EFFECT OF CONCEPTUAL CHANGE TEXTS ACCOMPANIED WITH ANALOGIES ON PROMOTING CONCEPTUAL CHANGE IN ACID AND BASE CONCEPTS

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ABSTRACT

EFFECT OF CONCEPTUAL CHANGE TEXTS ACCOMPANIED WITH ANALOGIES ON PROMOTING CONCEPTUAL CHANGE IN ACID AND BASE CONCEPTS

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This study was conducted to compare the effectiveness of conceptual change text oriented instruction accompanied with analogies over traditional instruction on tenth grade students' understanding of the acid and base concepts and attitude toward science as a school subject. In addition, effect of the gender difference and science process skills on students' understanding of acid and base concepts and effect of gender difference on students' attitudes toward chemistry as a school subject were also investigated.

Subjects of the study were fifty tenth grade students from the two chemistry classes of the same teacher from a public school at the center of Ankara. There were one experimental group and one control group. Two teaching methods used were randomly assigned to the already formed groups of the teacher. Experimental group received conceptual change oriented instruction by using conceptual change text accompanied with analogies and control group received traditional instruction over a period of four weeks. Acid and Base Conception Test and Attitude Scale Toward Chemistry were given to all groups as a pre-test and post-test. Science Process Skill Test was given to all groups at the beginning of the study to determine students' level of science process skills. At the end of the study, interviews were hold with randomly selected experimental and control group students from the medium achievement level to get an in-dept idea about the nature of the misconceptions related with the topic.

ANOVA and ANCOVA were used to test the hypotheses of the study. The results showed that establishing an analogical thinking during the course of instruction together with a conceptual change text caused a better acquisition of scientific conceptions and elimination of misconceptions related with acid and base concepts as compared to the traditional instruction. Because, the students in the experimental group taking conceptual change oriented instruction performed much better in the post-test than the students in the control group taking the traditional instruction. However, the two modes of the instruction and gender difference did not indicate a significant contribution to students' attitude toward chemistry as a school subject. Besides, results showed that science process skills of the students' could be

a strong predictor for their achievement in acid and base concepts whereas there was no significant effect of gender difference on students' understanding of acid and base concepts.

Keywords: Conceptual change text, analogy, traditional instruction, misconceptions, acids and bases.

ÖZ

BENZEŞTİRMELERLE VERİLEN KAVRAMSAL DEĞİŞİM METİNLERİNİN ASİT VE BAZLAR KONUSUNDA KAVRAMSAL DEĞİŞİM YARATMAYA ETKİSİ

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Bu çalışma, kavramsal değişim metinleriyle verilen benzeştirmelerin lise ikinci sınıf öğrencilerinin asit ve bazlar konusundaki başarılarına ve kimya dersine olan tutumlarına etkisini geleneksel kimya öğretim yöntemiyle karşılaştırarak incelemek amacıyla yapılmıştır. Ayrıca, cinsiyet farkı ve bilimsel işlem becerisinin öğrencilerin asit ve bazlar konusunu anlamalarına olan etkisi ve cinsiyet farkının öğrencilerin kimya dersi tutumlarına olan etkisi de incelenmiştir.

Çalışmanın örneklemi Ankara merkezindeki bir devlet okulunun aynı öğretmenin ders verdiği iki ayrı sınıfındaki elli lise ikinci sınıf öğrencisidir. Araştırmada bir deney, bir de kontrol grubu vardır. Kullanılan iki ayrı öğretim metodu öğretmenin mevcut sınıflarına göre rasgele belirlenmiştir. Deney grubuna kavramsal değişim metinleriyle birlikte verilen benzeştirme yöntemi, kontrol grubuna ise geleneksel kimya öğretim yöntemi 4 hafta süreyle uygulanmıştır. Asitler ve Bazlar Kavram Testi ve Kimya Dersi Tutum Ölçeği her iki gruba ön ve son test olarak verilmiştir. Bilimsel İşlem Beceri Testi çalışmanın başında öğrencilerin bilimsel işlem becerilerini tespit etmek amacıyla her iki gruba da uygulanmıştır. Çalışmanın sonunda, ortalama başarı sergileyen deney ve kontrol grubu öğrencilerinden rasgele seçilen bir örneklemle görüşmeler yapılmıştır.

Araştırmanın hipotezlerini test etmek amacıyla İki Yönlü Varyans ve Ortak Değişkenli Varyans analizleri kullanılmıştır. Analiz sonuçları, kavramsal değişim metinleriyle uygulanan benzeştirme yönteminin, asitler ve bazlar konusuyla ilgili kavramların daha iyi anlaşılmasında ve kavram yanılgılarının giderilmesinde, geleneksel yöntemden daha etkili olduğunu göstermiştir. Son testte, kavramsal değişim yöntemi uygulanan deney grubu öğrencileri, geleneksel öğretim yöntemi uygulanan kontrol grubu öğrencilerine göre çok daha iyi sonuçlar elde etmiştir. Fakat, her iki farklı öğretim yönteminin ve cinsiyet farkının öğrencilerin kimya dersine olan tutumlarına anlamlı bir etkisinin olmadığı görülmüştür. Ayrıca, bilimsel işlem becerisinin öğrencilerin asit ve bazlarla ilgili başarılarının tahmininde güçlü bir belirleyici olduğu görülürken, cinsiyet farkının öğrencilerin asit ve bazlar konusundaki başarısına belirleyici bir etkisinin olmadığı görülmüştür.

Anahtar Kelimeler: Kavramsal değişim metni, benzeştirme, geleneksel öğretim yöntemi, kavram yanılgıları, asit ve bazlar.

To My Family

Serdar & Mert ÇETİNGÜL

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LIST OF ABREVIATIONS

CCTI	: Conceptual Change Text Oriented Instruction
TDCI	: Traditionally Designed Chemistry Instruction
EG	: Experimental Group
CG	: Control Group
ABCT	: Acid and base conceptsion Test
ASTC	: Attitude Scale Toward Chemistry
SPST	: Science Process Skills Test
X	: Mean
F	: F statistic
t	: t statistic
df	: Degrees of Freedom
p	: Significance Level
MS	: Mean Square
MSE	: Mean Square Error
SS	: Sum of Squares
N/n	: Sample Size

CHAPTER I

INTRODUCTION

When students come into the science lesson, teachers hope and usually expect that they will develop new concepts and understandings in response to their teaching. In other words, it is believed that learning is the result of teaching. If the students are paying attention or are motivated, they will learn what has been taught and all teachers have to do is impart new information for the new learning to occur. But, constructivist learning theory maintains that learning is not the result of teaching, rather it is the result of what students do with the new information they are presented with. In other words, students are active learners who construct their own knowledge; they are not passive recipients of new information, somewhat like a sponge. If new information does not fit with what students already know, they may simply choose to reject it outright leaving the classrooms having learnt nothing. In that sense, much teacher instruction is a waste of time since teachers are failing to take into account the pre-existing beliefs of their students. While being motivated and paying attention is of course a factor in learning but there is even more important factor to be considered: what the students already know. Because, by the time children start school they already have a huge knowledge bank of their own explanations for the way the world is. These are the ideas that help them make sense of the world in which they live. They have been picked up from all sorts of experiences, events, places, and people in their lives and from the media. A child brings all this with him/her to the classroom and much of it is at odds with current scientific views. These are misconceptions or wrong beliefs and it is these beliefs that more than any other factor determines whether students will learn the new information that we present to them. According to Sewell (2002), when students come into a learning situation where they are presented with new information that differs from their previous understandings or knowledge, they can deal with it in one of the four different ways;

1. Delete the preexisting knowledge
2. Modify the preexisting knowledge so that it fits the new information
3. Modify the new information so that it fits the old knowledge
4. Reject the new information,

Deleting the existing wrong beliefs sounds easy, much like pressing the delete button on a computer. But, it is the most difficult of all four options. What we know is part of who we are. It is the human nature that not wants to change what we know. We will only alter or change what we know if it no longer meets our needs and if it becomes inadequate. Students in science classes are no different. During the instruction, they generate their own meaning and develop a set of well-defined ideas about objects and events based on their prior experiences, background, environment, world view, attitudes and abilities. These ideas often conflict with the accepted scientific explanations and difficulties arise (Osborne & Freyberg, 1985). These different ideas are referred as misconceptions (Cho, Kahle & Nordland, 1985; Griffiths & Grant, 1985). Because, new knowledge is linked to the existing conceptions, misconceptions affect further learning negatively. That's why, misconceptions are big obstacles to promote meaningful learning. Cognitive structures of learners determine their learning process and the most important single factor influencing learning is what the learner already knows (Ausebel, 1968). Modifying the preexisting knowledge so that it fits the new information is slightly easier because none of us like to admit that we are wrong but most of us are prepared to make small changes to our existing knowledge so that it will fit new information. When students are concerned, they will only change their beliefs if they no longer meet their needs. Modifying the new information so that it fits the old knowledge is often what happens in our classroom. In order to fit the existing misconceptions, the incoming information must be altered or distorted to such a degree that it is actually wrong. Thus, another misconception occurs. Rejecting the new information is the most preferred option of many students and their most common reaction to new information that conflicts with their existing beliefs. This requires no mental effort, no reconstruction of preexisting knowledge and students emerge from science lesson quite content with what they have always known.

Today, it is more obvious that the traditional textbook and lecture paradigm involving students as passive recipients of facts is not the most effective way to teach (Dykstra, Boyle & Monarch, 1992) and students interpretation of observed phenomena and laboratory experiences are frequently significantly different from the ideas which teacher's intended to convey. There are many researches showing that conceptual change may be a powerful frame for improving science teaching and learning. As a result, conceptual change approaches have widespread application in different disciplines (Okebukola, 1990; Dykstra et al., 1992; Beeth, 1998; Duit & Treagust, 2003).

There are some specific conceptual procedures for promoting conceptual change and removing misconceptions. For example, using conceptual change texts is one of them (Hynd, McWhorter, Phares & Suttles, 1994; Chambers & Andre, 1997; Markow & Lonning 1998). The conceptual change texts are different from the traditional textbooks in which they specifically designed to point out the students' misconceptions of the related topics and their weakness in explaining or answering a problem in order to remedy them. For this purpose, the topics are introduced with questions and student's possible answers that are not scientifically correct are mentioned directly to create dissatisfaction. Then, the scientifically acceptable explanations that are more plausible and intelligible are given. If the examples, figures, graphs, pictures are included in the conceptual change texts, they can further help the students in understanding the scientific concepts and realizing the limitations of their own conceptions.

Analogy could also be used as an alternative in leading conceptual change and overcoming misconceptions. They make the new material intelligible to students by comparing it to the material that is already familiar to them. This type analogical relation between the known and unknown help the students learn and accommodate new information better and discard or modify the misconceptions more easily (Orgill & Bodner, 2004). Moreover, students find topics more interesting when they have some relevance to their daily lives and experiences. For the past two decades, there has been a growing amount of research implying that the use of analogies in science teaching promotes meaningful understanding of scientific concepts (Gentner, 1983; Brown, 1992; Treagust et al. 1996; Silverstein, 2000; Savinainen et al. 2005). In the present study, daily life analogies related with the students' misconceptions and their similarities with the scientific knowledge of acid and base concepts were emphasized during the instruction via the conceptual change text.

Among the natural sciences, chemistry is an important part of our life in the sense that it is one of the cornerstones of science, technology, industry and contributes to our existence, our culture, and our quality of life. That's why, it should be taught comprehensively and coherently. But, it is full of abstract and theoretical concepts. As a result, students are having problems and misconceptions with some chemistry topics which are reported as chemical equilibrium, acids and bases, electrochemistry, the nature of matter, chemical bonding, physical & chemical changes and solutions (Griffiths, 1994 & Garnett et al., 1995). There are many studies focusing on the particulate nature of matter (Gabel; 1993), chemical bonding (Nicoll, 2001), mole concept (Utria-Echevarria & Bravo, 2001), chemical equilibrium (Van Driel et al., 1998), chemical and physical changes (Hesse & Anderson, 1992).

Acid and base concepts occupy an important and central role among the 10th grade high school chemistry topics. It is important for understanding other chemistry units at 11th grade such as the oxidation-reduction (redox) reactions and organic chemistry. According to Hackling and Garnett (1985), oxidation-reduction reactions is one of the topics that give the learners most difficulty. Especially, students' misconceptions and insufficient knowledge about acids and bases may cause of such difficulties. Moreover, some organic substances contain acidic and basic parts and organic reactants can be an acid or base. Students' clear knowledge about acid and base concepts helps them in better understanding organic chemistry concepts. That's why, we decided to examine the changes in the tenth-grade students' conceptions about acids and bases using the conceptual change text oriented instruction accompanied with analogies together with in-dept interviews of the students from the experimental and control groups. Conceptual change oriented instruction was used to correct the students' misconceptions related with acid and base concepts. Analysis of the results supported that we achieved this to some extent. Besides, effects of the treatments and the gender difference on students' attitudes toward chemistry were investigated because, there are many studies reporting that type of instruction affect students' attitudes toward chemistry as a school subject and attitudes affect the students' motivation, interest and achievement (Greenfield 1996, Chambers and Andre 1997, Parker 2000). In addition, effects of the gender difference and science process skills on students' understanding of acid and base concepts were also investigated. Low performance in utilization of science process skills can be considered as important indicator of serious instructional problems and poor teaching (Fraser, 2001). On these grounds, the findings of our study will give information about the nature of the changes that take place as a result of using conceptual change text oriented instruction accompanied with analogies which is simple and practical to use in teaching environments and also will give a deep understanding about the nature of students' misconceptions about the acid and base concepts.

CHAPTER II

RELATED LITERATURE

Teachers often assume that their students' failures to understand are because of something they did or did not do; we should have provided better examples or we did not challenge students to examine their ideas about course topics, or something students did or did not do; they allowed their attention to wander, they did not read the chapter before coming to class or they did not know how to study effectively. However, meaningful learning requires more than effective teaching and active, attentive students. Significant learning requires integrating new ideas with existing knowledge. Sometimes this old knowledge-new knowledge connection is successful, but sometimes it leads to errors in understanding causing misconceptions (Pines & West, 1986). Obviously, stronger conceptions or beliefs, or a firm commitment to existing conceptions slow down the meaningful learning (Dole, 2000).

In science education, meaningful understanding of science concepts and clear conceptual connection between scientific phenomena are the main goals of the science instruction. Learning of a new knowledge is meaningful when learners can relate it to the ideas they already understand; it is not merely adding information to existing knowledge instead it is restructuring of existing ideas (Hackling & Garnett, 1985). In recent studies, science learning and teaching is best viewed as a process of conceptual change (Carey, 2000; Duit and Treagust, 2003). Thus, one of the most important goals of science education is to provide conceptual change from alternative to scientific conceptions. Therefore, this study was conducted to identify the alternative conceptions of students about acid and base concepts and investigate the effect of conceptual change oriented instruction on conceptual change from alternative to scientific conceptions. On this ground, some previous studies that shaped the theoretical and empirical background of the present study will be given in this chapter. These studies basically include the students' misconceptions related with acid and base concepts, use of analogies and conceptual change texts as the reflection of the constructivism in the concept of conceptual change oriented instruction.

2.1 Misconceptions

Andre and Ding (1991) explain the misconceptions as the ideas that students have incorporated into their cognitive structures that they use to understand and make predictions about the world basing upon their experiences but often incorrectly represent the natural world. But, more simply, misconceptions can be explained as students' misinterpretations or misapplications of science principles (Garnett and Treagust, 1992). Clear learning requires not only learning the new information but also integrating the new ideas with previous knowledge and assessing the consistency and relevance of the new understanding. Therefore, misconceptions can happen to anyone. There are many other terminologies that bear the similar meanings as naive beliefs (Caramazza, McCloskey & Green, 1980), children's science (Gilbert, Osborne & Fensham, 1982), alternative conceptions (Abimbola, 1988), preconceptions (Bodner, 1986; Hashweh, 1988), pre-scientific conceptions (Good, 1991), pre-instructional conceptions (Treagust, Duit & Fraser, 1996), alternative frameworks (Driver & Easley, 1978) and students' descriptive and explanatory systems (Nussbaum & Novick, 1982) but among all the term misconception is the most frequently used one.

The amount of learning that occurs in the science classroom and indeed in any classroom is largely determined by the pre-knowledge that students bring with them to the lesson. It is the students' prior knowledge that influences what new or modified knowledge they will construct as a result of their learning experiences in the classroom. The student's motivation level and attentiveness certainly have a part, but what they already know about a topic is by far the most important factor to consider; it will either be a bridge to new learning or a barrier. There is a good deal of evidence that learning is enhanced when teachers pay attention to the knowledge and beliefs that learners bring to a learning task, use this knowledge as a starting point for new instruction, and monitor students' changing conceptions as instruction proceeds. If these initial ideas and beliefs are ignored, the understandings that students develop can be very different from what the teacher intends. That’s why, it is necessary to understand sources of misconceptions to overcome them. According to Marshall (1990), students derive misconceptions from three primary sources. One source is their attempt to make the sense of their physical world. Learners' attempts to explain everyday events or phenomena are often logical but incorrect. A second source is social settings, like movies, television or conversations with friends or family members. For example, students who are particularly influential or powerful speakers can persuade others of their misconceptions. A third source of misconceptions is instruction. Textbooks which are used more than any other educational materials with incorrect or out of date information or with illustrations drawn by artists unfamiliar with the content foster misconceptions (De Posada, 1999; Hurst, 2002). If such errors exist, untrained teachers and indeed trained teachers who are in the habit of believing the content of all textbooks to be true, fail to recognize these errors and unwittingly pass them on to their students. Teachers with little content knowledge who have to teach the subject transfer their misconceptions to students (Taber, 1995). Besides, many specialist science teachers themselves are often guilty of presenting course material in such a way that students form misconceptions as a result of what they omit to tell them. Sometimes, teachers who are expected and encouraged to teach subjects outside their areas of expertise are also in danger of contributing wrong beliefs; while themselves grappling with content that is unfamiliar to them they may unwittingly pass on their own misconceptions to students. Considering our study, students' misconceptions about acid and base concepts can be an example of the misconceptions mainly arising from everyday experiences and teachers' inadequate instruction of some prerequisite topics such as solubility and chemical bonds that form basis for acid and base concepts.

When children first start school, they have many wrong beliefs about their world from mummy and daddy, grandpa, television, comics; all sorts of places. By the time they begin middle and high school they have acquired many, many more. Researches (Lipson, 1984; Sewell, 2002) supported that students often have pre-existing ideas that are at variance with the concepts teachers attempt to teach in science, mathematics, social studies and other content areas. Because, students' construct the new information above their prior knowledge and when this prior knowledge includes some misconceptions, the result of the instruction is probably different than aimed by the teacher. Simply pointing out that these misconceptions are wrong is not helpful to eliminate them (Hewson & Hewson; 1984). That's why, teachers should be sensitive about the students' probable misconceptions about the instructional topics when designing their instruction to improve instructional methodology and promote a greater understanding of science by the students. According to Meyer (1993), there are some approaches that can be useful for teachers in diagnosing student misconceptions: (a) Asking students to think aloud as they solve problems, (b) Having them teach course topics, or explain ideas to others, and (c) Reviewing students' notes with them.

A think-aloud is a useful way to distinguish what students believe to be true and how they interrelate ideas. Think-aloud is used frequently in educational research to examine the processes of problem solving. During a think-aloud the student reports everything that comes to mind while exploring a particular idea, term, or topic. The critical aspect of applying this technique in the classroom is that the instructors should encourage students to talk about everything they are thinking while forming an answer. By relating their thoughts, students frequently expose relevant knowledge they had not considered previously, and irrelevant or inaccurate knowledge they should have dismissed.

A second method is to have students teach a topic. Teachers commonly use this in class presentations, in small group activities or in test questions. The process of organizing our thoughts to explain an idea to someone else is a powerful strategy for initially understanding the material, remembering it and checking our understanding. In generating a lesson or an explanation, students often will struggle with examples that do not appear to fit their conceptualizations. Besides, during this process, students' classmates also criticize and point out the gaps in their explanations.

Students' class notes are a third source of information about their understanding. Organization of notes or the lack of organization can highlight what students believe to be the major ideas in a lecture. Other clues in student notes that signal potential misunderstandings are verbatim notes and notes that do not include comments about how concepts are interrelated.

When choosing methods for increasing students' awareness of misunderstanding, teachers should be aware of the research finding that conceptual change occurs via different paths and at different rates (e.g., Burbules & Linn, 1988). A single approach will not be effective for all students. Teachers need continually to diagnose student misunderstanding (Anderson & Roth, 1989).

2.2 Students' Misconceptions in Acid and Base Concepts

Chemistry involves many abstract and theoretical concepts that can be incorrectly interpreted and learned by the students. That's why, students from secondary level to university struggle to learn chemistry and many do not succeed (Nakhleh, 1992). Research shows that many students do not correctly understand fundamental concepts (Griffiths, 1994) and also many of the scientifically incorrect ideas held by the students go unchanged from the early years of the schooling to university, even up to adulthood (Gil-Perez & Carrascosa, 1990). By not fully and appropriately understanding the fundamental concepts, students then have trouble in understanding the more advanced concepts that build upon these fundamental concepts (Thomas, 1997).

In high school chemistry curricula, the topic of acids and bases occupies a central place. It has an important role in understanding other chemistry units such as chemical reactions especially the oxidation-reduction reactions, acid-base equilibrium and organic chemistry. In addition, commercial use of acids and bases together with some environmental and health issues make the acids and bases unit essential among the high school chemistry courses. However, most students have difficulty in understanding acid and base concepts. One possible reason of that it is an abstract and theoretical topic; what happens at the molecular level makes the interpretation of chemical phenomena difficult. Besides, understanding of this concept requires some prerequisite knowledge such as solubility and chemical bonds but students are also having difficulty in deeply-understanding these concepts. As a result, students hold many misconceptions related to acid and base concepts. According to Nakhleh and Krajcik (1994), students were unable to understand the acid-base chemistry because they tended to have difficulties in understanding particulate model of matter and how that model relates to some chemistry classification systems as molecules, atoms and ions.

In the literature, it is possible to find researches about identifying and classifying student misconceptions based on acid and base concepts. For example, Cros et al. (1986) studied with 400 first year undergraduate students from the two different universities by asking questions about acids and bases. At the end of the study, students were found to have a good knowledge of formal descriptive but inadequate conceptions of concrete phenomena. For instance, most students had problems in answering questions as "what happens if you add an acid to a base?" or "what is the pH range for a beverage to be drinkable?" Besides, it was observed that the concept of bases was far less developed than that of acids because, students could not name bases as easily as acids; give only ammonia, sodium or potassium hydroxide as their responses. Misconceptions reported as a result of this study were,

- heat being released during an acid-base reaction,
- acids being more dangerous than bases,
- acidic substances can not be digested.

A follow-up of this study was performed in 1988 and it was reported that some of the students (then in their second year) had modified their concepts so that, for example, the former descriptive definition for acids (pH less than 7) replaced a scientific definition (an acid releases or can release H^+). However, other concepts, such as descriptive definition for pH (measure of acidity) had hardly changed.

Hand and Treagust (1988) carried a research with sixty 10th grade students of average and below-average achievement to identify the misconceptions about acid and base concepts by testing and holding interviews. Almost all of the misconceptions found were related specifically to acids.

- acid is something that eats material away,
- a strong acid can eat material away faster than a weak acid,
- acid can burn you,
- testing of an acid can only be done by trying to eat something away,

- to neutralize is to break down an acid or to change from an acid,
- a base is something which makes up an acid.

Hand (1989) followed up twenty-four of the students reported in Hand and Treagust (1988). At this later stage, some students had been taught much more sophisticated ideas in a pure chemistry course, while others had studied a broader based science course or biology. A test based on the five original misconceptions was administered to the group. The results indicated that only students studying chemistry could answer basic recall questions correctly, while those studying biology did best overall. He concluded that the biologists did better because they were not having any interference from new definitions.

In another study about misconceptions in chemical equilibrium including gaseous, ionic and acid-base equilibrium, Banerjee (1991) carried a research with undergraduate chemistry students and high school teachers of chemistry. He administered a written test and determined the following misconceptions related with the acid and base concepts,

- rain water is neutral,
- for the same concentration of acetic acid and hydrochloric acid solution, pH of the acetic acid will be less than or equal to the pH of HCl solution in water,
- there is no hydrogen ion in the aqueous solution of NaOH.

Ross and Munby (1991) analyzed the senior high school students' understanding of concepts related to acids and bases. Their methodology was grounded on a concept map constructed from curriculum. This map was used in the design of a multiple-choice test and of clinical interviews. It was reported that participants hold idiosyncratic concepts that are not consistently coincident with those of prescribed curriculum and everyday concepts are retained more than the scientific concepts. In addition, students' performance on the identified areas in which students lacked knowledge or possessed misconceptions were determined in decreasing order of difficulty as ions, bases, neutralization, acids, pH and everyday phenomena. Misconceptions reported by them were,

- all acids are strong and powerful,
- acids contain hydroxide ions,
- acidic substances are not to be digested,
- substances that burn are acids,
- strong acids contain more hydrogen bonds than weak acids,
- all substances with sharp or strong smells are acids,
- fruits are basic,
- acids taste bitter and peppery,
- soil couldn't be acidic because it is unlikely for something to grow in an acid.

Schmith (1991) investigated the 7500 elementary school students' problems with the concept of neutralization from their answers in a neutralization test and following group discussions. In this study, students were not prepared for the test; they had to activate their momentary knowledge. Analysis of the test results showed that many students understand the concept in its original meaning; in any neutralization reaction a neutral solution is formed even if a weak acid or base takes part in the reaction. As a result, he noted that the term neutralization acts as a hidden persuader, leading to the misconception “the product of neutralization is a neutral solution". He attributed part of this difficulty to the ambiguous use of the term neutral in ordinary language and in the chemical context.

Different from other researches, Bradley and Mosimege (1998) studied with the student teachers at a university or college of education about their misconceptions related with acids and bases. Subjects were 53 students' teachers at their first year, second year, third year or last year. The misconceptions were explored through the use of a twenty-item questionnaire divided into twelve multiple-choice items and eight discussion items. Those questions focused on a-) theory of acids and bases, b-) properties of acids and bases, c-) acid and base strength, d-) pH function, e-) equations for acid-base reactions, f-) molecular representation of acids and bases. They determined the undergraduate student teachers' misconceptions about acids and bases as,

- increasing order of acidic strength,
- an acidic solution turns red litmus blue,
- the aqueous solutions of all salts are neutral,
- indicators are used to test whether an acid is strong or weak,
- indicators neutralize the acidic property of a solution to a more basic one.

Later, Oversby (2000) provide further evidences of students' misconceptions at the secondary school level. He reported that confusions were often found between the terms weak acid and weakly acidic. Because, concepts of acidity and pH can be confusing at this level and can lead to the misconception that these terms define the same thing.

In a recent study, to investigate the students' understanding of acids and bases, Demerouti et al. (2004) constructed and utilized a questionnaire consisting of ten multiple-choice and eight open-type questions. The test was given to 119 Greek students in the twelfth grade. They found that the students had misconceptions and difficulties related with dissociation and ionization, definition of Brønsted-Lowry acids and bases, ionic equilibria, neutralization, pH, buffer solutions, and degree of ionization. Similar results were reported by Kousathana et al. (2005) who studied the twelfth-grade students' instructional problems in acid-base equilibrium. A total of 119 students/university candidates in their final school year participated in this study. They were given a questionnaire with multiple choice and open-ended questions. Results showed that most students seemed to be more familiar with the Arrhenius model, many students used wrong explanations as they did not understand the Brønsted–Lowry model or accepted that a substance can be described as amphoteric but this does not have the meaning that it can act both as acid and base, or took only the acid ionization into account for determining the pH value but in the case of low acid concentration, the ionization equilibrium of water is important and should be taken into account.

In the present study, Acids and Bases Conception Test used was mainly developed according to the above reported misconceptions.

2.3 Conceptual Change

Traditional education has tended to emphasize memorization and mastery of text and traditional textbooks and instructional strategies are not helpful in removing misconceptions. Conceptual change approaches as developed in the 1980s and early

1990s contributed substantially to improving science learning and teaching because simply presenting material, giving out problems and accepting answers back are ineffective in correcting misconceptions. But, misconceptions are important to consider since the new knowledge is linked to existing conceptions, they interfere with further learning i.e. students' ideas often interact with knowledge presented in formal science lessons resulting in unintended learning outcomes. The process of changing students' misconceptions (i.e., belief, idea, or way of thinking) is called as conceptual change (Duit and Treagust, 2003).

In teaching for conceptual change, the first and most significant step is to make the students aware of their own ideas about the topic or phenomenon under study. As students recognize the inadequacy of their conceptions through presentation to their classmates in explaining new situations or by discussing and evaluating those of their classmates, they become dissatisfied with their own ideas and be more open to changing them. After such dissatisfaction with pre-instructional conceptions, conditions for conceptual change to occur are the intelligibility, plausibility and fruitfulness of the new conception (Posner, Strike, Hewson, & Gertzog, 1982). According to them, a significant conceptual change is likely to occur under the following four essential conditions:

1. Dissatisfaction: If students are to change their ideas, they must first become dissatisfied with existing misconceptions which could result when these misconceptions are unable and inappropriate to explain anomalous or conflicting experiences and new situations. If the learner was dissatisfied with his/her prior conception and an available replacement conception was intelligible, plausible and/or fruitful, accommodation of the new conception may follow.

2. Intelligibility: The new conception that could replace the existing one must appear intelligible by providing a better explanation and being understandable.

3. Plausibility: The new conception must appear plausible by proposing solutions to particular problems and being believable. It must also be in accordance with knowledge matter in other areas.

4. Fruitfulness: The new conception must appear fruitful by leading new insights and being useful in variety of new situations i.e. it should do more than potentially solve current problems or answer questions.

A plausible conception must first be intelligible and a fruitful conception must be intelligible and plausible. Resultant conceptual change may be permanent, temporary or too tenuous to detect.

There are many studies reporting that the conceptual change approaches produce better acquisition of scientific conceptions than other alternative instructions (Hewson and Thorley, 1989; Hynd et al., 1994; Chambers and Andre, 1997; Weaver 1998). In a recent study, Azizoğlu (2004) investigated the effects of conceptual change oriented instruction accompanied by demonstrations on tenth grade students' understanding of gases concept. Hundred tenth grade students from two classes taught by the same teacher in a public high school were enrolled in the study. Control group students were taught by traditionally designed chemistry instruction and experimental group students were instructed by conceptual change oriented instruction accompanied by demonstrations. The results showed that conceptual change oriented instruction caused significantly better acquisition of the scientific conceptions related to gases than traditional instruction.

One of the most important goals of science education is to provide conceptual change from alternative to scientific conceptions. According to Novak (2002), conceptual change is a necessity for meaningful learning to occur. As a result of the emphasis given to this topic in teaching and learning process, students' conceptions and conceptual change were the most frequently investigated research topic of the recent years in science education (Tsai & Wen, 2005). Our study is also devoted to the students' conceptions and conceptual change in acids and bases. Experimental group students responded to the demands of the conceptual change oriented instruction and regularly applied the constructs of intelligibility, plausibility and fruitfulness that are the essential parts of the conceptual change learning. Analysis of the results showed experimental group students had better achievement than the traditionally instructed group.

2.4 Conceptual Change and Conceptual Change Texts

Researchers' analysis of commercial textbooks in different subject areas showed that texts are inconsiderate and not user-friendly; they assume too much prior knowledge on the part of their readers, they are organized in fragmented rather than connected bodies of knowledge, they introduce too many concepts and do not discuss them enough for adequate understanding (Cole & Sticht, 1981; Anderson & Armbruster, 1984). The difficulty of their reading and learning has also been addressed extensively in many researches and passages taken from basal textbooks (Davison, 1984), science textbooks (Anderson & Armbruster, 1984; Beck & Dole, 1992), and social studies textbooks (Calfee & Chambliss, 1988). All these textual inadequacies limited the quality and quantity of what students learn. This has been particularly problematic in many classrooms where teachers have relied so heavily on texts to facilitate student learning (Good & Shymansky, 1986). Especially, when readers have prior knowledge that conflict with the text information, their comprehension is impaired; students' prior knowledge appeared to get in the way of effective comprehension and learning. According to Beck and Dole (1992), texts were not written in ways that are helpful to the learning and conceptual change process.

As a result of studies investigating the reading of a science text, some innovative text types have been developed and conceptual change text has stimulated considerable research. A conceptual change text is a written passage that describes a certain misconception, argues why it is incorrect, and then explains the scientifically correct concept. Conceptual change text based instruction is one of the teaching strategies based on conceptual change theory. It supports conceptual change process because it illustrates inconsistencies between common misconceptions and scientific knowledge by indicating the usefulness and plausibility of scientific knowledge within text structure. Posner et al. (1982) identified dissatisfaction with existing understandings or explanations of scientific phenomena and a plausible alternative as necessary conditions for conceptual change learning. So, it makes sense to activate students' prior knowledge by directly stating the students' most likely naive conceptions and then to refute those conceptions in the conceptual change text. Acknowledging students' everyday ideas and then refuting them in some way is likely to lead readers to become dissatisfied with their existing knowledge. Because, the text presents plausible alternatives, students are more likely to attend to the new information and restructure their knowledge based on that information. There are many literatures about the usefulness of conceptual change texts as an instructional material. For example, Guzzetti et al. (1997) reported that the effectiveness of conceptual change text lies in its ability to create cognitive conflict by contrasting the correct ideas with the incorrect ones. As an instructional strategy it is therefore compatible with the constructivist view of learning, because it recognizes that students have prior conceptions and some of which may be at variance with the scientific viewpoint. Conceptual change texts are also interesting to research, because they only take a few minutes to read, they are extremely time-efficient and appeal classroom teachers when many schools are facing a crowded curriculum.

In a related paper, Dole (2000) stated that that it is difficult to change readers' prior knowledge from reading texts that are inconsistent with that knowledge. One particular kind of text variable appears to be successful in changing students' prior knowledge. Conceptual change text, in which students' naive conceptions are directly stated and then refuted, was shown to impact students' prior knowledge when that knowledge contained naive scientific conceptions.

Studies using conceptual change text have provided considerable evidence that this technique has positive effects in conceptual change process. For example, Chambers and Andre (1997) investigated relationships between gender, interest and experience in electricity, and conceptual change text manipulations on learning fundamental direct current concepts. Conceptual change text was found to lead a better conceptual understanding of electrical concepts than traditional didactic text. In this study, men and women who had higher or lower interest in electricity and greater or lesser experience with electricity read conceptual change or traditional text. When interest level, experience, and prior knowledge were not included in the analysis, both gender and text type produced significant main effects. When interest level, experience, and prior knowledge were included in the analysis, conceptual change text led to better understanding of electricity concepts than did the traditional text. Finding of this study also supported that conceptual change text manipulations are likely to be effective for both men and women.

Mikkila (2001) investigated the effect of conceptual change text on 5^{th} grade students understanding of photosynthesis concept. Two hundred and nine primary school students studied either a traditional text version about photosynthesis or a conceptual change text in a classroom situation. The conceptual change text design took common misconceptions about photosynthesis into account and tried to foster a conceptual awareness. It was found that students who studied the conceptual change text performed statistically better than the traditional text group on questions demanding the construction of an adequate mental model of photosynthesis.

Çakır et al. (2002) compared the effects of concept mapping and conceptual change text instruction over traditional instruction on tenth grade students understanding acid-base concepts. Two experimental group classes were instructed with concept mapping instruction, other two were instructed with conceptual change text instruction and two control group students were instructed with traditional instruction. The results indicated that the concept mapping and conceptual change texts oriented instruction produced significantly greater achievement in acid-base concepts than traditional chemistry instruction.

In another study, Palmer (2003) investigated the relationship between conceptual change text and conceptual change. Individual interviews were carried with a stratified sample of eighty-seven ninth grade students. Forty-four percent of them were found to have a misconception about the concept of ecological role. Students were asked to read either a text that refuted the conception or a control text of a didactic explanation of ecological role. Afterwards, an immediate post-test and a delayed post-test were given. Analysis of the results showed that conceptual change text was highly effective in inducing accommodation for majority of the students (68%) who read it.

In a recent study, Uzuntiryaki and Geban (2005) reported the effectiveness of conceptual change texts accompanied with concept mapping instruction in facilitating conceptual change in solution concept. There was one experimental and one control group with a total of 64 eight-grade students from two classes. Experimental group received conceptual change oriented instruction and control group received traditional instruction. At the end of the study, conceptual change text accompanied with concept mapping instruction caused a significantly better acquisition of scientific conceptions and produced significantly higher positive attitudes toward science as a school subject than traditional instruction.

In another study, Günay (2005) investigated the effectiveness of conceptual change texts oriented instruction accompanied with analogies over traditionally designed chemistry instruction on overcoming tenth grade students' misconceptions related to atoms and molecules concepts. For this aim, experimental group was instructed with conceptual change text oriented instruction accompanied with analogies and control group was instructed with traditionally designed chemistry instruction over a period of two weeks. The result of the study showed that students instructed with conceptual change text oriented instruction accompanied with analogies gained higher average scores in Atoms and Molecules Concept Test than students instructed by traditionally designed instruction.

Based on the implications in the literature, conceptual change approach seems to be satisfactory strategy in enhancing students' understanding of chemistry concepts. Using conceptual change texts is one of the effective tools in leading conceptual change and overcoming misconceptions. There are many other strategies that foster conceptual change but most of them are appropriate in small classes, however conceptual change texts can be used in large classes, which are common in our country. Besides, if the students miss a lesson, they have an opportunity to read what has been discussed regarding the misconceptions from the conceptual change texts.

2.5 Conceptual Change and Using Analogy

In cognitive science literature, analogies have been defined as a correspondence in some respects between concepts, principles or formulas otherwise dissimilar. More precisely, it is a mapping between similar features of concepts, principles or formulas (Glynn, 1988). Analogy is a powerful relation, as it comprises a set of relations among features of the corresponding concepts. Therefore, via analogy it is possible to produce meaningful learning. There are many researches highlighting the power of analogies in connecting information and in elaborating more comprehensive and integrated knowledge structures (Stepich and Newby, 1988;

Klauer, 1989; Prawat, 1989; Glynn, 1991; Duit, 1991, Brown, 1993; Clement, 1993, 2002).

In a recent study, Orgill and Bodner (2004) interviewed biochemistry students about the analogies that were used in their classes. There were 43 volunteer students from a population of advanced undergraduate and graduate students. Interviews were semi-structured, conversational and lasted approximately one hour. Majority of the interviews were spent by asking questions about the analogies in general: if they like analogies, what the advantages and disadvantages are of analogies, how they use analogies and how analogies should be used to be effective in classes. They found that students like, pay particular attention and remember the analogies their instructors provide. They use the analogies to understand, visualize and recall information from class. Analogies are very useful when difficult or challenging information is explained or when new conceptual material is introduced. However, they should not be used for easy concepts or when students are expected to memorize the information. In general, students do like their teachers to use analogies in class but they do not like their teachers to overuse analogies otherwise they may confuse the concepts between one analogy and another, and they do want to learn the content.

Analogies also play an important role in promoting conceptual change and overcoming misconceptions by providing conceptual understanding (Clement, 1993; Dagher, 1994; Mason, 1994; Venville et al., 1997; Gentner et al., 1997). Ideally, analogies can help students recognize errors in conceptions they currently hold, reject those conceptions and adopt new conceptions that are in line with those accepted by the scientific community. Analogies may make new ideas intelligible and initially plausible by relating them to already familiar information. If students can assimilate new information in terms of their existing knowledge, they are likely to be able to understand that information, relate it in their own words and comprehend how that new information might be consistent with reality; all necessary conditions for conceptual change. In addition, analogies engage students in high level of thinking skills because creating a systematic correspondence from two separate domains requires analytical and creative thinking skills (Clement, 2002). Glynn (1991) reported a high positive correlation among the level of conceptual understanding of the new science topic, the level of understanding of the analogy and the level of effective use of the analogy in integrating the new information into the pre-existing conceptual structures.

Many experimental studies have been carried out to probe the effect of analogies in learning complex scientific contents. For example, Stavy (1991) examined the use of analogical instruction to overcome misconceptions about conservation of matter. In this study, one hundred ninety-two students from grades 5 and 6 were divided into two groups. One group completed a task involving iodine evaporation where the gaseous iodine was visible as a colored gas before attempting a similar task using acetone, an invisible gas. The second group used acetone first, followed by iodine. It was found that performance in the acetone task was significantly higher when it followed the iodine task. The intuitively understood, perceptually supported iodine task apparently served as an analogical example for the misunderstood acetone case.

Else and Clement (2003) conducted a study that analyzed a subset of analogies used to help middle school students in understanding cellular respiration and body systems associated with it. Data sources were classroom observations, informal discussions with teachers and students, formative assessments, student interviews and analysis of students' classroom work. Analysis of the results showed that all of the analogies used have been successes and students showed considerable improvement in their understanding of the target concepts but, if analogies are complex and if used without thoughtful preparation they may not be effective.

In a recent study, Chiu and Lin (2005) studied promoting fourth graders' conceptual change in electric circuit via multiple analogies. They used several analogies in a set of learning materials to present the concepts of parallel and series circuits. Thirty-two students participated in the study. There was one control and three experimental groups. The results demonstrated that using analogies not only promoted profound understanding of complex scientific concepts such as electricity but it also helped students overcome their misconception of these concepts.

Analogies are also used by chemistry teachers in teaching the acid-base related concepts. For example, Delorenzo (1995) developed a dating analogy for acid-base titrations because his college students were having trouble in understanding the consequences of concentrating and diluting unknowns before titrating them. In his analogy, he considered two dormitories one for male students and one for female students. The concentration of man in the dorm for males is one per room and there are four rooms of women in the dorm for females. The related balanced equation shows that exactly one man reacts with one woman to become a dating pair in much the same way that one gram equivalent of acid reacts with exactly one gram equivalent weight of base. By this way, students' gained a better grasp of the titration problems. For example, he bring clarity and convince his students that concentrating or diluting the original NaOH solution does not change the number of gram equivalents of HCl needed to titrate the end point.

Silverstein (2000) used football analogy to explain weak and strong acid-base because partial ionization is a difficult concept for the students to comprehend. In his analogy, he likens an acid, which is a proton donor, to a quarterback. The quarterback is a football donor whose job is to deliver the ball by either passing it to a receiver or handing it off to a running back. The difference between a strong acid and a weak acid is very much like the difference between an excellent quarterback and a terrible one. A good quarterback delivers the ball efficiently just as a strong acid gets rid of a proton. At the end of the play, nearly 100% of excellent quarterbacks will have delivered the ball likewise at equilibrium nearly 100% of strong acids dissolved in water and have delivered a proton. A similar analogy was drawn for a base and a wide receiver. Just as a base is proton acceptor, a wide receiver is a football acceptor whose job is to catch the ball and hold onto it. By this football analogy, his students better understood the difference between strong and weak acids/bases.

Another analogy about acid and base concepts is developed by Last (2003) because his students were having difficulty in calculating the amount of species formed at equilibrium when acetic acid is titrated with sodium hydroxide (weak acid-strong base titrations). In this analogy, Canadian Tire Money (2% of the bonus given for the spending to be used when making a subsequent purchase at any of Canadian

Tire chain stores) represented the small amount of acetate ion that is hydrolyzed back to acetic acid. The amount refunded to the customer is essentially negligible in comparison to unspent in the pocket just as the amount of acetic acid formed by the hydrolysis of acetate ion is negligible compared to the initial amount of acetic acid present.

In this study, analogies were the original thoughts of the researchers. For example, bulb analogy is used to explain strength of acids and bases, bus analogy is used to explain the concentrated and dilute acids and bases, rainbow analogy is used to explain the function of indicators and so on.

Researches on students' conceptions as presented in this chapter show that students have misconceptions that influence their understanding of the chemistry concepts during and even after instruction. Especially, students have difficulties in understanding theoretical and abstract concepts. Acid and base concepts because of their abstract and theoretical nature are difficult to be learned. Besides, incorrect interpretations of daily life-experiences about acids and bases also add some incorrect conceptions to the students' minds. Conceptual change based teaching methods seem to be effective in remedying students' misconceptions. For this reason, in this study, we examined the effectiveness of the conceptual change oriented instruction on students' understanding of acid and base concepts and their attitudes toward chemistry as a school subject when students' science process skills were controlled. Changes in the tenth-grade students’ conceptions about acids and bases were examined via the conceptual change text oriented instruction accompanied with analogies as well as in-depth interviews of the students from the experimental and control groups. Besides, to get an in-dept idea of nature and reasons of students' misconceptions related with acid and base concepts, interviews were hold with randomly selected experimental and control group students after the treatment.

CHAPTER III

PROBLEMS AND HYPOTHESES

3.1 The Main Problems and Sub-problems

3.1.1 The Main Problems

The first aim of this study was to investigate the effectiveness of conceptual change text oriented instruction accompanied with analogies over traditional instruction on tenth grade students' understanding of acid and base concepts and their attitudes toward chemistry as a school subject.

The second aim of this study was to investigate the effect of gender difference and science process skills on the students' understanding of acid and base concepts. In addition, effect of the gender difference on students' attitudes toward chemistry as a school subject was also investigated.

3.1.2 The Sub-Problems

1. Is there a significant mean difference between the effects of traditionally designed chemistry instruction (TDCI) and conceptual change text oriented instruction (CCTI) accompanied with analogies on students' understanding of acid and base

concepts when the effect of students' science process skills is controlled as a covariate?

2. Is there a significant mean difference between males and females with respect to their understanding of acid and base concepts when the effect of students' science process skills is controlled as a covariate?

3. Is there a significant effect of interaction between gender and treatment with respect to students' understanding of acid and base concepts when the effect of students' science process skills is controlled as a covariate?

4. What is the contribution of students' science process skills on their understanding of acid and base concepts?

5. Is there a significant mean difference between the effects of TDCI and CCTI on students' attitudes toward chemistry as a school subject?

6. Is there a significant mean difference between males and females with respect to their attitudes toward chemistry as a school subject?

7. Is there a significant effect of interaction between gender and treatment with respect to students' attitudes toward chemistry as a school subject?

3.2 Hypothesis

The following hypothesis that are relevant to the main and sub-problems were developed in null form.

H_0 1: There is no significant mean difference between the post-test mean scores of the students taught with TDCI and those taught with CCTI with respect to achievement related to acid and base concepts when the effect of students' science process skills is controlled as a covariate.

H_0 2: There is no significant mean difference between the post-test scores of males and females with respect to their understanding of acid and base concepts when the effect of students' science process skills is controlled as a covariate.

H_0 3: There is no significant effect of interaction between gender and treatment with respect to students' understanding of acid and base concepts when the effect of students' science process skills is controlled as a covariate.

H_0 4: There is no significant contribution of students' science process skills to the variation in their achievement related to the acid and base concepts.

H_0 5: There is no significant mean difference between post-test scores of the students taught with TDCI and CCTI with respect to their attitudes toward chemistry as a school subject.

H_0 6: There is no significant mean difference between post-attitude scores of males and females.

H_0 7: There is no significant effect of interaction between gender and treatment with respect to students' attitudes toward chemistry as a school subject.

CHAPTER IV

DESIGN OF THE STUDY

4.1 The Experimental Design

In order to determine the effect of the two different instructional methods used, the non-equivalent control group design was selected (Gay, 1987). The research design of the study is presented in Table 4.1.

Table 4.1 Research Design of the Study

Groups	Pre-test	Treatment	Post-test
EG	ABCT, ASTC, SPST	CCTI	ABCT, ASTC
CG	ABCT, ASTC, SPST	TDCI	ABCT, ASTC

In this table, EG represents the Experimental Group instructed by conceptual change text oriented instruction accompanied with analogies. CG represents the Control Group instructed by traditionally designed chemistry instruction. ABCT is the acid and base conception test, ASTC is the attitude scale toward chemistry and SPST is the science process skill test.

To examine the effect of the treatment on dependent variables and to control the effect of students' previous knowledge and science process skills, three pre-tests (ABCT, ASTC, SPST) were administered to the students in both groups. After the treatment, two tests (ABCT, ASTC) were given to the both group students.

Two teaching methods were randomly assigned to the classes. The equivalence of the groups with regard to initial level of understanding of acid and base concepts, attitudes towards chemistry and science process skills was ascertained from the pre-tests (ABCT, ASTC, SPST). Experimental and control groups were instructed by the same teacher. Each group instruction was four 45-minute sessions per week and the topic was addressed over a 4-week period. In order to facilitate the proper application of conceptual change oriented instruction by using conceptual change text accompanied with analogies, teacher was given 45 minutes training prior to beginning of the study. In the control group, students received traditional instruction. The teacher followed lecture and discussion method to teach concepts in acid and base concepts. However, experimental group received conceptual change oriented instruction via using conceptual change text accompanied with analogies. During the treatment, experimental and control groups were assigned the same homework questions and used the same textbook. The teacher allowed the researcher to observe the groups during the treatment.

4.2 Population and Sample

The target population of the sample is all tenth grade high school students enrolled in a chemistry course in Turkey. The accessible population includes all tenth grade school students in science classes at a public high school in Ankara, Turkey. The results of the study would be generalized to the accessible population and the target population.

Subjects of the study were 50 tenth grade students (17 boys and 33 girls) from the two intact classes of the same chemistry teacher in a public high school. There were one experimental and one control group. Two teaching methods used were randomly assigned to the already formed groups of the teacher. The experimental group who received CCTI consisted of 26 students while the control group who received TDCI consisted of 24 students.

4.3 Variables

4.3.1 Independent Variables

The independent variables in this study were two different types of instruction (conceptual change text oriented instruction accompanied with analogies vs. traditionally designed chemistry instruction) and gender. In addition, students' science process skills as measured by SPST was taken to control their integrated process skills at the beginning of the treatment and to identify its' effect on their achievement of acid and base concepts.

Instruction type or treatment and gender were considered as categorical variables and were measured on nominal scale. Treatment was coded as 1 for the experimental group and 2 for the control group. Students' gender was coded as 1 for female and 2 for male students.

4.3.2 Dependent Variables

Dependent variables were students' understanding of acid and base concepts measured by post-ABCT and their attitudes toward chemistry as a school subject measured by post-ASTC. Post-ABCT and post-ASTC were measured by the Acids and Bases Conception Test (ABCT) and the Attitude Scale toward Chemistry (ASTC), respectively.

Table 4.2 Types of Variables

Variables	Type
ABCT Scores	Dependent
ASTC Scores	Dependent
Treatment (CCTI vs. TDCI)	Independent
Gender	Independent
SPST Scores	Independent

4.4 Instruments

There were four tools used to collect data in addressing the research questions of the present study. These were the Acids and Bases Conception Test (ABCT), Attitude Scale toward Chemistry (ASTC), and Science Process Skills Test (SPST). Additionally, semi-structured interviews were conducted with the students from experimental and control groups and non-systematic classroom observations were carried out both in the experimental and control groups.

4.4.1 Acids and Bases Conception Test (ABCT)

It was developed by the researchers in Turkish considering the objectives of national curriculum related with the concept and misconceptions reported in the literature (Cros et al., 1986; Ross and Munby, 1991; Schmith, 1991; Bradley and Mosimege, 1998). There were 21 four-alternative multiple-choice questions in the test including only the basic concepts related with acids, bases, pH, strength, concentration, indicators and neutralization. Hence, the purpose of the test was to measure students' understanding of acid and base concepts, all items in the test were conceptual and no quantitative calculations are needed to answer questions. Each question in the test had one correct answer and three distracters. Each item measured a specific learning outcome.

During the developmental stage of the test, the following procedure was followed: First, the instructional objectives of the unit acids and bases were stated (See Appendix A). Second, a classification of students' misconceptions in acid and base concepts was constructed by a careful examination of related the literature and from the results of the interviews with experienced teachers. During these interviews, teachers revealed the details of the results obtained from classroom observations and from the open-ended exam papers of the students who had studied the acid and base concepts before. Lastly, the test items were constructed in a manner that each distracter or item brings out students' misconceptions related to acid and base concepts. The distractors reflected the students' misconceptions are summarized in Table 4.3.

Table 4.3 Students' Misconceptions in Acid and Base Concepts

I. Theory of Acids and Bases
a. Any substance that contains H is an acid, OH is a base b. Acids contain sharp particles because they are burning, bases contain round particles because they are slippery
II. Properties of Acids and Bases
a. Acids and bases show opposite properties of each other b. Acids are more dangerous than bases c. Only acids conduct electricity, bases not d. Soil can not be acidic because things grow in it e. H_2O can not act as an acid or base only serve as a solvent f. Fruits are basic g. Acids are irritating and burning h. Acids have sharp and strong smell
III. pH
a. At pH=0 substances are neither an acid nor a base b. Acidity increase as pH value increase c. pH value shows the number of H atom that an acid contains d. pH value shows the number of H^+ ion that an acid can give
IV. Reactions of Acids and Bases
a. Strong acids only react with strong bases and weak acids only react with weak bases or vice versa. b. Solutions formed after the acid-base reactions do not conduct electricity
V. Indicators
a. Indicators are used to provide the neutralization in acid-base reactions b. Indicators are used to neutralize acidity
VI. Neutralization
a. Reactions of acids and bases always result in a neutral solution
VII. Strength
a. The strength of an acid depends on the number of hydrogen atom and base depends on the number of hydroxide molecule b. Strong acids have a higher pH than weak acids

Table 4.3 Continued

c. Strong acids contain more hydrogen bond than weak acids d. Strong acids are more concentrated than dilute acids
VIII. Concentration
a. Being concentrated acid means a higher pH, being dilute acid means a lower pH value b. Any concentrated acid solution is always more acidic than a dilute acid solution and any concentrated base solution is always more basic than a dilute base solution c. A concentrated acid is always stronger than a dilute acid

Based upon these misconceptions given in Table 4.3, taxonomy of misconceptions was constructed (see Table 4.4).

Table 4.4 Taxonomy of Students' Misconceptions in Acid and base concepts

MISCONCEPTION	ITEM
Theory of Acids and Bases	2, 5, 6, 14, 18
Properties of Acids and Bases	1, 2, 5, 8, 11, 18, 20
PH	4, 8, 9, 15, 17, 18
Reactions of Acids and Bases	3, 8, 15
Indicators	6, 13, 15
Neutralization	3, 15
Strength	7, 8, 10, 12, 16, 19
Concentration	12, 16, 21

Prior to the treatment, pilot test of Acids and Bases Conception Test was conducted. The pilot ABCT was administered to 97 tenth grade students from an urban public high school. Internal consistency (Cronbach's alpha) of the test was measured as 0.81.

Content validity and appropriateness of the test items were determined by a group of experts in chemistry education, chemistry and measurement & evaluation departments.

Test was given to all groups both as a pre-test to control students' knowledge of acid and base concepts at the beginning of the instruction and as a post-test to determine the effect of treatments on students' understanding of acid and base concepts (See Appendix B).

4.4.2 Attitude Scale Toward Chemistry (ASTC)

This scale was developed by Geban et al. (1994) to measure students' attitudes toward chemistry as a school subject. It includes 15 items in five point Likert type scale (fully agree, agree, undecided, partially agree, fully disagree) in Turkish. There are both positive and negative statements. Internal consistency (Cronbach's alpha) of the instrument was found to be 0.83. It was given to all students in the study as pre-test and post-test (See Appendix C). Total possible ASTC scores range is from 15 to 75 where lower scores show negative attitudes toward chemistry and higher scores show positive attitudes toward chemistry.

4.4.3 Science Process Skill Test (SPST)

This test was developed by Burns, Okey and Wise (1985) and translated into Turkish by Özkan, Aşkar and Geban (1991). It contains 36 four-alternative multiple-choice questions (See Appendix D). It measures the intellectual abilities of students including the items related to identifying variables, identifying and stating the hypotheses, operationally defining, designing investigations and graphing, and interpreting data. Total possible score of the SPST was 36. Internal consistency (Cronbach's alpha) of the test was found to be 0.85. It was given to all students at the beginning of study to determine and control the effect of science process skills throughout the study.

4.4.4 The Interview Scales

When treatment ended and post-tests were administered to all of the students, some of the students from experimental and control groups were interviewed to get an in-dept idea of the nature and reasons of students' misconceptions related with the concept.

Randomly selected 12 students (6 from experimental group and 6 from control group) from the medium achievement level of the experimental and control groups in the post-test were participated in the interviews. The interviews with the students were conducted in a semi-structured format involving the asking of structured questions followed by clarifying unstructured or open-ended questions. During the interviews participants were encouraged to write the answers or equations. Each interview lasted approximately in 45 minutes. All of the interview questions were audio taped and the transcribed verbatim by the researchers.

Interview questions were prepared on the basis of common misconceptions occurred in the post-ABCT. The questions basically focused on 1-) meaning of strong acid, 2-) if there is a relationship between the strength and concentration, 3-) if there is a relationship between the strength and pH, 4-) factors effecting the strength e.g. is there an effect of number of H/OH in the substance?, 5-) meaning of being dilute or concentrated 6-) meaning of concentrated HCl and dilute HCl, 7-) if there is a relation between being concentrated and pH value, 8-) explanation of pH, 9-) determination of pH of a solution after acid-base reactions, 10-) stating the conditions for the formation of neutral solutions.

4.4.5 The Classroom Observations

The observations during the treatment process in the experimental and control groups helped researcher to ensure the non-biased presentation of the topics. Additionally, the researcher observed the interactions between the teacher and the students in both groups and took notes describing the learning climate in the classes.

4.5 Treatment (CCTI vs. TDCI)

This study was conducted over four weeks. 50 tenth-grade students from the two intact classes of the same chemistry teacher in a public high school were enrolled in the study.

There were one experimental group and one control group in the study. Two teaching methods were randomly assigned to the classes. During the treatment, acid and base concepts were covered as a part of the regular tenth grade chemistry curriculum. The topics covered were definition of acids and bases, acidity and basicity of metal and non-metal oxides, properties of acids and bases, ionization of water (pH and POH), indicators, strength of acids and bases, ionization of weak acids and bases, acid-base titrations and neutralization, hydrolysis and amphoterism. Each group instruction was four 45-minute sessions per week.

At the beginning of treatment both groups were given ABCT, ASTC and SPST. ABCT was administered to determine whether there was any difference between the experimental and control group with respect to understanding acid and base concepts prior to the instruction. SPST was given to assess students' level of science process skills and ASTC was given to measure students' attitudes toward chemistry as a school subject.

In the control group, students received traditional instruction. The regular classroom instruction was teacher-directed strategy. The teacher followed the lecture and discussion method to teach concepts related with acids and bases. Teaching strategies heavily relied on teacher explanations and textbooks with no consideration of the students' misconceptions. Teacher structured the entire class as a unit, wrote notes on the board about the definition of concepts and solved enough number of quantitative problems. When the teacher finished her explanation, some concepts were discussed through the teacher directed questions. Students listened to the teacher and took notes. Sometimes, they asked some questions. The teacher answered the questions and directed new questions to explore whether the concept was understood. While students were solving problems on the blackboard, she gave some clues if needed. At the end of the lesson, teacher assigned homework questions from the textbook, which were same with the homework questions of experimental group.

The experimental group was thought under the conceptual change conditions. Before the treatment, teacher was informed about the conceptual change text oriented instruction accompanied with analogies to facilitate the proper application of conceptual change oriented instruction and given 45 minutes training. In addition, meetings were held during the study to ensure that she was carrying out the treatments in both groups appropriately. Besides, she was contacted several times a week to enable the researchers to answer any questions and review the treatment procedures. At least three random visits by the researchers were conducted to each group during the instruction and the researchers confirmed that lessons were delivered competently.

Addition to the classroom instruction of the experimental group, students were given the conceptual change text which contains previously stated collection of students' misconceptions in acid and base concepts, questions to activate these misconceptions, evidences of incorrectness of these misconceptions with correct explanations, related analogies with daily life examples (analogical examples were the original thoughts of the researchers) and some explanatory pictures, figures and equations in order to further help the students better understand the topic. It was prepared by the researchers in the light of the information obtained from literature review considering the national curriculum (See Appendix E). This text was given to the students to be read 4 or 5 days before the coverage of the related topics in the class hour. During the class, teacher directed the students to read the text silently. After reading each paragraph where a question was posed and evidence was presented that the related misconception was incorrect, students were asked to stop reading. Then, the teacher asked what they taught about the explanation they had just read. This type of discussion, questioning-answering in the guidance of teacher were handled through out the text at each paragraph for the related topics of that class hour. Similarly, all lectures carried through answering of the questions in the text by the students, discussing the answers and establishing an analogical thinking between the real life examples and the unknown while learning the new information and discarding the misconceptions. As an example for this process, teacher asked the question in the text 'Is there a relationship between the number of hydrogen atoms that the acids contain and acidic strength?'. The aim was to activate the students' misconceptions about the concept. Because, most of the students might think that as the number of H atoms increase in an acid, it becomes stronger. After taking students responses by guiding the discussions then teacher asked the following question in the text 'Is H_3PO_4 stronger than HCl?' and allowed students to discuss again, realize their misinterpretations by sharing them and reach the correct answer. In order to establish an analogical thinking with real life situations, this time teacher asked the other text question 'What is the measure of the strength of bulbs that we use at our homes?' and guided the discussions to help the students in understanding the analogies stated in the text such as 'If a bulb gives off a lot of light it is strong, a little light it is weak. Similarly, if an acid ionizes a lot, it is strong, ionizes a little, it is weak' or 'the light of only one bulb sometimes may be more powerful than the light of two or more bulbs (one bulb can give more light) like in the case of the acidic strength and the number of hydrogen atom(s) that an acid contain' i.e. HCl is stronger acid than H_3PO_4 because it gives more hydrogen ions (dissociates more) than H_3PO_4 when dissociates in water although it contains smaller number of hydrogen atom. In this way, teacher provided such an environment in which students notice their misconceptions and see the correct answers (dissatisfaction) because students had the opportunity to compare their misconceptions with the scientifically correct conceptions. Then, the lesson continued by presenting students with the new situations and examples to enhance understanding of concepts (plausibility). See Appendix F for an example lesson based on conceptual change text oriented instruction accompanied with analogies.

4.6. Analysis of Data

For the data obtained from the subjects in the experimental and control groups mean, standard deviation, skewness, kurtosis, range, minimum and maximum values were performed as descriptive statistics analyses. As inferential statistics, Analysis of Covariance (ANCOVA) and Analysis of Variance (ANOVA) were performed to address the research questions of the study.

After the treatment, affects of two different instructions on students' achievement related to acid and base concepts and effect of the gender difference on students' understanding of the topics were determined with analysis of covariance (ANCOVA) by controlling the effect of students' science process skills as a covariate. Analysis of variance (ANOVA) was performed to determine the effect of treatments and gender difference on students' attitudes toward chemistry as a school subject. Prior to the treatment, an independent t-test was used to determine whether there existed a statistically significant mean difference between the control and experimental groups with respect to their science process skills, prior knowledge in acid and base concept and prior attitude toward chemistry as a school subject.

4.7. Assumptions and Limitations

4.7.1. Assumptions

1. The teacher was not biased during the treatment.

2. All the subjects in both groups were accurate and sincere in answering the questions in measuring instruments and interviews.

3. The ABCT, ASTC and SPST were administered under standard conditions.

4. Interviews with the students were conducted under standard conditions.

5. Students in the experimental group did not interact with the students in control group.

6. There was no any other reason than use of the conceptual change text accompanied with analogies that modified the post-test results of students in the experimental group.

4.7.2. Limitations

1. The subjects of the study were limited to fifth tenth-grade students from a public high school.

2. The study was limited to the unit of "Acids and Bases".

CHAPTER V

RESULTS AND CONCLUSIONS

This chapter is devoted to the presentation of the results from testing of the hypotheses stated in Chapter III and results of the student interviews. The hypotheses were tested at the significance level of 0.05. ANOVA and ANCOVA were used to test the hypotheses. Statistical analyses were carried out by SPSS (Statistical Package for Social Sciences) (Noruis, 1991).

5.1 Descriptive Statistics

Descriptive statistics related to the students' pre- and post-test scores of Acids and Bases Conception Test, pre- and post-test scores of chemistry attitudes and science process skills’ test scores in the experimental and control group were analyzed. The results of analysis were given in Table 5.1.

Table 5.1 Descriptive Statistics Related to Acids and Bases Conception Test (ABCT), The Attitude Scale Toward Chemistry (ASTC) and The Science Process Skills Test (SPST)

GROUP		DESCRIPTIVE STATISTICS							
		N	Range	Min	Max	Mean	Std. Dev.	Skewness	Kurtosis
EG	Pre-ABCT	26	11	2	13	7.42	2.50	.090	.221
	Post-ABCT	26	10	7	17	12.92	2.52	-.550	.002
	Pre-ASTC	26	27	40	67	56.65	6.92	-.447	-.298
	Post-ASCT	26	27	45	72	58.15	5.82	.178	.426
	SPST	26	15	12	27	19.77	4.21	.133	-.504
CG	Pre-ABCT	24	10	2	12	6.29	2.42	.648	.300
	Post-ABCT	24	8	5	13	8.54	2.53	.113	-1.355
	Pre-ASTC	24	31	43	74	56.62	8.82	.131	-.894
	Post-ASCT	24	24	45	69	56.21	7.53	.036	-1.144
	SPST	24	16	11	27	17.75	5.05	.415	-.925

5.2 Inferential Statistics

This section includes the results of the analyses of seven null hypothesis stated in chapter III. Analysis of covariance (ANCOVA) and analysis of variance (ANOVA) were used to test the hypothesis. Prior to the treatment, an independent t-test was used to determine whether there existed a statistically significant mean difference between the control and experimental groups with respect to their science process skills, prior knowledge in acid and base concepts and prior attitude toward chemistry as a school subject. The pre-test results of the SPST, ABCT and ASTC showed that there was no significant mean difference between the experimental and control groups before the treatment in terms of understanding of acid and base concepts (t=1.62, p>0.05), science process skill level (t=1.54, p>0.05) and students' attitudes toward chemistry as a school subject (t=0.013, p>0.05).

5.2.1 Hypothesis 1

This hypothesis stated that there is no significant mean difference between the post-test scores of the students taught with traditionally designed chemistry instruction and those taught with conceptual change text oriented instruction accompanied with analogies with respect to achievement related to acid and base concepts when the students' science process skills are controlled. To test this hypothesis analysis of covariance (ANCOVA) was conducted. The results are summarized in Table 5.2.

Table 5.2 ANCOVA Summary (Understanding)

Source	Df	SS	MS	F	p
Covariate (Science Process Skills)	1	74. 008	74. 008	16.504	.000
Treatment	1	183.224	183.224	40.859	.000
Gender	1	8.099	8.099	1.806	.186
Treatment*Gender	1	15.701	15.701	3.501	.068
Error	45	201.78	4.484		

The analysis of the results showed that there was a significant mean difference between the post-test scores of the experiment and control group with respect to students' understanding of acid and base concepts, F (1, 45)=40.859, MSE

=201.78, p< 0.05. The mean of post-ABCT is 12.93 over 21 in the experimental group while it is 8.54 over 21 in the control group (51% difference in the favor of experimental group).

Figure 5.1 shows the proportions of correct responses of the questions in the post-ABCT for both groups. As seen from the figure, there was striking differences between the experimental and control group on several items of ABCT in the favor of the experimental group. Remarkable differences were observed in the students' answers to the questions 1, 4, 5, 12 and 21.

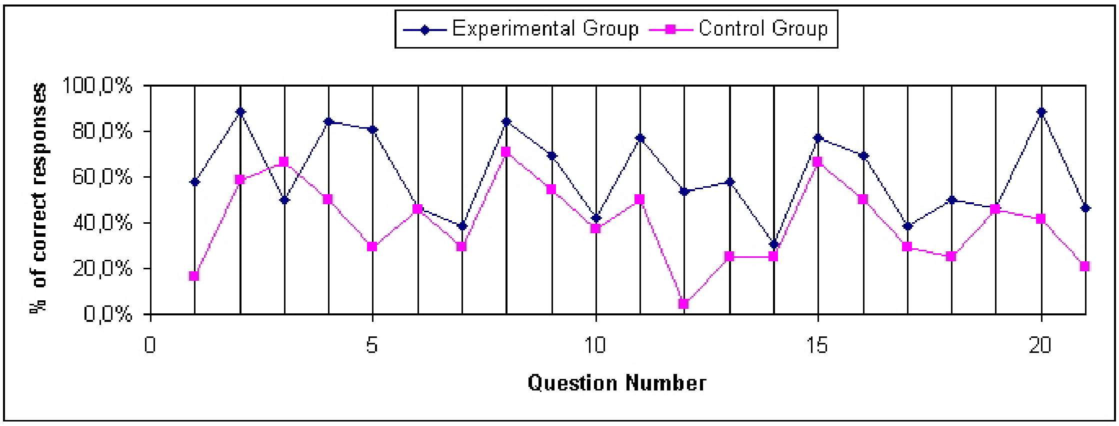

Figure 5.1 Comparison between post-ABCT scores of the CCTI and the TDCI group.

Question 1 was related to the nature and properties of acids. In this item, students were asked to select the true statement related with the nature and properties of acids. While 57% of the students in the experimental group selected ‘soil could be acidic’, only 16% of the students in the control group selected this correct response. The most prevalent misconception among control group students was ‘acids are irritating and burning' (66%). This misconception reflected from this item indicates that most of the students especially those in the control group failed to realize that not all acids are burning and irritating. In fact, it is a very common misconception about acids. Table 5.3 shows the percentages of students' selection of the alternatives for this question.

Table 5.3 Percentages of students' selection of the alternatives for Question 1

Item Which one of the statements is true related with acids?	Percentages of students' responses (%)	
	Experimental Group	Control Group
Alternative A Soil could be acidic (correct answer)	0.58	0.17
Alternative B Acids are irritating and burning	0.19	0.67
Alternative C Acids have strong and sharp smell	0.12	0.04
Alternative D Acids are more dangerous than bases	0.12	0.12

Question 4 was related with selecting the most acidic substance according to given pH values. While 85% of the students in the experimental group selected 'pH=0', only 50% of the students in the control group selected this correct response. The most prevalent misconception among control group students was 'pH=1' (25%). This misconception in this item indicates that some of the control group students failed to realize that pH can be 0 for acids. Again, it is very common misconception that if pH=0 substance is neither acid nor base. Table 5.4 shows the percentages of students' selection of the alternatives for this item.

Table 5.4 Percentages of students' selection of the alternatives for Question 4

Item Which one of the solutions with given pH value is the most acidic one?	Percentages of students' responses (%)	
	Experimental Group	Control Group
Alternative A pH=0 (correct answer)	0.85	0.50
Alternative B pH=1	0.11	0.25
Alternative C pH=14	0.00	0.17
Alternative D pH=6	0.04	0.08

Another remarkable difference among the students in experimental and control group was observed in question 5 which was related to the nature of acids and bases. In this item students were asked to select the wrong statement about the nature of acids and bases. While 80% of the students in the experimental group selected 'acids contain sharp particles due to their burning property, bases contain round particles due to their slippery property', only 29% of the students in the control group selected this correct response. The most prevalent misconception among control group students was 'a substance needn't contain H to be called as an acid and needn't contain OH to be called as base' (45%). This misconception indicates that a great deal of the students in the control group failed to realize that any substance without H atom can be an acid and without OH can be a base. In fact, it was one of the most common misconceptions related with acid and base concepts. Table 5.5 shows the percentages of students' selection of the alternatives related to this question.

Table 5.5 Percentages of students' selection of the alternatives for Question 5

Item Which is the wrong statement related with acids and bases?	Percentages of students' responses (%)	
	Experimental Group	Control Group
Alternative A Soil could be acidic and basic	0.12	0.16
Alternative B Acids contain sharp particles because they are burning, bases contain round particles because they are slippery (correct answer)	0.81	0.29
Alternative C A substance need not to contain H atom to be called as an acid and OH molecule to be called as base	0.08	0.46
Alternative D Our foods can contain acids or bases	0.00	0.08

Another very drastic difference among experimental and control group students was observed in question 12. This question was related with the properties of concentrated and dilute acid solutions; students were asked to select the true statement(s) related with concentrated and dilute acid solutions. While 54% of the students in the experimental group selected 'amount of particles in the concentrated acid solution is greater than the dilute acid solution of the same substance', only 4% of the students in the control group selected this correct response. The most prevalent misconceptions among control group students were 'a concentrated acid is always stronger than a dilute acid' (45%) and 'pH of a concentrated acid solution is always greater than the dilute acid solution' (29%). It was known that strength and concentration may mean the same thing to the students. In this study, it is obvious that students are having serious problems when considering concentration, strength and pH together. This is mainly because of their lack of knowledge and misconceptions in solutions and chemical bonds concept as understood from in-dept interviews. Table 5.6 shows the percentages of students' selection of the alternatives for this question.

Table 5.6 Percentages of students' selection of the alternatives for Question 12

Item Which one(s) of the following statements is true related with the concentrated and dilute acid solutions?	Percentages of students' responses (%)	
	Experimental Group	Control Group
Alternative A Amount of substance is greater in concentrated acid solution (correct answer)	0.54	0.042
Alternative B Concentrated acid solution is stronger than dilute acid solution	0.12	0.21
Alternative C Concentrated acid solution is stronger than dilute acid solution and pH of concentrated acid solution is always greater than dilute acid solution	0.27	0.29
Alternative D Amount of substance is greater in concentrated acid solution and concentrated acid solution is stronger than dilute acid solution	0.08	0.46

Question 21 was also searching for the similar misconceptions stated in question 12; it was asking to select the true statement(s) related with strength, concentration and pH relationship. While 46% of the students in the experimental group selected 'same substance can be both concentrated and strong acid/base', only 20% of the students in the control group selected this correct response. The most prevalent misconception among control group students was 'any concentrated acid solution is always more acidic than a dilute acid solution and any concentrated base solution is always more basic than a dilute base solution' (33%). Misconceptions measured and percentages of experimental and control group students' responses related with this item are given in Table 5.7.

Table 5.7 Percentages of students' selection of the alternatives for Question 21

Item Which one(s) of the following statements is true related with the concentrated and dilute acid solutions?	Percentages of students' responses (%)	
	Experimental Group	Control Group
Alternative A Same substance can be both concentrated and strong acid/base (correct answer)	0.46	0.20
Alternative B Any concentrated acid solution is always more acidic than a dilute acid solution and any concentrated base solution is always more basic than a dilute base solution	0.08	0.29
Alternative C Being a concentrated acid means having a high pH value, being a dilute acid means having a low pH value and same substance can be both concentrated and strong acid/base	0.11	0.17
Alternative D Same substance can be both concentrated and strong acid/base and any concentrated acid solution is always more acidic than a dilute acid solution and any concentrated base solution is always more basic than a dilute base solution	0.35	0.33

Although the students taking the conceptual change oriented instruction performed statistically better than students taking the traditional instruction, some students in both experimental and control groups showed serious conceptions at variance with the scientifically acceptable conceptions even after the treatments. For example, in question 14, it was asking 'which one of the substances is not a base?'. Percentage of correct responses (ones selecting HCOOH) was almost same (30%) for the experimental group before and after the treatment. The most prevalent misconception for both experimental and control groups was ‘PH_3’ (around 70%). It can be deduced that the misconception of ‘any substance that contains H is an acid and OH is a base’ is very resistant to change and special care should be given during the instruction to overcome this misconception. In addition to this, question 7 was asking to select the strongest acid among the given acids. Ones selecting HI (the correct response) was 26% and 38% before and after the treatment respectively, however, ones selecting the item ‘H_4SiO_4’ in the post-test were 57%in the experimental group. This is again very common and resistant misconception but the use of conceptual change text with analogies improved the correct response 12%. Situation was the similar when the same question were adopted for the bases (16% improvement in the correct response of KOH against $Ti(OH)_4$).

From the overall analysis of students’ percent correct responses in post-ABCT (See Appendix G), it can be deduced that experimental group students completed the treatment with fewer misconceptions than control group students and they were more successful than the control group students after the instruction. Especially, in some questions remarkable differences is observed in the favor of experimental group students. Table 5.8 summarizes the percentage of experimental and control group students’ selection of correct responses in pre-test and post-test for the selected questions.

Table 5.8 Percentages of Students' Correct Responses in Pre and Post-tests for the Selected Items

Item	Experimental Group		Control Group	
	Pre-test	Post-test	Pre-test	Post-test
1	0.15	0.57	0.08	0.17
4	0.42	0.85	0.41	0.50
5	0.42	0.81	0.12	0.29
12	0.15	0.54	0.08	0.04
21	0.19	0.46	0.17	0.21

5.2.2 Hypothesis 2

Hypothesis 2 stated that there is no significant mean difference on students' understanding of acid and base concept with respect to gender when effect of students' science process skills is controlled as a covariate. Table 5.2 shows the effect of gender difference on students' understanding of acid and base concepts. According to it, analysis of covariance indicated no significant difference between the performance of male and female students, $F(1, 45)=1.806$, $MSE=201.78$, $p=.186$. with respect to understanding acid and base concepts. The mean post-test scores were 12.20 for females and 13.90 for males.

5.2.3 Hypothesis 3

Hypothesis 3 states that there is no significant effect of interaction between the gender and treatment with respect to students' understanding of acid and base concepts when the effect of students' science process skills is controlled as a covariate. According to ANCOVA results in Table 5.2, there was no significant effect of interaction between gender and treatment on students' understanding of acid and base concepts, $F(1, 45)=3.501$, $MSE=201.78$, $p=.068$.

5.2.4 Hypothesis 4

To test hypothesis 4 which states that there is no significant contribution of students' science process skills to their understanding of acid and base concepts, analysis of covariance (ANCOVA) was used. Results indicated that there was significant contribution of students' science process on their understanding of acid and base concepts, $F(1, 45)=16.504$, $MSE=201.78$, $p=.000$. It accounted for a significant portion of variation in studenst' achievement.

5.2.5 Hypothesis 5

The null hypothesis 5 states that there is no significant mean difference between post-test scores of the students taught with traditionally designed chemistry instruction and those taught with conceptual change oriented instruction with respect to attitudes toward chemistry as a school subject. In order to test this hypothesis, two-way analysis of variance (ANOVA) was performed. Results were summarized in Table 5.9.

Table 5.9 ANOVA Summary (Attitude)

Source	df	SS	MS	F	p
Treatment	1	51.172	51.172	1.134	.292
Gender	1	78.006	78.006	1.729	.195
Treatment*Gender	1	.031	.031	.001	.979
Error	46	2075.152	45.112		

Analysis of variance (ANOVA) showed that there was no significant difference between the mean scores of the students in experimental group and those in the control group with respect to their attitudes toward chemistry as a school subject after the treatment, $F(1, 46)=1.134$, $p=.292$

5.2.6 Hypothesis 6

In order to test the hypothesis 6, which states that there is no significant difference between post-attitude mean scores of males and females, two-way analysis of variance (ANOVA) was carried out. Table 5.9 shows the effect of gender difference on students' attitudes toward chemistry as a school subject. According to the results, there was no significant mean difference between male and female students with respect to their attitudes toward chemistry as a school subject, $F(1, 46)=1.729$, $p=.195$.

5.2.7 Hypothesis 7

This hypothesis states that there is no significant effect of interaction between the gender and treatment with respect to students' attitudes toward chemistry as a school subject. According to ANOVA results in Table 5.9, there was no significant effect of interaction between gender and treatment with respect to students' attitudes toward chemistry as a school subject, $F(1, 46)=0.001$, $p=.979$.

5.3 The Interviews

Interviews were conducted with several experimental and control group students of moderate achievement level in post-ABCT. Interview questions were constructed according to the performances of experimental group students in the post-test by selecting the items that were the most resistance ones to change after the conceptual change based instruction. As a result, interview question were mainly related with being strong/weak, concentrated/dilute and pH concepts. Some selected responses of the students to the interview questions were given in below according to their being in the experimental group (EG) or in the control group (CG).

Interviewer: What is the meaning of strong acid?

EG Student A: If the hydrogen ion concentration is small in its water solutions then it is strong like HCl.

EG Student F: H_4Si0_4 is strong because it contains many hydrogen atom in its' structure and when it reacts it releases more hydrogen ion to the medium.

CG Student A: It means a high pH value.

CG Student B: It means a small pH value. If it enters a reaction with a base resulting solution should be acidic. For example, HCl and HBr.

Interviewer: Is there a relationship between the strength and concentration?

EG Student F: Yes there is relation. In dilution, number of molecules decreases as a result strength decreases. But, concentration increases the number of molecules and molecules become more effective.

CG Student C: Yes there is a relation. In both of them, hydrogen ions are common.

CG Student F: Yes there is relationship between being strong and concentrated. If something is dilute, its' strength decreases.

Interviewer: Is there a relationship between the strength and pH?

EG Student C: pH determines the strength of acids and bases. That's why, both are the same thing.

CG Student C: Yes. Something with high pH value is weak and low pH value is strong.

CG Student A: For acids, as the pH decrease acid becomes stronger, for bases as the pH increase base becomes stronger.

Interviewer: Explain the factors that affect strength e.g. is there an effect of number of H/OH in the molecule?

EG Student F: It is related with the number of hydrogen atom in its structure. For example if we consider H_2CO_3 and H_3PO_4, H_3PO_4 is stronger.

CG Student A: Number of H atoms affects the strength. As it increases, pH decreases and acidity increases.

CG Student B: The greater the H atom, the stronger the substance. For example, HBr is stronger than HF because of its atomic number.

Interviewer: What do you understand from being dilute or concentrated?

EG Student A: If the number of H or OH atoms in the formula is large, it means concentrated and being strong.

EG Student B: Being concentrated is related with dissolving. If substance dissolve less it means it is concentrated, if dissolves more it is dilute. If we add salt to water it does not dissolve completely so solution is concentrated.

EG Student C: Being concentrated is related with being strong.

EG Student D: Being concentrated acid means pH is closer to 7, being dilute means pH is closer to 1.

CG Student A: Being concentrated means saturated for example concentrated HCl means if you add more HCl it precipitates, dilute HCl means unsaturated you can add more HCl to get a concentrated solution.

CG Student B: Being concentrated means dissolving completely and being dilute means not dissolving completely.

CG Student C: If H^+ ion concentration or OH^- ion concentration of the solution is large, it can be said that it is concentrated as a result it is strong too.

CG Student D: Concentrated acids and bases dissolve other substances and form saturated solutions.

Interviewer: Is there any relation between being concentrated and pH value?

EG Student A: There is relation because if the number of H or OH atom in the formula is large it means concentrated and large amount of these ions means being strong. As a result, if something is concentrated acid it has small pH value, if concentrated base it has large pH value.

EG Student B: There is no relation because concentration is related with being strong. pH is related with being more acidic or basic.

EG Student C: If something is concentrated acid it means it is more acidic in other words pH value is bigger than the dilute acid.

CG Student A: There is a relationship between being strong and pH value but there is no relationship between being strong and being concentrated. As a result there is no relation between being concentrated and pH value.

CG Student B: Concentrated solutions contain more H^+ ion than dilute ones as a result pH will be smaller.

CG Student C: Concentrated substances have higher molarity as a result higher pH values.

Interviewer: Explain pH?

EG Student C: pH determines the strength of acids and bases. A substance with pH=2 is stronger than pH=4.

CG Student A: pH shows the strength. If you consider pH=2 and pH=4, pH=2 means stronger acid.

Interviewer: How do you determine pH of a solution after acid-base reactions?

EG Student B: If both acid and base is strong, pH will be equal to 7 (mean neutral). If the amount of acid is more than base, pH decreases, if base is more than acid, pH increases.

CG Student A: After adding the pH values of an acid and a base, resulting summation is divided by two. If it is between 1 and 7 it is acid.

Interviewer: State the conditions for the formation of neutral solutions?

EG Student C: Neutral solutions form as a result of the reactions of acids and bases having equal strengths.

CG Student A: If you add the pH values and divide the summation by two, 0 or 7 means a neutral solution.

CG Student B: Neutral solutions form as a result of weak acid-weak base or strong acid-strong base reactions.

Having considered the students' overall responses, it was observed that students had serious misconceptions while considering concentration concept (being dilute/concentrated) within acid and base concepts and had more difficulties in replacing them with the scientifically correct explanations than their misconceptions in pH and neutralization concepts which were removed to some degree for both groups (experimental and control) after the instruction. However, students had major problems in explaining concentration related questions of acids and bases even after the treatment.

5.4 Conclusions

In the light of the findings obtained from analyses, following conclusions can be deduced.

1. The CCTI caused a significantly better acquisition of scientific conceptions related to acid and base concepts than TDCI.
2. Both CCTI and TDCI produced statistically same positive attitudes toward chemistry as a school subject.
3. Science process skills were a strong predictor for the achievement of students in acid and base concepts.
4. When a comparison was made between the means of pre- and post-ABCT scores of the experimental group, a significant increase in post-ABCT scores was obtained. As a result, it can be said that the growth of students' understanding in acid and base concepts instructed by CCTI was significant. Hence, CCTI was aimed at increasing the number of scientifically acceptable conceptions of the students.

5. There was no significant effect of treatment, gender difference and interaction between gender and treatment on students' achievement related to acid and base concepts.

6. There was no significant effect of treatment, gender difference and interaction between gender and treatment on students' attitudes toward chemistry as a school subject.

CHAPTER VI

DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Discussion

The main purpose of this study was to compare the effectiveness of conceptual change text oriented instruction accompanied with analogies over traditionally designed chemistry instruction on tenth grade students' understanding of acid and base concepts and attitudes toward chemistry as a school subject. Besides, effect of the gender difference and science process skills on the students' understanding of acid and base concepts and effect of gender difference on students' attitudes toward chemistry as a school subject were also investigated. As a result, role of treatments, gender difference, and interaction between gender and treatment with respect to students' achievement related to acid and base concepts, and attitudes toward chemistry as a school subject were identified.

As indicated before, Acids and Bases Conception Test was administered to all subjects both before and after the treatment. There was no significant mean difference between the pre-test mean scores of the two groups. Thus, both groups were equal with respect to their prior knowledge in acid and base concepts. On the other hand, there was significant mean difference between the post-test mean scores of the two groups; the experimented group instructed by CCTI scored significantly higher than the control group instructed by TDCI. The difference between the instructional materials and learning activities provided by the conceptual change oriented instruction and traditional instruction may lead to this difference in achievement of the experimental and control groups. The traditional instruction only provided a unidirectional stream of data flowing from teacher to students and did not consider students' misconceptions. However, conceptual change oriented instruction was designed to deal with students' misconceptions and by this way caused a significantly better acquisition of scientific conceptions and elimination of misconceptions.

Through the conceptual change text oriented instruction accompanied with analogies, teacher, at first, initiated the experimental group students' alternative conceptions by asking questions, helping and encouraging them to express their ideas. Discussions continued until the students became aware of the fact that they possess different alternative ideas about the topics discussed. Instruction also enhanced with establishing daily life analogies related with the topic studied. Both discussions and analogical thinking helped the students to criticize their knowledge. This step (dissatisfaction) was important for conceptual change because students noticed that their existing ideas were not useful in explaining the scientific phenomena's discussed and establishing daily life analogies. To advance acquisition of the scientifically correct responses, teacher asked new questions and gave examples from daily life situations as much as possible focusing on students' incorrect ideas and discussing incorrectness of them. By this way, students realized that new conceptions were more effective in explaining the situations (plausibility).

The lesson ended with a question requiring further investigation on the newly learned concept (fruitfulness).

The control group students received traditionally designed chemistry instruction. The teacher used lecturing method and knowledge generally consisted of facts. Teaching strategies relied on teacher explanation and the traditional chemistry textbook with no consideration of students' alternative conceptions. The teacher structured the entire class as a unit, wrote notes on the blackboard and solved some problems. She also directed some questions, later explained the correct answers but did not consider students' prior knowledge. In fact, students in the control group were not aware of their alternative conceptions and passive; generally listened to the teacher and took notes. As a consequence, control group students added scientific conceptions to their conceptual framework where there were many alternative conceptions. However, better concept acquisition in the experimental group is provided by the continuous process of exchange and differentiation of existing concepts, integration of new conceptions with existing conceptions due to the emphasis given to students' misconceptions and efforts made to change them.

The other purpose of this study was to investigate whether there was a significant mean difference between male and female students with respect to understanding acid and base concepts. The analysis of the results showed that there was no significant mean difference between the achievement of male and female students. In addition, the interaction between gender and treatment had no significant effect on students' understanding of acid and base concepts. This may be because of their similar attitudes toward chemistry as measured during the study or their similar chemistry backgrounds. Çakır et al. (2002) also reported that gender difference was not effective on students' understanding of acid and base conceptss. In fact, students understanding of chemistry and their attitudes toward chemistry can be affected by many factors such as age; their perceptions change as they get older, teachers' sex, their interaction with teacher, teachers' interactions with students, their perceptions of the classroom environment, perceptions of the topic etc. That's why, there are also some studies reporting that there is a significant mean difference between male and female students with respect to their achievement in chemistry (Bunce & Gabel, 2002).

Attitude scale toward chemistry as a school subject was also administered to both groups before and after the treatment to investigate the effect of treatment and gender difference on students’ attitudes. Analysis of the results showed that there was no significant effect of treatment and gender difference on students’ attitude toward chemistry. In fact, during the conceptual change oriented instruction, more interaction between the teacher and the students was created; teacher guided discussions, helped and encouraged students share their ideas and ponder them in depth. In addition, conceptual change text with analogies helped the students to realize their existing conceptions, become dissatisfied with them and accept better explanations, which are intelligible, fruitful and plausible. All these efforts should have been produced more positive attitude toward chemistry as a school subject in the experimental group. But, the duration of the study was around four weeks and students might need more time to change their attitudes.

Science process skill test was the other test administered to both groups. It was given prior to the treatment to determine whether there was a significant mean difference between the groups regarding science process skills. Since they represent the rational and logical thinking skills that have great influence on students understanding of science, it is better if groups are similar with respect to these skills. Analysis of the test results showed that there was no significant mean difference between experimental and control group with respect to science process skills. However, the contribution of students' science process skills to the variation in their achievement related with acid and base concepts was significant. That's why, level of students' science process skill can be a significant predictor of their chemistry achievement in acid and base concepts.

6.2 Implications

The findings of this study have the following implications:

Most students have misconceptions in acid and base concepts. Because, it requires a clear knowledge about solutions concept and chemical bonds concept but students are also having problems related with these concepts (Abraham et al., 1994; Ebenezer & Ericson, 1996; Nicoll, 2001). For example, students often confuse concentration with dissolving resulting a misconception in acid and base concepts "being concentrated and strong are the same thing". In addition, words related with the acid and base concepts contain everyday terms that are used with different meanings than the scientific meanings such as it is irritating and burning like an acid. But, this is not the case for all acids. These kinds of alternative terminologies confuse students' minds and cause some misconceptions (Abimbola, 1988). That's why, teachers must be aware of the students' prior knowledge related to the course concepts and differences between the scientific and everyday usage of related terms when planning their instruction to increase quality of their instruction and provide a meaningful learning of the concepts.

It is very difficult to remove misconceptions from the minds of the students. Since students construct new information above their prior knowledge and if it includes misconceptions then they are barriers to the meaningful learning. Simply pointing out that these misconceptions are wrong is not helpful to eliminate them (Hewson & Hewson; 1984). But, a well-designed conceptual change oriented instruction will be helpful for changing the old and useless conceptions with the new and plausible conceptions (Posner et al., 1982).

The conceptual change text oriented instruction accompanied with analogies caused significantly better acquisition of the concepts and elimination of misconceptions than the traditional instruction. The greater success of experimental group students in this study is mainly because of the instructional method and the materials used. Because, the activities based on conceptual change approach helped the students revise their prior knowledge, struggle with their misconceptions and eliminate them. The conceptual change text as an instructional material facilitated that process. Because, in conceptual change text, emphasis was given to students' misconceptions that helped the students to realize their existing conceptions, become dissatisfied with them and accept better explanations by the help of questions, examples and explanations. Besides, enhancement of the analogical thinking during the instruction provided a better understanding of confusing concepts by serving as a bridge between the real life examples and misunderstood concepts. When planning an instruction, the most important steps to be considered are determining which instructional methods and materials to use to provide the meaningful learning of students.

Textbooks are the most important element of instructional materials. That's why, chemistry textbooks should seriously focus on dissatisfying students with their misconceptions and getting the true interpretations of the topics based on the conceptual change conditions.

Teachers can be faced with the challenge of changing students' misconceptions. So, teacher education should place an emphasis to teaching strategies based on conceptual change approach.

School administrators could also enhance teachers to investigate and use conceptual change approaches in classroom environment.

Teachers should be aware of their students' attitudes toward chemistry and help them in developing positive attitudes toward chemistry.

Science process skill level is a strong predictor of chemistry achievement. Since acid and base concepts includes theoretical and abstract concepts, teachers must realize their students' problems and difficulties in comprehending. This realization will require teachers to adjust their teaching strategies to develop science process skills.

6.3 Recommendations

On the basis of the findings of this study, followings can be recommended:

To make the generalization of the results to a bigger population, more high schools can be selected and sample size can be increased.

The conceptual change text oriented instruction accompanied with analogies can be applied to different grade levels and also different topics of the chemistry.

A longitudinal research study can be conducted to investigate the effectiveness of conceptual change oriented text oriented instruction accompanied with analogies on retention of the concepts related with acids and bases.

Further research studies can be conducted using conceptual change approach with different teaching strategies like concept maps, classroom demonstrations, use of technology or laboratory activities in removing the misconceptions and increasing students' understanding. Because, visualization of the events increases the understanding and retention of the concepts, and acid and base concepts is a suitable topic for such kind of applications.

Different instruments such as worksheets with conceptual questions and problems can be included to enrich the instruction. Further research studies can be conducted to evaluate the effect of students' prior grade of chemistry, logical thinking ability, motivation, attitude toward conceptual change texts etc. on their achievement of the topic.

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APPENDIX A

INSTRUCTIONAL OBJECTIVES

1.To define acids and bases according to Arrhenius definition.

2. To define acids and bases according to Bronsted-Lowry definition.
3. To explain properties of acids.
4. To explain properties of bases.
5. To distinguish properties of acids from bases.
6. To define pH.
7. To define pOH.
8. To distinguish acids and bases according to pH values.
9. To solve problems related with pH and pOH.
10. To tell the function of indicators.
11. To give examples to several indicators.
12. To define neutralization reactions.
13. To distinguish between neutralization and acid-base reactions.
14. To solve problems related with neutralization reactions.
15. To solve problems related with acid-base reactions.
16. To explain the strength in terms of acids and bases.
17. To tell the factor(s) that affect strength.
18. To list the given acids or bases according to their strength.
19. To explain the meaning of concentrated and dilute acids.
20. To explain the meaning of concentrated and dilute bases.
21. To distinguish concentrated and dilute acids/ bases from strong acids/bases.

APPENDIX B

ASİTLER VE BAZLAR KAVRAM TESTİ

Yönerge: Bu test sizin Asit ve Bazlar konusundaki kavramları ne derecede öğrendiğinizi değerlendirmek için hazırlanmıştır. Testte toplam yirmi bir (21) tane çoktan seçmeli soru vardır. Her bir sorunun dört tane seçeneği ancak sadece bir tane doğru cevabı vardır. Soruları cevaplarken dikkatli olmanız ve cevapları cevap anahtarına işaretlemeniz gerekmektedir!

1)Asitlerle ilgili olarak aşağıdaki ifadelerden hangisi DOĞRUDUR?

a- toprak asidik olabilir.
b- tüm asitler tahriş edici ve yakıcıdır.
c- güçlü ve keskin kokan tüm maddeler asittir.
d- tüm asitler bazlardan daha tehlikelidir.

2)Bazlarla ilgili olarak aşağıdaki ifadelerden hangisi DOĞRUDUR?

a- bazlar tatlıdır.
b- meyvalar genellikle baziktir.
c- bazların pH değeri asitlerin pH değerinden büyüktür.
d- baz molekülleri yuvarlaktır.

3)Bir beherdeki asit çözeltisine azar azar bir baz çözeltisi eklendiğinde aşağıdakilerden hangisinin gerçekleşmesi kesindir?

a- oluşan çözeltinin nötr olması.

b- pH değerinin düşmesi.

c- oluşan çözeltinin elektrik akımını iletmemesi.

d- pH değerinin yükselmesi.

4) Aşağıda pH değeri verilen çözeltilerden en asidik olan hangisidir?

a- pH=0 b- pH=1 c- pH=14 d- pH=6

5) Asit ve bazlarla ilgili olarak aşağıdaki ifadelerden hangisi YANLIŞTIR?

a- toprak asidik veya bazik olabilir.

b- asitler yakıcı oldukları için sivri uçlu, bazlar kayganlık hissi verdikleri için yuvarlak tanecikler içerir.

c- bir maddenin asit olması için hidrojen (H), baz olması için hidroksit (OH) içermesi şart değildir.

d- yediğimiz gıdalarda asit ve bazlar vardır.

6)Bromlu suyun kırmızı rengi, çözeltiye seyreltik NaOH eklenirse kaybolur. Karışımın yeniden kırmızı renk kazanması için aşağıda verilen dört öneriden hangisi veya hangileri DOĞRUDUR?

I. HCl çözeltisi eklenmesi

II. indikatör (belirteç) eklenmesi

III. derişik CH_3COOH eklenmesi

IV. NH_3 eklenmesi

a- yalnız I b- I ve IV c- I ve II d- I ve III

7) Eşit derişim ve hacimli aşağıdaki maddelerden hangisi en kuvvetli asittir?

a- H_2CO_3 b- H_3PO_4 c- HI d- H_4SiO_4

8)Asit ve bazlarla ilgili olarak aşağıdaki ifadelerden hangisi veya hangileri DOĞRUDUR?

I. asit ve bazların bütün özellikleri birbirinin tersidir

II. pH=0 olunca madde ne asidik ne bazik özellik gösterir

III. asitlerin pH değeri bazların pH değerinden daha küçüktür

IV. kuvvetli asitler sadece kuvvetli bazlarla, zayıf asitler sadece zayıf bazlarla tepkimeye girer.

a- yalnız II b- yalnız III c- I ve II d- II ve IV

9) Bir A asidi B asidinden daha asidik, bir C bazı D bazından daha bazik ise eşit derişimli çözeltilerinin pH değerinin büyükten küçüğe doğru sıralanışı nasıl olur?

a- A>B>C>D b- B>A>D>C c- C>D>B>A d- D>C>B>A

10) Bir asidin kuvvetini anlamak için aşağıdakilerden hangisi veya hangilerinin mutlaka bilinmesi gerekir?

I. derişiminin

II. yapısındaki hidrojen (H) atomu sayısının

III. sudaki iyonlaşma yüzdesinin

IV. pH değerinin

a- I ve II b- yalnız III c- II ve III d- II ve IV

11) Aşağıda bir olay (I) ve bunun nedeni olan bir açıklama veriliyor (II)

I. H_2O hem asit hem de baz olarak davranabilir.

II. Bunun nedeni bazı tepkimelerde H_2O 'nun H^+ iyonu verebilmesi ve bazılarında da H^+ iyonu alabilmesidir.

Bu olay ve açıklaması için aşağıdakilerden hangisi söylenebilir?

a- I doğru, II yanlış b- I yanlış, II doğru c- ikiside yanlış d- ikiside doğru

12) Derişik asit çözeltileri ve seyreltik asit çözeltileriyle ilgili olarak aşağıdaki ifadelerden hangisi veya hangileri daima DOĞRUDUR?

I. derişik asit çözeltisindeki madde miktarı daha fazladır.

II. derişik asit çözeltisi seyreltik asit çözeltisinden daha kuvvetlidir

III. derişik asit çözeltisinin pH değeri seyreltik asit çözeltisinin pH değerinden daima büyüktür.

a- yalnız I b- yalnız II c- II ve III d- I ve II

13) İndikatör (belirteç) kullanma amacı aşağıdakilerden hangisidir?

a- asit-baz tepkimelerinde nötrleşmeyi sağlaması

b- asidin kuvvetli veya zayıf olduğunu göstermesi

c- asitliği nötrleştirmesi

d- asit ve bazların şiddetini göstermesi

14) Aşağıdaki maddelerden hangisi baz değildir?

a- $Mg(OH)_2$ b- HCOOH c- PH_3 d- KOH

15) Asit ve baz tepkimeleriyle ilgili olarak aşağıdakilerden hangisi DOĞRUDUR?

a- tüm asit-baz tepkimelerinde oluşan çözeltinin pH değeri 7 'dir.

b-asit-baz tepkimelerinde nötrleşmeyi sağlamak için indicator (belirteç) kullanılmalıdır.

c- asit-baz tepkimeleri sonucu oluşan çözeltiler asidik veya bazik olabilir.

d- asit-baz tepkimeleri sonucu oluşan çözeltiler elektrik akımını iletmez.

16) HCl ve HBr kuvvetli iki asittir. HBr, HCl'den daha kuvvetli bir asit olduğuna göre aşağıdakilerden hangisi veya hangileri DOĞRUDUR?

I. HBr suda çözündüğünde HCl'e oranla daha fazla iyonlarına ayrışır.

II. HBr'in molekül içi bağları daha kuvvetli olduğundan daha kararlıdır.

III. HBr daha kuvvetli bir asittir çünkü daha fazla hidrojen bağına sahiptir.

IV. HBr daha kuvvetli bir asit olduğu için daha derişiktir.

a- yalnız I b- yalnız IV c- II ve III d- III ve IV

17) pH değeri aşağıdakilerden hangisini gösterir?

a- asidin sahip olduğu hidrojen atomu sayısını

b- asit ve baz çözeltilerinin şiddetini

c- asidin veya bazın kuvvetini

d- asidin verebileceği hidrojen iyonları sayısını

18) NH_3, CH_3COOH, H_2O maddeleriyle ilgili olarak aşağıdaki ifadelerden hangisi veya hangileri DOĞRUDUR?

I- H_2O asit veya baz olarak davranamaz sadece çözücüdür.

II- CH_3COOH yapısında OH bulundurduğu için bazdır.

III- NH_3 yapısında H bulundurduğu için asittir.

IV- eşit derişimli çözeltilerinde NH_3 'ün pH değeri CH_3COOH'ün pH değerinden büyüktür.

a- II ve III   b- yalnız IV   c- I ve IV   d- I, II, III

19) Eşit derişimli ve hacimli aşağıdaki maddelerden hangisi en kuvvetli bazdır?

a- KOH   b- $Al(OH)_3$ c- $Zn(OH)_2$ d- $Ti(OH)_4$

20) Asit, baz ve tuzlarla ilgili aşağıdaki özelliklerden hangisi YANLIŞTIR?

a- asit çözeltileri elektriği iletir.

b- baz çözeltileri elektriği iletir.

c- tuz çözeltileri elektriği iletmez.

d- (b) ve (c).

21) Aşağıdaki ifadelerden hangisi veya hangileri DOĞRUDUR?

I- derişik asit çözeltisi olmak pH değerinin büyük, seyreltik asit çözeltisi olmak pH değerinin küçük olmasıdır.

II- bir maddenin çözeltisi hem derişik, hem de kuvvetli asit/baz olabilir.

III- derişik asit çözeltileri daha asidik, derişik baz çözeltileri daha baziktir.

a- Yalnız II   b- Yanlız III   c- I ve III   d- II ve III

APPENDIX C

KİMYA DERSİ TUTUM ÖLÇEĞİ

Açıklama: Bu ölçek, kimya dersine ilişkin tutumunuzu ölçmek için hazırlanmıştır. Her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneği işaretleyiniz.

AD: SOYAD: SINIF:	TAMAMEN KATILIYORUM	KATILIYORUM	KARARSIZIM	KATILMIYORUM	HİÇ KATILMIYORUM
1.Kimya çok sevdiğim bir alandır.					
2. Kimya ile ilgili kitapları okumaktan hoşlanırım.					
3. Kimyanın günlük yaşantıda çok önemli bir yeri yoktur.					
4. Kimya ile ilgili ders problemleri çözmek hoşuma gider.					
5. Kimya konularıyla ilgili daha çok şey öğrenmek isterim.					
6. Kimya dersine girerken sıkıntı duyarım.					
7. Kimya dersine zevkle çalışırım.					
8. Kimya dersine ayrılan ders saatinin daha fazla olmasını isterim.					
9. Kimya dersine çalışırken canım sıkılır.					
10. Kimya konularını ilgilendiren günlük olaylar hakkında daha fazla bilgi edinmek isterim.					
11. Düşünce sistemimizi geliştirmede kimya öğrenimi önemlidir.					
12. Kimya çevremizdeki doğal olayların anlaşılmasında önemlidir.					
13. Dersler içinde kimya dersi sevimsiz gelir.					
14. Kimya konularıyla ilgili tartışmaya katılmak cazip gelmez.					
15. Çalışma zamanımın önemli bir kısmını kimya dersine ayırmak isterim.					

APPENDIX D

BİLİMSEL İŞLEM BECERİ TESTİ

AÇIKLAMA: Bu test, özellikle Fen ve Matematik derslerinizde ve ilerde üniversite sınavlarında karşınıza çıkabilecek karmaşık gibi görünen problemleri analiz edebilme kabiliyetinizi ortaya çıkarabilmesi açısından çok faydalıdır. Bu test içinde, problemdeki değişkenleri tanımlayabilme, hipotez kurma ve tanımlama, işlemsel açıklamalar getirebilme, problemin çözümü için gerekli incelemelerin tasarlanması, grafik çizme ve verileri yorumlayabilme kabiliyelerini ölçen sorular bulunmaktadır. Her soruyu okuduktan sonra kendinizce uygun seçeneği yalnızca cevap kağıdına işaretleyiniz.

1. Bir basketbol antrenörü, oyuncuların güçsüz olmasından dolayı maçları kaybettklerini düşünmektedir. Güçlerini etkileyen faktörleri araştırmaya karar verir. Antrenör, oyuncuların gücünü etkileyip etkilemediğini ölçmek için aşağıdaki değişkenlerden hangisini incelemelidir?

a. Her oyuncunun almış olduğu günlük vitamin miktarını.

b. Günlük ağırlık kaldırma çalışmalarının miktarını.

c. Günlük antreman süresini.

d. Yukarıdakilerin hepsini.

2. Arabaların verimliliğini inceleyen bir araştırma yapılmaktadır. Sınanan hipotez, benzine katılan bir katkı maddesinin arabaların verimliliğini artıdığı yolundadır. Aynı tip beş arabaya aynı miktarda benzin fakat farklı miktarlarda katkı maddesi konur. Arabalar benzinleri bitinceye kadar aynı yol üzerinde giderler. Daha sonra her arabanın aldığı mesafe kaydedilir. Bu çalışmada arabaların verimliliği nasıl ölçülür?

a. Arabaların benzinleri bitinceye kadar geçen süre ile.

b. Her arabnın gittiği mesafe ile.

c. Kullanılan benzin miktarı ile.

d. Kullanılan katkı maddesinin miktarı ile.

3. Bir araba üreticisi daha ekonomik arabalar yapmak istemektedir. Araştırmacılar arabanın litre başına alabileceği mesafeyi etkileyebilecek değşkenleri araştımaktadırlar. Aşağıdaki değişkenlerden hangisi arabanın litre başına alabileceği mesafeyi etkileyebilir?

a. Arabanın ağırlığı.

b. Motorun hacmi.

c. Arabanın rengi

d. a ve b.

4. Ali Bey, evini ısıtmak için komşularından daha çok para ödenmesinin sebeblerini merak etmektedir. Isınma giderlerini etkileyen faktörleri araştırmak için bir hipotez kurar. Aşağıdakilerden hangisi bu araştırmada sınanmaya uygun bir hipotez değildir?

a. Evin çevresindeki ağaç sayısı ne kadar az ise ısınma gideri o kadar fazladır.

b. Evde ne kadar çok pencere ve kapı varsa, ısınma gideri de o kadar fazla olur.

c. Büyük evlerin ısınma giderleri fazladır.

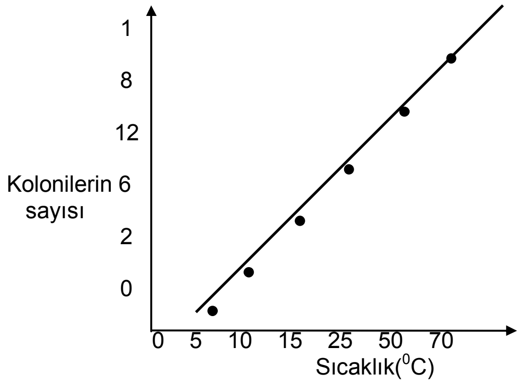
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir.

5. Fen sınıfından bir öğrenci sıcaklığın bakterilerin gelişmesi üzerindeki etkilerini araştırmaktadır. Yaptığı deney sonucunda, öğrenci aşağıdaki verileri elde etmiştir:

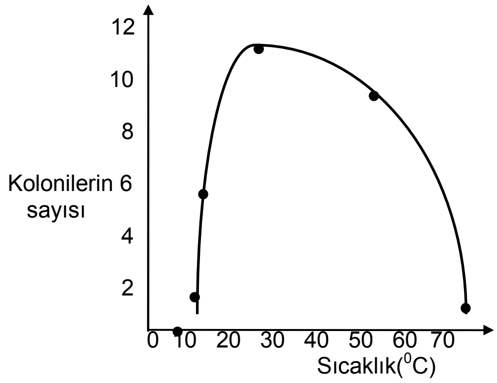
Deney odasının sıcaklığı (^{0}C)	Bakteri kolonilerinin sayısı
5	0
10	2
15	6
25	12
50	8
70	1

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?

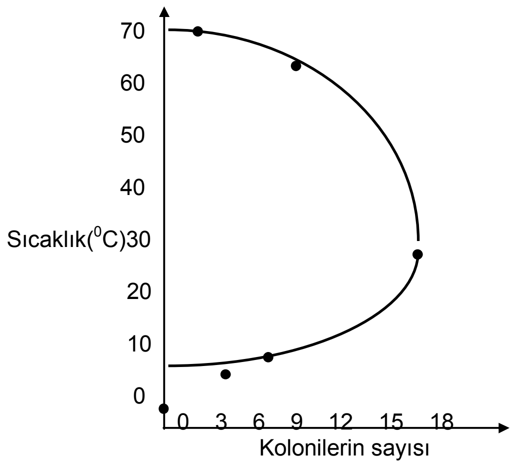
a.



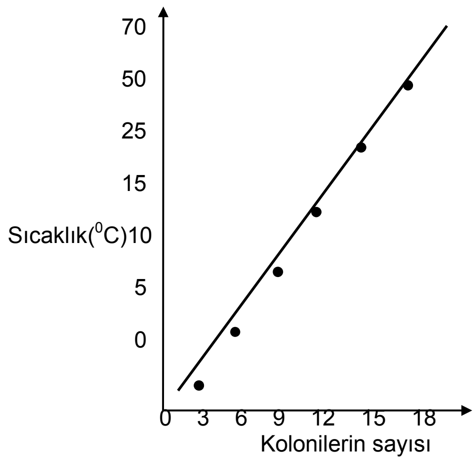
b.



c.



d.



6. Bir polis şefi, arabaların hızının azaltılması ile uğraşmaktadır. Arabaların hızını etkileyebilecek bazı faktörler olduğunu düşünmektedir. Sürücülerin ne kadar hızlı araba kullandıklarını aşağıdaki hipotezlerin hangisiyle sınayabilir?

a. Daha genç sürücülerin daha hızlı araba kullanma olasılığı yüksektir.

b. Kaza yapan arabalar ne kadar büyükse, içindeki insanların yaralanma olasılığı o kadar azdır.

c. Yollarda ne kadar çok polis ekibi olursa, kaza sayısı o kadar az olur.

d. Arabalar eskidikçe kaza yapma olasılıkları artar.

7. Bir fen sınıfında, tekerlek yüzeyi genişliğinin tekerleğin daha kolay yuvarlanması üzerine etkisi araştırılmaktadır. Bir oyuncak arabaya geniş yüzeyli tekerlekler takılır, önce bir rampadan (eğik düzlem) aşağı bırakılır ve daha sonra düz bir zemin üzerinde gitmesi sağlanır. Deney, aynı arabaya daha dar yüzeyli tekerlekler takılarak tekrarlanır. Hangi tip tekerleğin daha kolay yuvarlandığı nasıl ölçülür?

a. Her deneyde arabanın gittiği toplam mesafe ölçülür.

b. Rampanın (eğik düzlem) eğim açısı ölçülür.

c. Her iki deneyde kullanılan tekerlek tiplerinin yüzey genişlikleri ölçülür.

d. Her iki deneyin sonunda arabanın ağırlıkları ölçülür.

8. Bir çiftçi daha çok mısır üretebilmenin yollarını aramaktadır. Mısırların miktarını etkileyen faktörleri araştırmayı tasarlar. Bu amaçla aşağıdaki hipotezlerden hangisini sınayabilir?

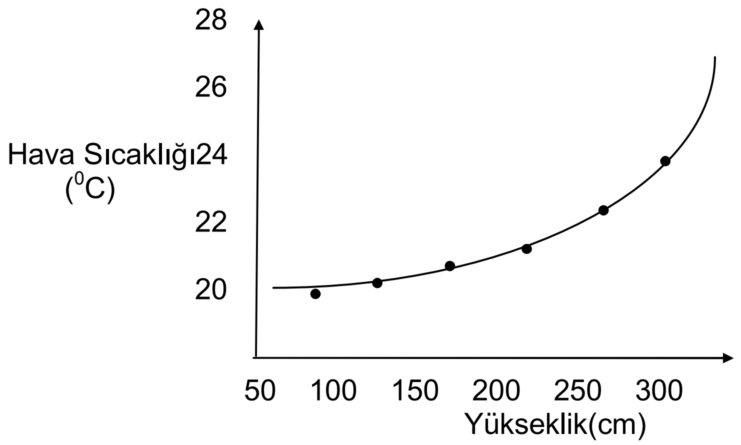
a. Tarlaya ne kadar çok gübre atılırsa, o kadar çok mısır elde edilir.

b. Ne kadar çok mısır elde edilirse, kar o kadar fazla olur.

c. Yağmur ne kadar çok yağarsa , gübrenin etkisi o kadar çok olur.

d. Mısır üretimi arttıkça, üretim maliyeti de artar.

9. Bir odanın tabandan itibaren değişik yüzeylerdeki sıcaklıklarla ilgli bir çalışma yapılmış ve elde edilen veriler aşağıdaki grafikte gösterilmiştir. Değişkenler arasındaki ilişki nedir?



a. Yükseklik arttıkça sıcaklık azalır.

b. Yükseklik arttıkça sıcaklık artar.

c. Sıcaklık arttıkça yükseklik azalır.

d. Yükseklik ile sıcaklık artışı arasında bir ilişki yoktur.

10. Ahmet, basketbol topunun içindeki hava arttıkça, topun daha yükseğe sıçracağını düşünmektedir. Bu hipotezi araştırmak için, birkaç basketbol topu alır ve içlerine farklı miktarda hava pompalar. Ahmet hipotezini nasıl sınamalıdır?

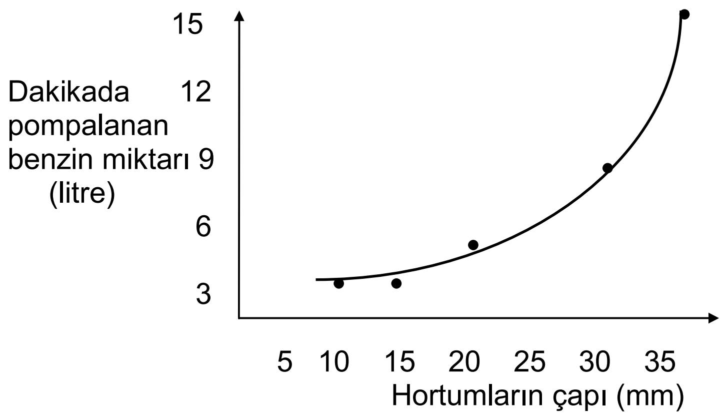
a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.

b. İçlerinde farlı miktarlarda hava olan topları, aynı yükseklikten yere bırakır.

c. İçlerinde aynı miktarlarda hava olan topları, zeminle farklı açılardan yere vurur.

d. İçlerinde aynı miktarlarda hava olan topları, farklı yüksekliklerden yere bırakır.

11. Bir tankerden benzin almak için farklı genişlikte 5 hortum kullanılmaktadır. Her hortum için aynı pompa kullanılır. Yapılan çalışma sonunda elde edilen bulgular aşağıdaki grafikte gösterilmiştir.



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi açıklamaktadır?

a. Hortumun çapı genişledikçe dakikada pompalanan benzin miktarı da artar.

b. Dakikada pompalanan benzin miktarı arttıkça, daha fazla zaman gerekir.

c. Hortumun çapı küçüldükçe dakikada pompalanan benzin miktarı da artar.

d. Pompalanan benzin miktarı azaldıkça, hortumun çapı genişler.

Önce aşağıdaki açıklamayı okuyunuz ve daha sonra 12, 13, 14 ve 15 inci soruları açıklama kısmından sonra verilen paragrafı okuyarak cevaplayınız.

Açıklama: Bir araştırmada, bağımlı değişken birtakım faktörlere bağımlı olarak gelişim gösteren değişkendir. Bağımsız değişkenler ise bağımlı değişkene etki eden faktörlerdir. Örneğin, araştırmanın amacına göre kimya başarısı bağımlı bir değişken olarak alınabilir ve ona etki edebilecek faktör veya faktörler de bağımsız değişkenler olurlar.

Ayşe, güneşin karaları ve denizleri aynı derecede ısıtıp ısıtmadığını merak etmektedir. Bir araştırma yapmaya karar verir ve aynı büyüklükte iki kova alır. Bumlardan birini toprakla, diğerini de su ile doldurur ve aynı miktarda güneş ısısı alacak şekilde bir yere koyar. 8.00 - 18.00 saatleri arasında, her saat başı sıcaklıklarını ölçer.

12. Araştırmada aşağıdaki hipotezlerden hangisi sınanmıştır?
a. Toprak ve su ne kadar çok güneş ışığı alırlarsa, o kadar ısınırlar.
b. Toprak ve su güneş altında ne kadar fazla kalırlarsa, o kadar çok ısınırlar.
c. Güneş farklı maddelari farklı derecelerde ısıtır.
d. Günün farklı saatlerinde güneşin ısısı da farklı olur.

13. Araştırmada aşağıdaki değişkenlerden hangisi kontrol edilmiştir?
a. Kovadaki suyun cinsi.
b. Toprak ve suyun sıcaklığı.
c. Kovalara koyulan maddenin türü.
d. Herbir kovanın güneş altında kalma süresi.

14. Araştırmada bağımlı değişken hangisidir?
a. Kovadaki suyun cinsi.
b. Toprak ve suyun sıcaklığı.
c. Kovalara koyulan maddenin türü.
d. Herbir kovanın güneş altında kalma süresi.

15. Araştırmada bağımsız değişken hangisidir?
a. Kovadaki suyun cinsi.
b. Toprak ve suyun sıcaklığı.
c. Kovalara koyulan maddenin türü.
d. Herbir kovanın güneş altında kalma süresi.

16. Can, yedi ayrı bahçedeki çimenleri biçmektedir. Çim biçme makinasıyla her hafta bir bahçedeki çimenleri biçer. Çimenlerin boyu bahçelere göre farklı olup bazılarında uzun bazılarında kısadır. Çimenlerin boyları ile ilgili hipotezler kurmaya başlar. Aşağıdakilerden hangisi sınanmaya uygun bir hipotezdir?

a. Hava sıcakken çim biçmek zordur.

b. Bahçeye atılan gürenin miktarı önemlidir.

c. Daha çok sulanan bahçedeki çimenler daha uzun olur.

d. Bahçe ne kadar engebeliyse çimenleri kesmekte o kadar zor olur.

17, 18, 19 ve 20 nci soruları aşağıda verilen paragrafı okuyarak cevaplayınız.

Murat, suyun sıcaklığının, su içinde çözünebilecek şeker miktarını etkileyip etkilemediğini araştırmak ister. Birbirinin aynı dört bardağın herbirine 50 şer mililitre su koyar. Bardaklardan birisine 0 ^{0}C de, diğerine de sırayla 50 ^{0}C, 75 ^{0}C ve 95 ^{0}C sıcaklıkta su koyar. Daha sonra herbir bardağa çözünebileceği kadar şeker koyar ve karıştırır.

17. Bu araştırmada sınanan hipotez hangisidir?

a. Şeker ne kadar çok suda karıştırılırsa o kadar çok çözünür.

b. Ne kadar çok şeker çözünürse, su o kadar tatlı olur.

c. Sıcaklık ne kadar yüksek olursa, çözünen şekerin miktarı o kadar fazla olur.

d. Kullanılan suyun miktarı arttıkça sıcaklığı da artar.

18. Bu araştırmada kontrol edilebilen değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

19. Araştımanın bağımlı değişkeni hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

20. Araştırmadaki bağımsız değişken hangisidir?
a. Her bardakta çözünen şeker miktarı.
b. Her bardağa konulan su miktarı.
c. Bardakların sayısı.
d. Suyun sıcaklığı.

21. Bir bahçıvan domates üretimini artırmak istemektedir. Değişik birkaç alana domates tohumu eker. Hipotezi, tohumlar ne kadar çok sulanırsa, o kadar çabuk filizleneceğidir. Bu hipotezi nasıl sınar?
a. Farklı miktarlarda sulanan tohumların kaç günde filizleneceğine bakar.
b. Her sulamadan bir gün sonra domates bitkisinin boyunu ölçer.
c. Farklı alanlardaki bitkilere verilen su miktarını ölçer.
d. Her alana ektiği tohum sayısına bakar.

22. Bir bahçıvan tarlasındaki kabaklarda yaprak bitleri görür. Bu bitleri yok etmek gereklidir. Kardeşi "Kling" adlı tozun en iyi böcek ilacı olduğunu söyler. Tarım uzmanları ise "Acar" adlı spreyin daha etkili olduğunu söylemektedir. Bahçıvan altı tane kabak bitkisi seçer. Üç tanesini tozla, üç tanesini de spreyle ilaçlar. Bir hafta sonra her bitkinin üzerinde kalan canlı bitleri sayar. Bu çalışmada böcek ilaçlarının etkinliği nasıl ölçülür?
a. Kullanılan toz ya da spreyin miktarı ölçülür.
b. Toz ya da spreyle ilaçlandıktan sonra bitkilerin durumları tespit edilir.
c. Her fidede oluşan kabağın ağırlığı ölçülür.
d. Bitkilerin üzerinde kalan bitler sayılır.

23. Ebru, bir alevin belli bir zaman süresi içinde meydana getireceği ısı enerjisi miktarını ölçmek ister. Bir kabın içine bir liter soğuk su koyar ve 10 dakika süreyle ısıtır. Ebru, alevin meydana getirdiği ısı enerjisini nasıl öiçer?
a. 10 dakika sonra suyun sıcaklığında meydana gelen değişmeyi kayeder.
b. 10 dakika sonra suyun hacminde meydana gelen değişmeyi ölçer.
c. 10 dakika sonra alevin sıcaklığını ölçer.

d. Bir litre suyun kaynaması için geçen zamanı ölçer.

24. Ahmet, buz parçacıklarının erime süresini etkileyen faktörleri merak etmektedir. Buz parçalarının büyüklüğü, odanın sıcaklığı ve buz parçalarının şekli gibi faktörlerin erime süresini etkileyebileceğini düşünür. Daha sonra şu hipotezi sınamaya karar verir: Buz parçalarının şekli erime süresini etkiler. Ahmet bu hipotezi sınamak için aşağıdaki deney tasarımlarının hangisini uygulamalıdır?

a. Herbiri farklı şekil ve ağırlıkta beş buz parçası alınır. Bunlar aynı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

b. Herbiri aynı şekilde fakat farklı ağırlıkta beş buz parçası alınır. Bunlar aynı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

c. Herbiri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar aynı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

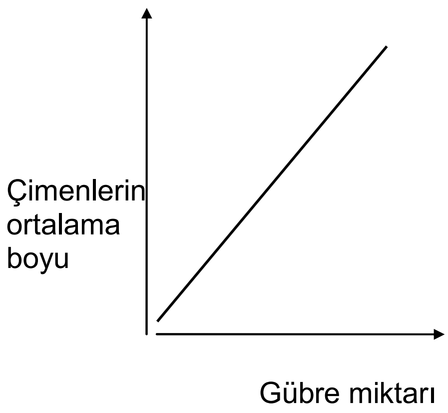
d. Herbiri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar farklı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

25. Bir araştırmacı yeni bir gübreyi denemektedir. Çalışmalarını aynı büyüklükte beş tarlad yapar. Her tarlaya yeni gübresinden değişik miktarlarda karıştırır. Bir ay sonra, her tarlada yetişen çimenin ortalama boyunu ölçer. Ölçüm sonuçları aşağıdaki tabloda verilmiştir.

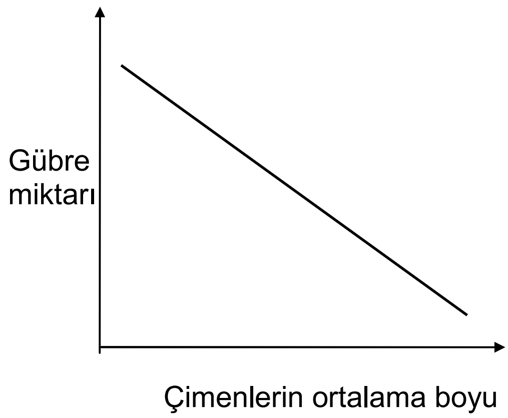
Gübre miktarı (kg)	Çimenlerin ortalama boyu (cm)
10	7
30	10
50	12
80	14
100	12

Tablodaki verilerin grafiği aşağıdakilerden hangisidir?

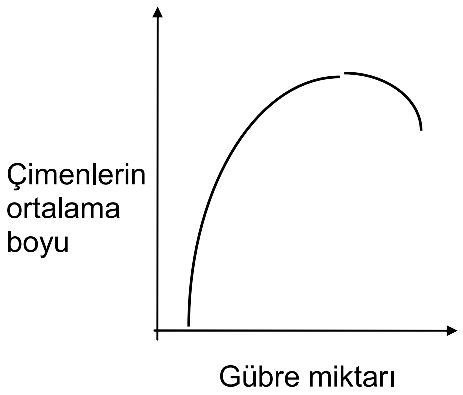
a.



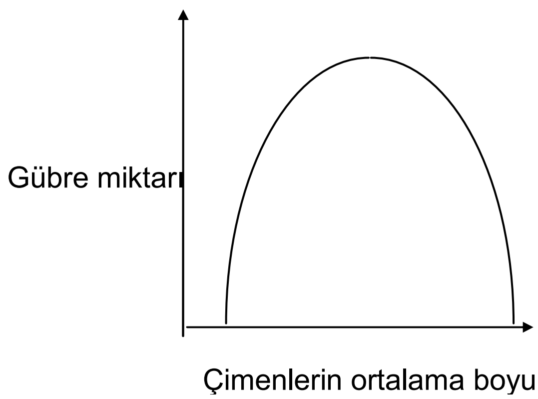
b.



c.



d.



26. Bir biyolog şu hipotezi test etmek ister: Farelere ne kadar çok vitamin verilirse o kadar hızlı büyürler. Biyolog farelerin büyüme hızını nasıl ölçebilir?

a. Farelerin hızını ölçer.

b. Farelerin, günlük uyumadan durabildikleri süreyi ölçer.

c. Hergün fareleri tartar.

d. Hergün farelerin yiyeceği vitaminleri tartar.

27. Öğrenciler, şekerin suda çözünme süresini etkileyebilecek değişkenleri düşünmektedirler. Suyun sıcaklığını, şekerin ve suyun miktarlarını değişken olarak saptarlar. Öğrenciler, şekerin suda çözünme süresini aşağıdaki hipotezlerden hangisiyle sınayabilir?

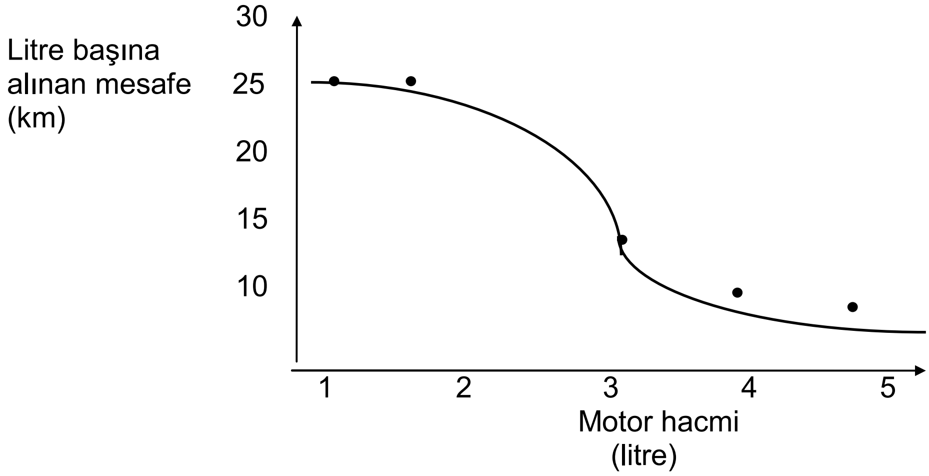
a. Daha fazla şekeri çözmek için daha fazla su gereklidir.

b. Su soğudukça, şekeri çözebilmek için daha fazl akarıştırmak gerekir.

c. Su ne kadar sıcaksa, o kadar çok şeker çözünecektir.

d. Su ısındıkça şeker daha uzun sürede çözünür.

28. Bir araştıma grubu, değişik hacimli motorları olan arabalaıın randımanlarını ölçer. Elde edilen sonuçların garfiği aşağıdaki gibidir:



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi gösterir?

a. Motor ne kadar büyükse, bir litre benzinle gidilen mesafe de o kadar uzun olur.

b. Bir litre benzinle gidilen mesafe ne kadar az olursa, arabanın motoru o kadar küçük demektir.

c. Motor küçüldükçe, arabanın bir litre benzinle gidilen mesafe artar.

d. Bir litre benzinle gidilen mesafe ne kadar uzun olursa, arabanın motoru o kadar büyük demektir.

29, 30, 31 ve 32 nci soruları aşağıda verilen paragrafı okuyarak cevaplayınız.

Toprağa karıtırılan yaprakların domates üretimine etkisi araştırılmaktadır. Araştırmada dört büyük saksıya aynı miktarda ve tipte toprak konulmuştur. Fakat birinci saksıdaki torağa 15 kg., ikinciye 10 kg., üçüncüye ise 5 kg. çürümüş yaprak karıştırılmıştır. Dördüncü saksıdaki toprağa ise hiç çürümüş yaprak karıştırılmamıştır.

Daha sonra bu saksılara domates ekilmiştir. Bütün saksılar güneşe konmuş ve aynı miktarda sulanmıştır. Her saksıdan eled edilen domates tartılmış ve kaydedilmiştir.

29. Bu araştırmada sınanan hipotez hangisidir?

a. Bitkiler güneşten ne kadar çok ışık alırlarsa, o kadar fazla domates verirler.

b. Saksılar ne kadar büyük olursa, karıştırılan yaprak miktarı o kadar fazla olur.

c. Saksılar ne kadar çok sulanırsa, içlerindeki yapraklar o kadar çabuk çürür.

d. Toprağa ne kadar çok çürük yaprak karıştırılırsa, o kadar fazla domates elde edilir.

30. Bu araştırmada kontrol edilen değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

31. Araştırmadaki bağımlı değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

32. Araştırmadaki bağımsız değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

33. Bir öğrenci mınatısların kaldırma yeteneklerini araştırmaktadır. Çeşitli boylarda ve şekillerde birkaç mıknatıs alır ve her mıknatısın çektiği demir tozlarını tartar. Bu çalışmada mıknatısın kaldırma yeteneği nasıl tanımlanır?

a. Kullanılan mıknatısın büyüklüğü üle.

b. Demir tozalrını çeken mıknatısın ağırlığı ile.

c. Kullanılan mıknatısın şekli ile.

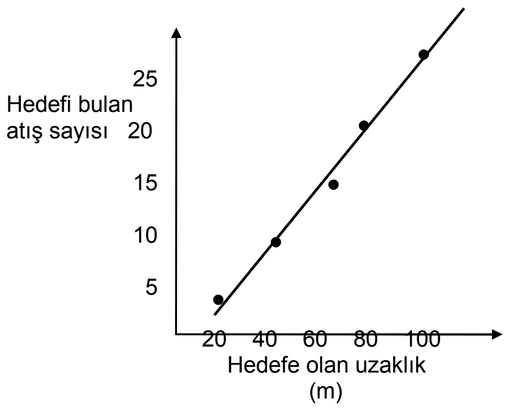
d. Çekilen demir tozlarının ağırlığı ile.

34. Bir hedefe çeşitli mesafelerden 25 er atış yapılır. Her mesafeden yapılan 25 atıştan hedefe isabet edenler aşağıdaki tabloda gösterilmiştir.

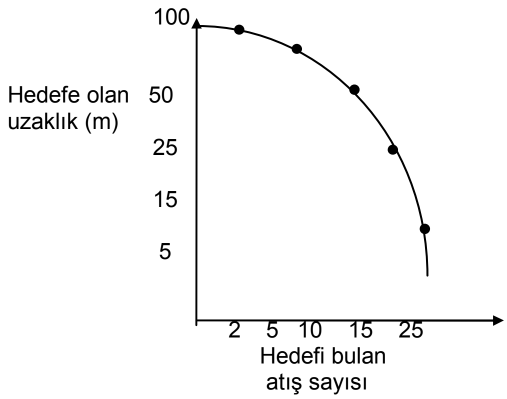
Mesafe(m)	Hedefe vuran atış sayısı
5	25
15	10
25	10
50	5
100	2

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?

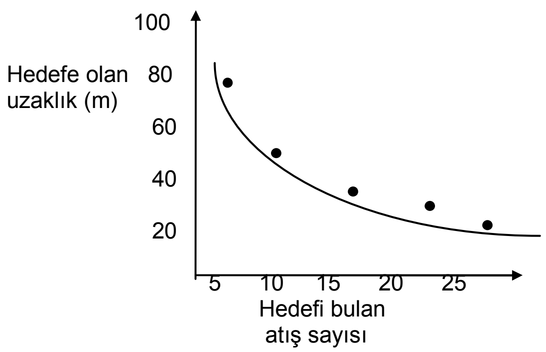
a.



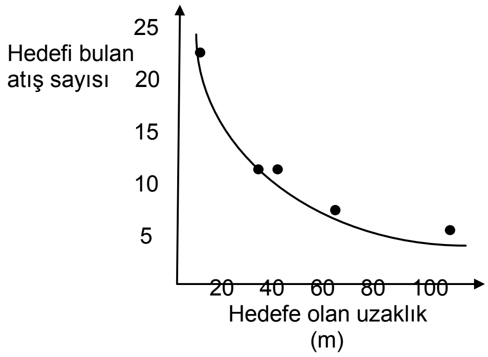
b.



c.



d.



35. Sibel, akvaryumdaki balıkların bazen çok haraketli bazen ise durgun olduklarını gözler. Balıkların hareketliliğini etkileyen faktörleri merak eder.Balıkların hareketliliğini etkileyen faktörleri hangi hipotezle sınayabilir?

a. Balıklara ne kadar çok yem verilirse, o kadar çok yeme ihtiyaçları vardır.

b. Balıklar ne kadar hareketli olursa o kadar çok yeme ihtiyaçları vardır.

c. Su da ne kadar çok oksijen varsa, balıklar o kadar iri olur.

d. Akvaryum ne kadar çok ışık alırsa, balıklar o kadar hareketli olur.

36. Murat Bey'in evinde birçok elektrikli alet vardır. Fazla gelen elektrik faturaları dikkatini çeker. Kullanılan elektrik miktarını etkileyen faktörleri araştırmaya karar verir. Aşağıdaki değişkenlerden hangisi kullanılan elektrik enerjisi miktarını etkileyebilir?

a. TV nin açık kaldığı süre.

b. Elektrik sayacının yeri.

c. Çamaşır makinesinin kullanma sıklığı.

d. a ve c.

APPENDIX E

ASİTLER VE BAZLAR KAVRAMSAL DEĞİŞİM METNİ

Asit-baz terimleri kimyada çok önemli iki kavramı ifade eder. Kimyasal reaksiyonların büyük çoğunluğu asit-baz reaksiyonları olduğundan asit ve bazlar kimyanın en önemli konularından birisidir. Bunun yanı sıra günlük hayatta sıkça kullandığımız sabun, çamaşır suyu, tuz ruhu, bazı ilaçlar, gazoz, sirke, tıraş köpüğü, cilt bakım kremi, ketçap vs. maddelerin yapısında da asit yada baz bulunmaktadır. Bazı asit ve bazlar yediğimiz sebze ve meyvelerde doğal olarak vardır. Hatta bu asit ve bazların eksikliğinde canlı vücudunda birtakım hastalıklar meydana gelir. Folik asit eksikliğinde aneminin oluşması gibi. Günlük hayatımızda da bu kadar iç içe olduğumuz asit ve baz ne anlama gelmektedir? NH_3, PH_3, CH_3COOH, HCOOH gibi maddelerin hangileri baz, hangileri asittir? Yapısında H atomu bulunduran her maddeyi asit, OH bulunduran her maddeyi de baz diye tanımlamak doğru mudur? Bu maddelerin ilk ikisi tepkimelerde bazik, son ikisi ise tepkimelerde asidik özellik göstermektedir. Örneğin,

$NH_3 + H_2O \rightarrow NH_4^+ + OH^-$ tepkimesinde

NH_3 maddesi suya OH^- iyonu verdiği için yapısında H atomu olmasına rağmen bazdır. Arrhenius asit-baz tanımına göre *sulu çözeltilerine hidrojen iyonu veren maddeler asit, hidroksit iyonu veren maddeler bazdır.*

$CH_3COOH + H_2O \rightarrow CH_3COO^- + H_3O^+$ tepkimesinde

CH_3COOH maddesi suya H^+ iyonu verdiği için yapısında OH olmasına rağmen asittir. Bu durumda,

Bir maddenin asit olması için hidrojen (H), baz olması için hidroksit (OH) içermesi şart değildir!

Bronsted-Lowry asit-baz tanımına göre ise *asitler proton verme eğilimi olan, bazlar ise proton alma eğilimi olan maddelerdir*. Bu durumda, yukarıdaki tepkimelerde H_2O'nun sadece çözücü olduğunu söylemek doğru mudur? NH_3'e proton verdiği için ilk tepkimede H_2O asittir, 2. tepkimede H_2O CH_3COOH' den proton aldığı için bazdır. Yani H_2O sadece çözücü olmakla kalmayıp tepkimelerde asit veya baz gibi davranabilmektedir.

H_2O sadece çözücü değildir hem asit hemde baz gibi davranabilir!

Asit ve bazların genel özellikleri nelerdir? Tüm asitler yakıcı, zararlı, güçlü ve keskin kokulu mudur? Aynı şekilde, tüm bazlar yakıcı ve zararlı mıdır? Süt içer, elma ve portakal yer misiniz? Mutfağınızda soda, nane ve kabartma tozu kullanır mısınız? Süt, elma ve portakalda asit olduğunu biliyor musunuz? Sütte laktik asit, elmada malik, portakalda ise sitrik asit vardır. Yediğimiz gıdalardaki asitler genellikle organik asittir ve vücudumuz için yararlıdır. Çok keskin olmamakla birlikte kendilerine özgü kokuları vardır. Fakat sanayide kullanılan bazı asitler zararlı, keskin kokulu ve tahriş edici olabilir. Bu durumda,

Tüm asitler yakıcı, zararlı, güçlü ve keskin kokulu değildir!

Mutfağınızda kullandığınız soda, nane ve kabartma tozu, kişisel ve ev temizlik malzemeleri ise baz içermektedir. Yani, bazların hepsi yakıcı ve zararlı değildir. Asitler gibi sanayide kullanılan bazı bazlar zararlı ve yakıcı olabilir. O halde,

Tüm bazlar yakıcı ve zararlı değildir!

Bu durumda televizyondaki bazı diş macunu ve deterjan reklamlarında da yanlış gösterildiği gibi asitler yakıcı ve delici olduğu için sivri (iğne) uçludur, bazlar ise kayganlık hissi verdiği için yuvarlaktır diye nitelemek doğru değildir. Ayrıca, asitlerin bazlardan daha tehlikeli olduğu düşüncesi de yanlıştır. Tüm asit ve bazlar tehlikeli olmadığı gibi, bazı bazlar derişim ve kuvvetine bağlı olarak bazı asitlerden daha tehlikeli olabilir. Mesela, derişik NaOH çözeltisi seyreltik H_3PO_4 çözeltisine göre daha dikkat edilmesi gereken bir çözeltidir. Peki, asitler ve bazlar birbirinin tersi özellik gösteren maddelerdir gibi bir genelleme yapmak doğru mudur? Gösterdikleri özellikler, örneğin asitlerin mavi turnusolu kırmızıya, bazların kırmızı turnusolu maviye çevirmesi gibi bazen birbirine zıt gibi görünse de her ikisininde benzer özellik gösterdiği durumlar vardır. Örneğin, her ikiside iyonlaşma yüzdelerine bağlı olarak elektrik akımını iletebilir, derişim ve kuvvetlerine bağlı olarak yakıcı ve tehlikeli olabilir.

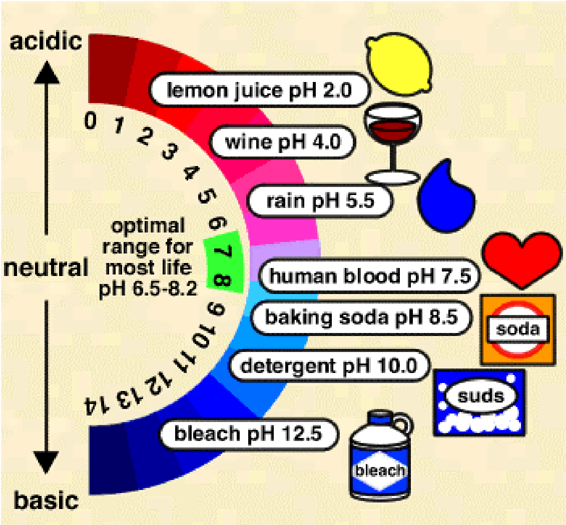
Asit ve bazlar her zaman birbirinin tersi özellik göstermez!

Peki toprak asidik olabilir mi? Asidik bir toprakta bitki yetişebilir mi? Özellikle Yalova ilinde sıkça rastlanan iri mavi ve pembe çiçekli ortanca bitkisinin bu özelliği cinsinden kaynaklanan bir özellik midir? Ortancalarının çiçeğinin farklı renklerde olması cinsinden kaynaklanan bir durum değildir. Eğer ortancalar asitli toprakta yetişiyorsa çiçeği mavi renkli, bazik toprakta yetişiyorsa çiçeği pembe renkli olur. Eflatun çiçekli ortancalar nötr topraklarda yetişir. Yani toprak asidik olabilir fakat toprağın çok asidik olması toprağın verimini düşürür. Çiftçiler bu durumda toprağa bazik olan kireç tozu serperek toprağın asitliğini azaltır ve böylece verimi arttırmaya çalışır.

Toprak asidik olabilir!

Limon suyunun pH değerinin 2, kolanın pH değerinin 5 olması ne ifade etmektedir? Hangisi daha asidiktir? Asitlik ve bazlık ile pH arasında nasıl bir ilişki vardır? Limon suyunu tek başına içmek, kola içmeye göre daha zordur çünkü limon suyu, kolaya göre daha asidiktir; yani pH değeri sayıca küçük olan limon suyu, pH değeri sayıca büyük olan koladan daha asidiktir. 0,0001 M HCl mi, 0,1 M HCl mi daha düşük pH değerine sahiptir? Hangisi daha şiddetlidir/

daha asidiktir? HCl tam olarak iyonlaştığından sulu çözeltilerinde 0,1 M HCI, 0,0001 M HCI den daha fazla H^+ iyonuna sahip olacaktır yani daha asidiktir. Peki bu durum pH değerlerini nasıl etkilemektedir? pH bir çözeltinin asitlik veya bazlık derecesini tarif eden bir ölçü birimidir. Asitlik-bazlık ile pH arasındaki ilişki matematiksel bir ilişkidir.



$$pH= -\log [H^+]$$

$[H^+]$= 1L çözeltideki H^+ iyonlarının mol sayısı / çözeltideki hidrojen iyonlarının derişimidir.

$$[H^+]\uparrow,\ pH\downarrow$$

H^+ iyonu derişiminin artması, pH değerinin azalması yani asidin şiddetinin artması anlamına gelmektedir.

0,0001 M HCl için,

$$[H^+]=0{,}0001M=10^{-4}M \quad \Rightarrow \quad pH= -\log [H^+]=-\log 10^{-4} \quad \Rightarrow pH_1=4$$

0,1 M HCl için,

$$[H^+]=0{,}1M=10^{-1}M \quad \Rightarrow \quad pH= -\log [H^+]=-\log 10^{-1} \quad \Rightarrow pH_2=1$$

$$[H^+]_1 < [H^+]_2 \quad \text{fakat} \quad pH_1 > pH_2$$

Görüldüğü gibi, 0,1 M HCl daha düşük pH değerine sahiptir ve daha asidiktir/şiddetlidir. O halde,

<u>pH değeri arttıkça asitlik derecesi/şiddeti azalır!</u>

Aynı matematiksel bağıntı [OH^-] ve pOH ilişkisi içinde kullanılmaktadır.

$$pOH= -\log [OH^-]$$

[OH^-]=1L çözeltideki OH^- iyonlarının mol sayısı / çözeltideki hidroksit iyonlarının derişimidir.

[OH^-]↑, pOH↓

OH^- iyonu derişiminin artması, pOH değerinin azalması ve bazlık şiddetinin artması anlamına gelmektedir. Yukarıdaki örnekte de olduğu gibi 0,1M NaOH (pOH=1) çözeltisi 0,0001M NaOH (pOH=4) çözeltisinden daha baziktir ($pOH_{0,1} < pOH_{0,0001}$). Bu durumda,

<u>pOH değeri arttıkça bazlık derecesi/şiddeti azalır!</u>

pH değerinin "0" olması ne anlama gelir? Nötr çözeltilerin pH değeri "0" olabilir mi? Bir çözeltideki H^+ veya OH^- derişimi en fazla 1 M olabilir. Bu durumda pH / pOH= -log[H+ / OH-] = -log 1= 0 olur. pH=0 bir asidin alabileceği en büyük değerdir. Bu değer 7 ye doğru arttıkça asidik özellik azalır. pH=14 (pOH=0) bir bazın alabileceği en büyük değerdir. Bu değer 7'ye doğru azaldıkça bazik özellik azalır. Nötr çözeltilerde H^+ ve OH^- derişimi eşit olduğu için pH=7' dir.

Asit ve bazın kuvvetliliği ile pH ve pOH değeri arasında bir ilişki var mıdır? Kuvvetli asitlerin pH değeri her zaman az mıdır? Önce asit ve bazın kuvvetli ve zayıf olması ne anlama geliyor onu araştıralım. Mesela H_2CO_3, HCl 'e göre daha mı kuvvetlidir? Asidin yapısındaki hidrojen sayısı veya hidrojen bağının, kuvvetiyle bir ilişkisi var mıdır? NaOH mu, $Mg(OH)_2$ mi daha kuvvetli bir bazdır? Bazın yapısındaki OH sayısı arttıkça kuvveti artar mı? Evlerimizde kullandığımız ampuller hangi özelliklerinden dolayı kuvvetli ve zayıf olarak adlandırılır? Bir ampul ne kadar fazla ışık verirse o kadar kuvvetlidir, ne kadar az ışık verirse o kadar zayıf bir ampuldür. Üstelik, sadece bir ampulün verdiği ışık, üç ampulün verdiği ışığa eşit olabilir yani ampulün kuvveti ampul sayısından bağımsızdır. Aynı şekilde, asit ve bazın kuvveti içerdiği H ve OH sayısından bağımsızdır, suya ne kadar çok iyon verdiğiyle ilgilidir. Mesela HCI yapısında sadece bir hidrojen atomu olmasına ve hidrojen bağı yapmasına rağmen en güçlü asitlerden bir tanesidir çünkü sahip olduğu bütün hidrojen ve klorları suya kolayca vermiştir; yüzde yüz iyonlaşmıştır. Aynı durum bazlar içinde geçerlidir. Kuvvetlilik iyonlaşmayla ilişkili bir kavramdır. Suda çok iyonlaşan (çok iyon veren) asit ve bazlar kuvvetli, az iyonlaşanlar (az iyon verenler) ise zayıftır. Eğer, H atomu sayısıyla kuvvetlilik arasında ilişki olsa H_2CO_3, H_3PO_4 gibi asitlerin HCl'den daha kuvvetli olması gerekirdi. Bu durum kuvvetli bir baz olan NaOH ve daha zayıf bir baz olan $Al(OH)_3$ içinde geçerlidir. İyonlaşma oranı düşük olan H_2CO_3, H_3PO_4 gibi asitler zayıf asit, $Al(OH)_3$, $Zn(OH)_2$ gibi bazlar ise zayıf bazdır. Bu asitler ve bazlar sulu ortamda oldukça az çözündüklerinden dolayı bir denge reaksiyonu oluştururlar ve Ka / Kb adı verilen, çözünürlük sabiti (Ksp) gibi sabitleri vardır. O halde,

<u>Kuvvetlilik ve zayıflık az ve çok iyonlaşmayla ilgilidir!</u>

Peki kuvvetli bir asit olarak bildiğimiz 10^{-5} M HCl mi, yoksa daha zayıf bir asit olan 10^{-5} M CH_3COOH mi daha şiddetlidir? Hangisinin pH'ı daha düşüktür? Kuvvetli olmakla pH arasında bir ilişki var mıdır? HCl'in kuvvetli olması tam olarak iyonlaştığı anlamına gelir. Bu durumda,

$$[H^+]=10^{-5}\ M \text{ ve } pH= -\log [H^+]=-\log 10^{-5} \quad \Rightarrow \; pH_1=5 \text{ tir.}$$

Zayıf bir asit olan CH_3COOH ise suda tam olarak iyonlarına ayrışamaz. CH_3COOH' in ne kadarının iyonlaştığını gösteren asitlik sabiti $K_a=1.8.10^{-5}$ tir. Bu durumda 10^{-5} M CH_3COOH çözeltisindeki $[H^+]$ iyonu derişimi aşağıdaki gibi bulunur.

$$CH_3COOH \leftrightarrow CH_3COO^- + H^+$$

	CH_3COOH	CH_3COO^-	H^+
başlangıçta	10^{-5} M	-	-
	-x	+x	+x
dengede	10^{-5} -x	+x	+x

$$K_a = [CH_3COO^-][H^+] / [CH_3COOH] = 1.8.10^{-5}$$

$$K_a = x.x / (10^{-5} - x) = 1.8.10^{-5}$$

$$pH_2 = 4.8$$

$pH_2 < pH_1$ olduğu için zayıf bir asit olan CH_3COOH 'ün 10^{-5} M lık sulu çözeltisi, kuvvetli bir asit olan HCl in 10^{-5} M lık sulu çözeltisinden daha şiddetlidir. O halde,

pH asit veya bazın kuvvetini değil şiddetini gösteren bir ölçüdür!

Bir belediye otobüsünün hafta içi ve sabah saatlerinde tıklım tıklım dolu olması ile hafta sonu sabah saatlerinde neredeyse boş olmasını derişime göre nasıl yorumlarsınız? Hangisi derişik, hangisi seyreltiktir? Otobüsün dolu veya boş olması onun motor gücünden veya kuvvetinden bir şey eksiltir mi? Otobüsün dolu olmasını derişik, neredeyse boş olmasını da seyreltik olması olarak ifade edebiliriz. Her iki durumda da otobüsün motor gücü /kuvveti değişmez, aynıdır. Bu örneği asit ve bazlara uyarladığımızda eğer birim hacimdeki madde miktarı fazlaysa derişik, madde miktarı azsa seyreltik asit/baz olarak yorumlanabilir. Derişik bir asit/baz iyonlaşma yüzdesine göre kuvvetli veya zayıf olabilir. Bu durumda,

Derişik olmak birim hacimdeki madde miktarının fazla, seyreltik olmak da madde miktarının az olması anlamına gelmektedir. Kuvvetli veya zayıf olmakla ilgili değildir!

Derelerin ırmaklara, ırmakların denizlere karışması arasındaki kuvveli-zayıf ilişkisi yani derenin ırmaklaşması veya ırmağın denizleşmesi asit ve baz tepkimelerine uyarlanabilir. Eğer kuvvetli bir asit, eşit derişime sahip zayıf bir bazla tepkimeye girerse, kuvvetli asit zayıf bazdan daha çok iyonlaşacağı için ortamda OH^- iyonlarından daha fazla H^+ iyonları olacaktır. Bu durumda, ortamdaki bütün OH^- iyonları, eşit sayıdaki H^+ iyonları tarafından nötralize edilecektir. Asit, baza göre daha fazla iyonlaştığı içinde ortamda H^+ iyonu bulunmaya devam edecektir. Yani bu tepkime sonucu oluşan çözelti asidik özellik gösterecektir. Aynı şekilde, kuvvetli bir baz eşit derişimdeki zayıf bir asitle reaksiyona girdiğinde OH^- iyonlarının bir kısmı H^+ iyonlarını nötrleştirdikten sonra ortamda OH^- iyonları kalacağı için oluşan çözelti bazik özellik gösterecektir. O halde,

Kuvvetli asitler zayıf bazlarla veya kuvvetli bazlar zayıf asitlerle tepkimeye girebilir!

Peki, tüm asit-baz tepkimeleri sonucu oluşan çözelti her zaman nötr müdür? Yukarıdaki örnekte de açıklandığı gibi asit-baz tepkimeleri sonucu oluşan çözelti, ortamda H^+ iyonları fazlaysa asidik çözelti, OH^- iyonları fazlaysa bazik çözelti olur. Eğer ortamda H^+ ve OH^- iyonları eşit sayıda bulunuyorsa, o zaman nötr bir çözelti olur ve pH=7 dir.

Asit-baz tepkimeleri sonucu oluşan çözelti her zaman nötr özellik göstermez!

Elektrik iletkenliğinin ölçütü nedir? Eşit derişimli HCl ve H_3PO_4 çözeltileri elektriği aynı şekilde mi iletir? NaOH, Mg $(OH)_2$ çözeltileri elektriği iletir mi? Elektrik iletkenliği ortamda serbest halde iyonların bulunup bulunmamasıyla ilgilidir. Ortamda çok iyon (H^+, OH^- ve diğerleri) varsa yani asit veya baz kuvvetliyse elektrik iletkenliği fazla, ortamda az iyon varsa yani asit veya baz zayıfsa elektrik iletkenliği düşüktür. Bu durum, asit ve bazların birbirinin tersi özellik göstermediğini de doğrulamaktadır. Hem asitler, hem bazlar, suda iyonlaşmalarına bağlı olarak, elektrik akımını iletebilirler.

Hem asitler hem bazlar elektrik akımını iletebilirler!

İndikatörler ne için kullanılır? Nötrleşmeyle ilgileri var mıdır? Güneş ışınlarının su damlalarında farklı açılarda kırılması nasıl gökkuşağındaki değişik renklere neden oluyorsa indikatörlerde çözeltinin pH'sına bağlı olarak renk değiştiren kompleks yapıdaki organik bileşiklerdir. Sanıldığının aksine asit-baz tepkimelerinde nötrleşmeyi sağlamak için kullanılmazlar sadece çözeltinin pH'ı hakkında bilgi verirler. Buradan da çözeltinin asidik mi, bazik mi veya nötr mü olduğu sonucuna ulaşılabilir.

İndikatörler sadece çözeltinin pH'ı hakkında bilgi verir!

APPENDIX F

A SAMPLE LESSON ON PROPERTIES OF ACIDS AND BASES

Teacher: Who wants to tell what we have seen related with acid and base concepts last lesson?

Students: We have learned the definition of acids and bases.

Teacher: Good. Who will give their definitions to us?

Students: Substances that give H^+ ion to water solution is called as acid, ones giving OH^- is called as base.

Teacher: Yes, true. We have a specific name for this definition. Do you remember it?

Students: Arrhenius definition.

Teacher: Good. But, I gave another definition too. Can you explain this definition?

Students: Acids are proton donors, bases are proton acceptors. This is called as Bronsted-Lowry definition.

Teacher: Yes, very good. After remembering these, today we will deal with the properties of acids and bases. What can you say about the properties of acids and bases. For example, if I say all acids are burning and irritating, is it true?

(Some students claimed that all acids are burning and irritating or burning and irritating things are acids like aqua fortis. Some students claimed that not all acids are burning if we think we eat and drink acid containing things like apple, milk and cola. If all acids were burning and irritating, we couldn't have been eating and drinking them. At the end, they satisfied from all discussions and explanations)

Teacher: Now, think about the red peppers that we use at our homes. They are not always very hot isn't it? Sometimes they are really hot, sometimes they are not hot even being a red pepper. This is related mainly with the type of red pepper used and may be with its production. Similarly, not all acids are burning and irritating. Of course, there are burning and irritating ones but this depends on some factors like their concentration or strength. So, if this is clear, tell me if soil can be acidic?

(Some students said that it can not be acidic otherwise things can not grow in it.

Teacher: Why do you think that things can not grow in acidic soil?

Students: Acidic soil burns the plants.

Teacher: Remember our previous discussion. What we talked about the burning property of acids? Acid does not mean that always burns and irritates. Do you agree? Think about it once more.

(students discussed their ideas and teacher guided discussions where necessary)

Teacher: To sum, we can conclude that soil can be acidic. For example, hydrangea (ortanca) gives blue flowers in acidic soil and pink flowers in basic soil. This property of hydrangea is not because of its type but because of the acidity or basicity of the soil. It is a good example of soil both can be acidic and basic.

Now, let's continue discussing about properties of acids. For example, do they show opposite properties of each other?

(Students shared their ideas; some said they show opposite properties and some said they do not show opposite properties)

Teacher: As you discussed, we know that NaOH, for example, is a base and conduct electricity. Some of you claimed that only acids can conduct electricity bases not. But, you know NaOH conducts electricity and it is a base. Conducting electricity is related with percentage of ionization not directly related with being an acidity or base. So, bases can conduct electricity as long as they dissociate good. From here, you can also deduce that they do not always show opposite properties.

Now, give me some examples of bases that we use at our homes.

(Students mostly said soaps, detergents and toothpastes …)

Teacher: Considering all your discussions and examples, tell me if it is true if I say acids are always more dangerous than bases.

(Students satisfied with all the previous discussions and agreed that it is wrong to say acids are always more dangerous than bases).

Teacher: We have to stop here now. Time is over. But, for the next lesson I want you to prepare a diet list for me, which includes one fruit at each meal. Keep in mind that I am suffering from ulcer. Give the name of the acid(s) or base(s) that the fruit contains with their pH's.

APPENDIX G

Table G. Students' Responses on Acids and Bases Conception Test

		Experimental Group Super Fen B		Control Group Super Fen A	
Item	**Response**	**Pretest**	**Post Test**	**Pretest**	**Post Test**
1	**A**	**0,15385**	**0,57692**	**0,08333**	**0,16667**
	B	0,69231	0,19231	0,62500	0,66667
	C	0,00000	0,11538	0,08333	0,04167
	D	0,15385	0,11538	0,20833	0,12500
2	A	0,03846	0,00000	0,04167	0,04167
	B	0,03846	0,00000	0,08333	0,25000
	C	**0,76923**	**0,88462**	**0,87500**	**0,58333**
	D	0,15385	0,11538	0,00000	0,12500
3	A	0,19231	0,11538	0,12500	0,12500
	B	0,34615	0,38462	0,16667	0,16667
	C	0,07692	0,00000	0,25000	0,04167
	D	**0,38462**	**0,50000**	**0,45833**	**0,66667**
4	**A**	**0,42308**	**0,84615**	**0,41667**	**0,50000**
	B	0,23077	0,11538	0,29167	0,25000
	C	0,15385	0,00000	0,12500	0,16667
	D	0,19231	0,03846	0,16667	0,08333
5	A	0,23077	0,11538	0,29167	0,16667
	B	**0,42308**	**0,80769**	**0,12500**	**0,29167**
	C	0,15385	0,07692	0,54167	0,45833
	D	0,19231	0,00000	0,04167	0,08333
6	A	0,30769	0,23077	0,08333	0,20833
	B	0,23077	0,26923	0,41667	0,12500
	C	0,19231	0,03846	0,25000	0,20833
	D	**0,26923**	**0,46154**	**0,25000**	**0,45833**
7	A	0,03846	0,00000	0,20833	0,16667

Table G. Continued

		Experimental Group Super Fen B		Control Group Super Fen A	
Item	**Response**	**Pretest**	**Post Test**	**Pretest**	**Post Test**
	B	0,07692	0,03846	0,08333	0,16667
	C	**0,26923**	**0,38462**	**0,12500**	**0,29167**
	D	0,61538	0,57692	0,58333	0,37500
8	A	0,11538	0,07692	0,08333	0,16667
	B	**0,61538**	**0,84615**	**0,54167**	**0,70833**
	C	0,26923	0,07692	0,37500	0,04167
	D	0,00000	0,00000	0,00000	0,08333
9	A	0,07692	0,00000	0,08333	0,16667
	B	0,38462	0,03846	0,12500	0,08333
	C	**0,42308**	**0,69231**	**0,50000**	**0,54167**
	D	0,11538	0,26923	0,29167	0,20833
10	A	0,23077	0,03846	0,12500	0,12500
	B	**0,26923**	**0,42308**	**0,12500**	**0,37500**
	C	0,19231	0,07692	0,25000	0,20833
	D	0,30769	0,46154	0,50000	0,29167
11	A	0,34615	0,15385	0,20833	0,16667
	B	0,19231	0,00000	0,29167	0,33333
	C	0,03846	0,07692	0,25000	0,00000
	D	**0,42308**	**0,76923**	**0,25000**	**0,50000**
12	**A**	**0,15385**	**0,53846**	**0,08333**	**0,04167**
	B	0,15385	0,11538	0,37500	0,20833
	C	0,38462	0,26923	0,33333	0,29167
	D	0,30769	0,07692	0,20833	0,45833
13	A	0,19231	0,07692	0,33333	0,20833
	B	0,38462	0,23077	0,37500	0,41667
	C	0,07692	0,11538	0,08333	0,12500
	D	**0,34615**	**0,57692**	**0,20833**	**0,25000**
14	A	0,15385	0,00000	0,00000	0,04167
	B	**0,30769**	**0,30769**	**0,12500**	**0,25000**

Table G. Continued

		Experimental Group Super Fen B		Control Group Super Fen A	
Item	**Response**	**Pretest**	**Post Test**	**Pretest**	**Post Test**
	C	0,46154	0,69231	0,83333	0,70833
	D	0,07692	0,00000	0,04167	0,00000
15	A	0,26923	0,19231	0,20833	0,08333
	B	0,23077	0,03846	0,25000	0,16667
	C	**0,46154**	**0,76923**	**0,50000**	**0,66667**
	D	0,03846	0,00000	0,04167	0,08333
16	**A**	**0,50000**	**0,69231**	**0,29167**	**0,50000**
	B	0,07692	0,15385	0,20833	0,25000
	C	0,19231	0,03846	0,29167	0,16667
	D	0,23077	0,11538	0,20833	0,08333
17	A	0,19231	0,07692	0,12500	0,16667
	B	**0,38462**	**0,38462**	**0,20833**	**0,29167**
	C	0,26923	0,07692	0,33333	0,25000
	D	0,15385	0,46154	0,33333	0,29167
18	A	0,23077	0,07692	0,20833	0,16667
	B	**0,30769**	**0,50000**	**0,12500**	**0,25000**
	C	0,23077	0,38462	0,25000	0,45833
	D	0,23077	0,03846	0,41667	0,12500
19	**A**	**0,30769**	**0,46154**	**0,37500**	**0,45833**
	B	0,15385	0,11538	0,16667	0,04167
	C	0,03846	0,07692	0,08333	0,20833
	D	0,50000	0,34615	0,37500	0,29167
20	A	0,03846	0,00000	0,08333	0,08333
	B	0,15385	0,11538	0,12500	0,16667
	C	**0,61538**	**0,88462**	**0,25000**	**0,41667**
	D	0,19231	0,00000	0,54167	0,33333
21	**A**	**0,19231**	**0,46154**	**0,16667**	**0,20833**
	B	0,23077	0,07692	0,50000	0,29167
	C	0,23077	0,11538	0,12500	0,16667

Table G. Continued

		Experimental Group Super Fen B		Control Group Super Fen A	
Item	**Response**	**Pretest**	**Post Test**	**Pretest**	**Post Test**
	D	0,34615	0,34615	0,20833	0,33333

VITA

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