini açıklayınız?	
1. Erlen için:	
Kullandığınız çözelti, molaritesi ve pH değeri nedir?	
Kullandığınız metal	
Oluşan tepkimeyi yazınız	
2. Erlen için:	
Kullandığınız çözelti, molaritesi ve pH değeri nedir?	
Kullandığınız metal	
Oluşan tepkimeyi yazınız	
<u>Tepkimeyi gerçekleştirdikten sonra:</u> Gerçekleşen bu iki tepkime arasında bir fark gözlemlediniz mi? Açıklayınız? Aynı derişim ve hacimde bulunan çözeltilere, aynı miktarda magnezyum metali eklendiğine göre, balonların şişkinlik oranı beklediğinizden farklı oldu mu? Asetik asit ve hidroklorik asit arasındaki fark nedir? Grup arkadaşlarınızla tartışınız ve açıklayınız.	

F-6. WHAT IS THE DIFFERENCE BETWEEN A STRONG ACID AND A WEAK ACID?

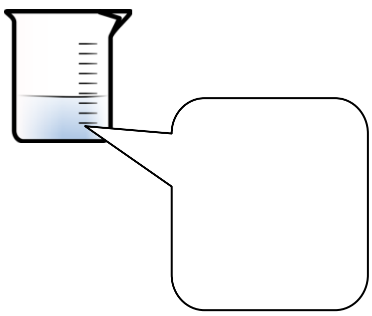
Kuvvetli Asit – Zayıf Asit arasında ne fark vardır?

Aşağıda dört farklı durum anlatılmaktadır. Her bir durumu önce bireysel daha sonra da grup arkadaşlarınızla değerlendirin, çözeltileri tanecik boyutunda nasıl görürdünüz resmediniz. Kutucuklardaki soruları arkadaşlarınızla tartışarak cevaplayınız.

<u>I. durum:</u>

Bu beherde kuvvetli bir asit olan 1M hidroklorik asit (HCl) çözeltisinden 100 mL bulunmaktadır. Bu çözeltiden bir kesit alındığında çözelti içerisindeki HCl taneciklerini nasıl görürdünüz? Dairenin içine resmediniz (Daha sade bir çizim için su moleküllerini resmetmeyiniz).

1M HCl

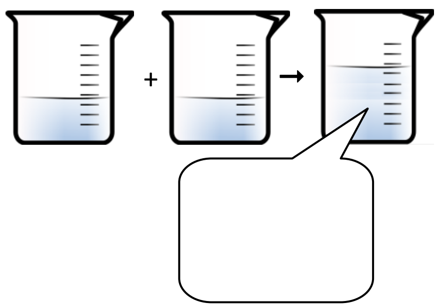


Yukarıdaki çiziminizi açıklayınız:

<u>II. durum:</u>

Kuvvetli bir asit olan 1M'lik 100 mL HCl çözeltisine 100 mL saf su ilave edilmektedir. Oluşan çözeltinin derişimi ne olur? Çözeltiden bir kesit alındığında çözelti içerisindeki HCl taneciklerini nasıl görürdünüz? Dairenin içine resmediniz (Daha sade bir çizim için su moleküllerini resmetmeyiniz).

1M HCl   Saf Su   ? M



Son çözeltinin derişimi:

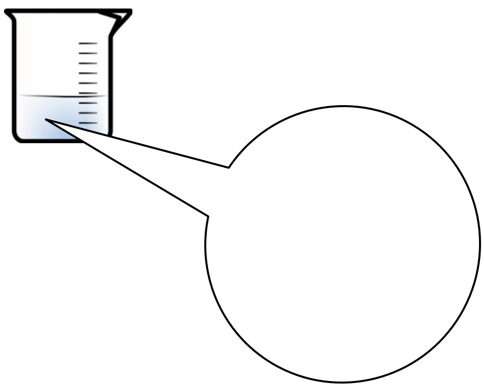
Yukarıdaki çiziminizi açıklayınız:

Yukarıdaki çizimin I. Durumdan benzerliğini/farkını açıklayınız:

III. durum:

Bu beherde zayıf bir asit olan 1M hidroflorik asit (HF) çözeltisinden 100 mL bulunmaktadır. Bu çözeltiden bir kesit alındığında çözelti içerisindeki HF taneciklerini nasıl görürdünüz? Dairenin içine resmediniz (Daha sade bir çizim için su moleküllerini resmetmeyiniz).

1M HF

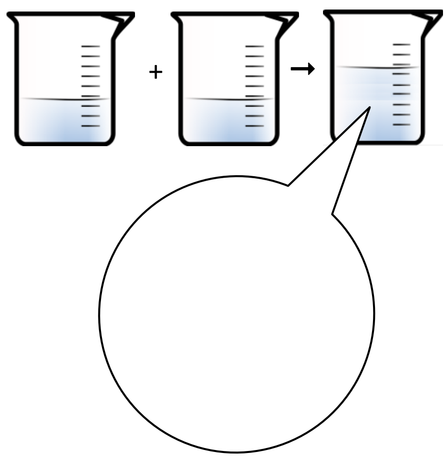


Yukarıdaki çizimin I. durumdan benzerliğini/farkını açıklayınız:

IV. durum:

Zayıf bir asit olan 1M'lik 100 mL HF çözeltisine 100 mL saf su ilave edilmektedir. Oluşan çözeltinin derişimi kaç olur? Çözeltiden bir kesit alındığında çözelti içerisindeki HF taneciklerini nasıl görürdünüz? Dairenin içine resmediniz (Daha sade bir çizim için su moleküllerini resmetmeyiniz).

1M HF Saf Su ? M



Yukarıdaki çizimin III. durumdan benzerliğini/farkını açıklayınız:

Yukarıdaki çizimin II. Durumdan benzerliğini/farkını açıklayınız:

F-7. WHAT IS NEUTRALISATION?

NÖTRLEŞME NEDİR?

Etkinliğin amacı:

Nötrleşme tepkimesini kırmızılahana suyu ortamında gözlemek.
Nötrleşme kavramını tanecik boyutunda tartışmak.

Etkinliğin gerçekleştirilmesi:

Asidik bir maddenin ve bazik bir maddeyle tepkimesini gözlemleyeceğiniz etkinliğin malzemelerini grup arkadaşlarınızla beraber kontrol ediniz. Elinizde iki adet damlalık bulunmaktadır; birisinin içerisinde seyreltik hidroklorik asit (HCl) çözeltisi diğerinde ise seyreltik sodyum hidroksit ($NaOH$) çözeltisi bulunmaktadır. Bir beherde de kırmızılahana suyu bulunmaktadır.

Etkinliği gerçekleştirmeden önce aşağıdaki soruları grup arkadaşlarınızla yanıtlayınız.

- HCl çözeltisi asidik mi bazik midir? Neden?
- $NaOH$ çözeltisi asidik mi bazik midir? Neden?
- Kırmızılahana suyu asidik bir madde varlığında hangi rengi alır?
- Kırmızılahana suyu bazik bir madde varlığında hangi rengi alır?

Güvenliğiniz için: Laboratuarda kullandığınız hiçbir maddenin tadına bakmayınız – Etkinlikte kullandığınız çözeltiler seyreltilmiş olmalarına rağmen kuvvetli asit ve baz çözeltileridir. Gözlerinizi koruyunuz!

Elinizde bulunan kırmızılahana suyu bulunan behere rengi değişinceye kadar birkaç damla hidroklorik asit çözeltisi damlatınız (10 damla kadar). Gözlemlediğiniz rengi aşağıdaki tabloya not ediniz.

Daha sonra aynı behere yavaş yavaş sodyum hidroksit çözeltisi damlatınız. Kırmızılahana suyundaki değişimleri kaç damla kullandığınızı da belirterek aşağıdaki tabloya not ediniz.

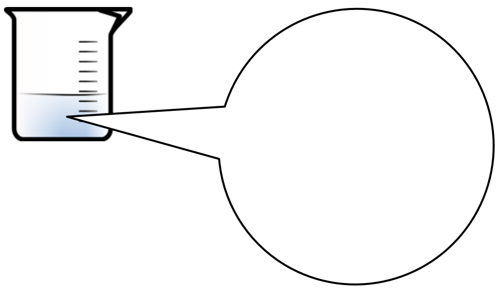
- Kırmızılahana suyu asit ortamında hangi rengi almıştır?
- Kırmızılahana suyu + asidik çözelti bulunan behere:
  - ____ damla eklendiğinde rengi:
  - ____ damla eklendiğinde rengi:
  - ____ damla eklendiğinde rengi:
  - ____ damla eklendiğinde rengi:
- Kırmızılahana suyunda neden bazik madde eklendikçe renk değişimi gözlendi, grup arkadaşlarınızla bu durumu tartışınız. Tartışma sonucunuzu belirtiniz.

Hidroklorik asit ve sodyum hidroksit çözeltisi arasındaki tepkimeyi yazınız:

$HCl + NaOH \rightarrow$

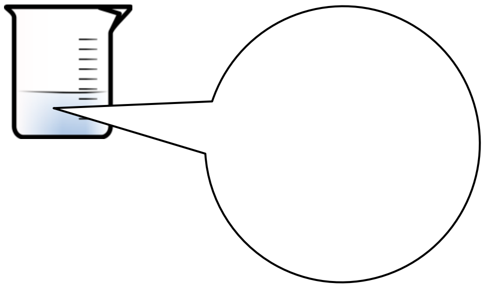
Kırmızılahana suyunda gerçeklesen tepkimeyi tanecik boyutunda düşünürsek, aşağıdaki durumları göz önüne alarak kesit çizimlerinizi gerçekleştiriniz (Çizimlerinizin daha sade olması açısından, ortamdaki kırmızılahana ile ilgili tanecikleri göz önüne almayınız, sadece asidik, bazik ve tepkime sonucu oluşan maddeleri düşünerek çizimleriniz gerçekleştiriniz).

Sadece HCl çözeltisi durumu:



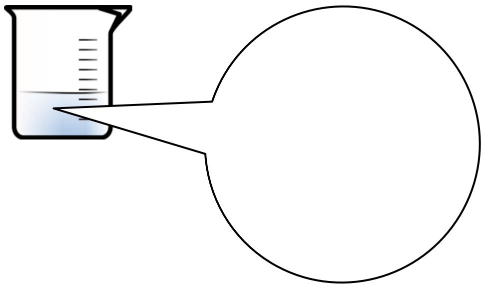
Açıklayınız:

Birkaç damla NaOH ilave edilmesi durumu:



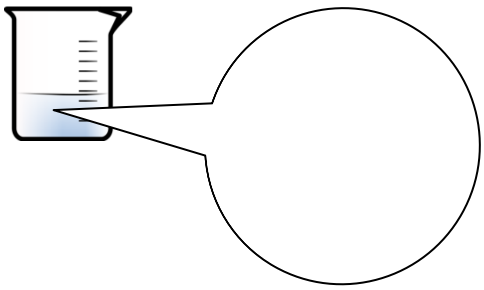
Açıklayınız:

Nötrleşme durumu:



Açıklayınız:

Daha fazla bazik madde ilave edilmesi durumu:



Açıklayınız:

F-8. HOW A CAKE RISE?

KEK NASIL KABARIR?

<u>Etkinliğin amacı:</u>

Karbonatın nötrleşme tepkimesini gözlemlemek.

Etkinliğin gerçekleştirilmesi:

Her bir grup aktiviteyi gerçekleştirmek için malzeme kutusunda bir paket kabartma tozu, bir paket karbonat (yemek sodası, $NaHCO_3$) ve miktar sirke (CH_3COOH) bulacaktır.

Aktiviteyi gerçekleştirmeden önce aşağıdaki soruları grup arkadaşlarınızla yanıtlayınız.

- Karbonat paketinin arkasında içindekiler kısmında ne yazıyor?
- Karbonat asidik bir madde mi yoksa bazik bir madde midir? Emin olmak için mor lahana pH kağıdı ve turnusol kağıdı ile test yapabilirsiniz.
- Kabartma tozu paketinin arkasında içindekiler kısmında ne yazıyor?
- Kabartma tozu asidik bir madde mi yoksa bazik bir madde midir? Emin olmak için mor lahana pH kağıdı ve turnusol kağıdı ile test yapabilirsiniz.

Bir behere iki kaşık karbonat, başka bir behere de iki kaşık kabartma tozu ekleyin. Her iki behere de aynı miktar su ilavesi yaptıktan sonra gözlemlerinizi yazınız.

- Karbonat içeren beherde herhangi bir değişiklik gözlemlediniz mi?

- Kabartma tozu içeren beherde herhangi bir değişiklik gözlemlediniz mi?

- Bu farkın sebebini tartışınız ve sonucunuzu buraya belirtiniz.

Başka bir behere yine iki kaşık karbonat ekleyin ve bir miktar sirke ilave ettikten sonra gözlemlerinizi yazınız.

- Karbonat ile sirkeyi karıştırdıktan sonra herhangi bir değişiklik gözlemlediniz mi?

- Oluşan tepkimesi yazınız.

APPENDIX G

TEACHER HANDOUTS

G-1A. ACIDS AND BASES IN DAILY LIFE

HAYATIMIZDAKİ ASİTLER VE BAZLAR

Etkinlik: Asidik ve Bazik Maddeleri Tanıyor Muyuz?

Konu: Asitler ve Bazlar ünitesine giriş

1. Günlük hayatımızda asitler veya bazlarla karsılaşıyor muyuz?
2. Asit denince aklımıza ne geliyor?
3. Baz denince aklımıza ne geliyor?

Kazanımlar:

Bilişsel Kazanımlar:

- Günlük hayatta birçok asidik maddelerle karsılaştığını fark eder.
- Günlük hayatta birçok bazik maddelerle karsılaştığını fark eder.

Süre: 1 ders saati

Dersin İşlenişi:

- Öğrencilere asitler ve bazlar hakkında ne bildiklerini ve ne de öğrenmek istediklerini sorgulayan bir form dağıtılır ve gerekli bilgileri yazmaları istenir (10 dk).
  - Bu etkinlikte amaç, öğrencilerin zaman içerisinde nasıl ilerleme kaydettiklerini farkına varmalarını sağlamaktır. Zaman ilerledikçe asitler ve bazlar ünitesindeki konuları öğrendiğini fark eden öğrenci kimya dersini öğrenmeye daha motive olacaktır. Bu etkinlik, koşullara göre bir önceki "Kimyasal Denge" ünitesinin son kısmında, son dersin sonunda uygulanabilir aksi takdirde "Asitler ve Bazlar" ünitesinin ilk dersinde uygulanacaktır.

- Öğretmen, öğrencilere günlük hayatta asidik veya bazik maddelerle karsılaşıp karsılaşmadıklarına dair sorular sorar ve öğrencilerin fikirlerini alır. Fikirlerini belirten öğrencilere ne tür asitler veya bazlarla karsılaştıkları sorulur (5 dk).
    - Burada amaç, asitler ve bazlar ünitesine giriş yapmak ve bu ünite sonunda öğrencilerin ne öğreneceklerinin farkına varmalarını sağlamaktır. Bunun yanında, öğretmen sorular sorarak asitler ve bazlar konusunda öğrencilerin ön bilgilerini de sorgular. Öğrenciler, ortaokul bilgilerinden molekül formüllerinde hidrojen içeren maddelerin asidik ve hidroksit iyonu içeren maddelerin bazik olduğunu, asidik maddelerin turnusol kağıdını kırmızıya ve bazik maddelerin turnusol kağıdını maviye çevirdiğini bilir.
- Öğrenciler gruplara ayrılır ve her ders aynı grup arkadaşları ile oturacakları belirtilir (5 dk).
- 'Melis'in Bir Günü' etkinlik belgesi her bir öğrenciye verilir ve üniversiteye giden bir kızın günü hakkında bilgi veren bu etkinlik belgesini okumaları istenir (5 dk).
    - Bu etkinlikte amaç, öğrencilerin genellikle zararlı olarak bildikleri asidik veya bazik maddelerin günlük hayatimizin içinde olduklarının üzerinde durmak ve öğrencilerin bu maddeleri farkına varmalarını sağlamak. Böylece, öğrencilerin öğrendikleri kimyanın gün içerisinde kendilerine faydası olacağının farkına varmalarını sağlayarak, kimya dersine yönelik öğrencilerin ilgilerini ve motivasyonlarını arttırmak hedeflenmiştir.
- Etkinlik kağıdını okumayı tamamlayan öğrenciler, öncelikle hangi maddelerin asidik veya bazik olabileceklerine dair kendi fikirlerini etkinlik kağıdına yazarlar. Daha sonra da, grup arkadaşları ile tartışarak ortak fikirlerini yazarlar (10 dk).
- Öğretmen metin içerisinde asidik veya bazik maddeleri bulmakta zorlanıp zorlanmadıklarını sorar. Maddelerin asidik veya bazik olduğuna nasıl karar vereceklerini ünite boyunca öğreneceklerini ifade eder. Bazı durumlarda bilim insanlarının da sınıflama yapmakta zorlandıklarını belirterek, neden sınıflamaya yapmaya ihtiyaç vardır sorusunu öğrencilere yöneltir (5 dk).

- Öğrencilere yardımcı olmak için köpek denince akıllarına ne geldiği sorulur. Öğrenciler köpeklerin özelliklerini belirtirler. Benzer şekilde, asit veya baz denince akıllarında belirli özelliklerin çağrışması sınıflamanın getirdiği kolaylıklardan biri olduğu belirtilir. İlerleyen derslerde, asitler ve bazlar hakkında birçok özellik öğrenecekleri belirtilerek öğrenciler motive edilir.

- Öğretmen, ders sonunda öğrencilere metin içerisinde karşılaştıkları maddelerden merak ettiği en az üçünün eve gittiklerinde arkalarında var olan tanımları incelemelerini ve içerdiği maddelere bakarak asitliği veya bazlığı hakkında karar vermelerini belirtti. Özellikle kararsız kaldıkları malzemeleri bir sonraki derse getirebileceklerini söyledi.

G – 1B. ACIDS AND BASES IN DAILY LIFE

HAYATIMIZDAKİ ASİTLER VE BAZLAR

Etkinlik: Asidik ve Bazik Maddeleri Tanıyor Muyuz?

Konu: Asitler ve Bazlar ünitesine giriş

1. Günlük hayatımızda asitler veya bazlarla karsılaşıyor muyuz?
2. Asidik maddeleri nasıl tanıyabiliriz?
3. Bazik maddeleri nasıl tanıyabiliriz?

Kazanımlar:

Bilişsel Kazanımlar:

- Günlük hayatta birçok asidik maddelerle karsılaştığını fark eder.
- Turnusol kağıdının renk değişikliğinin ne anlama geldiğini açıklar
- Asidik maddeleri turnusol kağıdı yardımıyla tanır.
- Bazik maddeleri turnusol kağıdı yardımıyla tanır.
- Günlük hayatta birçok bazik maddelerle karsılaştığını fark eder.

Duyuşsal Kazanımlar:

- Birçok asidik ve bazik maddenin çevresinde olduğunu kabul etme
- Çevresindeki birçok asidik ve bazik maddeye ile ilgilenme
- Arkadaşlarıyla birlikte öğrenme etkinliğine katılma

Psikomotor Kazanımlar:

- Çevresinde karşılaştığı birçok maddenin asitliğini veya bazikliğini turnusol kağıdı ile test eder.
- Deney sonuçlarını rapor eder.

Süre: 1 ders saati

Dersin İşlenişi:

- Öğretmen, bir önceki ders, "Melis'in Bir Günü" etkinliğini tamamlayan öğrencilere onların gün içerisinde asidik veya bazik maddelerle karşılaşıp karşılaşmadıklarını sorarak ve öğrencilerin fikirleri alınır (5 dk).
    - Öğretmen, yanlış da olsa öğrencilerin fikirlerine müdahalede bulunmaz. Ünite boyunca öğrenciler yapacakları etkinliklerde fikirlerinin doğru olup olmadıklarını sınayacaklardır.

- "Melis'in Bir Günü" etkinliğinin sonucunda öğrencilerin verdikleri yanıtlar doğrultusunda öğrencilerin hangi maddeleri test edeceklerini belirleyip derse bu malzemeler hazırlanacaktır.
  - Bu seçimde dikkat edilmesi gereken öğrencilerin kararsız kaldıkları veya hatalı düşündükleri malzemeleri test etmelerini sağlamaktır. Dolayısıyla, etkinlik sonucundan yararlanarak öğrencilerin hataya düştükleri veya kararsız kaldıkları malzemeleri sınıf ortamına getirilir (Öğrencilerin test edebileceği maddelerden bazıları: limon, sirke, kola, gazoz, üzüm suyu, maden suyu, elma, portakal, sabun, cam silmek için kullanılan deterjan, kabartma tozu, karbonat, süt, su, ayran, aspirin, mide ilacı, vb).
- Öğretmen, evlerindeki araştırma sonuçlarını sorar. Onları buldukları sonuçları söylemeye teşvik ederek arkadaşlarıyla paylaşmalarını ister (5 dk).
  - Burada amaç, öğrencilerin çevresindeki malzemelere karşı duyarlığını arttırmak ve ev içerisinde karşılaştıkları malzemelerin asitliği ve bazlığı hakkında merak uyandırmalarını sağlamaktır.
- Öğretmen, öğrencilerin etkinlik sonuçlarını sınıfa duyurur. Hatalı veya kararsız kaldıkları malzemeleri belirtir. Öğretmen ünite boyunca bu malzemeleri kullanacaklarını ve öğrencilere test ederek bu maddelerin asitliğine veya bazlığına karar verebileceklerini söyler (5 dk).
  - Burada amaç, öğrencilerin hatalı veya kararsız kaldıkları durumları kendileri test ederek öğrenmelerinin daha kalıcı olmalarını sağlamaktır.
- Öğretmen, maddelerin asidik mi bazik mi olduklarının nasıl tespit edilebileceğini sorarak öğrencilerin düşüncelerini alır (5 dk).
  - Öğrenciler, ilköğretim ikinci kademedeki fen ve teknoloji dersinden asidik maddelerin turnusol kağıdını kırmızıya ve bazik maddelerin de maviye çevirdiğini bilirler. Turnusol kağıdı cevabını öğrencilerde almaya çalışarak bir maddenin asidik mi bazik mi olduğuna karar vermede turnusol kağıdı kullanılabilir ifadesine sahip olup olmadıkları sorgulanır. Böylelikle, öğrencilere doğrudan turnusol kağıdı yanıtı belirtilmez, onların fikirleri alınır. Turnusol kağıdı cevabi gelmesi durumunda öğretmen bu bilgiyi veren öğrenciye/öğrencilere teşekkür

ederek ve maddelerin asidik veya bazikliğini test etmek için turnusol kağıdı gibi maddelerin kullanıldığını açıklar. Turnusol kağıdı gibi aynı amaçla kullanılan başka maddelerin de olduğu belirtilmeli ve daha sonraki derslerde detaylı bilgi verileceği vurgulanmalıdır. Turnusol kağıdı cevabı gelmez ise sınıftan, her gruba kırmızı ve mavi renkli turnusol kağıtları dağıtılır fakat öğrencilere turnusol kağıdı hakkında açıklama yapılmaz.

- Öğretmen, öğrencilere gruplar halinde ellerindeki malzemeleri turnusol kağıdı kullanarak test edebileceklerini belirtir. Öğrencilere, evlerinden getirdikleri malzemeleri test edebilecekleri gibi öğretmenin getirdiği malzemeleri de kullanarak test edebileceklerini söylenir (10 dk).
    - Bir grup en azından 4 malzemeyi test etsin ki, gruptaki her öğrenci turnusol kağıdını kullanmış olsun. Burada amaç, öğrencilerin hatalı veya kararsız kaldıkları durumları kendileri test ederek öğrenmelerinin daha kalıcı olmalarını sağlamaktır.
- Her grup farklı malzemeleri test edeceğinden bütün sınıfın kullanılan malzemelerden ve sonuçlarından haberdar olması açısından, öğretmen tahtaya bütün gruplara yetecek bir sonuç posteri asar. Öğrenciler, buldukları sonuçları bu postere rapor eder (5 dk).
    - Eğer öğrenciler, etkinlik başında turnusol kağıdının asidik ve bazik ortamdaki davranışı hakkında doğru yanıtlar veremezse: Turnusol kağıdının bazı maddelerde kırmızı renk aldığı, bazı maddelerde ise mavi renk aldığı ayrımını öğrencilerden çıkarım yapmaları beklenir. Turnusol kağıdını kırmızı renge dönüştüren maddelerin ortak özellikleri ve turnusol kağıdını mavi renge dönüştüren maddelerin ortak özellikleri olup olmadığı öğrencilere sorulur. Asidik maddeler mavi turnusol kağıdının rengini kırmızıya, bazik maddeler kırmızı turnusol kağıdının rengini ise maviye dönüştürürler bilgisini öğrenciler kendileri deneysel olarak test etmiş olurlar.
    - Bu sonuç posteri aynı zamanda, aynı malzemeleri kullanan grupların test sonuçlarını da doğrulamaya olanak sağlar.

- Öğretmen daha sonra, Melis'in bir günü isimli etkinliğin ikinci formatını öğrencilere dağıttı ve öğrencilerin burada günlük hayatta birçok asidik ve bazik maddeyle veya onların özelliklerinden kaynaklanan sonuçlarla karsılaştıklarını belirtti. Metni okuyarak birinci etkinlik sonuçlarını göz önüne alarak asidik veya bazik olarak düşündükleri maddelerin doğru olup olmadığını kontrol etmelerini istedi. Metin sonunda yer alan soruyu da dikkatle cevap vermelerini belirtti (5dk).
    - Metni okumak ve soruyu cevaplamak için yeterli süre kalmazsa öğrencilere inceleyip bir sonraki ders getirmeleri belirtilir. Metin ünite süresinde öğrencilerin yanında bulunacağı hatırlatması yapılır ve sadece sorunun cevaplandığı kısım toplanır.

G – 2. DEFINITIONS OF ACIDS AND BASES

ASİT VE BAZ TANIMLARI

Etkinlik: Asit – Baz Tanımlarının Tarihçesi

Konu: Asitler ve Bazlar Tanımları

1. Arrhenius asit-baz tanımı nedir?
2. Bronsted-Lowry asit-baz tanımı nedir?
3. Lewis asit-baz tanımı nedir?
4. Bu tanımlar arasındaki farklılıklar nelerdir?

Kazanımlar:

Bilişsel Kazanımlar:

- ➢ Arrhenius asit-baz tanımını tanımlar.
- ➢ Brosnted-Lowry asit-baz tanımını tanımlar.
- ➢ Lewis asit-baz tanımını tanımlar.
- ➢ Arrhenius ve Bronsted-Lowry tanımlarının sınırlılıklarını fark eder.
- ➢ Asit-baz tanımları arasındaki farklılıkları söyler.
- ➢ Asidik ve bazik maddeleri asit-baz tanımlarını kullanarak değerlendirir.

Duyuşsal Kazanımlar:

- Asit-baz tanımlarını öğrenmek için arkadaşları ile işbirliği yapar.
- Asit-baz teorilerinin tarihçesini öğrenme etkinliğine katılır.

Psikomotor Kazanımlar:

- Etkinlik sonuçlarını rapor eder.

Süre: 3 ders saati

Dersin İşlenişi:

Asit ve bazların birçok tanımı olması öğrencilerin bu konuyu anlamasında ve kavramasında zorluk çekmelerine neden olmaktadır. Müfredat sadece Svante August Arrhenius, Johannes Bronsted – Thomas Lowry ve Gilbert Lewis'in tanımlarına yer verdiği için bu tanımlar çerçevesinde asitler veya bazlar nasıl tanımlanır açıklanacaktır. Bu konunun anlatılmasında önemli olan, her üç tanımın da yaygın olarak kullanıldığı fakat bazı tanımların diğerine göre eksiklerinin veya yetersiz kaldığı anlayışını öğrencilere vermektir. Asit ve baz tanımları konusu genel olarak, Arrhenius'un tanımından başlayarak bu tanımının kullanışlı bir tanım olduğu fakat sadece asit ve bazların sulu çözeltilerini kapsadığı için yetersiz kaldığı vurgusunu yaparak, sonrasında Arrhenius'un asit-baz tanımının getirdiği yetersizlikle ihtiyaç doğrultusunda farklı yerlerde ikamet eden Bronsted ve Lowry'nin birbirinden habersiz olarak benzer tanıma ulaşmaları, daha sonrasında aynı şekilde bu tanımın da zamanla yetersiz kaldığı durumda Lewis'in asit ve baz tanımlarını başka açıdan ele alarak asit-baz tanımını nasıl geliştirdiğini tarihsel gelişim çerçevesinde öğrencilere aktarılacaktır.

Konunun aktarımı sırasında izlenecek basamaklar:

- Öğretmen, bir önceki dersteki öğrenmeleri sorgulamak amacıyla öğrencilere asit ve baz denince ne düşündüklerini sorar (5 dk).
    - Öğretmen birkaç öğrenciden cevap almaya çalışarak verdikleri yanıtların doğruluğu veya yanlışlığı hakkında yorum yapmaz. Burada amaç, öğrencilerin asitleri veya bazları tanımlamak için nasıl bir tanım kullandıklarını belirlemektir. Maddelerin asidik ve bazik olduklarını tayin etmek için bilim insanlarının farklı yollar kullandıklarını belirtilerek, asidik ve bazik maddelerin özelliklerini anlamak için aynı zamanda onların moleküler özelliklerini de incelemenin faydalı olacağı açıklanır.
- Öğretmen, tahtaya HCl, H_2SO_4, HNO_3, HBr, HI gibi birkaç Arrhenius asit örneği yazar. Mide özsuyunda hidroklorik asit, evde kullanılan tuz ruhunda da hidroklorik asit, arabalarda kullanılan akülerde sülfürik asit ve kezzapta nitrik asit bulunduğunu belirtir ve öğrencilerden bu maddelerin ortak özelliklerini söylemesini ister (3 dk).
    - Öğrenciler asit olduklarını belirteceklerdir, öğretmen de bu durumda bu karara nasıl vardıklarını sorar. Öğretmen, hepsinin ortak özelliği, H içermesi yanıtını öğrencilerden almaya çalışır.
- Öğretmen, benzer şekilde NaOH, KOH, $Mg(OH)_2$, $Al(OH)_3$, $Ca(OH)_2$ gibi Arrhenius baz örneklerini yazar. Kalıp el sabununda sodyum hidroksit, sıvı sabunda ve şampuanlarda potasyum hidroksit, mide ilaçlarında magnezyum hidroksit veya alüminyum hidroksit ve kireç suyunda kalsiyum hidroksit bulunduğunu belirtir. Öğrencilerden bu maddelerin ortak özelliklerini söylemesini ister (3 dk).

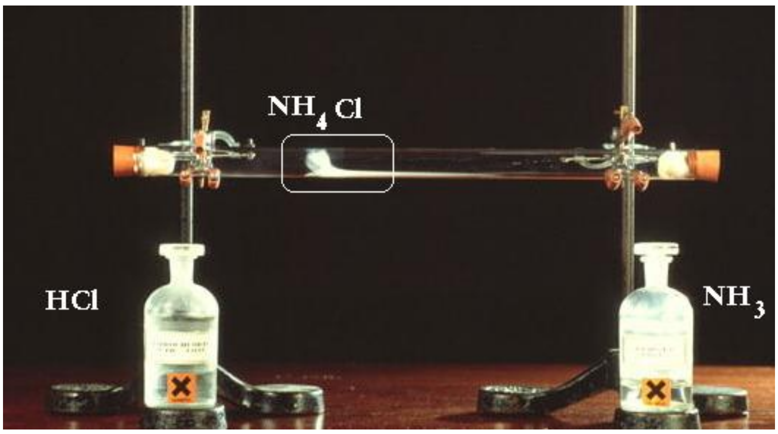
- o Öğrenciler baz olduklarını belirteceklerdir, öğretmen de bu durumda bu karara nasıl vardıklarını sorar. Öğretmen, hepsinin ortak özelliği, OH içermesi yanıtını öğrencilerden almaya çalışır.

➢ Öğretmen, öğrencilerden, bir önceki asit veya baz denince ne düşündüklerine dair alınan yanıtları düşünerek (Arrhenius asit-baz tanımına uyan cevaplarını kullanarak) Arrhenius'un da asit ve bazları öğrencilerin belirttiği gibi tanımladığı belirtilir. Böylelikle, Arrhenius'un asit ve bazların sulu ortamda hidrojen ve hidroksit iyonlarının iyonlaşmasına dayanan tanımının açıklamasını yapılır. Tahtaya yazılan örnekler kullanılarak asit ve bazların iyonlaşmalarını öğrencilerden göstermeleri istenir (4 dk).

➢ Öğretmen CH_4, NH_3 ve CH_3COOH örneklerini tahtaya yazar ve öğrencilerden bu maddeler hakkında yorum yapmalarını ister (5 dk).

- o Bu örneklerle amaç, Arrhenius asit-baz tanımının yetersiz kaldığı durumları göstermektir. H içermesine rağmen Arrhenius'un asit-baz tanımına uyan CH_4 molekülünün asidik bir özelliğinin olmadığını ve NH_3 çözeltisinin baz gibi davrandığı fakat Arrhenius asit-baz tanımı kapsamında OH grubu içermediği için baz olarak sınıflanamadığı ve CH_3COOH ise molekül formülünde OH grubu içerdiği düşünülse de aslında iyonlaşmasının beklenildiği gibi olmadığı belirtilir.

➢ Öğretmen, bir parça pamuğa bir miktar HCl, diğer bir parça pamuğa da bir miktar NH_3 damlatarak iki ucu açık bir borunun uçlarına şekildeki gibi yerleştirir (10 dk, ders öncesi bu malzemeler hazırlanır).



- o Öğrencilerden gazların difüzyonu konusundaki bilgileri hatırlamaları istenir. Asidik bir çözelti olan HCl ile bazik bir çözelti olan NH_3

arasında susuz bir ortamda gerçekleşen bu tepkimeyi öğrencilerin izlemeleri sağlanır. Öğrencilerin, HCl damlatılmış pamuğun bulunduğu uca yakın tarafta oluşan beyaz bulutu gözlemeleri sağlanır, gerçekleşen tepkime sonucunda oluşan maddenin NH_4Cl olduğu tepkimesini yazmaları istenir.

- Öğrencilerden, Arrhenius asit-baz tanımı kullanarak bu tepkimedeki asidik ve bazik olayları açıklamaları istenir (5 dk).
  - Buradaki amaç, öğrencilerin Arrhenius asit-baz tanımındaki yetersizliğin farkına varmalarını sağlanmaktır. Arrhenius asit-baz tanımını öğrencilere hatırlatarak onların gaz fazında gerçekleşen bu tepkimeyi asidik ve bazik maddelerin sulu çözeltilerine dayanan bu tanım çerçevesinde açıklanmasının mümkün olmadığını algılamalarını sağlamaktır.
- Danimarkalı kimyacı Johannes Bronsted ve İngiliz kimyacı Thomas Lowry'nin birbirinden habersiz olarak Arrhenius'un asit ve baz tanımını genişleterek önerdikleri proton transferine dayanan asit-baz tanımı açıklanır (5 dk).
  - Burada, Arrhenius asit-baz tanımının yanlış veya geçersiz olduğu değil bu tanımın asidik ve bazik karakterli birçok maddeyi kapsamadığını ve Bronsted ve Lowry tarafından daha kapsamlı hale getirildiği vurgusu yapılır. Bilimde kabul edilen gerçeklerin zamanla ihtiyaçlar doğrultusunda değişebileceği veya tekrardan düzenlenebileceği vurgusu yapılır.
- Öğretmen, Bronsted-Lowry asit-baz tanımının asit ve bazların sudaki davranışlarını açıkladığı, H^+ iyonu üzerine odaklandığı ve bazların H^+ iyonu alan maddeler olarak tanımlanarak Arrhenius asit-baz tanımına uymayan birçok bazik maddeyi kapsadığı açıklanır (5 dk).
  - Burada amaç, öğrencilerin Arrhenius asit-baz tanımı ile Bronsted-Lowry asit-baz tanımı arasındaki farklılıkları dikkat etmelerini sağlamaktır.
- Bronsted-Lowry asit-baz tanımı birkaç örnek üzerinde açıklanırken konjuge asit-baz çiftleri hakkında da bilgi verilir. Değişik örnekler verilerek öğrencilerin bu tanımı kavramları sağlanır (15 dk).

- Konjuge asit-baz çiftlerini açıklarken suyun hem asit hem de baz gibi davrandığı örnekler üzerinde durulur. Böylece asidik veya bazik özellik göstermeyen suyun, kimyasal tepkimelerdeki koşullara göre asidik veya bazik davranabileceği gösterilir. Bunun için:
  $HCl + H_2O \rightarrow H_3O^+ + Cl^-$ ve $NH_3 + H_2O \rightarrow NH_4^+ + OH^-$
  örnekleri verilerek Bronsted-Lowry asit-baz tanımına göre H^+ iyonu veren maddeler asit, alanların da baz olduğu açıklaması verilir. Asit ve bazların diğer özelliklerine sahip olmasa da suyun bazı tepkimelerde asit bazı tepkimelerde de baz gibi davrandığı durumu öğrencilerle tartışılır. Bu şekilde duruma göre asit veya baz gibi davranan maddelere amfoterik madde denildiği belirtilir. Aşağıda verilen birkaç konjuge asit-baz çiftlerinin biri öğrencilere sunularak konjuge asit veya baz çiftini tahmin etmeleri istenir:

Konjuge asit-baz çiftlerinin bazıları

Asit		Baz
HCl		Cl^-
H_2SO_4		HSO_4^-
H_3O^+	H^+ verir	H_2O
HSO_4^-	$\longrightarrow$ / $\longleftarrow$	SO_4^{2-}
$HC_2H_3O_2$	H^+ alır	$C_2H_3O_2^-$
NH_4^+		NH_3
HCO_3^-		CO_3^{2-}
H_2O		OH^-

- Öğretmen, öğrencilere Lewis denince ne düşündüklerini sorar (10 dk).
  - Burada amaç, öğrencilerin önceki kimya bilgilerini hatırlayarak elektron-nokta Lewis formülünü kullanarak değerlik elektronlarının dizilimini hatırlamaları amaçlanır. N, O ve Cl gibi örnekler verilerek elektron-nokta formülünü hatırlamaları istenir.
- Lewis'in elektron-nokta formülünün asit-baz tepkimelerine başka bir bakış açısı eklediği vurgulanarak elektron-çifti alan maddelerin Lewis asidi ve

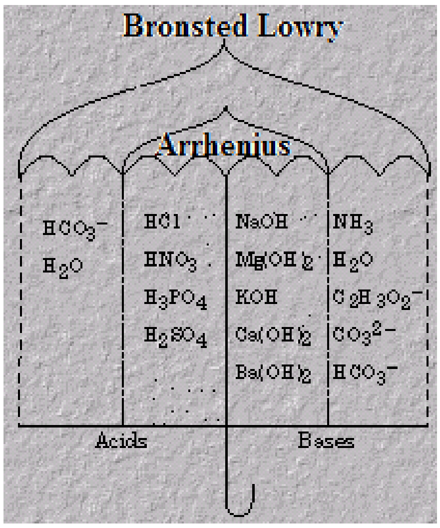
elektron-çifti veren maddelerin Lewis bazı olduğu ile ilgili açıklama yapılır (10 dk).

- Burada vurgulanması gereken, Arrhenius ve Bronsted-Lowry asit-baz tanımlarının hatalı olmadıklarını sadece asit-baz tanımının elektron çifti alıp-verme yorumu ile genişletildiğidir. Daha önce Arrhenius asit-baz tanımına göre OH grubu içeren ve Bronsted-Lowry tanımına göre de proton alarak baz olarak kabul edilen tüm maddelerin de aynı zamanda Lewis bazı tanımına uydukları örneklerle açıklanır. Boylelikle, Lewis'in elektron-çifti alıp-vermesine dayanan asit-baz tanımı birçok maddeyi içine alarak asidik veya bazik olarak anılan maddelerin kapsamını genişletmiştir. NH_3 ve BF_3 arasındaki tepkime örnek gösterilerek H içermemesine rağmen BF_3'un elektron çifti alarak Lewis asidi olduğu açıklanır.

➢ Öğrencilere asit-baz tanımlarının tarihçesi etkinliği dağıtılır ve gruplar halinde etkinliği gerçekleştirmeleri sağlanır (30 dk).

➢ Etkinlik sonunda hangi asit-baz tanımı etkinliği de yapılır (10 dk).

- Zamanın yetmemesi durumunda bu etkinlik diğer ders başında öğrencilerin asit-baz tanımları ile ilgili öğrenmelerini değerlendirmek için de kullanılabilir. Bu etkinlikte vurgulanması gereken, eğer bir tepkime Arrhenius asit-baz tanımı ile açıklanabiliyorsa aynı zamanda o tepkime Bronsted-Lowry ve Lewis asit-baz tanımlarıyla da açıklanabilir; fakat tersi durum geçerli değildir. Başka bir ifadeyle, Lewis asit-baz tanımı ile açıklanabilen bir tepkime, daha sınırlı olduğu için Arrhenius veya Bronsted-Lowry asit-baz tanımı ile açıklanamaz. Yandaki şekilde ifade edildiği gibi maddelerin asidik ve bazik olarak değerlendirilmesi hangi tanımın kullanıldığı ile



ilişkilidir. Arrhenius'un asit-baz tanımı daha dar kapsamlı olduğu için (veya şemsiyesi daha küçük olduğu için) asit veya baz olarak değerlendirilen maddelerin daha az sayıda olduğu ifade edilir. Brosted-Lowry'nin proton transferine dayanan asit-baz tanımı, Arrhenius'un asit ve baz olarak kabul ettiği maddeleri de içine alarak daha geniş kapsamdaki maddeler (veya daha büyük şemsiyesi olduğu için) asidik veya bazik olarak değerlendirilir.

Aşağıda verilen tablo öğrencilerle tamamlanır:

	Arrhenius	Bronsted-Lowry	Lewis
Asit	Suya H^+ veren	Proton veren	Elektron-çifti alan
Baz	Suya OH^- veren	Proton alan	Elektron-çifti veren
Nötrleşme	Su oluşumu	Proton transferi	Koordine kovalent bağın oluşumu
Denklem	$H^+ + OH^- \rightarrow HOH$	$HA + B \rightarrow BH^+ + A^-$	$A + B \rightarrow A:B$
Eksikliği	Sadece sulu çözeltiler	Sadece proton transferin olan tepkimeler	Genel teori

G – 3. LET’S DO MAGIC!

HAYDİ SİHİR YAPALIM!

Etkinlik: Haydi Sihir Yapalım!

Konu: İndikatörler

1. Asidik maddeler indikatörler varlığında karakteristik renk alırlar.
2. Bazik maddeler indikatörler varlığında karakteristik renk alırlar.
3. Günlük hayatımızda indikatörlerle karşılaşıyor muyuz?

Kazanımlar:

Bilişsel Kazanımlar:

- Asidik maddeleri tanımak için indikatör kullanabileceğini fark eder.
- Bazik maddeleri tanımak için indikatör kullanabileceğini fark eder.
- İndikatörün renk aralığını bilirse asidik veya bazik madde olması hakkında yorum yapar.

Duyuşsal Kazanımlar:

- İndikatörler hakkında bilgi öğrenmek için arkadaşları ile işbirliği yapar.
- İndikatörlerin asit ve bazik maddeler üzerindeki etkisini inceleme etkinliğine katılır.

Psikomotor Kazanımlar:

- Etkinlik sonuçlarını rapor eder.

Süre: 10 dakika

Dersin İşlenişi:

Öğrencilerin indikatörler konusuna dikkatlerini çekmek için dersin başında bu etkinlik uygulanacaktır. İndikatörlerin asidik ortamda ve bazik ortamda farklı renk aldığını göstermek amacıyla bu etkinlik hazırlanmıştır. Etkinlik için grup sayısına göre öğrencilere dağıtılacak boş dosya kağıdı hazırlanır.

Sınıfta 10 grup olduğu düşünülürse her grup için iki adet kağıt düzenlenir. Her grup bir kelime elde edeceği için 10 kelimelik derse giriş cümlesi belirlenir, bu cümle: “Bugünkü – dersimizin – konusu – asidik ve bazik – maddeleri – belirlememizi – sağlayan – indikatörleri – yakından – tanımaktır.”

Her bir kelime, fenolftalein indikatörü kullanılarak dosya kağıdına yazılır, her gruba hem asidik hem de bazik çözeltiyi test etmeleri için iki adet kağıt verileceği için cümle iki adet olarak hazırlanır. Kağıtların kuruması sağlanır. Etkinlik için seyreltilmiş asidik ve bazik çözeltileri hazırlanır.

Etkinlik uygulamasında izlenecek adımlar:

- Öğretmen, öncelikle öğrencilere gecen ders yapılan asit-baz etkinliğini hatırlatarak onlara Arrheius, Bronsted-Lowry ve Lewis asit-baz tanımlarının temel farklılıklarını sorar.
  - Eğer önceki ders "Hangi Asit-Baz Tanımı" etkinliğini yapmaya zaman kalmadıysa bu ders bu etkinlik ile derse başlanacaktır. Eğer ki etkinlik bir önceki ders tamamlandıysa, etkinlikte yer alan tepkimelerin doğru yanıtları tartışılır.
- Ogretmen, dersin başında her gruba aynı kelimenin gelmesini sağlayarak kağıtları öğrencilere dağıtır (1 dk).
- Öğrencilere kağıtlarda bir şey yazıp yazmadığını sorar (1 dk).
- Öğrencilere asidik ve bazik çözelti içeren spreyleri dağıtır (1 dk).
  - Seyreltilmiş asit ve baz çözelti içermesine rağmen, öğrenciler spreyleri kullanırken uyarılır.
- Her bir grubun ikiye bölünerek birinci grup asidik çözeltiyi diğer grup da bazik çözeltiyi kullanarak kağıtlar üzerinde test edebilecekleri belirtilir (3 dk).
  - Burada bazik çözelti içeren her grup bir kelime elde edecektir, grup numaralarını sırayla tahtaya yazarak kelimesini bulan her öğrenci grubunun tahtaya, grup numarasının altına, bulduğu kelimeyi yazması istenir.
- Çıkan sonucu grup numaralarının altına yazarlar.
- Öğretmen, indikatörlerin asidik ve bazik çözeltilerde farklı renk aldıkları için asit ve bazları tanımak için kullanıldıklarını belirtir (4 dk).
  - Bu etkinlikte fenolftalein indikatörünün kullanıldığı, bu indikatörün asidik ortamda renksiz ve bazik ortamda ise pembe renk aldığı belirtilir. Bazik çözelti içeren sprey kağıdın üzerine püskürtüldüğünde renksiz olan bazik çözeltinin indikatör varlığında pembe renk aldığı belirtilir.

G – 4. THE MAGIC OF RED CABBAGE

KIRMIZI LAHANANIN SİHRİ

Etkinlik: Kırmızılahananın sihri

Konu: İndikatörler

1. Asidik maddeler indikatörler varlığında karakteristik renk alırlar.
2. Bazik maddeler indikatörler varlığında karakteristik renk alırlar.
3. Günlük hayatımızda indikatörlerle karşılaşıyor muyuz?

Kazanımlar:

Bilişsel Kazanımlar:

- ➢ Asidik maddeleri tanımak için indikatör kullanabileceğini fark eder.
- ➢ Bazik maddeleri tanımak için indikatör kullanabileceğini fark eder.
- ➢ İndikatörün renk aralığını bilirse asidik veya bazik madde olması hakkında yorum yapar.
- ➢ Kırmızı lahananın renk aralığını inceler.

Duyuşsal Kazanımlar:

- İndikatörler hakkında bilgi öğrenmek için arkadaşları ile işbirliği yapar.
- İndikatörlerin asit ve bazik maddeler üzerindeki etkisini inceleme etkinliğine katılır.

Psikomotor Kazanımlar:

- Maddelerin asitlik veya bazikliğini belirlemek için kırmızılahana kağıtlarını kullanarak birçok maddenin asitliğini veya bazikliğini test eder.
- Etkinlik sonuçlarını rapor eder.

Süre: 30 dakika

Dersin İşlenişi:

"Haydi Sihir Yapalım!" etkinliğiyle beraber geliştirilen bir etkinliktir. Öğrencileri indikatörler hakkında daha detaylı bilgilendirmek amacıyla «Kırmızı Lahananın Sihri » etkinliğini gerçekleştirmeden önce, öğrencilere kırmızı lahananın da günlük hayatta karsılaştığımız bir indikatör olduğunu belirterek kırmızı lahananın asidik ve bazik ortamda hangi renkleri aldığını gözlemleyecekleri bir gösteri etkinliği sunacağınızı belirtiniz.

Bu etkinlik için, kırmızılahana suyu daha önceden hazırlamanız gerekmektedir. Bunun için kırmızılahanadan bir miktar keserek tencereye koyarak üzerine yeteri miktarda su ilave ediniz. Yarım saat kadar kaynamaya bırakınız ve ılıttıktan sonra da elde ettiğiniz kırmızılahana suyunu süzünüz. Şeritler halinde kestiğiniz süzgeç kağıtlarını (kahve filtre kağıtları da kullanabilirsiniz) geniş bir kaba koyarak, lahana suyunu iyice emmesini sağlayınız. Lahana suyunu iyice emen süzgeç kağıtlarının kurumalarını sağlayınız. Böylelikle, kırmızılahana suyundan elde edilen kırmızı lahana indikatör kağıtlarını öğrencilerin gerçekleştireceği etkinlikler için hazırlayınız, kağıtları kapalı bir zarfa koyarsanız daha uzun vadede kullanabilirsiniz. Kırmızılahananın suyunu ders içi etkinlikte kullanmak üzere buzdolabında saklayınız.

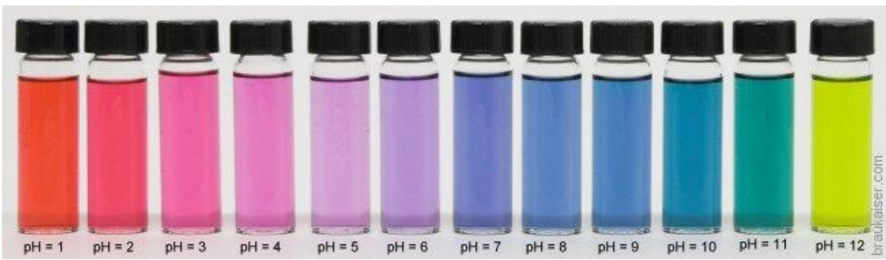
Adım 1:

Adım 2:

Adım 3:

Adım 4:

Adım 5:



Ders esnasında izlenecek adımlar:

- Öğrenciler kendi malzemelerini test etmeden önce siz kırmızılahananın asidik ve bazik ortamda aldığı renkleri göstermek için bir tüplük içerisine bir kaç tane tüp koyarak öğrencilerin renk yelpazesini gözlemeleri sağlanır.
- Kullanılacak olan malzemeler asidik olandan bazik olana doğru sıralanır. Bu malzemeler seyreltik HCl, limon suyu, sirke, herhangi bir meyve suyu, su, suda çözdürülmüş karbonat, sabun, temizlik malzemelerinden herhangi biri, seyreltik NaOH şeklinde olabilir. Bu malzemeleri en asidik maddeden en bazik maddeye doğru sıralayarak tüplerin içerisine bir miktar konur ve sonrada her bir tüpe birkaç damla kırmızılahananın suyu damlatılarak öğrencilerin renk değişimini gözlemesi sağlanır. Adım 5' teki gibi bir renk yelpazesi elde edilir (5 dk).
- Sadece kırmızılahananın değil, kiraz, üzüm, kırmızı erik, kırmızı soğan, ıhlamur çayı, gül. ortanca çiçeği, sardunya gibi doğadaki başka maddelerin de asidik ve bazik ortamlarda farklı renk alarak asit veya baz belirteci olarak kullanıldığı belirtilir (5 dk).
- Öğrenciler "Kırmızı Lahananın Sihri" etkinliğini gerçekleştirmeleri için teşvik edilir, etkinlik gruplar halinde gerçekleştirilir (15 dk).
    - Bu ders öncesi öğrencilere, evlerinden asitliğini veya bazlığını merak ettikleri istedikleri malzemeleri test etmek amacıyla derse getirebilecekleri belirtilir. Öğretmen de, "Melis'in Bir Günü" etkinliğinde öğrencilerin yanıldıkları veya kararsızlığa düştükleri malzemeleri sınıf ortamına getirmeye dikkat eder. Öğrencilere, kırmızı lahana kağıdındaki sonucu yorumlayabilmek için bir önceki gösteri etkinliğinden elde edilen renk yelpazesinden yararlanabilecekleri söylenir. İndikatör kağıdını nasıl yorumlayacakları da ifade edilir. Elde edilen renkten maddenin asidik veya bazik olduğuna karar vermeleri teşvik edilir.
- Öğrenciler, etkinlik sonuçlarını sınıf arkadaşları ile paylaşır. Öğretmen, tahtaya poster asarak onların bu sonuçları rapor etmelerine yardımcı olur. Öğrenciler, test edilen maddeleri inceleyerek benzer maddelerin benzer sonuç verip vermediğini incelerler (5 dk).

- Öğrencilere test edilen maddeler arasında onları şaşırtan herhangi bir sonuç var mı diye öğretmen öğrencilerin düşüncelerini alır. Neden o şekilde düşündüklerini açıklamalarını ister. "Melis'in Bir Günü" etkinliğindeki öğrencilerin düşünceleri ile bu etkinlikten elde edilen sonuçlardaki çelişkili olanların üzerinde durun. Öğrenciler hangi maddeleri asit veya baz gibi düşündüyse onları belirtip, test sonuçlarında farklı sonuç bulunduğuna dikkat çekilir.

G – 5. DILUTED AND CONCENTRATED SOLUTIONS

DERİŞİK – SEYRELTİK ÇÖZELTİLER

Limon, zayıf bir asit olan sitrik asit içerir. Öğrenciler genellikle kuvvetli – zayıf kavramlarını günlük hayattaki kullanımları ile ilişkilendirerek asit ve bazlar açısından farklı anlamlar yükleyebiliyorlar. Bu günlük hayattan gelen kavram karmaşası yanında öğrenciler bazen derişik asit dendiğinde kuvvetli bir asit veya seyreltik bir asit dendiğinde zayıf bir asit düşünmektedir.

Gerçekleştireceğiniz bu etkinlik öğrencilerin derişik ve seyreltik kavramlarını kuvvetli ve zayıf kavramlarıyla karıştırmaması amacıyla tasarlanmıştır. Çözeltilerde derişim olayını vurgulamak amacıyla «Asitlerin Kuvveti» etkinliğinden önce tasarlanmış bir gösteri etkinliğidir.

Etkinlik için:
Bir limonun suyunu bir behere sıkınız. Bu esnada, öğrencilere aşağıdaki soruları iletiniz:

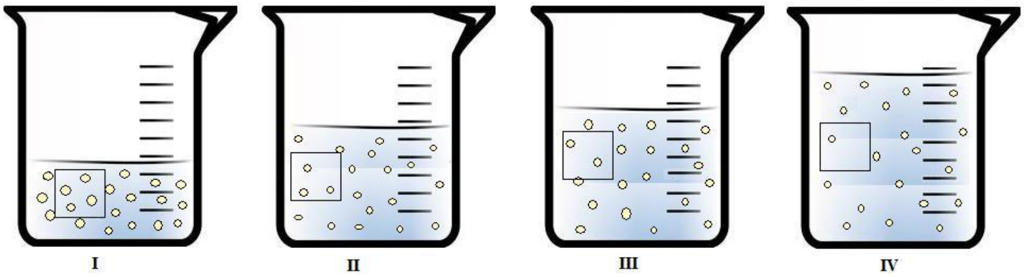
- Sizce limon asidik midir yoksa bazik midir?
- Limonun içerdiği bu asidin kuvvetli bir asit mi yoksa zayıf bir asit mi olduğunu düşünüyorsunuz? (Öğrencilerden neden öyle düşündüklerinin açıklamalarını isteyiniz.)

Öğrencilere limonun zayıf bir asit olan sitrik asit içerdiğini belirtiniz. Daha sonraki etkinlikte, kuvvetli ve zayıf asitler hakkında daha detaylı bilgiler edineceklerini belirterek sıktığınız limon suyunu öğrencilere gösteriniz. Bu limon suyuna 10 ml su ilave edilmesi nasıl bir etki yaratacağını öğrencilere sorunuz; su ilavesiyle limon suyunun görünüm ve tadı ile ilgili öğrencilerle tartısınız. Böylelikle su ilavesinin, çözeltiyi sadece seyrelttiğini belirtiniz. Su ilavesiz limon suyunun su ilaveli limon suyuna kıyasla daha derişik olduğunun vurgusunu yapınız.
Daha sonra, behere yine 10 ml su ilave ediniz, bu kez üçüncü durumun ikinci duruma kıyasla daha seyreltik olduğunu ve ikinci durumun üçüncü duruma kıyasla daha derişik

olduğunu vurgulayınız. Deriklik olayının, kıyaslanan çözeltiye göre nasıl değiştiğinin vurgusunu yapınız. Aynı şekilde, bir kez daha su ilave yapıldığında öğrencilere durumlar arası derişik ve seyreltik çözelti kıyaslaması yaptırınız.

Öğrencilerden tahtaya bu dört durum arasındaki birim hacme düşen tanecik sayısını resmetmelerini isteyiniz. Tahtaya aşağıdaki gibi gösterim çizerek, birim hacme düşen tanecik sayısında nasıl bir azalma olduğunun gösterimini açıklayınız (Limon suyu modellemesini yaparken, su moleküllerini şeklin daha basit olması açısından çizmediğinizi belirterek, limonun içerdiği taneciklerin daha anlaşılır olması acısından da yuvarlak çizdiğinizi belirtmeyi unutmayın).

Öğrencilerle beraber yapacağınız limon suyunun seyreltilmesi modellemesi aşağıdaki gibi olacaktır:



Limon örneğinde olduğu gibi zayıf asitler derişik olarak bulunabildikleri gibi seyreltik olarak da bulunabilirler. Asitlerin veya bazların kuvvetli veya zayıf olarak adlandırmanın farklı bir durum olduğunu, kuvvetli veya zayıf asitlerin hem derişik hem de seyreltik halde bulunabileceklerinin vurgusunu yapınız.

G – 6. pH ve pOH CONCEPTS

pH ve pOH KAVRAMLARI

Etkinlik: pH ve pOH

Konu: pH ve pOH

1. Asidik maddelerin pH ve pOH özellikleri.
2. Bazik maddelerin pH ve pOH özellikleri.
3. pH ve pOH değerinin derişimle ilgisi.
4. pH ve pOH arasındaki ilişki.

Kazanımlar:

Bilişsel Kazanımlar:

- Asitlerin pH ve pOH özelliklerini tanımlar.
- Bazların pH ve pOH özelliklerini tanımlar.
- pH veya pOH değerlerine gore maddeleri birbirinden ayırt eder.
- pH veya pOH degerlerini etkileyen etmenleri açıklar.
- Kuvvetli asitler ve bazların pH veya pOH değerilerini yorumlar.

Duyuşsal Kazanımlar:

- pH ve pOH kavramlari ilgisini çeker.
- Etkinliği gerçekleştirmek için işbirliği yapar.

Psikomotor Kazanımlar:

- Birçok asidik ve bazik maddenin pH ve pOH değerini rapor eder.

Süre: 1 ders saati

Dersin İşlenişi:

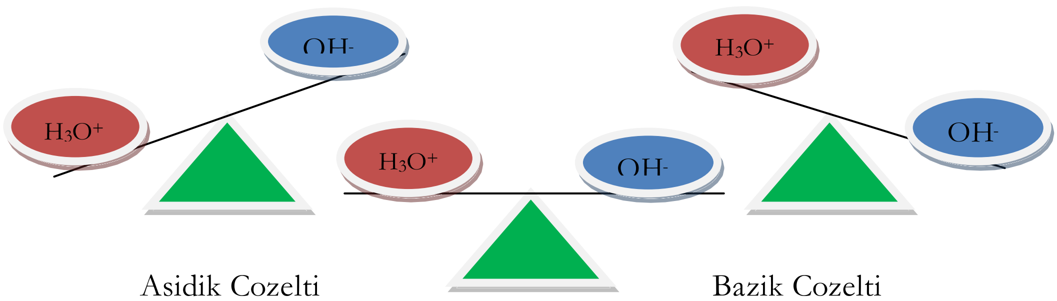
Ögrenciler genellikle pH kavramını asitlerin ve bazların kuvveti ile ilişkilendirir. pH değeri yüksek asidik bir maddenin zayıf bir madde olduğuna yönelik önyargıları bulunmaktadır. Önceki bölümde öğrencilerin kuvvetli-zayıf asit/baz kavramlarından çözeltideki iyonlaşma yüzdesi ifadesini anlamaları gerektigi vurgulanmıştı, bu bölümde ise pH kavramının ortamdaki hidrojen iyonu derişimi ile ilgili oldugu vurgusu yapılacaktır. Öğrenciler aynı zamanda bazik çözeltilerin pH değeri olmadığına dair yanlış bilgilere sahip olabilmektedirler, bunun icin pH kavramını açıklarken bu değerin sadece asidik çözeltiler icin değil aynı zamanda bazik çözeltiler için de geçerli oldugu vurgusu yapılacaktır. Bunların yanında, öğrenciler pH değeri 7 olarak verilen bir çözelti için nötr cevabı verebilmekte fakat açıklama yapmaları veya tanecik boyutunda çizim yapmaları istendiğinde ortamda hiç iyon bulunmayacağı gibi yanlış ifadeler veya çizimler yapabilmektedirler.

- Ders başında öğretmen, öğrencilere derişik asit çözeltisini göstererek onlardan çözeltinin pH değeri hakkında yorum yapmalarını ister. (5 dk)
    - Öğrencilere HCl çözeltisini gösterebilirsiniz. Öğrencilere bu tahminlerini nasıl ve neye dayanarak yaptıklarını sorunuz.
    - Kırmızı lahana veya indikator kağıtlarını kullanarak çözeltinin pH değeri ile ilgili öğrencilerin yorumlarını tartışınız.
- Elinizdeki çözeltiye bir miktar su ilave ederek seyrekleştiriniz ve yine öğrencilerden çözeltinin pH değeri hakkında yorum yapmalarını isteyiniz. (5dk)
    - Öğrencilere bu tahminleri nasıl yaptıklarını sorunuz.
    - Kırmızı lahana veya indikator kağıtlarını kullanarak çözeltinin pH değeri ile ilgili öğrencilerin yorumlarını tartışınız.
    - Bir önceki çözeltiyi düşündüerek, iki çözelti arasında ne fark vardır? sorusu uzerinde yogunlasiniz. Öğrencilerin seyreltme olayını nasıl yorumladıklarını dikkate alınız, bir önceki konu ile ilgili yanlış öğrenmeler olup olmadığını sorgulayınız.
- Öğretmen, öğrencilere az da olsa suyun elektrigi ilettiğini, bu iletkenliğin az da olsa iyonlaşabilmesinden kaynaklandığını açıklar (5 dk).
    - Asit ve bazların iletkenlik özelliklerini ileriki konularda tartışılacağını belirtiniz ve sadece suyun kendi iyonlaşması hakkında bilgi veriniz. Suyun iyonlasma tepkimesini göstererek bunun üzerinden açıklamalarınızı yapınız.
- Suyun otoiyonizasyonunu tanecik boyutunda resmederek öğrencilere durum hakkında bilgi verir. (15 dk)
    - Öğrencilerle saf suyun hem hidronyum hem de hidroksit iyonlarını içermesine rağmen neden asidik veya bazik olmadığını tartışınız.

- Saf suyun 25^{0}C'de 1 litre sudaki iyon değerlerini belirtiniz. Hidronyum ve hidroksit iyon derişimlerinin eşit olmasından dolayı nötr çözelti olarak ifade edildiğini açıklayınız.
- Bir önceki kimyasal denge konusu ile ilişkilendirerek oğrencilerle beraber hidronyum ve hidroksit arasındaki bağlantıyı bulmalarını sağlayınız.

➢ Asidik çözeltilerde hidronyum iyon derişiminin, bazik çözeltilerde ise hidroksit iyon derişiminin daha fazla olduğu ifade edilir. (10 dk)

- Öğrencilerin, iyon dengesini kavramaları için tahtaravelli örneğini gösterebilirsiniz. Böylelikle, iyon derişimi miktarının çözelti hakkında bilgi verdiğini açıklayınız.



Asidik Cozelti
$[H_3O^+]>10^{-7}M>[OH^-]$

Notr Cozelti
$[H_3O^+]=10^{-7}M=[OH^-]$

Bazik Cozelti
$[H_3O^+]<10^{-7}M<[OH^-]$

➢ Öğretmen, öğrencilerden derişimlere dikkat etmelerini ister. Bu derişimlerin çok küçük değerler olduğunu öğrencilerin kavramalarını sağlayınız. (10 dk)

- Danimarkalı bir biyokimyacı olan Soren Sorensen çözeltilerdeki hidronyum iyon derişimlerini daha basit ifade edebilmek icin bir önerme sunmuştur. pH ve H_3O^+ iyonları arasındaki bağlantı açıklanır.

➢ Dersin başındaki, çözeltiler hakında öğrencilerden tekrar yorum yapmalarını isteyiniz. (10 dk)

- İki cozelti arasında pH veya H_3O^+ iyonları arasında fark olup olmadığını belirtmelerini isteyiniz.
- Kırmızı lahana ve indikator kağıtlarındaki renk tonu farkını tartışınız.
- Aynı türden fakat değişik derişimdeki maddelerin pH değerlerinin farklı olabileceğinin öğrencilerin farkına varmalarını sağlayınız.

- pH ve pOH arasındaki bağıntıyı öğrencilerle beraber cıkarınız. (15 dk)
    - Indikatörlerin kabaca pH hakkında bilgi verdiklerini belirtiniz.
    - Günlük hayatımızda karşılaştığımız birçok maddenin pH değerlerini öğrencilerle beraber tespit etmeye calışınız. Öğrenciler önceki etkinliklerde kırmızı lahana ile ilgili birçok test yapmışlardı, renk skalasını kullanarak günlük hayatta karşılaştıkları maddeleri asitlikten bazikliğe doğru sıralamalarını isteyiniz. Aşağıdaki gibi bir tablo oluşturabilirsiniz:

Çözelti	pH değeri
Akü asidi	0
Mide asidi	1.4–1.8
Limon suyu	2.1
Sirke	2.9
Şarap	3.5
Domates suyu	4
Şekersiz kahve	5
Ekşimil süt	6
Yağmur suyu	6.5
Saf su (25^{0}C)	7
Kan	7.35–7.4
Deniz suyu	8
Sabun, şampuan	8-9
Deterjan	9-10
Çamaşır suyu	12
Çamaşır sodası	14

G – 7. STRONG AND WEAK ACIDS

KUVVETLİ VE ZAYIF ASİTLER VE BAZLAR

Etkinlik: Kuvvetli ve zayıf asitler

Konu: Asit ve bazların kuvveti

1. Kuvvetli ve zayıf asit arasında ne fark vardır?
2. Kuvvetli ve zayıf baz arasında ne fark vardır?
3. Günlük hayatımızda kuvvetli ve zayıf asit ve bazların yeri.

Kazanımlar:

Bilişsel Kazanımlar:

- Kuvvetli ve zayıf asit arasındaki farkı açıklar.
- Kuvvetli ve zayıf baz arasındaki farkı açıklar.
- İyonlaşma kavramını ifade eder.

Duyuşsal Kazanımlar:

- Asit ve bazların kuvvetli ile ilgili ogrenmelerini grup arkadaşları ile işbirligi yapar.
- Kuvvetli ve zayıf asit veya bazların arasındaki farkları tartısır.

Psikomotor Kazanımlar:

- Asitlerin veya bazların kuvvetli veya zayıf olma farkını tanecik boyutundaki gosterimini resmeder.
- Etkinlik sonuçlarını rapor eder.

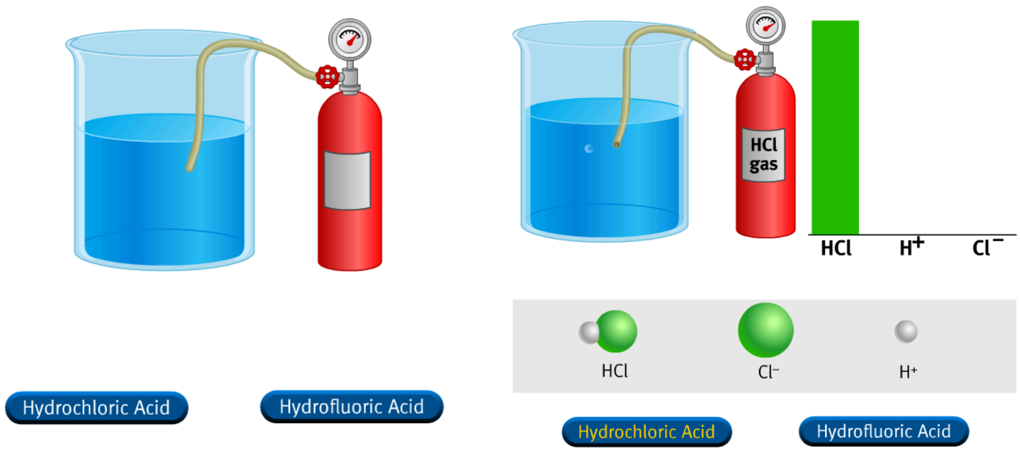
Süre: 120 dakika

Dersin İşlenişi:

Öğrenciler genellikle kuvvetli ve zayıf asitler arasındaki farkı anlamakta zorlanırlar. Tam olarak kavrayamadıkları için de doğru olmayan kavramlar geliştirmektedirler. Özellikle bu kavramları, günlük kullanımdaki kuvvetli ve zayıf anlamlarıyla ilişkilendirmektedirler; örneğin kuvvetli asitlerde tanecikler arasındaki bağların daha kuvvetli veya zayıf asitlerde tanecikler arasındaki bağların daha zayıf olduğu görüsünü savunmaktadırlar.

Öğrencilerin bu iki durum arasındaki farkı daha iyi anlayabilmeleri için verilen öğrenci etkinlikleri ve simülasyon kullanılacaktır. Simülasyon basamakları adım adım öğrencilerle tartışarak ilerleyecektir.

- Öğrencilerin aynı derişim ve hacimde asitler kullanılarak gerçeklesen tepkime sonucunda farklılıklar gözlenmesini sağlamak amacıyla, öncelikle yapılan öğrencilerin "Asitlerin Kuvveti" etkinliğini gerçekleştirmeleri sağlanır.
    - Burada amaç, öğrencilerin aynı miktarda giren kullanılarak gerçekleştirilen tepkimede sonucunda, oluşan madde miktarında farklılık olduğunu gözlemelerini sağlamaktır. Asitlerin metallerle olan tepkimeleri hakkında daha sonra detaylı bilgi verilecektir.
- Simülasyonun başlangıcında öğrencilere neden bazı asitlere kuvvetli veya bazılarına zayıf asit denildiğini sorarak onların fikirlerini alınız. Bu farkı incelemek için simülasyondan faydalanacaklarını belirtiniz. Öğrencilere elimizde HCl ve HF olmak üzere iki farklı madde bulunduğunu belirterek bu maddeleri teker teker su dolu bir behere aktardığınızda tanecik boyutunda öğrencilerin ne beklediklerini sorgulayarak onların düşüncelerini alınız.



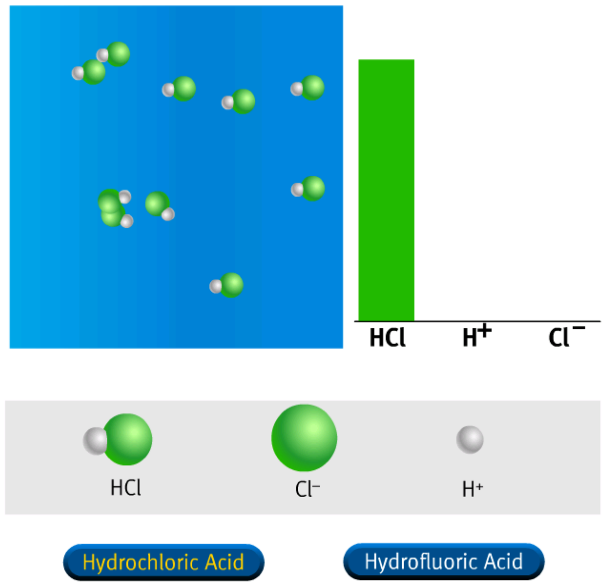
- Tanecik boyutunda HCl moleküllerinin şekildeki gibi göründüğünü belirtiniz (Görüntünün daha basit ve kolay anlaşılır olması acısından su moleküllerinin tanecik boyutunda gösterilmediğini ve HCl moleküllerinin renklendirildiğini ifade ediniz.)

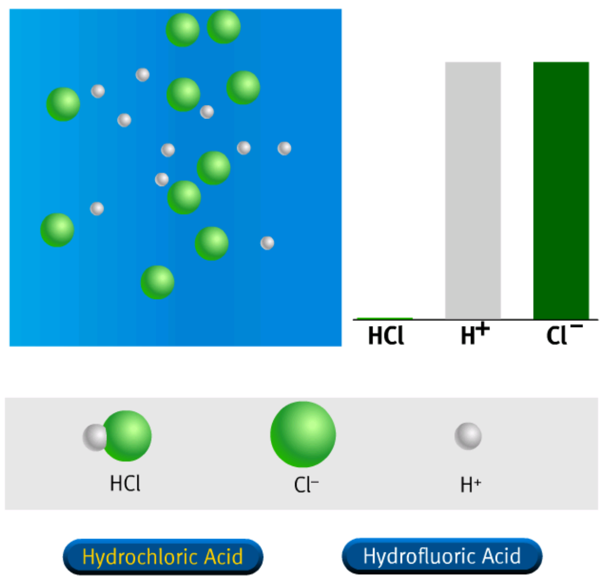
  Kuvvetli bir asit olan HCl'nin, ortamdaki su molekülleri ile etkileşerek H_3O^+ iyonlarını oluşturduğunu ve %100'e yakın iyonlarına ayrıştığını belirtiniz.

Kuvvetlilik kavramının iyonlaşma yüzdesi ile ilişkili olduğu vurgusunu yapınız. Kuvvetli asitlerde, HCl’de olduğu gibi, tamamına yakın iyonlaştığını ve ortamda baskın sayıda H^{+} ve Cl^{-} iyon taneciklerinin bulunduğunu eser miktarda da olsa HCl moleküllerinin bulunabileceğini belirtiniz.

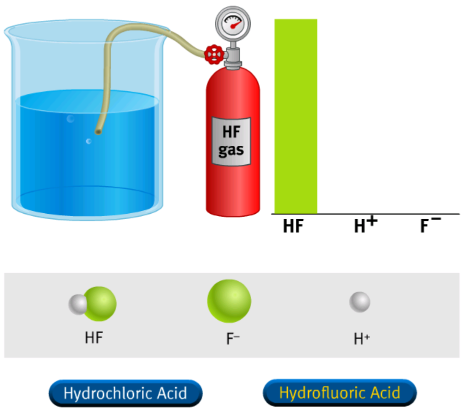
1 litre suya 1 mol HCl molekülleri ilave edildiğinde, çözelti içerisinde 1M H_3O^{+} ve 1 M Cl^{-} iyonlarının oluşacağını belirtiniz.

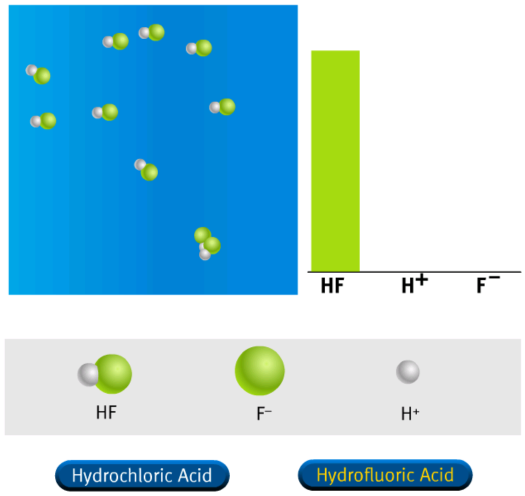
Kuvvetli bazların da aynı şekilde, %100’e yakın iyonlaştıklarını belirtiniz. Kuvvetli asitler ve bazların tamamına yakın iyonlaştıkları için aynı zamanda da kuvvetli elektrolitler olduklarını ifade ediniz.





- Zayıf bir asit olan HF maddesinde nasıl bir durum gerçekleşmiş olabileceğini öğrencilere sorarak onların düşüncelerini alınız. Zayıf asitlerin durumunu, zayıf bağlara sahip olmasıyla açıklayan öğrencilere simülasyon gösterimi sonrası dönerek, aynı düşünceyi koruyup korumadığını sorgulayınız.

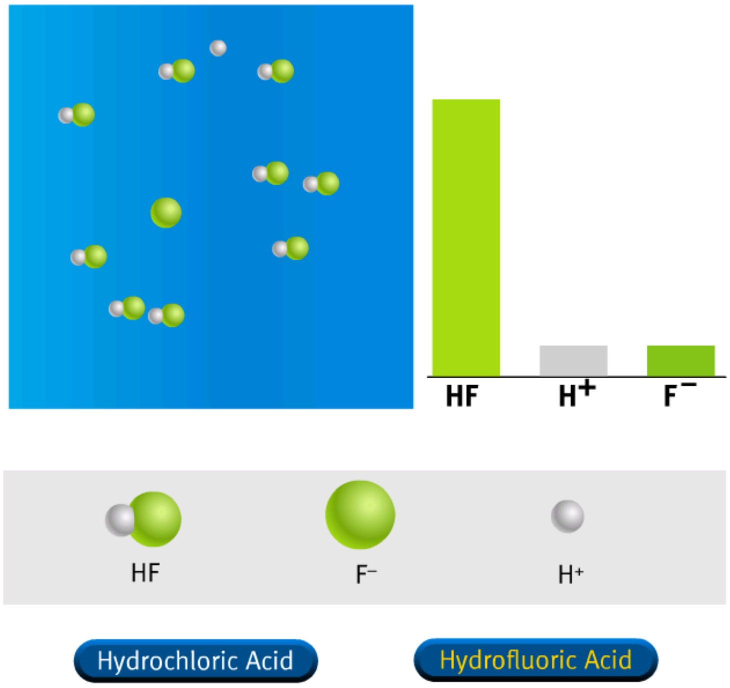




- HF taneciklerinin, HCl gibi, su ile etkileşmeden önce moleküller halde olduklarını gösteriniz. Fakat kuvvetli asitlerden farklı olarak zayıf asitlerin yapılarındaki H^+iyonlarını suya kısmen aktardıklarının vurgusunu yapınız.

  Öğrencilerden geçen dönemlerde öğrendikleri elektronegatiflik kavramını hatırlamalarını isteyiniz ve ne hatırladıklarını sorgulayınız. Periyodik tablodan F ve Cl elementlerinin yerlerini tespit etmelerini sağlayınız. H–F, H–Cl, H–Br, H–I bağlarının polarlığını karşılaştırmalarını isteyiniz (Elementlerin elektronegatiflik değerlerini veriniz). Elektronegativite farkının en büyük H–F bağında olduğunu ve en zayıf asit olduğunun tespitini öğrencilerin yapmasını sağlayınız (HF, su molekülleriyle hidrojen bağı yaptığı için de serbest H_3O^+ iyon derişiminin olması gerekenden daha az olduğunu, fakat hidrojen bağı ile ilgili detaylı bilgileri bir sonraki dönemde öğreneceklerini belirtiniz).

  1 litre suya 1 mol HF ilave edilmesiyle, HF'in asitlik iyonlaşma sabitinden yararlanarak iyonlaşan madde miktarının bulunabildiğini ve iyonlaşma sabitinin de sıcaklıkla değiştiğini belirtiniz. 25^0C'de HF için K_a değerinin $7.1x10^{-4}$ olduğunu ve hesaplama sonucunda da H^+ iyon derişiminin $2.66x10^{-4}$ M bulunarak öğrencilere bu değerin 1M'in yanında oldukça küçük bir sayı olduğuna dikkat etmelerini sağlayınız.



İyonlaşma sabiti büyük olan asitlerin, daha kuvvetli asit olduğunun öğrencilerin yorum yapmasını sağlayınız.

Etkinlik sonunda, asidik maddelerde hidrojenini daha kolay veren maddelerin daha kuvvetli asit ve dolayısıyla da iyonlaşma yüzdelerinin de daha büyük olduğunun vurgunu yapınız.

Bazik maddeler için de kuvvetlilik kavramının iyonlaşma yüzdesi ile ilgili olduğu sonucunu öğrencilerin tespit etmelerini sağlayınız.

Zayıf asit veya bazların elektrik akimini iyi iletmediklerini ve bunun nedenini öğrencilere sorunuz. Elektrik akımını sağlayacak iyon sayısı azaldıkça, çözeltilerin daha zayıf elektrolit olduklarının sonucuna varmalarını sağlayınız.

- Öğrencilerin "Kuvvetli asit – Zayıf asit arasında ne fark vardır?" etkinliğini gerçekleştirmelerini sağlayınız.
    - Bu etkinlikte öğrenciler, kuvvetli asit veya zayıf asit denildiğinde ne düşündüklerini resmetmeye çalışacaklardır. Öğrencilerin, ortaya koydukları modeller incelenerek, daha kalıcı ve doğru bir öğrenme için ve herhangi bir kavram yanılgısının oluşmaması amacıyla modellerin incelenmesi önemlidir.

- Çözünürlük ve iyonlaşma aynı şeyleri mi ifade eder sorusu öğrencilere sorulur.
    - Bu soruda amaç, öğrencilerin çözünürlük kavramı ile iyonlaşma kavramını birbirinden ayırt etmelerini sağlamaktır. Çözünme olgusunu ve iyonlaşma ile farkını ayırt edebilmesi için öğrencilere sirke örneğini vererek sirkenin asetik asit içerdiğini belirtin. Asetik asidin iyonlaşma yüzdesi düşük olduğu için zayıf asit olduğu belirtilir, fakat örneğin turşu yapımında kullanılan sirkenin az çözündüğü söylenebilir mi sorusu sorulur. Çözünme olayının gerçekleşebilmesi için maddenin iyonlaşması şart olmadığı, şeker örneğini de vererek şekerin iyonlaşmadığı moleküler olarak suda çözündüğünü belirtilir. Bunun sonucunda, öğrencilerin çözünme ve iyonlaşma kavramlarını birbirinden ayırt etmeleri amaçlanır.

G – 8. THE PROPERTIES OF ACIDS AND BASES

ASİTLER VE BAZLARIN ÖZELLİKLERİ

Etkinlik: Asit ve Bazların Özellikleri

Konu: Asit ve bazların özellikleri

1. Asitler ve bazların genel özellikleri.
2. Asitlerin metallerle tepkimeleri.
3. Asitlerin karbonatlarla tepkimeleri.

Kazanımlar:

Bilişsel Kazanımlar:

- Asitlerin ve bazların fiziksel ve kimyasal özelliklerini tanımlar.
- Asitler ve bazları fiziksel ve kimyasal özelliklerini kullanarak birbirinden ayırt eder.
- Asitlerin aktif metallerle olan tepkimelerinde hidrojen gazi çıktığını açıklar.
- Asitlerin karbonatlarla olan tepkimelerinde karbondioksit gazi çıktığını açıklar.
- Bazların genellikle metallerle tepkime vermediklerini açıklar.
- Asitler ve bazların elektrik iletkenliğini açıklar.
- Asitler ve bazların birbirleriyle tepkimeye girerek tuz ve su oluşturduklarını yorumlar.

Duyuşsal Kazanımlar:

- Asitlerin metallerle olan tepkimeleri ilgisini çeker.
- Asitlerin ve bazların elektrik iletkenliği ilgisini çeker.
- Etkinliği gerçekleştirmek için işbirliği yapar.

Psikomotor Kazanımlar:

- Asitler ve bazlar arasındaki benzer ve farklı özellikleri rapor eder.

Süre: 4 ders saati

Dersin İşlenişi:

- Ders başında öğretmen, öğrencilere iki çözelti göstererek bu çözeltilerden birinin asidik bir çözelti diğerinin de bazik bir çözelti olduğunu belirterek bu çözeltilerden hangisinin asidik ve hangisinin bazik çözelti olduğunu nasıl tespit edeceklerini sorar (5 dk).

- o Öğretmen, en son dersle ilgili öğrencilerin neler hatırladıklarını sorgular. Asidik ve bazik maddelerin turnusol, kırmızılahana, ve indikatör kağıtlarında farklı renk aldıkları için asidik ve bazik maddelerin belirlenebilmesini öğrencilerin nasıl test ettiklerini hatırlatır.

- ➢ Fiziksel olarak bakıldığına asidik ve bazik çözeltiyi birbirinden ayırt etmenin mümkün olmadığını fakat asitleri bazlardan ayıran birçok özelliklerin olduğunu ifade edilir. Asitler ve bazlar arasında az olan ortak özelliklerinden birinin bazı çözeltiler için görünümlerinin benzer olduğu belirtilir (5 dk).
- ➢ Öğrencilere limon yediklerinde nasıl tat aldıkları sorulur ve öğrenci yanıtları alınır. Asit kelimesinin Latinceden (acidus) geldiği belirtilerek anlamının ekşi olduğu ifade edilir. Asitler suda çözündüklerinde ekşi tat verdikleri söylenir. Her gün yediğimiz yiyeceklerden bu tadı tattığımız ifade edilir. Portakal ve greyfurt gibi meyvelerin sitrik asit, yoğurt ve ekşi sütun laktik asit, gazlı içeceklerin karbonik asit, sirkenin asetik asit içerdiği belirtilir (10 dk).
  - o "Melis'in Bir Günü" etkinliğinin ikinci formatından yararlanarak günlük hayatımızdaki başka hangi yiyeceklerin hangi asitleri içerdiği öğrencilerden araştırmaları istenir. Süt ve ekşimiş süt arasında fark olduğu eklenir, sütun normal koşullarda laktik asit içermediği ama ekşime olayı başladıkça içerisindeki laktik asit oranın arttığı ifade edilir, bunun için süt ve ekşimiş süt test edilirse farklı sonuçlar bulunur. Fakat öğrencilere laboratuar ortamında hiçbir maddenin tadına bakmamaları vurgulanır. Bazı kimyasallar zararsız oldukları gibi bazılarının ise oldukça tehlikeli ve zehirli oldukları belirtilir. Yiyeceklerdeki asitlerin seyreltik asit olduğu ve deriyi tahriş etmediği fakat laboratuar ortamında bulunan birçok asidin oldukça derişik ve deri ile olan temasında çok ciddi yanıklara neden olduklarını vurgulayın.
- ➢ Asitlerden farklı olarak bazların ise, tatlarının acı olduğu ifade edilir. Yanlışlıkla sabunu tatmış olanların bu tadı almış oldukları veya mide ekşimelerinde yemek sodası suda çözündürerek içildiği belirtilir, bu yemek sodasının bazik olduğu ve acı tadı olduğu belirtilir. Öğrencilere bazik olan sabunda her gün ellerini

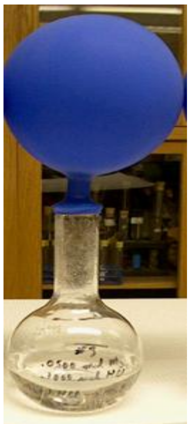
yıkarken kolayca gözlemledikleri başka bir özellik olduğu ifade edilir. Bazların kayganlık hissi verdikleri eklenir (5 dk).

- Öğrencilere laboratuar ortamında hiçbir kimyasal maddeyi tatmamaları veya dokunmamaları tekrar hatırlatılır.

➤ Asitleri bazlardan ayıran temel özelliklerden birinin de metallere olan davranışları olduğu belirtilir. Öğrencilere, metallerin asidik ve bazik çözeltilerdeki farklı davranışlarını göstermek üzere gösteri deneyi hazırlanır.

- Bu adımda, öğrencilerin gruplar halinde çalışması tehlikeli olabileceği için öğrencilerle tartışma ortamı yaratarak metallerle olan tepkimeler tartışılır. Laboratuar ortamının havalandırma koşulları uygun olmadığından bazı deneylerin video gösterimleri hazırlanır.

➤ İki erlen alınarak aynı derişimli olmak üzere birisine HCl çözeltisi ve diğerine de NaOH çözeltisi hazırlanır. İki erlenin ağzına tutturmak üzere de iki balon hazırlanır. Eşit miktarlarda magnezyum şerit alarak erlenlerin içerisine atılır ve balonlar erlenlerin ağızlarına tutturulur. Yanda verilen resimdeki gibi HCl asit bulunan erlende balonun şiştiği gözlemlenir. NaOH çözeltisinde herhangi bir değişiklik gözlenmez. Erlende meydana gelen tepkimeyi ve değişimin her öğrencinin görmesi sağlanır (5 dk).



➤ Kalsiyum karbonat için de aynı işlemler tekrarlanarak hem HCl hem de NaOH çözeltisine eşit miktarda $CaCO_3$ konup, erlenlerin ağızlarına balon tutturulur. HCl asit çözeltisinin bulunduğu erlendeki balonda yine şişme gözlenir. Erlende meydana gelen bu tepkimenin her öğrencinin gözlemlemesi sağlanır. NaOH çözeltisinde herhangi bir değişiklik gözlenmez (10 dk).

- Öğrencilere "Melis'in Bir Günü" etkinliği hatırlatılarak bu etkinlikte Melis'in heykellerdeki aşınmalara dikkat ettiği hatırlatılır. Bu etkinliğin ikinci formatı öğrencilerle incelenerek heykellerdeki aşınmaların asitlerin hangi özelliklerinden dolayı oluştuğu tartışılır. Asitlerin karbonatlı bileşiklere etki ederek karbondioksit gazı oluşturduğu belirtilir.

- Öğrencilerin asitlerin magnezyum ve kalsiyum karbonatla olan tepkimelerini yazmaları istenir. Bu esnada öğretmen, balonların ağızlarını sıkıca bağlar (10 dk).
    - Balonların birinde hidrojen gazı ve diğerinde ise karbondioksit gazı bulunur. Başka bir balon da bir öğrenciye verilerek şişirmesi istenir. Her iki tepkime sonucunda farklı gazlar oluştuğunu göstermek amacıyla balonlar aynı noktalardan bırakılır. Balonların serbest bırakılmasıyla gözlenen değişiklik öğrencilerle tartışılır. Bu etkinlikte amaç, öğrencilerin iki tepkime sonucunda farklı gazların oluştuğunu kavramalarını sağlamaktır. Oluşan tepkimeler üzerinde tartışılır.
- Na metali ile (http://www.youtube.com/watch?v=p8pZzO9DOWE) ve K metalinin (http://www.youtube.com/watch?v=gQagFoHQhOg) HCl asit ile tepkimelerinin videoları öğrencilere gösterilir. Bu metallerin aynı zamanda su ile de şiddetli tepkimeler verdiklerini belirtilir. Bu metallerin ortak noktası öğrencilere sorulur (10 dk).
    - Öğrencilerden 1A grubu alkali metaller olduklarına dair cevap aranır. Bir sonraki konu olan elektrokimya konusunda, metallerin aktifliği ile ilgili daha detaylı bilgiler öğrenecekleri ifade edilir.
- Cu metalinin HCl asit çözeltisine atarak tepkime vermediği öğrencilerin görmesi sağlanır. Nitrik asit çözeltisinde atılan bakır metalinin tepkime verdiği video (http://www.youtube.com/watch?v=1stvvo4x31E) gösterilir. Bakırın neden hidroklorik asit çözeltisinde tepkime vermediği fakat nitrik asit çözeltisinde tepkime verdiği sorulur. Aynı durumun gümüş ve cıva için de geçerli olduğu belirtilir, HCl veya HBr gibi çözeltilerde Ag veya Hg tepkime vermediği fakat HNO_3 ve H_2SO_4 çözeltilerinde tepkime gözlendiği belirtilir (15 dk).
    - Öğrencilerin bu metallerin yarısoy metaller olduğu farkına varmaları sağlanır. Yarısoy metallerin HNO_3 ve H_2SO_4 gibi oksijen içeren asitlerle tepkime verdikleri ifade edilir. Daha kalıcı öğrenme için videolarla bu tepkimeler desteklenerek öğrencilerin görsel olarak bu tepkimeleri izlemeleri sağlanır. Nitrik asit ile olan tepkimelerde çıkan gazın hangi gaz olduğunu öğrencilerin tepkime denkleminden

bulmaları sağlanır ve çözeltinin mavi rengi ve gazın kahve renkli olması durumu açıklanır ($3Cu + 8HNO_3 \rightarrow 3Cu(NO_3)_2 + 2NO + 4H_2O$). Oksijenli metallerle tepkime sonucunda hidrojen gazi oluşmadığı asidin içeriğine göre SO_2, NO_2, NO gibi gazların açığa çıktıkları tespit edilir.

- Bazik çözeltiler düşünüldüğünde metallere pek etki etmedikleri gözlendiği belirtilir. Öğrencilere bu durumda asitler metallere etki eder fakat bazlara etki etmezler genellemesi yapılabilir mi diye sorulur. Bunun ardından, HCl ve NaOH çözeltilerine Al metali atılır. Bu durumda, öğrencilerin her iki çözeltide de tepkime olduğunu gözlemeleri sağlanır. Bu durumun, çinko veya kalay gibi diğer metaller için de geçerli olduğu belirtilir. Bu metallerin neden hem asidik hem de bazik çözeltilerde tepkime verdikleri sorgulanır (10 dk).
    - Öğrencilerin bu metallerin amfoter metaller olduklarını hatırlamaları sağlanır. Zn, Sn, Cr, Pb, Al gibi amfoter metaller hem asidik hem de bazik çözeltilerden etkilenirler. Amfoter metalleri daha iyi hatırlayabilmeleri için öğrencilere "Zengin Sinan Çarşıdan Pabuç Aldı" cümlesini söyleyiniz. Boylece, bazik çözeltilerin genel olarak metallere etki etmediği fakat NaOH veya KOH gibi kuvvetli bazların Zn veya Al gibi amfoter metallere etki ederek hidrojen gazi oluşturduğu vurgulanır.
- Asit ve bazların başka bir ortak özelliği olan elektrik iletkenliği hakkında bilgi vermek amacıyla bir video kullanılacaktır (http://www.youtube.com/watch?v=4WillWjxRWw&feature=related). Elektrik iletimi ile ilgili öğrencilere ne düşündüklerini sorarak, asidik ve bazik çözeltiler kullanılarak bir düzenek kurulduğunda elektrik akımı sağlanır mı hakkında onların düşünceleri alınır (15 dk).
    - Burada amaç, iyon hareketiyle elektrik akımının iletildiğinin belirtilmesidir. Videoda hem kuvvetli hem de zayıf çözeltiler kullanılmıştır. Neden bazı çözeltilerin elektriği daha iyi ilettiği öğrencilere sorulur. Yorum getiremeyen öğrencilere kuvvetli veya zayıf asit olup olmamaları sorulur, bu durum nasıl açıklanabilir diye öğrenci yorumları alınır.

- Son özellik olarak, asit ve bazların birbirleriyle tepkimeye girerek nötrleşme tepkimesi vermesi ve tepkime sonucunda da genellikle tuz ve su oluşturmasına değinilecektir. Bunun için aynı derişimdeki asit ve baz çözeltilerinden yararlanılacaktır. Nötrleşme tepkimesinin gözlenebilmesi için metiloranj kullanılacaktır. Bir behere bir miktar NaOH çözeltisi ve başka bir behere de HCl çözeltisi koyunuz. HCl çözeltisine birkaç damla metiloranj damlatarak öğrencilerin pembe rengi aldığını gözlemelerini sağlayınız. Daha sonra HCl bulunan behere NaOH bulunan beherden yavaş yavaş ilave ediniz. Öğrencilerin bu değişimi gözlemeleri sağlanır. Bazik çözeltiden eklendikçe neden renk değişimi gözlendiği tartışılır (20 dk).
- Öğrenciler "Nötrleşme Nedir?" etkinliğini gerçekleştirirler (20 dk).
    - Öğrenciler, etkinlik esnasında tanecik boyutunda gerçekleşen olayları ortaya koymaya çalışacaklardır. Tanecik boyutunda neler oluştuğunu iyi bir şekilde kavrayan öğrencilerin öğrenmeleri daha kalıcı olmaktadır. Bunun için, öğretmen öğrencilerin çizdiği modelleri dikkate alarak onların eksiklerini veya yanlışlarını gidermeye yönelik etkinlikleri gerçekleştirecektir.
- Öğrencilerin "Kek Nasıl Kabarır?" etkinliğini gerçekleştirirler (20dk).
    - Burada amaç, karbonatın nötrleşme tepkimesini gözlemleyerek günlük hayattaki durumlarla ilişkilendirmek. Bu etkinlikte "Melis'in Bir Günü" etkinliğine değinerek mide problemlerinde kullanılan bazı ilaçların bazik olduğu ve mideyi rahatlatmak için kullanıldığı belirtilir. Karbonatın da bazik bir çözelti oluşturduğu için mideyi rahatlattığı belirtilir.
- Öğrencilere, kabartma tozu ve karbonat arasındaki farklılık hatırlatılır. Önceki etkinliklerde kabartma tozu ve karbonat kırmızılahana kağıdı ile test edildiğinde farklı sonuçlar elde edilmişti, bu bilgi günlük hayattaki olaylara nasıl yorumlanabilir öğrencilerle tartışılır. Kek gibi yiyeceklerde kullanılan kabartma tozu ve karbonatın arasında pH farkının olduğu bilmek öğrencilerin ne işine yarar sorusunu sorulur.
    - Kabartma tozunun sulu çözeltisi nötr'e yakın ve karbonatın sulu çözeltisi ise bazik olduğu tespit edilmiştir; bunun için kek yapımında

kullanılan malzemelerin farklılaştığı belirtilir. Karbonat bazik bir madde olduğu için ağızda acı bir tat bırakır. Bundan dolayı, kek yapımında karbonat kullanılacaksa tadını nötr yapmak için limon suyu veya yoğurt gibi asidik maddeler kullanılır; fakat kabartma tozu kullanılacaksa kek yapımında bu şekilde asidik maddeler kullanılmamalıdır çünkü bu asidik maddeler kekin tadının ekşi olmasına neden olurlar. Kabartma tozunun içinde karbonatla birlikte asit düzenleyici maddeler olduğu için tadı ne ekşi ne de acıdır bilgisi verilir.

G – 9. TITRATION

TİTRASYON

Öğrenciler titrasyon olayını anlamakta bazen zorlanmaktadırlar. Titrasyonun bir nevi kontrollü bir nötrleşme tepkimesi olarak düşünmelerini isteyiniz. Öğrencilerin titrasyon olayını daha iyi kavrayabilmeleri için, iki aşamalı bir etkinlik gerçekleştirilecektir. Öğrencilerin, titrasyon olayını daha iyi anlamaları ve tanecik boyutunda neler gerçekleştiğini kavrayabilmeleri için bir gösteri deneyi ve simülasyon kullanılacaktır. Gösteri deneyi için titrasyon düzeneğini kurunuz ve 0.2 M'lik bir sodyum hidroksit çözeltisi ve derişimi bilinmeyen hidroklorik asit çözeltisini hazırlayınız. Gösterilecek olan simülasyon ile paralellik göstermesi açısından kullanılacak olan hidroklorik asit çözeltisini 0.1 M olarak hazırlayınız (Öğrencilere hidroklorik asit çözeltisinin derişimini bildirmeyiniz).

Simülasyondaki gibi 60 ml hidroklorik asit çözeltisinden ve 50 ml 0.M sodyum hidroksit çözeltisinden kullanarak düzeneği ayarlayınız. Titrasyon düzeneğinde gerçekleştirdiğiniz her adımı es zamanlı olarak simülasyonda da gerçekleştiriniz. Simülasyon aşamasında aşağıda belirtilen adımları öğrencilerle tartışınız:

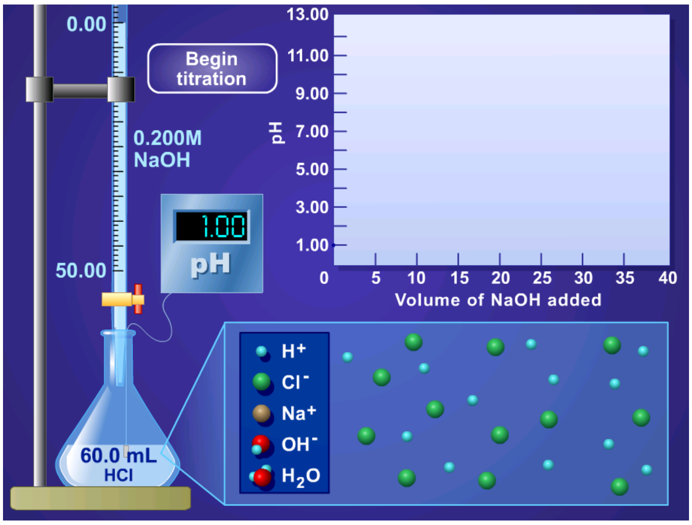
- İlk durumda öğrencilerin simülasyonu tanımaları için biraz sure veriniz (simülasyonda belirtilen taneciklerin gerçekte renkli olmadıklarını, daha anlaşılır olması için simülasyonda renklerin kullanıldığının vurgusunu yapınız; durumun daha basit olması için de su moleküllerinin ihmal edilerek gösterilmediğini belirtiniz).

  Tanecik boyutunda verilen birim hacim kesitinin erlenmayerden alındığını gösteriniz. Hidroklorik asidin kuvvetli bir asit olduğu için, hidroklorik asit moleküllerinin su içerisinde %100'e yakın iyonlaştığını önceki bolümde öğrendiklerini hatırlatınız.

  Çözeltiye NaOH ilave edildikçe, grafikteki pH değerini ve tanecik boyutundaki değişimleri gözlemelerini isteyiniz.

  Simülasyonda, ifade edilmemiş fakat her adımda öğrencilere pH ile pOH arasındaki ilişkiyi hatırlatarak, ilk altı durum için ortamdaki OH^- iyonlarının ve son iki durum için de H^+ iyon derişimini sorgulayınız, bu durumu açıklamalarını isteyiniz.

1



- İkinci durum için, titrasyon düzeneğinde 5 ml NaOH çözeltisinden HCl çözeltisine ilave ediniz. NaOH ilavesiyle erlende nasıl bir değişiklik olduğunu simülasyon yardımıyla öğrencilerle tartışınız. Öğrencilerden 1.durum ile şimdiki durum arasında nasıl bir fark gözlemlediklerini sorunuz. Öğrencilerin NaOH ilavesiyle aşağıda belirilen durumların farkına varmalarını sağlayınız:

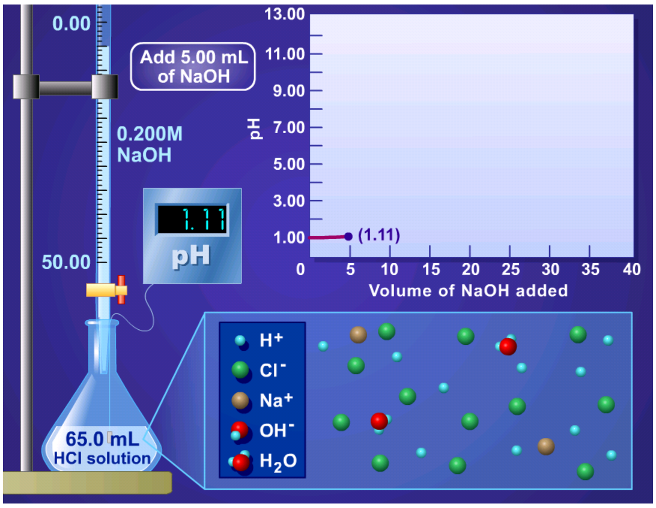
  HCl + NaOH → NaCl + H_2O tepkimesine göre,

  NaOH çözeltisinden gelen OH^- iyonlarının ortamdaki H^+ iyonlarıyla etkileşerek su moleküllerinin oluşması

  NaCl tuzunun oluştuğunu fakat bu tuzun çözelti içerisinde iyon tanecikleri olarak bulunması

  Grafikteki pH değerindeki değişim, OH^- iyonlarının derişimi

2



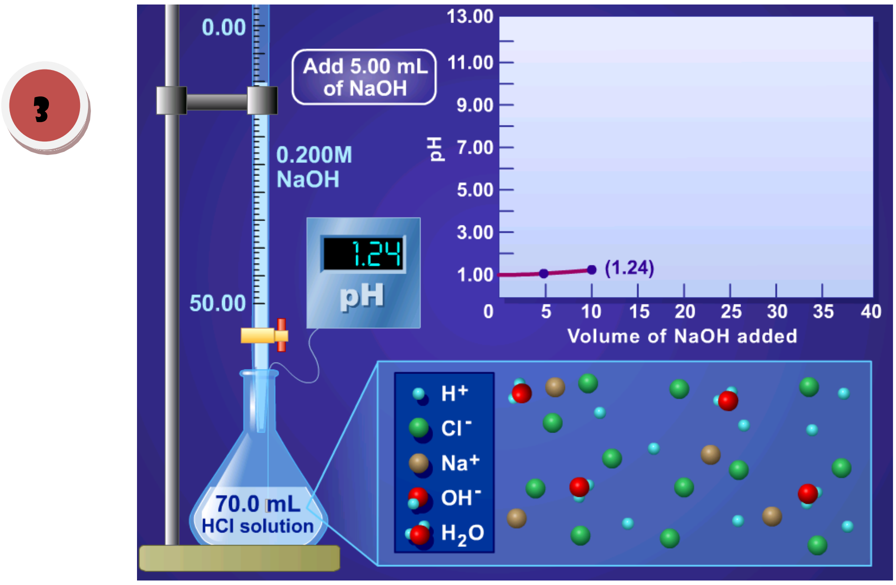
- Üçüncü durumda, 5 ml daha NaOH çözeltisinin ilavesiyle erlendeki çözeltide nasıl bir değişim gözlendiğini simülasyon yardımıyla öğrencilerle tartışınız. Öğrencilerin NaOH ilavesiyle aşağıda belirilen durumların farkına varmalarını sağlayınız:

  $HCl + NaOH \rightarrow NaCl + H_2O$ tepkimesine göre,

  NaOH çözeltisinden gelen OH^- iyonlarının ortamdaki H^+ iyonlarıyla etkileşerek su moleküllerinin oluşması ve bir önceki duruma göre su moleküllerindeki artış

  NaCl tuzunun oluştuğunu fakat bu tuzun çözelti içerisinde iyon tanecikleri olarak bulunması ve bir önceki duruma göre Na^+ iyonlarındaki artış

  Grafikteki pH değerindeki değişim, OH^- iyonlarının derişimi



- Dördüncü durumda (Beşinci ve Altıncı durumlar için aynı şekilde tartısınız), 5 ml daha NaOH çözeltisinin ilavesiyle erlendeki çözeltide nasıl bir değişim gözlendiğini simülasyon yardımıyla öğrencilerle tartışınız. Öğrencilerin NaOH ilavesiyle aşağıda belirilen durumların farkına varmalarını sağlayınız:

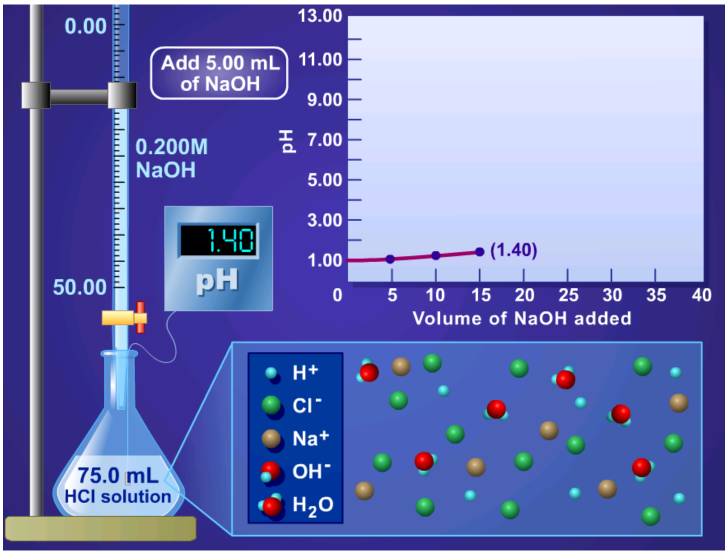
  $HCl + NaOH \rightarrow NaCl + H_2O$ tepkimesine göre,

  NaOH çözeltisinden gelen OH^- iyonlarının ortamdaki H^+ iyonlarıyla etkileşerek su moleküllerinin oluşması ve bir önceki duruma göre su moleküllerindeki artış ve H^+ iyonlarındaki azalma

  NaCl tuzunun oluştuğunu fakat bu tuzun çözelti içerisinde iyon tanecikleri olarak bulunması ve bir önceki duruma göre Na^+ iyonlarındaki artış

Grafikteki pH değerindeki değişim, OH^- iyonlarının derişimi

4



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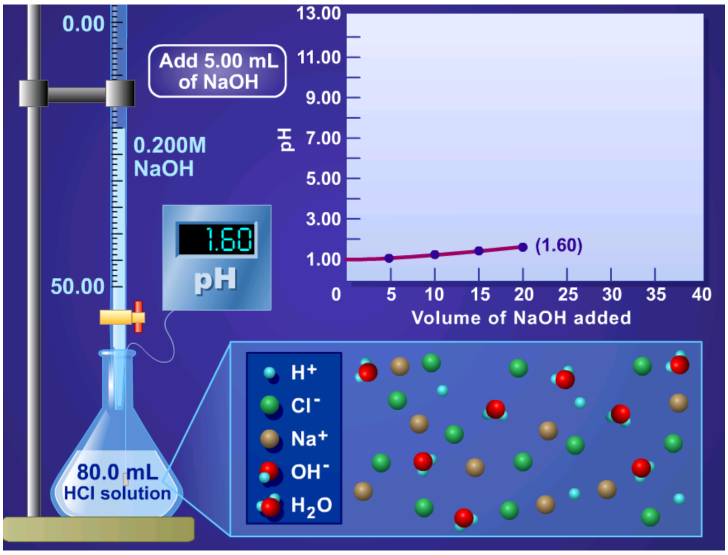

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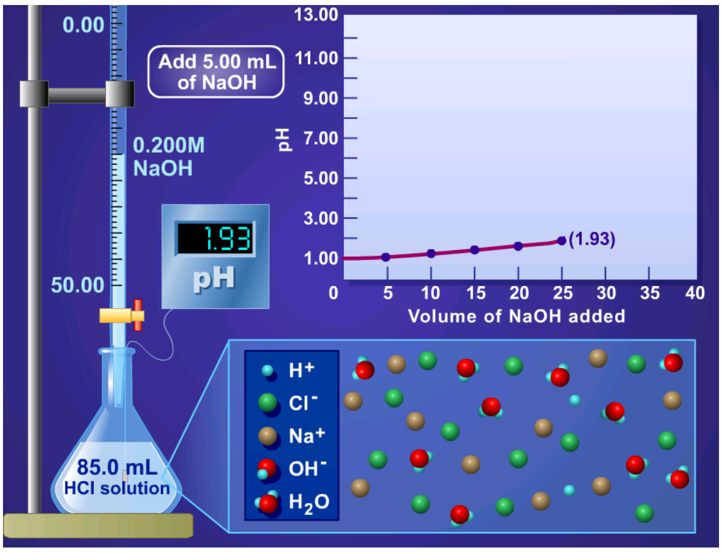
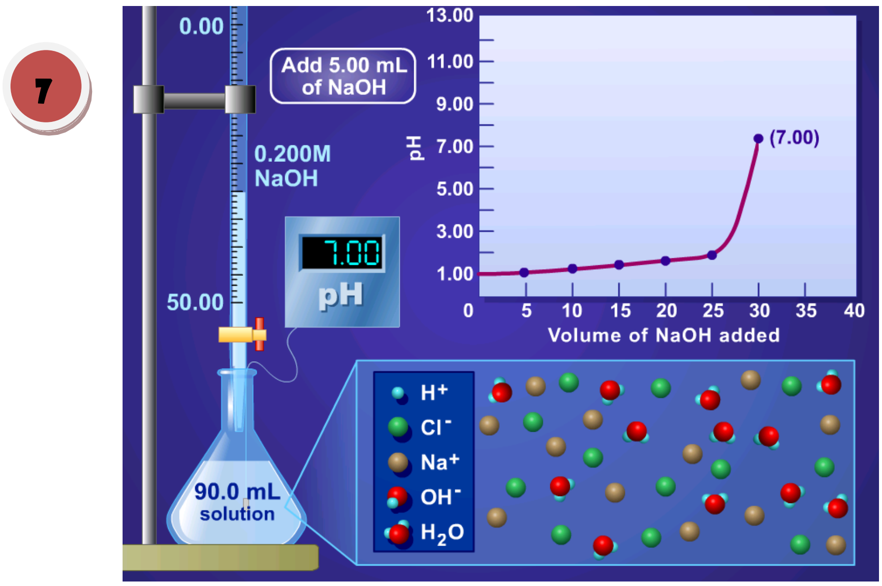


- Yedinci durumda, 5 ml daha NaOH çözeltisinin ilavesiyle erlendeki çözeltide nasıl bir değişim gözlendiğini simülasyon yardımıyla öğrencilerle tartışınız. Öğrencilerin NaOH ilavesiyle aşağıda belirilen durumların farkına varmalarını sağlayınız:

  Bu durumda, çözeltide bulunan H^+ ve OH^- iyonlarının derişiminin eşit olduğunu ifade ediniz (Simülasyonda belirtilmemesine rağmen, önceki derslerden suyun iyonlaşması konusunu hatırlamalarını isteyiniz) ve bundan dolayı bu andaki çözeltiye nötr çözelti denildiğini ve bu noktaya da eşdeğerlik noktası denildiğini belirtiniz. Öğrenciler genellikle bu durumu, pozitif ve negatif iyonların eşit olması veya ortamda H^+ ve OH^- iyonlarının bulunmaması olarak yorumlarlar. Bu tur yanlış kavramalara meydan vermemek için öğrencilerin bu durumu iyice anladığından emin olunuz.

  Kuvvetli asit ve kuvvetli baz tepkime sonucunda oluşan tuz, notr bir tuzdur; asidik veya bazik bir tuz oluşmadığı için ortamın pH değerinin 7 olduğunu, fakat daha sonraki derslerde zayıf – kuvvetli asit ve baz tepkimelerinde ortamın pH değerinin 7 olmadığı durumunu öğreneceklerini belirtiniz.



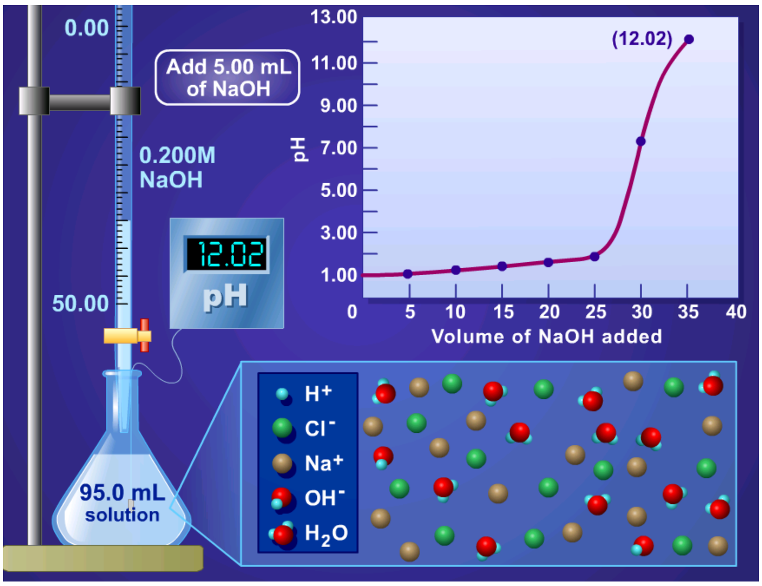
Gerçekleştirilen titrasyonda çözelti hala renksiz olduğu için eşdeğerlik noktasının tespitinin zor olduğunu öğrencilere belirtiniz. Damla damla NaOH çözeltisinden ilave ederek renk değişiminin gerçekleştiği hacmi not ediniz. Bu noktaya ise dönüm noktası denildiğini belirtiniz. İndikatörlerin bu dönüm noktasını belirlemekte yardımcı olduklarını ifade ediniz. Teoride eşdeğerlik noktası ile dönüm noktasının eşit olduğunu, fakat pratikte küçük oynamalar olduğunu deney esnasında onların da gözlemlediğini belirtiniz.

Dönüm noktasının belirlenmesi ile derişimi bilinmeyen HCl asit çözeltisinin derişiminin tespiti burada elde edilen hacim ile hesaplandığını belirtiniz. Çünkü bu noktada, harcanan baz miktarı ile başlangıçta var olan asit miktarı eşitlenmiştir.

- Sekizinci durumda (son durumu da benzer şekilde tartışınız), eşdeğerlik noktası sonrası 5 ml daha NaOH çözeltisinin ilavesiyle erlendeki çözeltide nasıl bir değişim gözlendiğini simülasyon yardımıyla öğrencilerle tartışınız. Öğrencilerin NaOH ilavesiyle aşağıda belirilen durumların farkına varmalarını sağlayınız:
    - NaOH çözeltisinden gelen OH^- iyonları ile ortamdaki OH^- iyonlarındaki artış
    - NaOH çözeltisinin ilavesiyle, Na^+ iyonlarındaki artış devam etmekte fakat ortamda tuz oluşturacak Cl^- iyonlarında değişim olmadığı için tuz oluşumunda artış gözlenmemektedir
    - Grafikteki pH değerindeki değişim, H^+ iyonlarının derişimi

NaOH çözeltisinin ilavesinin devam etmesiyle, erlendeki çözeltinin bazik özelliği artmaktadır. Ortamda OH^- iyonlarının üstünlüğü olduğu için çözelti bazik bir çözeltidir; fakat ortamda eser miktarda da olsa suyun iyonlaşmasından kaynaklanan H^+ iyonlarının varlığı devam etmektedir. Öğrencilerden bu iyon derişimini bulmalarını isteyiniz.

8



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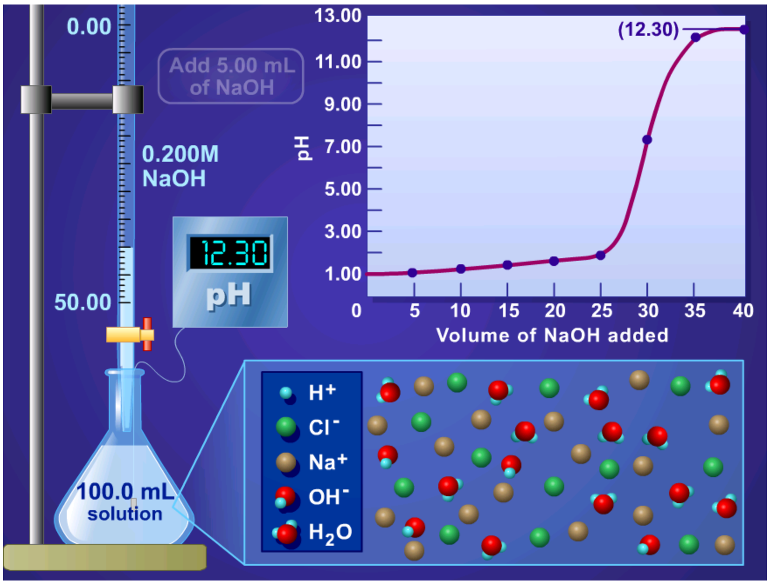

Titrasyonun sadece kimya bilimi kapsamında değil birçok diğer alanda da kullanıldığını ifade ediniz. Diğer bilim alanlarında da titrasyonun değişik amaçlar için kullanıldığını belirtiniz. Titrasyon işleminin laboratuarlarda kan ve idrardaki bilinmeyen madde derişimini tespit etmek amacıyla sıklıkla kullanıldığını belirtiniz. Eczacıların da yeni ilaç üretiminde de titrasyon işlemine başvurduklarını ekleyin. Aynı zamanda, yiyeceklerdeki kimyasalların miktarını belirlemek amacıyla titrasyona başvurulduğunu, bunun icin yiyeceklerin yağ içeriğini, su içeriğini veya vitaminlerin derişimininin titrasyon ile tespit edildiğini ifade ediniz. Bunun yanında, dağıtıma ve satışa çıkmadan önce peynir ve şarabın yeterince yıllanıp yıllanmadığını test etmek için titrasyon işleminin kullanıldığını belirtiniz.

APPENDIX H

AN EXAMPLE OF TRADITIONAL GROUP LESSON PLAN

GELENEKSEL GRUP DERS PLANI ÖRNEĞİ

Konu: Asitler ve Bazlar ünitesine giriş

Kazanımlar:

- Günlük hayatta birçok asidik maddelerle karşılaştığını fark eder.
- Günlük hayatta birçok bazik maddelerle karşılaştığını fark eder.
- Asit ve bazlari kavrar.
- Degisik asit-baz tanimlarini kullanarak asit ve bazlari tanimlar.
- Farkli asit-baz tanimlarinin ayrimini yapar.
- Asidik ve bazik maddelerle ilgili ornekler verir.

Süre: 3 ders saati

Dersin İşlenişi:

- Öğretmen, öğrencilere asit ve bazik maddelerle günlük hayatta karşılaşıp karşılaşmadıklarını sorar. (5dk)
- Öğrencilerin görüşlerini alan öğretmen, asidik ve bazik maddelerin günlük hayatta sıklıkla karşılaştıklarını belirtir. (5dk)
    - Öğrencilere limon, elma, sirke, akü veya meyve gibi asidik madde örnekleri ve sabun, karbonat, diş macunu ve deterjan gibi bazik madde örnekleri verilir.
- Öğretmen, öğrencilere ikinci sürüm "Melis'in Bir Gunu" adlı etkinlik okumasını dağıtır. (10dk)
    - Okuma etkinliğinde öğrencilerin günlük hayatta karşılaşabilecekleri asidik ve bazik maddeleri bulmalarını ve açıklamalarını okumalarını isteyiniz.

- Öğretmen daha sonra asitlerin ve bazların tanımları ile ilgili bilgi verir. Öncelikle Arrhenius asit-baz tanımı açıklanır. (20dk)
    - Hangi maddelere asit ve hangi maddelere baz dendiğini, bununla ilgili öğrenci görüşlerini alınız.
    - Arrhenius asit-baz tanımını açıklayınız. Asitler icin HCl, H_2SO_4, HNO_3, HBr ve HI ve bazlar için de NaOH, KOH, $Mg(OH)_2$, ve $Ca(OH)_2$ örneklerini verebilirsiniz.
    - Daha sonrasında, öğrencilere CH_4, NH_3 ve CH_3COOH bu maddelerin asitligi ve bazlığı hakkında ne söyleyebileceklerini sorunuz.
    - Tahtaya NH_3 ve HCl arasındaki tepkimeyi yazarak, bu tepkimede amonyak'in baz olarak davrandığından bahsediniz. Arrhenuis ast-baz tanımındaki eksiklikleri öğrencilere açıklayınız.
- Öğretmen, Bronsted-Lowry asit-baz tanımı ile ilgili açiklamalar yapar. (40 dk)
    - Bronsted-Lowry asit-baz tanımını öğrencilere açıklamak için öğrencilere birçok asit-baz tepkime örneği gösterilir.
    - Öğrencilere, konjuge asit-baz çiftleri ile ilgili açiklamalar yapılır. Örnek tepkimelerdeki konjuge asit-baz çiftlerini öğrencilerin bulmalarını isteyiniz.
    - Brinsted-Lowry asit-baz tanımının eksiklerinden bahsediniz ve açıklayınız.
- Öğretmen, Lewis asit-baz tanımı ile ilgili açıklamalar yapar. (15 dk)
    - Lewis tanımını vermeden once öğrencilere, Lewis elektron-nokta yapısını hatırlatmak için tahtaya birkaç örnek yazınız ve öğrencilerin bu yapıyı hatırlayıp hatırlamadıklarını sorunuz.
    - Öğrencilere, Lewis elektron-nokta yapısını hatırlatmak için birkaç örnek üzerinde açıklama yapınız.
    - Daha sonrasında, Lewis'in asit-baz tepkimelerinde elektron çifti özelliğini keşfederek elektron çifti alan ve veren üzerinden asit-baz tanımını genişlettiğinden bahsediniz.
- Öğrencilere, asit-baz tepkimeleri yazdırarak, bir maddenin üç tanım çerçevesinde de asit olarak adlandırılabileceği örnekleri veriniz. Arrhenius asit-baz tanımını veya Bronsted-Lowry asit-baz tanımının yanlış olmadıklarını

sadece bazı asit-baz tepkimeleri ele alındığında eksiklerinin olduğundan bahsediniz. (15 dk)

- “Asit ve Baz Tanımlarının Tarihçesi” isimli etkinlik okumasını öğrencilere dağıtınız. (10dk)

APPENDIX I

SOME EXAMPLES OF STUDENTS' RESPONSES FOR ACTIVITIES

ACTIVITY – ACIDS AND BASES

1) What do I know?

Example 1

• Suda çözündüğünde H^+ iyonu veren maddelere Asit OH^- iyonu veren maddelere baz diyoruz
• Asitler mavi turnusol kağıdını kırmızı yapar. Bazlar kırmızı turnusol kağıdını maviye dönüştürür
• Ph 0-7 arası asit
7-14 arası baz

Example 2

Asit: Suda çözündüğünde H^+ iyonu verebilen bileşiklerdir.

Baz: Suda çözündüğünde OH^- iyonu verebilen bileşiklerdir.

PH cetvelinde 0-7 arası asit, 7'den sonrası bazdır.

Example 3

Tepkimelerde H^+ iyonu verenlere Asit.
" OH^- " " Baz denir.

Asitler turnusol kağıdının rengini maviden kırmızıya, bazlar ise kırmızıdan maviye dönüştürür.
Asitlerin tadı ekşi, bazların tadı acıdır.

2) What I want to know?

Example 1

• Bildiklerim dışındaki özelliklerini

Example 2

Günlük hayatımızda bize ne gibi yararları olduğu.
Bunları hangi ortamlarda ne şekilde bulunduğu.
Bunları hangi ortamlarda kullanabileceğimiz.
İleri sınıflar teoriler ve halen kabul gören görüşler nelerdir.
Bu konunun bize kazandıracakları ve gireceğimiz LYS ve YGS sınavındaki gerekliliği nedir.

Example 3

Asit ve baz hakkında herşeyi öğrenmek istiyorum.

3) What I have learned?

Example 1

Kuvvetli asitlerin tadlarına bakılmaz fakat genel olarak tadları ekşidir, mavi turnusol kağıdını kırmızıya dönüştürürler

Temizlik malzemelerinde kullanılan bazların tadları acıdır kırmızı turnusol kağıdını maviye çevirirler

Asitler suda çözündüğünde H^+ iyonu verirler bazlar ise OH^-.
Amfoterler yerine göre hem baz hem de asit özellik gösterirler

Asitler sadece suda çözündüklerinde elektriği iletirler.
Bazların sudaları elektriği iletir

Example 2

Asitler günlük hayatımızda sıklıkla karşımıza çıkarlar. Yiyecekler de vardır, örneki Yoğurt, domates, kola, limon, sirke, Meyvelerde Bazlar yiyeceklerde yok. Yemek sodasını test ettik baz çıktı, turnusolde. Temizlik için kullanılanlar genelde bazı

Kırmızı lahana suyu turnusolun bir çeşidi. Asit bazda değişik renkler aldı

Asit ve baz için üç tanım öğrendik. Arhenius suda H^+ ve OH^- verenler için asit ve baz demiş. Bronsted-Lory proton veren asit alan baz demiş, Lewis elektron alan asit veren baz demiş,

Example 3

Yapılan testte birçok yeni bilgi öğrendim. Bunlar hakkında pek bilgim yoktu

Turnusol kağıdı ve Fenolftalein
çözeltisiyle olarak, pH ile pOH'la
H^+, OH^- derişimi olarak

Asitler ve Bazlar tepkimeye
girdiklerinde sut tuz oluşur.
oluşan madde nötr olmayabilir.
Tepkimeyi asit-baz tepkimesi
veya nötrleştirme tepkimesi
denir.

Example 4

PH çözeltideki H^+ ve OH^- derişimini
ölçer. Bazlarında ölçer.
Zayıf asitler az iyonlaşır kuvvetli
asitler çok iyonlaşır.
Fenolftalein sadece renk değişimini
gösterir nötürleşme olur. titrasyonlardan.
Nötürleşme tepkimesi sonucunda illa nötür
olması gerekmez.

Example 5

Zayıf asitler az iyonlaştıkları için zayıf derler. Kuvvetli asitler, çok iyonlaşır.

Kırmızı lahana suyu ile birçok maddeyi test ettik. Yapılan testte kırmızı lahana kağıtları sarı, yeşil, kırmızı renkler aldı.

Bronstet-Lowry tanımında proton alışverişi veren asit, alan baz. Arrhenius'e göre de suya H^+ veren asit OH^- veren baz. Lewis elektron çifti alışverişi önemli, alan asit veren baz.

ACTIVITY – A DAY WITH MELIS

Step 1 – Student Prior Individual Ideas for Substances

Example 1

elma → asit
sirke → asit
aspirin → asit
kola → asit
soda → baz
NaCl → nötr
sabun → baz
deterjan → baz.
Tatları ve görünüşlerinden dolayı buna karar verdim.

Example 2

* elma asit aspirin → asit sirke → asit
deterjan → baz sabun → baz
soda → baz kola → asit.

Example 3

Asitler ve bazlar, bilinen bir yöntemle tatlarından ayırt edilebilir.
Sirkenin ekşi, deterjanın tadının acı olması gibi. Kesin bir yöntem daha
tepkimede verdiği iyonlara bakılır.

Sirke → asit
Bulaşık Deterjanı → Baz
tuz → nötr

Example 4

Asit ve bazları ayırt etmek için tatları, su
ya verdikleri iyonlar farklıdır.
Sirkenin tadı ekşidir.
Soda → bazdır.
Elma → asittir.
Sabun bazdır, B. deterjanı bazdır.

Example 5

Baz
Sabun, diş macunu, bulaşık deterjanı (Temizlik araçlarının genelinde baz bulunuyor)

Asit
Kola, Sirke, Soda

Example 6

Elma ve Sirkede asitle karşılaşmıştır. Yoğurdada asit vardır.
Sabunda baz vardır. Yemek sodasında asit var.
Yemeğine attığı tuz asit ve baz karışımı

Example 7

Elini Yıkadığında sabun vardır. Sabun vb temizlik araçlarında Baz bulunur.
Sirke de Asit vardır.
Tuz Asit ve Bazın tepkimesi sonucu oluşur.
Diş macununda Baz var.
Kola da Asit var.
Meyvelerdede Asit var.
Bulaşık deterjanında da Baz vardır.
Soda da Asit vardır.

Example 8

Bence;	ASIT	BAZ	:)
	Ayran	Kahve	
	Limon	Dişmacunu	
	Sirke	Aspirin	
	Elma	Sabun	
	Soğan	Bulaşık deterjanı	
	Süt		

Student Prior Group Ideas for Substances

Example 1

Kendi Görüşlerim ile hemen hemen Aynı.

Soğanın tadı Acı olduğundan Baz olarak karar verdik

Example 2

Benzer maddeler: sirke, sabun, deterjan, soda, aspirin

Farklı: diş macunu, yağmur, süt, tuz

Example 3

Heykelin aşınması

Bulaşık deterjanı → baz

Diş macunu → asit

Example 4

Günlük hayatta farkına varmadığı asit ve bazlar mevcuttur,

Example 5

Kolada ve sodada asit

diş macununda asit

bulaşık deterjanı baz

Example 6

Benzer görüşler var. İlaca baz yada asit konusunda ayrılık yaşadık.

Example 7

Günlük kullandığımız maddeler asit ve baz olabilir. Bunları tatlarına göre ayırt edebiliriz.

Example 8

Gözlemlerimizin çoğu aynı pek bir farklılık yok elmanında asit olduğunu düşündüklerini söylediler ve elmanında asit olduğuna karar verdik. Soğanında acı tadından dolayı baz olduğuna karar verdik.

Step 2 – Student Posters

Step – 3

Student responses for the acidic and basic substances in their everyday lives (the first question)

Example 1

Asitler;

Kola; çünkü mavi turnusol kağıdını kırmızıya çevirdi ve CO_2 gazı açığa çıkarır.

Elma; çünkü mavi turnusol kağıdını kırmızıya çevirdi ve çok az oranda asittir.

Ayran; çünkü mavi turnusol kağıdını kırmızıya çevirdi

Gazoz; çünkü mavi turnusol kağıdını kırmızıya çevirdi. Gaz çıkışı vardır.

Bazlar;

Deterjan; tatları acıdır. Kırmızı turnusol kağıdını maviye çevirirler. Yapısında Cl iyonu bulundururlar.

Patates; az da olsa bazik özellik gösterirler

Karbonat; tatları acıdır. Genelde ek kullanarak tüketilir.

Yumurta akı; az da olsa bazik özellik gösterirler. Turnusol kağıdını maviye çevirirler.

Example 2

Evet karşılaşıyoruz. İçtiğimiz içeceklerde kolada, sütte, ayranda vb. Ellerimizi yıkadığımız sabunlarla, temizlik malzemelerinde. Kısacası hayatımızın her yerinde asit ve bazlarla karşılaşıyoruz. Bir maddenin asit ve bazlığını anlamak için turnusol kağıdını ne renge çevirdiğine bakmalıyız.

Example 3

Sabun : kayganlık hissi veriyor, tadı acı ve aynı zamanda bir temizlik malzemesi olduğu tam bazdır.

Diş macunu : yiyecekler tüketildikten sonra ağızdaki asidik ortamı florun hidroksit iyonunun yerine geçerek nötrleştirmesi bazik old. göst

Portakal suyu : İçerisinde ekşi tad ve C vitamini bulundurması (askorbik asit)

– Kimya derslerinde yaptığımız deneyler sırasında maddelerin turnusol kağıdına etkileri belirleyici sonuçlardır.

Yoğurt : Sütün ekşimesi, l. asit oluşumu.

Example 4

Bu rerisinde asit ve baza her yerde rastlayabiliyoruz. Özellikle kaşıma yendik yerler, meyve yerler yada evde annemin kullandığı temizlik malzemelerinde.

örneğin;

Asit	Baz
Limon	Sabun
Domates	Deterjan
Portakal	

Bunlar asit olarak düşünmemin nedeni acı ekşi olmaları ve ekşi tatlarının olmasıdır.

Bunları baz olarak düşünmemin nedeni tatlarının acı özelliğinin olmasından.

Example 5

Kola içerken.

Dişimi fırçalarken..

Student responses for the most interesting sections in the activity

Example 1

- En çok ilgimi çeken bazı tariflerde karbonat, bazılarında kabartma tozu kullanılmasıydı.
- Ben hep kabartma tozu kullanılır diye biliyordum.
- Karbonat yeteri kadar kullanılmazsa CO_2 gazı açığa çıkıp kabarmayacağı dikkatimi çekti.
- Kabartma tozunda ise hem asit hem baz bulunur.
- Aslında yapılan tarifin cinsine göre kabartma tozu ya da karbonat kullanılırmış.
- Örneğin; karbonat bazik özellik taşır. Yoğurt, limon gibi malzemelerle karıştırılmazsa ağızda acı bir tat verir.

Kabartma tozu hem asit hem de bazik özellik gösterdiği için ağızda acı hası bırakmaz. O yüzden genellikle kek tariflerinde kullanılır.

Example 2

Ayşegül sınav yaklaştıkça stresle birlikte midesinde yanma hissediyordu. Midesini rahatlatmak için yemek sodası ile suyu karıştırıp içti.

Abur-cubur kahvaltısı ve sınav öncesi stresi hazımsızlık yaptı. Böylece midesindeki fazla asit içeriği sodasıyla nötrleşti.

[illegible] gelmemesinin nedeni bazen benim gibi önemli der okul sınavlarında [illegible] fazla [illegible] için düzgün bir sabah kahvaltısı yapmıyoruz. Bu da genellikle bir süre sonra midemizde yanmaya neden oluyor. [illegible] bazı zaman karbonat için yaptığımız o kadar sıvılı kahvaltı genellikle yapılmalı değil [illegible] diye. Bunu öğrendiğim için iyi oldu ve bu yaptığımı yediklerimi yapmamaya çalışacağım.

Example 3

Heykellerin aşınması. Bizimde yağmurun asitliğini artırmış olmamız (NO$_2$ ve SO$_2$ gazı ile)

Example 4

En çok ilgimi çeken yer; bazı tariflerde kabartma tozu, bazı tariflerde karbonatın neden kullanıldığıydı. Karbonat bazik bir madde olduğu için herhangi bir asitik maddeyle karıştırılmadığı sürece tadı ekşidir. Ama yoğurt ve limon gibi bir asitik maddeyle karıştırılınca ekşi tadı kaybolur.

Kabartma tozu hem asit, hem baz içerdiği için tadında bir ekşilik yoktur. Genelde tariflerde süt gibi nötr maddeler kullanılır.

Example 5

Alabalık, ıspanak, maydanoz, piliç eti, brokoli, lahana, börek, portakal, marul, muz, yumurta gibi gıdalarda folik asit bulunur. Yeşil yapraklarda yaygın olarak folik asit bulunduğundan bu ad verilmiştir.

Example 6

Asit yağmurunun bitkileri öldürmesi, heykellere binalara zarar verip onları aşındırmasıdır.

Tariflerin bazılarında neden karbonat veya neden kabartma kullanılması dikkatimi çekti...

Example 7

- fazla şeker yemenin dişlere zarar verdiği hep söylenir, ama açıkçası bunun nedenini pek bilmiyordum. Ağızdaki şekerin aside dönüşmesi ve doğada elmastan sonra en sert madde olan mineyi eritmesi, yiyeceklerdeki yüksek şeker miktarından laktik asit ve asetik asit oluşması, içtiğimiz sularda ve diş macunundaki flor'un bu asitlerin zararını azaltması.

- Çamaşır suyuyla tuvalet asidik temizleyicilerinin birlikte kullanılmamasının nedeni ortamda bazik oluşacak nötrleşme tepkimesi sırasında, bazik çözeltideki ters tepkimeyi yavaşlatması ve ileri tepkimenin aynı hızla devam etmesi sonucu tehlikeli düzeyde klor gazı oluşumu.

- Kömürün yanmasıyla oluşan SO_2'nin doğadaki tepkimeleri sonucunda H_2SO_4'le, N_2 ve O_2 içeren havanın arabanın silindirlerinde ısınmasıyla tepkime veren iki gazın NO'ya dönüşüp havadaki diğer tepkimeleriyle kuv. bir asit olan HNO_3'ü oluşt.

Asit yağmurları, toprakta bulunan, ancak asit etkisiyle serbest hale geçtiğinde bitkilere zararlı olan Al gibi maddelerin mik. artmasına neden olur. Bu durum ağaç köklerinin gerekli besinleri almalarını engeller.

- çay, kırmızı lahana, gül yaprağı, kırmızı soğan kabuğu, çilek, kuşburnu, kiraz gibi maddeler doğal pH belirteçleridir.

- Karbonat bazik bir maddedir ve yemek tariflerinde asitli maddelerle karıştırılmazsa ağızda acı bir tad bırakır, karbonatla tozu ise hem baz hem asit içerdiği için böyle bir tad bırakmaz ve yemekte malzeme olarak da nötr'e yakın tadlar kullanılır.

→ Bunları öğrenmek benim için büyük bir zevkti; ilginç gelmelerinin en önemli sebebi de bu, teşekkürler...

ACTIVITY – LET'S DO MAGIC!

Two shots from the groups

ACTIVITY – THE MAGIC OF RED CABBAGE

The color rainbow of red cabbage (the first picture) and red cabbage paper's color change with the material the students used in the activity (the second picture).

ACTIVITY – HOW CAUSES A CAKE TO RISE?

The students conducted an activity related to the properties of acids, observing the differences between baking soda and baking powder (the first picture) and the reaction between baking soda and vinegar (the second picture).

APPENDIX J

KEYWORD LIST

LIST OF KEYWORDS

- Science Education
- Chemistry Education
- Constructivism
- Conceptual Change
- Learning Cycle
- 5E model of instruction
- Alternative Conceptions
- Acids
- Bases
- Neutralization
- Indicators
- Properties of Acids and Bases
- Motivation
- Motivation to Learn
- Various combinations of these keywords

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name : Cetin Dindar, Ayla
Nationality : Turkish (TC)
Date of Birth : 6 June 1980
Place of Birth : Kardzhali/Bulgaria
Marital Status : Married
e-mail : aylacetin@gmail.com

EDUCATION

Degree	Institution	Year of Graduation
BS and MS	Dokuz Eylul University, Faculty of Education, Department of Secondary Science and Mathematics Education, Chemistry Education	2003
High School	Bursa Boys High School, Bursa	1998

WORK EXPERIENCE

Year	Place	Enrollment
2004 – Present	Middle East Technical University, Faculty of Education, Department of Secondary Science and Mathematics Education	Research Assistant
2008 – 2009	University of Georgia, College of Education, Department of Science Education	Visiting Scholar