THE EFFECT OF CONCEPTUAL CHANGE APPROACH ON STUDENTS' UNDERSTANDING OF SOLUBILITY EQUILIBRIUM CONCEPT

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ABSTRACT

THE EFFECT OF CONCEPTUAL CHANGE APPROACH ON STUDENTS' UNDERSTANDING OF SOLUBILITY EQUILIBRIUM CONCEPT

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The main purpose of this study was to compare the effectiveness of instructions one based on conceptual change approach and the other based on traditional chemistry instruction on tenth grade high school students' understanding of solubility equilibrium concept. In addition, students' attitudes toward chemistry as a school subject and toward conceptual change texts were investigated. Moreover, students' science process skills were also investigated.

125 tenth grade students from four classes of a chemistry course taught by three teachers in Kocatepe Mimar Kemal High School in 2004-2005 spring semesters were enrolled in the study. Quasi-experimental research design where intact groups were randomly assigned to experimental and control groups, was applied since it was difficult to arrange students randomly to experimental and control groups. Students in experimental group instructed by conceptual change approach in which conceptual change texts were used. On the other hand, in control group students were instructed by traditionally designed chemistry instruction.

Solution concept test was administered as a pre test before the study to all groups. In addition, science process skill test and attitude scale toward chemistry as a school subject were also administered to students before the study. Solubility equilibrium concept test was administered as a post test to all groups. Moreover, each group also received attitude scale toward chemistry after the treatment and the students in experimental group also received attitude scale toward conceptual change texts after the treatment.

The hypotheses were tested by using correlation analysis, t-test, ANOVA and analysis of covariance (ANCOVA). The results indicated that instruction based on conceptual change approach caused significantly better acquisition of concepts related to solubility equilibrium than the traditionally designed chemistry instruction. In addition, no significant difference was found between experimental group and control group students with respect to attitudes toward chemistry as a school subject. However, significant mean difference was found between male and female students with respect to both their attitudes toward chemistry and their attitudes toward CCTs. Moreover, no relationship was obtained between attitudes toward CCTs and understanding of solubility equilibrium concept. In addition, students' science process skills and prior achievements were strong predictor of understanding of concepts related to solubility equilibrium. On the other hand, no significant effect of interaction between gender difference and treatment with respect to both students' understanding of solubility equilibrium concept and their attitudes toward chemistry as a school subject was found.

Results obtained revealed that students have several misconceptions that hinder learning, related to solubility equilibrium concept. Therefore, it is important to find ways for remediation of those misconceptions. Therefore, the effectiveness of instruction based on CCA in which CCTs were used in this study on remediation of misconceptions and enhancing understanding of solubility equilibrium concept compared to instruction based on traditional methods was investigated and instruction based on CCA was found more effective.

Keywords: misconception, conceptual change approach, conceptual change text, attitude toward chemistry as a school subject, science process skill, solubility equilibrium.

ÖZ

KAVRAMSAL DEĞİŞİM YAKLAŞIMININ ÖĞRENCİLERİN ÇÖZÜNÜRLÜK DENGESİ KONUSUNU ANLAMASINA ETKİSİ

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Çalışmanın temel amacı kavramsal değişim yaklaşımını baz alan öğretim yöntemi ile geleneksel yöntemleri baz alan öğretim yönteminin, 10. sınıf lise öğrencilerinin çözünürlük dengesi konusunu anlamalarına etkisini karşılaştırmaktır. Ayrıca, öğrencilerin kimya dersine karşı tutumları ve kavramsal değişim metinlerine karşı tutumları araştırılmıştır. Aynı zamanda, öğrencilerin bilimsel işlem becerileri de araştırılmıştır.

Bu çalışmaya, 2004-2005 ilkbahar döneminde, Kocatepe Mimar Kemal Lisesinde üç öğretmenin kimya dersi verdiği dört 10. sınıftan 125 öğrenci katılmıştır. Öğrencileri rastgele deney ve kontrol gruplarına yerleştirmek zor olduğundan, sınıfların bir bütün olarak rasgele deney ve kontrol gruplarına dağıtıldığı deneysel araştırma planı uygulanmıştır. Deney grubundaki öğrenciler kavramsal değişim metinlerinin kullanıldığı kavramsal değişim yaklaşımı ile öğrenim görmüşlerdir. Kontrol grubundaki öğrenciler ise geleneksel yöntemlere göre tasarlanmış kimya öğrenimi görmüşlerdir.

Bütün sınıflara çalışmadan önce ön test olarak çözünürlük testi verilmiştir. Aynı zamanda çalışmadan önce öğrencilere bilimsel işlem beceri testi ve kimya dersine karşı tutum ölçeği de verilmiştir. Çalışmanın sonunda her bir gruba çözünürlük dengesi testi verilmiştir. Aynı zamanda çalışmanın sonunda her bir gruba kimya dersine karşı tutum ölçeği verilmiş ve deney grubundaki öğrencilere ek olarak kavramsal değişim metinlerine karşı tutum ölçeği verilmiştir.

Hipotezleri test etmek için korelasyon analizi, t-testi, varyans analizi (ANOVA) ve kovaryans analizi (ANCOVA) kullanılmıştır. Elde edilen sonuçlar, kavramsal değişim yaklaşımını baz alan öğretim yönteminin çözünürlük dengesi ile ilgili konuların öğrenilmesinde geleneksel yöntemleri baz alan öğretim yöntemine göre daha etkili olduğunu göstermiştir. Aynı zamanda deney grubu öğrencileri ile kontrol grubu öğrencileri arasında kimya dersine karşı tutumları göz önüne alındığında istatistiksel bir fark bulunamamıştır. Fakat, kız ve erkek öğrenciler arasında kimya dersine karşı tutumları ve kavramsal değişim metinlerine karşı tutumları göz önüne alındığında istatistiksel bir fark bulunmuştur. Kavramsal değişim metinlerine karşı tutum ile çözünürlük dengesi konusunu anlama arasında bir ilişki bulunamamıştır. Öğrencilerin bilimsel işlem becerilerinin ve ön bilgilerinin, çözünürlük dengesi ile ilgili kavramların anlaşılmasında önemli birer etken oldukları saptanmıştır. Çözünürlük dengesi kavramının anlaşılmasında ve öğrencilerin kimya dersine karşı tutumlarında cinsiyet ile uygulama (kullanılan yöntem) arasındaki etkileşimin önemli bir etkisinin olmadığı görülmüştür.

Elde edilen sonuçlar öğrencilerin, çözünürlük dengesi kavramının öğrenilmesini engelleyen birçok kavram yanılgısına sahip olduklarını göstermiştir. Bu nedenle öğrencilerin sahip olduğu bu kavram yanılgılarının giderilmesine yönelik yöntemlerin bulunması önem kazanmaktadır. Bu nedenle, bu çalışmada kavramsal değişim metinlerinin kullanıldığı kavramsal değişim yaklaşımına dayanan öğretim yönteminin öğrencilerin kavram yanılgılarını gidermede ve çözünürlük dengesi kavramlarının anlaşılmasında geleneksel yöntemleri baz alan öğretim yöntemine göre daha etkili olup olmadığı araştırılmış ve daha etkili olduğu sonucuna ulaşılmıştır.

Anahtar Sözcükler: kavram yanılgısı, kavramsal değişim yaklaşımı, kavramsal değişim metni, kimya dersine karşı tutum, bilimsel işlem becerisi, çözünürlük dengesi.

To my parents.

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LIST OF SYMBOLS

ASTC: Attitude Scale toward Chemistry

ASCCT: Attitude Scale toward Conceptual Change Texts

ICCA: Instruction based on Conceptual Change Approach

TM: Instruction based on Traditional Methods

SPST: Science Process Skill Test

SCT: Solution Concept Test

SECT: Solubility Equilibrium Concept Test

CCTs: Conceptual Change Texts

CG: Control Group

EG: Experimental Group

N: Number of Students

f: Effect Size Index

df : Degrees of Freedom

SS : Sum of Squares

MS : Mean Square

X : Mean of the Sample

p : Significance Level

F : F Statistic

t : t Statistic

CHAPTER I

INTRODUCTION

Students develop ideas about objects and events based on their experiences, attitudes and abilities before coming to school. Some of the views that students bring to chemistry instruction is inconsistent with scientific views and these conceptions have been documented in the science educational literature (Driver, Squires, Rushworth & Wood-Robinson, 1994; McDermott, 1993; Griffiths, 1994; Garnett, Garnett & Hackling, 1995). These ideas which are different from scientific explanations are called misconceptions. In other words, students' conceptual knowledge, which is different from the commonly accepted scientific consensus, is named as misconception. In addition, misconceptions are found highly resistant and can not easily be removed by traditional methods since students often fail to construct consistent relations between concepts and fail to integrate their ideas into appropriate conceptual frameworks after traditional instruction. Therefore, misconceptions hinder learning and understanding of chemistry. In other words, meaningful learning can not occur. Therefore, overcoming misconceptions is an important subject or field of study. Alternative instructional approaches are developed to overcome misconceptions and facilitate learning. These instructional approaches are consistent with constructivist view of learning where each learner is actively engaged in constructing knowledge where links between new information and prior knowledge is constructed actively. Moreover, in order to remove or remediate misconceptions these approaches stresses the importance of conceptual change. Several models are proposed for conceptual change which addresses how misconceptions can be removed, such as Posner et al's., diSessa's, Vosniadou's and Chi's Models. In addition, several strategies for overcoming misconceptions are also developed such as conceptual change text or refutation text, analogies and graphic organizers. These strategies involve recognition of the prior knowledge of students, weighting of its value against new information and if necessary restructuring the prior knowledge. Several researchers indicated the importance of conceptual change instruction in overcoming students' misconceptions in science concepts. Moreover, conceptual change text oriented instruction is found to help students' understanding of science and help them to construct correct scientific concepts (Yürük, 2000; Dole & Niederhauser, 1990; Chambers & Andre, 1997; Hynd, McWhorter, Phares & Suttles, 1994; Cakir, Uzuntiryaki & Geban, 2002; Tekkaya, 2003; Sungur, Tekkaya & Geban, 2001; Uzuntiryaki & Geban, 2005; Hynd, Alvermann & Qian, 1997; Çetin, Ertepınar & Geban, 2004; Diakidoy, Kendeou & Ioannides, 2002; Çakır, Geban & Yürük, 2002; Yürük & Geban, 2001; Alparslan, Tekkaya & Geban, 2003).

Many researchers indicated that chemistry is considered as an abstract and difficult subject to learn by students (Nieswandt, 2001; Chittleborough, Treagust & Mocerino, 2002). Therefore, it is important to find ways which will prevent rote learning while encouraging and promoting meaningful learning which will improve chemistry learning. Therefore, it is important to conduct research which deals with students' misunderstandings, learning difficulties in chemistry education. The works in which the misconceptions of students are investigated in chemistry, are generally limited to some fundamental topics such as mole concept (Duncan & Johanstone, 1973), entropy (Frazer, 1980), chemical equilibrium (Camacho & Good, 1989; Gussarsky & Gorodetsky, 1990; Chiu, Chou & Liu, 2002), covalent bonding (Peterson & Treauget, 1989), electrochemistry (Garnett & Treaguest, 1992a; 1992b) and acid-base chemistry (Cakir, Uzuntiryaki & Geban, 2002). Although secondary school students are often confused by concept of solubility equilibrium (Raviolo & Alexander, 2001) studies that focus specifically on solubility equilibrium are not many. However, in high school chemistry curricula solubility equilibrium occupies a central role. It is considered as a difficult concept since some topics such as solubility, physical and chemical equilibrium, Le Chatelier's principles, molarities, ions, should be learned before solubility equilibrium is taught. Therefore, while learning solubility equilibrium concept, teachers need methods that encourage conceptual change to instruct students. In addition, it is important to find out students' earlier conception in order to plan future activities and prevent misconceptions which hinder meaningful learning. Therefore, developing teaching methods which prevent misconceptions and enhances learning in meaningful way, gain importance. In addition, several researchers underline the importance of active and meaningful learning. In other words, they stressed the importance of helping students to become aware of their own learning process. Therefore, many researchers advised instructional approaches that enhance metacognition which can improve quality of science learning.

From the evidence shown above, it can be said that misconceptions influence students' understanding of chemistry concepts. It is also found that the concept of solubility equilibria is considered by many students as a difficult subject. Therefore, it is very crucial to find a method that can prevent and overcome misconceptions in solubility equilibria. This shows the necessity to conduct further research to improve learning activities in chemistry education. Several researchers have demonstrated that conceptual change text instruction can be effective at changing students' conceptions related to chemistry concepts. Although conceptual change occurs within an individual, it also is affected by the beliefs and attitudes of the individual. For this reason, the study focused on the effectiveness of instructions, one based on traditional methods and the other based on conceptual change approach, on tenth grade students' understanding of solubility equilibrium which is considered as a difficult subject by many students and investigated their attitudes towards science.

1.1 Purpose

The purpose of the study was to: (1) determine misconceptions students hold about solubility equilibrium; (2) investigate the effectiveness of conceptual change texts; (3) compare the effectiveness of conceptual change text instruction and traditional instructional on understanding of solubility equilibrium concept; (4) investigate the change in students' attitudes toward chemistry before and after the conceptual change text instruction and traditional instruction; (5) determine students' attitudes towards conceptual change texts; (6) observe students' science process skills; (7) search for patterns of relation between chemistry achievement and treatment applied.

1.2 Significance of the Study

Science educators need knowledge of the concepts that students already held since meaningful learning occurs when students relate new knowledge with previously learned ones. Therefore, preconceptions of students are important. This study presents the list of those concepts that are inconsistent with scientific ones called misconceptions students hold about solubility equilibrium. Knowing that students have preconceptions and some of them contradict with scientific view would help science educators to realize that students have misconceptions and develop their lessons by finding ways to remediate these misconceptions. Therefore, a method that will help in both investigation and elimination of misconceptions is necessary. A method that uses conceptual change approach is based on that necessity and will help teachers in investigation of the misconceptions and will provide ways to deal with misconceptions. Moreover, this study presents strategies that chemistry instructors can use to remediate misconceptions and promote conceptual change such as conceptual change text analogy and graphic organizers. Moreover, how effective these strategies are also discussed.

Conceptual change involves modifying or replacing misconceptions to accommodate new ones and conceptual change texts developed in this study can help students in remediation of solubility equilibrium misconceptions. In other words, conceptual change approach helps child form links between existing knowledge and new knowledge resulting meaningful learning. In this method, concepts are learned from simple to complex which helps better acquisition of new knowledge. Therefore, conceptual change approach fosters teachers to arrange environment in a way that students express their ides, construct their knowledge and if there is, realize their misconceptions.

Curriculum developers could realize the effectiveness of instructional methods based on conceptual change approach and develop curriculum by considering its success in identifying and eliminating misconceptions.

Textbook authors would realize that textbooks are one of the sources for misconceptions. Therefore, they can write textbooks more carefully. Moreover, they would realize the effectiveness of conceptual change strategies in remediation of misconception. Therefore, they could give special attention to conceptual change approach while writing.

Teachers will realize that there exist some methods that are better than traditional methods. Therefore, special attention can be given at pre-service trainings to conceptual change approach.

Students will realize that some of their knowledge is inconsistent with that of what teacher teaches. Therefore, conceptual change texts developed can help them both realize their misconceptions and remediate them. This will facilitate their metacognitive awareness.

Students' attitudes towards science are a key factor in chemistry achievement since they are positively correlated. Conceptual change text instruction can facilitate developing positive attitudes towards science.

This study also provides instruments and procedures for conducting related research in the future.

1.3 Definition of Terms

The following terms are defined in relation to the study:

Accommodation: the creation of new schemata or the modification of old schemata which reflects the child's current level of understanding and knowledge of the world (Wodsworth, 1996).

Adaptation: the organism's tendency to adjust its structures to environmental demands (Bjorklund, 1995).

Analogy: involves the mapping of two domains called base which is more accessible and familiar concept in the students' prior knowledge, and target which is more difficult to conceptualize concept (Duit, Roth, Komorek & Wilbers, 2001).

Assimilation: the cognitive process by which a person integrates new perceptual, motor, or conceptual matter into existing schemata or patterns of behavior (Wodsworth, 1996).

Attention: means selecting certain stimuli from the environment (Yıldırım, Güneri, & Sümer, 2002).

Attitude: tendency to respond positively or negatively to things, people, places, events or ideas (Simpson, Koballa, Oliver & Crawley, 1994).

Base Domain: concept related to the topic of the analogy (Duit, 1991).

Cognitive Conflict: providing students with evidence that contradicts with their existing conceptions.

Conception: means one's particular application or interpretation of a concept (Kaplan, 1964).

Concept: a general idea, usually expressed by a word, which represents a class or group of things or actions having certain characteristics in common (Quillen & Hanna, 1961).

Conceptual Change: a process of learning science in meaningful way that requires the learner to rearrange or replace existing misconceptions in order to accommodate new ideas (Smith et al. 1993).

Conceptual Change Text: a text where students are asked explicitly to predict what would happen in a situation before being presented with information that demonstrates the inconsistency between common misconceptions and the scientific conceptions (Çakır, Geban & Yürük, 2002).

Concept Map: a graphic means of portraying relationships among ideas (Smith & Ragan, 1999).

Constructivism: is a theory of learning in which every learner constructs his or her ideas (Rasmussen, 1998).

Discrepant Event: a phenomenon that occurs in a way that seems to run contrary to initial reasoning (Wright & Govindarajan, 1995).

Epistemological Beliefs: beliefs about knowledge and how it is acquired (Charles, 2003).

Equilibration: a balance between assimilation and accommodation (Yıldırım, Güneri, & Sümer, 2002).

Framework Theories: are built in infancy and are based on some fundamental ontological and epistemological presuppositions (Mazens & Lautrey, 2003).

Graphic Organizer: identifying and representing ideas presented in instruction and spatially indicating the relationships among these ideas (Smith & Ragan, 1999).

Misconception: conceptual knowledge that differs from commonly accepted scientific consensus (Sanger, 1996).

Metacognition: knowledge, awareness and control of one's own learning (Baird, 1990).

Ontological Beliefs: beliefs about the nature of existence and the fundamental categories and properties of the world (Charles, 2003).

Organization: relating all the intellectual operations to the other acts of intelligence (Bjorklund, 1995).

Phenomenological Primitives: smallest unit of knowledge (diSessa, 1993).

Perception: means the meaning we attached to the stimuli we are exposed to (Yıldırım, Güneri, & Sümer, 2002).

Preconception: conceptual framework already present from everyday experience and from previous formal and informal education (Teichert & Stacy, 2002).

Schema: basic mental structures for organizing information and concepts (Woolfolk, 1995).

Solubility Equilibrium: means the equilibrium established between the saturated slightly soluble salt and its solution (Ebbing, 1996).

Specific Theories: are based on the individual observation of the world and as well as instruction to explain a limited range of phenomena (Mazens & Lautrey, 2003).

Target Domain: concept associated with the unfamiliar phenomena (Duit, 1991).

Traditional Teaching: means lectures given by the teacher, use of textbooks, and clear explanation of important concepts to students with no consideration of students' misconceptions.

CHAPTER II

REVIEW OF RELATED LITERATURE

This chapter contains a review of literature relevant to this research study. This literature review is organized in inductive way. That is, before discussing conceptual change approach, some of the related concepts that have to be considered in order to understand conceptual change are discussed first. Therefore, literature review starts with learning theories since conceptual change is a process of learning science in meaningful way which requires being familiar with how individuals learn which is described by learning theories.

2.1 Learning Theories

Learning theories can be divided into two major categories which are behavioral and cognitive. A behavioral approach to learning is concerned with "behavior which is observable and to some extends measurable" (Yıldırım, Güneri, & Sümer, 2002). In other words, behavioral approach focuses on the observable behavior of the learner and not on learners' mental processes. In general, behavioral theories are concerned with stimuli and response and views mind as a machine. Moreover, environment is responsible for development; therefore, external experiences are considered critical in shaping learning and development (Wodsworth, 1996). Therefore, in this approach education is responsible for direct transmission of knowledge, information, skills and values of the culture. Teachers are the experts and are there to teach through direct instruction.

Cognitive approach on the other hand focuses on "knowledge which is not observable and difficult to measure" (Yıldırım, Güneri, & Sümer, 2002). In other words, cognitive approach focuses on the mental processes involved in the learning while learner interacts with the environment. Mental development is a product of interaction between the learner and the environment (Wood, 1998). Moreover learner is considered as explorer or inquirer since he or she constructs and organizes his or her development (Wodsworth, 1996).

Behavioral approach as mentioned above is interested in stimuli that produces desired responses and not in mental processes. Therefore, concept formation is outside of behavioral approach. However, cognitive approach focuses on mental processes. Therefore, concept formation gains importance; that is, construction of knowledge by the learner, receives a great interest. Since in conceptual change process some of the prior conceptions of individual are restructured, it is therefore important to understand how knowledge is constructed by the learner. Therefore, in this study there will be no more consideration about behavioral approach and the cognitive approach will be investigated deeply.

There are two forces that shape theory of cognitive development. The first one is Piaget's Cognitive Stage Theory and the other force is Information Processing Theory of Cognition (Flavell, 1977; McShane, 1991).

2.1.1 Piaget's Cognitive Stage Theory

Jean Piaget has had a greet impact on the field of developmental psychology (Bjorklund, 1995). His studies of children from infants through adolescence tried to discover the nature of the internal world of the individual. His theory describes cognitive development from infancy through adolescence in four stages which are sensorimotor, preoperational, concrete operational and formal operational. These stages are gradual and consecutive in style. Piaget linked each stage with an age interval; however, this does not mean that every stage has strict stage borders. In fact, not every child reaches each stage exactly at the same age (Yıldırım, Güneri, & Sümer, 2002). Moreover, Bjorklund (1995) mentioned some of the characteristics of stages of Piaget's cognitive development as:

1. Qualitatively different in form from each preceding or following stages.
2. Culturally universal, so that all children progress through them in a single invariant order.
3. Based on earlier, more primitive cognitive structures (hierarchy).

Piaget's main argument is our thinking differs from stage to stage. For example, a child in sensorimotor stage does not think as adult thinks. Therefore, there are many implications for improving children's cognitive abilities in school (Yıldırım, Güneri, & Sümer, 2002). For example, while organizing and selection of knowledge and deciding on teaching strategies the characteristics of stage in which target learner group is included should be considered carefully. This will enhance students' understanding since they will not face with information that is inappropriate for their age level.

Piaget believed that human beings have two tendencies in thinking which are organization and adaptation (Yıldırım, Güneri, & Sümer, 2002; Bjorklund, 1995; McShane, 1991; Flavell, 1977; Wodsworth, 1996).

Organization means relating all the intellectual operations to the other acts of intelligence. Therefore, one structure does not exist independently of other structures but is coordinated with them (Bjorklund, 1995). Yıldırım et al (2002) gave an example which describes organization. In that example, they state that the term "apple" is stored in mind in relation to other fruits rather than as an independent unit.

Adaptation is the organism's tendency to adjust its structures to environmental demands (Bjorklund, 1995). Two aspects of adaptation are assimilation and accommodation.

Assimilation means interpreting or constructing external objects and events in terms of ones own presently available and favored ways of thinking about things (Flavell, 1977). According to Wodsworth (1996) assimilation is the cognitive process by which a person integrates new perceptual, motor, or conceptual matter into existing schemata or patterns of behavior. That is, individual tries to explain new information by the help of his or her existing schemata. Below, an example presented by Wodsworth (1996) is given to clarify the concept of assimilation.

> "One might say that a child has experiences; sees new things (cows) or sees old things in new ways, and hears things. The child tries to fit these new events or stimuli into the schemata he or she has at the time. Suppose, a boy is walking down a country road with his father and the father points to a cow in the field and says, "What is that?" The child looks at the cow (stimulus) and says, "That's dog". What has happened? The boy seeing the object (cow) in the field, shifted through his collection of schemata until he found one that seemed appropriate and that could include the object. To the child the object (cow) had all the characteristics of a dog –it fits into his dog schemata- so the child concludes that the object was a dog. The stimulus (cow) was assimilated into dog schema." (p: 17).

Therefore, assimilation can be understood as which people transform incoming information so that it fits within their existing ways of thinking.

Accommodation is the process where the current schema is changed, rearranged or reformulated in order to incorporate new information (Siegler, 1991; Bjorklund, 1995). Flavell (1977) describes accommodation as noticing and taking cognitive account of the several real properties and relationships among properties that external objects and events hold; it means the mental apprehension of the structural attributes of the environmental data. According to Wodsworth (1996) accommodation is the creation of new schemata or the modification of old schemata which reflects the child's current level of understanding and knowledge of the world.

Assimilation and accommodation operate continuously to control the detection of the information by the cognitive system (McShane, 1991). Therefore, assimilation and accommodation are necessary for cognitive growth and development (Yıldırım, Güneri, & Sümer, 2002; Wodsworth, 1996). When there is a balance between assimilation and accommodation the situation called equilibration which is a process where individual comfortably makes sense of new information based on his or her past experience (Yıldırım, Güneri, & Sümer, 2002) occurs. When this does not happen; that is, when there is an imbalance between assimilation and accommodation, the state of disequilibration occurs and when disequilibrium occurs, it activates child to seek equilibrium. In other words, disequilibrium activates the process of equilibration and striving to return to equilibrium. Moreover, equilibrium is a necessary condition toward which the organism constantly strives.

Piaget relates the development at different stages of our lives to four factors (Wodsworth, 1996).

1. Maturation: is the term used for explaining "biological changes we go through from conception through death" (Yıldırım, Güneri, & Sümer, 2002). Heredity alone can not account for intellectual development but it has an effect on cognitive development (Wodsworth, 1996).
2. Active Experience: is the term used for explaining that knowledge a child constructs requires him or her to interact with environment (Wodsworth, 1996). The interaction with the environment can be in the form of "exploring, observing, organizing and interpreting the phenomena that exist in our environment" (Yıldırım, Güneri, & Sümer, 2002).
3. Social Interaction: is the term used to explain the interchange of ideas among people (Wodsworth, 1996).

4. Equilibration: All the factors mentioned above can not sufficiently explain cognitive development. Therefore, the concept of equilibration is used to explain the coordination of other factors and regulation of development in general (Wodsworth, 1996).

2.1.2 Limitations of Piaget's Theory

Yıldırım, Güneri and Sümer (2002) presented some limitations of Piaget's theory of cognitive development.

1. Piaget's theory underestimates young child's cognitive ability and overestimates older child's cognitive ability.
2. Theory overemphasizes the biological influence on cognitive development.
3. Theory does not take into account the important effects of the culture and social group on children.
4. The sequence of stages appears to be universal but the rate of development may vary from one culture to another (p: 42-43).

Piaget's comprehensive theory of cognitive development, describing individual as active participants in their intellectual development, has given rise to the constructivist theory of learning (Bodner, 1986). Moreover, conceptual change approach is based on constructivist theory of learning therefore it is discussed in the following pages.

2.1.3 Information Processing Approach

Piaget's theory explains in general what develops in qualitatively district levels of intelligence. However, it is also important to understand "How does development occur?" Information processing approach to development tries to explain this question by explaining the way we perceive information and the ways we process and use it (Siegler, 1991; Yıldırım, Güneri, & Sümer, 2002). In information processing the mental processes of learner is considered in a same way analogous to computer processing (Flavell, 1977; Bjorklund, 1995). Moreover, information processing approaches deal with knowledge and processes we perform with that knowledge. Information processing approach explains that our thinking is limited both in amount of information that can be attended to simultaneously and the speed with which the information can be proceed. Moreover, it explains that our thinking is flexible and capable to adopting constantly changing goals. Although there are many information processing theories they share some common assumptions. The basic assumption is that thinking is information processing (Siegler, 1991). A second assumption is an emphasis on change mechanisms and the third one is that change is produced by a process of continuous self modification. The fourth common characteristics is that careful task analysis are viewed as necessary for understanding children's thinking (Siegler, 1991).

According to information processing approach there are three stages which are sensory register, short-term memory and long term-memory.

2.1.3.1 Sensory Register or Sensory Memory

Sensory register memory is the initial registration of information received from the environment selectively (Yıldırım, Güneri, & Sümer, 2002). Siegler (1991) defines it as capacity for briefly retaining relatively large amount of information that is just encountered. The capacity of sensory register is very large. Therefore, many stimuli received from the environment can be coded briefly and if we pay further attention this coded information is sent to the short term memory. According to Yıldırım et al. (2002), perception and attention are two important concepts which explain why we select certain information and ignore others.

Perception is "meaning we attached to the stimuli we are exposed to" and attention is "selecting certain stimuli from the environment" (Yıldırım, Güneri, & Sümer, 2002). Therefore, while teaching teachers should try to get students' attention in order to achieve what they want students to get and attention can be increased by presenting information to students in more interesting and meaningful ways.

2.1.3.2 Short Term Memory or Working Memory

Short term memory is analogous to computers central processing unit. It is the place where information sent from sensory register and information retrieved from long term memory are combined to perform whatever calculations are necessary (Siegler, 1991). Because of that active nature of short term memory it is also called working memory. The capacity of short term memory is limited. Therefore, a small amount of information can be processed. In addition, information processed in short term memory is lost rapidly (Siegler, 1991). That is, when attention shifts to new information the previous is forgotten (Yıldırım, Güneri, & Sümer, 2002). However, there are several strategies to retain or remember new information in the short term memory for a long time. Some of these strategies are maintenance rehearsal, elaborative rehearsal and chunking.

2.1.3.3 Long Term Memory

Unlike sensory register and short term memory there are no limits on either how much information can reside and how long the information can remain in long term memory. An interesting property of the way people store information in long term memory is that the storage is not in all-or-non form (Siegler, 1991). That is, people store information in separable form and can recall some part of stored information. The information in long term memory is stored in different way compared to short term memory. The information in long term memory is stored in structured ways and in relation to each others (Yıldırım, Güneri, & Sümer, 2002). Therefore, sometimes although it is stored in long term memory the information or part of it can not be recalled if it is not organized in meaningful way.

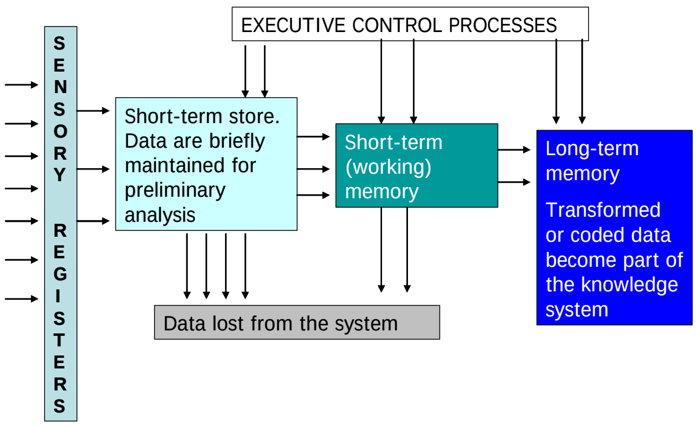

Figure 2.1 Conceptual interpretation of the human memory as a structural system (Gredler, 1992).

2.1.4 Implications of the Information Processing Approach

Yıldırım, Güneri and Sümer (2002) presented several implications of information processing approach to teaching.

1. Students need to attend the knowledge they are supposed to learn.
2. Teachers should help students to establish meaningful connections between new information and their experiences.
3. Teachers should promote elaboration by using analogies and mnemonic devices (p: 119-121).

In summary, in information processing the learner constructs external connections between the newly organized knowledge in short term memory and existing relevant knowledge that the learner retrieves from long term memory and this process involves connecting the organized information to the other familiar knowledge structures already in memory.

As it is mentioned before, cognitive development theories have given rise to constructivist theories of learning to which conceptual change approach is based on. Therefore, it is important to understand what constructivism is and what makes it differ from traditional approaches.

2.2 Constructivism

Constructivism became a dominant ideology for the past fifteen years. It is a way of thinking about knowing a referent for building models for learning, teaching and curriculum (Tobin, 1993). Constructivism is a theory of learning in which every learner constructs his or her ideas. That is, constructivism stresses that each individual must construct meaning for himself or herself (Rasmussen, 1998). Bodner (1986) states that “knowledge is constructed in the mind of the learner”. Therefore, the fundamental assumption of constructivism is that the student must recognize his or her own conceptions, analyze them and decide if they need reconstruction. If the student decides his or her conceptions require reconstruction then he or she will restructure these conceptions so that the new conceptions will be appropriate to scientific explanations. Therefore, it is necessary to connect new information with already existing knowledge, experiences or conceptualizations (Martin, 1997). Selley (1999) also stresses that construction is an internal, personal and often unconscious process and construction consist largely of reinterpreting piece of knowledge that one obtained from his or her experiences and interaction with other people, to build a satisfactory and coherent picture of the world. Moreover, constructivism is a meaning making theory where individuals create their own new understandings based on the interaction of what they already know (Richardson, 1997; von Glasersfeld, 1995). Therefore, every individual constructs his or her own realities and then it is not meaningful to talk of the objective truth. For example, when teachers believe they have been understood by their students they should not put themselves into believing that they share the same opinions as their pupils. No one can ever be sure of this, because understanding is also a personal construction of things that you understand in one way may be understood quite differently by someone else (Rasmussen, 1998).

2.2.1 Constructivist Approach to Teaching and Learning

Students should be active participants in the learning process since every student will construct his or her individual meaning. Therefore, the instructional activities must attract the learner and require active participation. However, this does not mean that active participation of students will be obtained by just letting students to fill worksheets and perform step by step laboratory experiments. This approach is nothing but behaviorism. Active participation in constructivist manner means that the student is actively testing the new concepts so that they can realize whether the new concepts can be explained by existing or prior knowledge so that he or she can evaluate how well new concept is explained by existing schema and can choose whether to modify or change current schema. Therefore, constructivism is a theory of learning that rejects the idea that it is possible to transfer the content of teaching to pupils (Rasmussen, 1998). That is, constructivism states that knowledge is present in the individual and that knowledge can not be transferred completely without any change from the teachers' head to that of students (Lorsbach & Tobin, 1992).

Constructivist approach is student centered. However, this does not mean that teacher have no function. On the contrary, teacher in constructivist approach has a very important and active role (Selley, 1999). Constructivist teaching requires teacher to act as a facilitator and create constructivist learning experiences. That is, teacher is no longer teaches by imposition, but by negotiation. Moreover, constructivist teaching typically involves more student-centered, active learning experiences, more student-student and student-teacher interaction, and more work with concrete materials and in solving realistic problems (Shuell, 1996).

Constructivist classroom can support inquiry and students can express their ideas and feelings freely. However, constructivist approach to learning is not appropriate for all school learning. Some factual knowledge such as learning the alphabet, symbols used in mathematics, requires direct transmission since in that cases do not require creative thinking and personal imagination (Selley, 1999).

Selley (1999) presented characteristics of non constructivist learning activities where constructivist approach is not,

1. just the provision of the tasks for pupil to engage in;
2. a project in which predetermined information has to be found;
3. a practical activity conducted according to a predetermined method, even if this is called an investigation (unless, that is, the objective is for the children to discuss and interpret, entirely freely, the results which they obtain);
4. the kind of lesson which leads children to an achievement which is exactly what the teacher expected.

Constructivist approach on the other hand "…places emphasis on the meaning and significance of what the child learns, and the child's active participation in constructing this meaning" (Selley, 1999). Moreover, constructivist learning environments are designed to satisfy seven pedagogical goals (Honebein, 1996):

1. Provide experience with the knowledge construction process: students take primary responsibility in selecting topics and methods of how to learn.
2. Provide experience in and appreciation for multiple perspectives: students must engage in activities which enables them to think about several ways for solution since the real life problems rarely have one correct solution.
3. Embed learning in realistic and relevant context: learning activities are designed so that they reflect all the complexity that surrounds them outside the classroom.
4. Encourage ownership and voice in the learning process: illustrates the student centeredness of constructivist learning.
5. Embed learning in social experience: learning should reflect collaboration between student and teacher and student and student.
6. Encourage the use of multiple modes of representation: a variety of activities and instructional strategies coupled with variety of media provides richer experiences.
7. Encourage self-awareness of the knowledge construction process: it is important students to know how they know.

It is important to realize that although teacher supports all the items mentioned above and provides a rich learning environment one should not forget that each student in the class will perceive the environment in a different way. Therefore, in order to understand learning in a constructivist classroom context, it is important to consider each student's interactions with the environment and how those interactions affect the learning process.

2.2.2 A Comparison of Traditional and Constructivist Approaches

Traditional view assumes that there exists a knowable reality outside of human perceptions. However, constructivist view acknowledges that there exists an external reality but realizes that cognizing beings can never know what that reality is actually like (Tobin & Tippins, 1993).

Constructivist teaching focuses on student learning as opposed to a focus on completing the curriculum (Mintzes, Wandersee, & Novak, 1998).

Traditional view sees learning as a process of transmitting the knowledge. However in constructivism, learning is considered as a process where the learner is actively engaged in constructing knowledge while interacting with environment and society (Richardson, 1997).

In traditional view the mind is considered as if it is a blank slate that is something that is waiting to be filled up. On the contrary, constructivism takes in to account the prior ideas (Rumelhart, 1980; Martin, 1997; Mintzes, Wandersee, & Novak, 1998).

Traditional teacher is responsible for effectiveness and extend of the learning. Moreover, information should be presented to the pupil in a clear, systematic and stimulating way (Selley, 1999). However, constructivist teachers must find ways to understand their students' viewpoints and their alternative conceptions develop classroom tasks which help knowledge construction and while performing all that task teachers play the role of facilitator (Selley, 1999).

In traditional perspective successful teaching leads to growth of students' stock of knowledge and understanding which leads improvement in academic performance. On the other hand, from constructivist perspective successful teaching leads growth of understanding, breadth of vision and maturation (Selley, 1999).

Chin (1997) summarized the difference between the constructivist and traditional perspectives in Table 2.1 below.

Table 2.1 Constructivist vs. Traditional Perspectives

Traditional	Constructivist
I. Epistemological Perspectives	
1. Truth is out there to be discovered	1. Reality / Truth is unknown
2. Learner as blank slate. • Learner is viewed as cumulative accretion of knowledge. • Learner has passive role as absorber of information.	2. Learner has prior ideas. • Learning is constructive process, involving restructuring of ideas (conceptual change view). • Learner is actively engaged in constructing knowledge in social settings through social interaction with others so meanings can be negotiated.
3. Knowledge acquisition is straightforward, unproblematic. • Ready-made science.	3. Knowledge construction is problematic. • Science-in-the-making.
II. Teacher and Teaching	
1. Sees curriculum as body of knowledge or skills.	1. Sees curriculum as program of activities from which students construct knowledge.
2. Teaching conceptualized as conduit metaphor. • Teacher is didactic, authoritative dispenser of knowledge. • Teacher sees role as transmitting science content, giving expositions. Subscribes to frequent drill and practice.	2. Teacher is facilitator of learning. • Teacher promotes interaction of students with materials and ideas. 3. Elicitation and assessment of prior ideas. • Teacher elicits students' prior ideas, encourage students to make prediction, ask questions, answer their own questions, explain their reasoning, and apply ideas. • Teacher asks guided questions and suggest ideas, rather than tell students directly what to do. 4. Teacher provides supportive learning environments. • Non-evaluative, sensitive to and respects students ideas.
III. Learner and Learning	
1. Students sit in rows and typically listen to teachers lecture, copy notes.	1. Students are involved in hands-on activities, group work and discussion.
2. Student is told ready-made knowledge; results of how other have made sense of the world. Passive.	2. Minds-on learning, student is encouraged to make predictions about phenomena, ask questions, attempt to answer own questions and explain reasoning, apply ideas to new situations, evaluate alternative points of view.
3. Laboratory activities recipe like which emphasize verification of known laws. Step-by-step procedures are given.	3. Laboratory activities involve more open-ended investigations, exploration and experimentation.

Before conceptual change is discussed, one should understand what concept, conception and misconception is, since conceptual change requires reconstruction of pre conceptions in order to remediate misconceptions.

2.3 What is Concept and Conception?

Martorella, Jensen, Kean and Voelker (1972) presented several definitions of concept by sampling of definitions from the literature.

"A concept is a kind of unity in terms of which one thinks; a unit smaller than a judgment, proposition, or theory, but one which necessarily enters into these" (Gould & Kolb, 1964).

"In brief, concepts are properties of organismic experience-more particularly they are the abstracted and often cognitively structured, classes of mental experience learned by organisms in the course of their life histories" (Carroll, 1964).

"A concept may be thought of as the common element shared by an array of objects or the relationship between the constituents or parts of a progress" (George, 1962).

"Concepts are artifacts extracted by verification from the contexts or sentences in which they occur" (Bronowski & Bellugi, 1970).

"The basic concepts are essentially high-level abstractions expressed in verbal cues and labels" (Taba, 1965).

"A concept is generalized and abstract symbol; it is the sum total of all our knowledge of particular class of objects…In short, a concept is a condensation of experience" (Viaud, 1960).

"A concept is a general idea, usually expressed by a word, which represents a class or group of things or actions having certain characteristics in common" (Quillen & Hanna, 1961).

"A concept…is something about an idea expressed in the words of our language" (Platt, 1963).

“A concept is a continuum of inferences by which a set of observed characteristics of an object or event suggests a class identity, and then additional inferences about other unobserved characteristics of the object or event” (Bruner, Goodnow, & Austin, 1962).

“Concept is an ordered information about the properties of one or more things-objects, events, or processes-that enables any particular thing or class of things to be differentiated from and also related to other things or classes of things” (Klausmerer, Ghatala & Frayer, 1974).

According to Carey (2000) concepts are units of mental representation roughly equivalent to a single word, such as object, animal, heat and matter. Moreover, concepts are themselves complex representational structures and many properties of the entities picked by a concept are represented as a part of it and serve roles in explaining, inferring, and referring. Carey (2000) also added that;

> “Individual concepts can be connected to build complex representational structures, such as propositions (e.g., all animals die) and theories (e.g., the theory of natural selection). Within a particular representational structure, concepts help us to make inferences and explain complex ideas. For example, from the proposition “aardvarks are mammals”, one may infer that aardvarks bear live young. One may also explain a particular aardvark’s coloring by considering the color of its mother and father and appealing to the concept of inheritance. Outside of particular concept system, concepts have a referential role: they pick out entities in the world that fall under them” (p. 14).

Every individual constructs concept according to his or her unique learning experience and maturational pattern. Therefore, the past experiences of the individual, the way in which these experiences relate to new ones will influence the unique construction of concept network (Klausmerer, Ghatala & Frayer, 1974). However, one should not forget that although every individual has unique concepts, people share some common futures about concepts that help individuals to meaningfully discuss their daily life. For example, a teacher will probably have a different concept of education then the parent. However, both teacher and parent have some common attributes about the education concept, so that they can communicate about education.

The major objective of instruction should be teaching for understanding which occurs when concepts become real part of mental structure. Therefore, one should no expect understanding to occur in occasions where subject is learned as isolated skills and processes.

Understanding develops through interaction with environment and other individuals and when individual have an opportunity to construct their own interpretation when they first meet a new topic (Lind, 2000).

Concepts are stored in various sections of the brain and this complex structure can be explained by the analogy of postal storing system. Students are constructing new concepts through assimilation and accommodation of new information while they are exploring the world and store those concepts in correct mental categories in their minds. Brain behaves like a postal worker and classifies and stores information in an appropriate places. New information is placed close to related ones (Slotta, Chi, & Joram, 1995). These closely related facts that are stored in nearby places, relates to a concept called cognitive structure (Lind, 2000). That is, all the information we know about atom for example is stored in the same area in the brain. The concept of an atom develops as individuals' experience or information about the atom concept increases. However, the information that is stored in relation to a definite concept is not always true. In other words, our understanding of world is imperfect since there might be a point at which our true understanding will end and misconceptions will exist and stored without any questioning. This is because the incorrect interpretations of the world are stored in similar place with that of correct ones (Lind, 2000).

Vygotsky (1962) characterized learning situation as spontaneous and scientific. Spontaneous concepts are those concepts that are developed by individuals' connection with the environment. On the other hand, the scientific concepts are developed either self-generated or externally generated by formal instruction.

Klausmerer, Ghatala and Frayer (1974) explained variability among concepts by eight attributes which are identifying features of concept and are discusses below.

2.3.1 Learnability

Learnability varies among concepts since some concepts are more easily learned than others by the same individual. For example, the concept of computer is more readily learned compared to concept of an atom which is an abstract concept. Moreover, learning of definite concept can also vary from people to people since they will probably vary in their mastery of the concept.

2.3.2 Usability

Some concepts are used more compared to others in solving problems and understanding principles. For example, chemistry concept of an atom is probably used more compared to distillation.

2.3.3 Validity

A concept is considered as valid to the extent that experts agree on its definition. Therefore, individuals' validity increases about a concept when he learns and his concept comes closer to that of an expert.

2.3.4 Generality

Concepts are arranged from more general to more specific. That is, there is a hierarchical arrangement. Therefore, if an individual has a concept organization same as any of the taxonomical system then his or her concept varies in generality.

2.3.5 Power

The power refers to how essential is concept in attainment of the other concepts. For example, without concept of an atom understanding of chemistry is difficult.

2.3.6 Structure

Concepts have a structure that shows relatedness of the defining attributes. For example a concept of an atom is related with concept of an element and concepts of neutron, electron and proton is related with a concept of an atom. That is, concepts are linked by relations forming a structure.

2.3.7 Instance Perceptibility

Instances that can be sensed differ from concept to concept. For example, computer has many instances that can be manipulated, seen, and touched, whereas electricity has less perceptible instances.

2.3.8 Instance Numerousness

The number of instances that a concept has varies in amount. That is, some of the concepts occur more compared to others and the number of instances that a concept has ranges from one to infinity.

Kaplan (1964) distinguished between concept and conception where conception means one's particular application or interpretation of a concept.

In classroom, the basic aim of teachers should be then to help students acquire critical or criterion attributes of a particular concept since it is clear that the concepts vary in attributes which are necessary in explaining or defining the particular concept.

2.4 Misconception

In the 1970, the science education researchers started to investigate the actual understanding of students gained from science courses (White & Tisher, 1985). It was assumed that students that receive good grades; that is, the students that are considered as successful, learn the subject well. The idea was supported by tests prepared by instructors since the test items were mostly composed of recall type questions and problems that can be solved with simple equations. Therefore, if the students were able to solve that kind of tests then the objectives of science curriculum were considered as met. However, when the students were asked to explain their responses they were unable to explain the reason why do they choose the alternative. In other words, the students were taught in a way that they can memorize facts, rules and definitions. That is, connections with prior knowledge were not made and therefore the students were not able to transfer the knowledge in to different occasions (Anderson, 1987).

In recent years researchers obtained lots of information which shows that students do not hold conceptions of science and scientific concepts that are similar to those held by scientists and science educators (Nakhleh, 1992; Wandersee, Mintzes & Novak, 1994). Sanger (1996) defined conceptual knowledge that differs from commonly accepted scientific consensus as misconception. Moreover, misconceptions are deeply held beliefs that fail to provide a complete and accurate description of the scientific world (Keig, 1990). Variety of terms has been used to describe those beliefs that differ from commonly accepted scientific consensus such as “preconception” (Ausubel, 1968; Benson, Wittrock, & Bauer, 1993; Novak, 1977), “misconceptions” (Abimbola, 1988; Brown, 1992; Chambers & Andre, 1997; Din, 1998; Driver & Easley, 1978; Gonzalez, 1997; Griffiths, 1994; Griffiths & Preston, 1992; Helm, 1980; Lawson & Thompson, 1988; Michael, 2002; Nussbaum, 1981; Schmidt, 1997; Treagust, 1988), “folk theories” (Medin & Atran, 1999), “intuitive ideas” (Hynd, McWhorter, Phares & Suttles, 1994), “children’s science” (Gilbert et al., 1982; Osborne et al., 1983; Stenhouse, 1986), “children’s scientific intuitions” (Sutton, 1980), “common sense understanding” (Hills, 1983), “common sense concepts” (Halloun & Hestenes, 1985), “conceptual frameworks” (Southerland et al., 2001),“intuitive conceptions” (Lee & Law, 2001), “intuitive science” (Preece, 1984), “alternative conception” (Gilbert & Swift, 1985; Niaz, 2001; Palmer, 2001; Taber, 2001; Wandersee et al., 1994; Dykstra, Boyle, & Monarch, 1992), “alternative frameworks” (Gonzalez, 1997; Kupier, 1994; Taber, 1999), “spontaneous reasoning” or “spontaneous conception” (Viennot, 1979), “spontaneous knowledge” (Pines & West, 1986), “naïve conception” or “naïve beliefs” (Caramaza, McCloskey & Green, 1981), and “naïve theories” (Resnik, 1983) by several researchers. The common thing among these explanations is that students hold explanations about phenomena which differ from scientifically accepted explanation.

In this study the terms “misconception” and “alternative conception” will be used interchangeably to refer inappropriate ides which are incompatible with or different from those held by scientific community.

Wandersee, Mintzes and Novak (1994) summarized the eight claims of alternative conceptions that are documented in the research literature.

“Claim 1: Learners come to formal science instruction with a diverse set of alternative conceptions concerning natural objects and events” (p. 181). Mayer (2003) indicated that students are coming to the science classroom with many misconceptions that are somewhat resistant to traditional teaching. Moreover, Ausubel (1968) states that “the most important single factor influencing learning is what the learners already knows”.

“Claim 2: The alternative conceptions that learners bring to formal science instruction cut across age, ability, gender, and cultural boundaries” (p. 185). Research studies show that students covering all grade and experience levels from pre school age children (Driver, 1989) to collage student (Crosby, 1987; Sanger, 1996) to pre service teachers (Lee,

1999) to teachers (Kruger & Summers, 1989; Harlen, 1997; Harlen & Holroyd, 1997; Pardhan & Bano, 2001) to university professors (Birk & Kurtz, 1999; Lin & Cheng, 2000) hold many misconceptions.

"Claim 3: Alternative conceptions are tenacious and resistant to extinction by conventional teaching strategies" (p. 186). Treagust, Duit and Fraser (1996) indicated that alternative conceptions are held strongly and resistant to change since students learn concept and principle in science to a limited degree. Moreover, they indicated that students sometimes hold two contradictory approaches which are intuitive one and formal one. Moreover, they have added that generally teachers are unaware of alternative conceptions which may affect learning and instruction in unpredicted ways. In addition, Tsai (1998; 1999) mentioned also that studies documenting students' alternative conceptions show that these conceptions are content-dependent and they are resistant to change through conventional teaching strategies.

"Claim 4: Alternative conceptions often parallel explanations of natural phenomena offered by previous generations of scientists and philosophers" (p. 186). Wandersee, Mintzes, and Novak (1994) mentioned that students tend to hold alternative conceptions of chemical equilibrium similar to ancient scientists and philosophers.

"Claim 5: Alternative conceptions have their origins in a diverse set of personal experiences including direct observation and perception, peer culture, and language, as well as in teachers' explanations and instructional materials" (p. 188). Students can attain misconceptions from personal experiences with the world, from interaction with peers, from written materials and teachers.

"Claim 6: Teachers often subscribe to the same alternative conceptions as their students. Teachers can unwillingly pass those alternative conceptions to their students. A teacher's knowledge can also interact with the pre scientific knowledge students bring to the classroom" (p. 189-190). The research studies show that teachers and even university professors have misconceptions (Birk & Kurtz, 1999; Lin & Cheng, 2000).

"Claim 7: Learner's prior knowledge interacts with knowledge presented in formal instruction, resulting in a diverse set of unintended learning outcomes" (p. 190).

"Claim 8: Teachers' use of instructional approaches that facilitate conceptual change can be effective classroom tools" (p. 190). Researches have shown that students' misconceptions are remarkably difficult to change by means of instruction (Minstrell, 1984). However, the conceptual change theories present strategies for teachers that can help students to change their misconceptions with scientifically accepted ones.

Students' alternative conceptions are fairly primitive. These alternative conceptions are useful in every day life but they can not explain the scientific phenomenon. Moreover, alternative conceptions still remain after learning more sophisticated concepts since students generally prefer to revert to preexisting ideas (Reif, 1990).

Gaddis (2001) summarized the findings of numerous descriptive studies of misconceptions in chemistry and presented in seven items.

1. Chemistry is a complex, abstract subject that lends itself to many alternative conceptions.
2. Misconceptions are deeply held and persist, even after instruction.
3. Misconceptions are ubiquitous, occurring in all age and education levels.
4. Students' inability to visualize at the molecular level leads to common misconceptions about structure, bonding and other chemical principles.
5. Misconceptions are often internally consistent and coherent.
6. Misconceptions arise from a variety of sources.
7. Misconceptions are resistant to change (p: 46-47).

Developing correct students concepts in chemistry is a desired outcome which requires first to distinguish and examine the reasons that causes misconceptions.

2.4.1 Sources of Misconceptions

There are number of sources that may cause misconception. Wandersee, Mintzes and Novak (1994) stated that students enter their classrooms with ideas about science that have been influenced by their prior experiences, textbooks, teachers' explanations, or everyday language. Therefore, if the origin of misconceptions is known, misconceptions will probably be altered more easily. Therefore, below some of the sources of misconceptions are presented.

2.4.1.1 Prior Knowledge

Prior knowledge is very important in constructivism since the new knowledge is constructed by the help of prior knowledge. In other word, what an individual has already knew, will affect his or her further knowledge construction. Therefore, prior knowledge plays a paradoxical role in the learning process (Pintrich, Marx & Boyle, 1993; Dole, 2000). In other words, prior knowledge can help foundation of new knowledge; however, it can also hinder construction of new knowledge if the prior constructs are incompatible with the new information. Research has shown that children bring to lessons a lot of preexisting conceptions about scientific phenomena that can interfere with students' learning of correct scientific principles or concepts (Driver & Easley, 1978; Driver & Erickson, 1983; Fleer, 1999; Palmer, 1999; 2001; Posner et al., 1982; Taber, 2000).

Teichert and Stacy (2002) mentioned the importance of prior conceptions and added that students are coming into the classroom with a conceptual framework already present, from everyday experience and from previous formal and informal education. Moreover they suggested instructors to consider fallowing two points: "(a) Students have preconceptions or prior existing knowledge of many chemistry concepts, which may or may not be scientifically correct, and (b) students may or may not integrate this prior knowledge with the new material being covered in class."

2.4.1.2 Language

The language may cause misconception. Scientists use terms to explain some scientific phenomena but the term they used sometimes can be same as those people commonly use. However, generally what scientists mean by those words are not the same as the meaning attributed by people. In other words, people confuse scientific and everyday meanings of the terms. That is, there is a discrepancy between scientific and common meaning of the term. Papageorgiou and Sakka (2000) showed that teachers made use of everyday language to interpret the scientific terms. For example, 'salt', in common language, is used to term NaCl compound, but in chemistry there are many salts other than NaCl.

2.4.1.3 Instruction

Chemistry is a complex, abstract subject. Therefore, formal instruction can not eliminate misconceptions and four reasons suggested as a reason by Tiskus (1992).

1. Students fail to make connections between topics since subject matter is too compartmentalized.
2. The lack of prior knowledge hinders understanding of basic scientific concepts.
3. Misinterpretation of complex, formal, and abstract language of science by students.
4. Students generally prefer to use algorithmic methodologies in solving problem rather then conceptual understanding.

Instructional strategies such as analogies and metaphors used by teachers to describe abstract phenomena can lead to incorrect scientific conceptions. In schools, analogies are used as specific tools to help learners relate new information to their prior knowledge (Taylor & Coll, 1997). However, sometimes people take the analogy too far, which gives rise to misconceptions (Gentner & Gentner, 1983). That is, analogies and metaphors may cause misconception since students interpret analogies and metaphors too literally.

Haidar (1997) indicated instruction as one major source of misconception. He also noted that the source creates two difficulties. The first difficulty is students' failure to apply correct information and used the closest available information to solve given problem. The second difficulty is that the knowledge of concepts was compartmentalized. Both of these difficulties indicates that students' understanding of scientific concepts is fragmented, inconsistent, and at variance with scientific knowledge.

2.4.1.4 Instructor

Instructors may also be a source of misconceptions. The research showed that pre service teachers (Lee, 1999), teachers and even university professors (Birk & Kurtz, 1999; Lin & Cheng, 2000) have misconceptions. These instructors may confuse the student and may teach them misconceptions. Therefore, if teachers hold alternative conceptions, teachers will have difficulties in identifying their students' alternative conceptions and correcting those conceptions (Calik & Ayas, 2005). Moreover, Ebenezer and Erickson (1996), Ebenezer and Gaskell (1995), Ginns and Watters (1995), Goodwin (1995), and Valanides (2000) suggested that students' alternative conceptions may result from their teachers. Moreover, Taber (2001) indicated the possibility that teachers may themselves misunderstand the content they are supposed to teach which may then cause students to acquire concepts that differ from commonly accepted scientific consensus.

2.4.1.5 Terminology

Terminology used by teacher and text books can also be a source of misconception. Many terms in chemistry have roots in other disciplines. Moreover, in some cases difficulties arise, for example, when students reason about concepts that have changed with time. Therefore, the influence between chemical terms and concepts has to be considered. In addition, new theories have often been connected to old terms. Therefore, the meaning of terms may change. As a result, terms contain both old and a new aspect. Therefore, alternative concepts arise due to students' logical interpretations of chemical terms that have shifted meaning with time (Schmidt, Baumgartner, & Eybe, 2003).

Schmidt, Baumgartner and Eybe (2003) gave en example for meaning change in the term of neutralization. They presented that originally neutralization was used to explain the reactions between acids and bases, in other words acids and bases was considered to consume (neutralize) each other. Therefore, students have good reason to believe that any reaction between an acid and an equivalent amount of a base results in a neutral solution. However, that is not always true. If, for example, acetic acid reacts with an equivalent amount of sodium hydroxide, a basic solution is formed. That is, reaction of strong acid with weak base or strong base with weak acid will not result in a neutral solution.

Another example is the term chemical reaction which originally referred to a one-way process in which reactants disappear because they are transformed into products. However, to day chemical reaction is seen as an equilibrium in which a forward and a reverse reaction compete with each other. Therefore, students have difficulties in understanding the new concept because they still have the original concept in their mind (Schmidt, Baumgartner, & Eybe, 2003).

2.4.1.6 Social Environment

Interaction with friends, parents and others in addition to mass media such as television, newspapers, internet, etc. can be a source of misconception. According to Taber

(2000) the child interacts with its physical environment and learns from that experience. Children are constantly bombarded by information from a variety of sources: parents, siblings, friends, television and so forth. Therefore, some of the child's early learning about its surroundings provides the alternative conceptions that can later interfere with the learning of formal science. Moreover, some researchers also indicated that alternative conceptions may arise as a result of the variety of contacts students make with the physical and social world or as a result of personal experience, interaction with teachers, other people, or through the media (Gilbert et al., 1982; Gilbert & Zylberstajn, 1985; Griffiths & Preston, 1992). In addition, according to Vosniadou (1992), alternative conception can be a "synthetic mental model" in which children combines socially and instructionally derived information where socially derived information is obtained through interaction with family, peers and media. In addition, Claxton (1993) stated that children are told many things by peers, family and the media, and much of these explanations may be wrong or misunderstood.

2.4.1.7 Textbooks

Textbooks which are the general source in teaching can be a source of misconception. For example, misconception may result from diagrams or models used in textbooks. These tools are used to gain a better understanding; however, if not properly constructed, they may give rise to misconceptions (Mayer, 2001). Additionally, Kikas (1998) showed that the diagram used in textbooks can be interpreted incorrectly which may result in misconception.

Uhlik (2004) indicated that students and teachers consider textbooks as a source of authoritative information. However, it is possible to make error while developing a textbook. Therefore, teachers and students may be affected to some degree by an error which may change in effect. Uhlik (2004) stated that error can be classified into three types which are "typographical", "editorial" and "conceptual". Typographical error means "misplacement of alphanumeric symbols in text". Editorial errors results from incorrect grammar or minor factual misstatements. Finally, conceptual errors according to Uhlik (2004) are the "third and most troublesome kind, because they are not "mistakes" in the same sense as the first two. Rather, they represent an essential misunderstanding of the topic at hand, and the erroneous statements are accepted as well-founded common knowledge by authors, editors and readers alike. In other words, no one recognizes that there even is a problem". That is, indication of first two errors is easy; however, indication of third type is a bit difficult so these errors may persist unquestioned and unexamined. Moreover, several research studies interpreted textbooks as a source of misconception (Chiu, 2005; Özkaya, Üce, & Şahin, 2003; Storey, 1989; 1990).

Barrow (2000) analyzed the content of elementary science methods textbooks to determine how magnet concepts were presented and obtained that in some textbooks information presented may lead misconception.

Sheldon (2002) found that most introductory psychology textbooks and their companion web sites may add to students' confusion about operant conditioning concepts and these textbooks and web sites may cause misconception by presenting inaccurate information and terminology.

Gauld (1997) indicated that textbooks were considered as the main source of information about scientific concepts by the most of the students. However, Gauld (1997) added that frequently in the textbooks, there appear number of errors and these errors are consequently transmitted to both teachers and students.

2.4.2 Misconceptions in Chemistry

A review of literature shows that in all areas of science students hold many misconceptions on a wide variety of topics (Treagust, Duit, & Fraser, 1996) covering virtually all grade and experience levels from pre school age children (Driver, 1989) to collage student (Crosby, 1987; Sanger, 1996) to pre service teachers (Lee, 1999) to teachers (Kruger & Summers, 1989; Harlen, 1997; Harlen & Holroyd, 1997; Pardhan & Bano, 2001) to university professors (Birk & Kurtz, 1999; Lin & Cheng, 2000).

A review of literature shows that in the area of chemistry, students hold many misconceptions on a variety of topic. Some topics are mole concept (Duncan & Johanstone, 1973; Griffiths & Preston, 1992; Harrison & Treagust, 1996), nature of matter (Andersson, 1990; Gabel, Samuel & Hunn, 1987; Novick & Nussbaum, 1981; Renstrom, Andersson & Marton, 1990; Tvieta, 1990), particulate and molecular views of matter (Novick & Nussbaum, 1978; Novick & Nussbaum, 1981), entropy (Frazer, 1980), chemical equations (Niaz & Lawson, 1985; Ben-Zvi, Eylon & Silberstein, 1987; Garnett, Hackling, Vogiatzakis & Wallace, 1992), chemical equilibrium (Banerjee, 1991; Bergquist & Heikkinen, 1990;

Camacho & Good, 1989; Gussarsky & Gorodetsky, 1988; Gussarsky & Gorodetsky, 1990; Chiu, Chou & Liu, 2002; Hackling & Garnett, 1985; Huddle & Pilay, 1996; Johnstone, Macdonald & Webb, 1977; Wheeler & Kass, 1978), bonding (Peterson & Treauget, 1989; Nicoll, 2001), electrochemistry (Garnett & Treagust, 1992a; Garnett & Treagust, 1992b; Ogude & Bradley, 1994; Roberts, 1993; Sanger, 1996; Sanger & Greenbowe, 1997) and acid-base chemistry (Cakir, Uzuntiryaki & Geban, 2002; Cros, Chastrette & Fayol, 1988; Hand & Treagust, 1988; Ross & Munby, 1991), thermochemistry (Boo, 1998), molecular geometry and polarity (Furio & Calatayud, 1996), and solubility equilibrium (Raviolo & Alexander, 2001).

It is important to find ways to overcome misconceptions and fascilitate meaningful learning. Therefore, it is important to understand the ways we can alter the misconceptions, some of which are presented below.

2.4.3 How to Alter Misconceptions

Treagust, Duit and Fraser (1996) indicated that students hold preinstructional conceptions in many fields of science and these preconceptions are generally different from science concepts taught in school. Moreover, these misconceptions are resistant to change since they are hold by students strongly. Therefore, it is important to know way to alter them. Five issues which can help in overcoming misconceptions are (1) students' prior knowledge, (2) relevance of content, (3) organization of content, (4) presentation of content in different ways and (5) language.

2.4.3.1 Students Prior Knowledge

Students' preexisting beliefs influence how students learn new scientific knowledge and play an essential role in following learning (Arnaudin & Mintez, 1985; Boujaoude, 1991; Driver & Oldham, 1986; Shuell, 1987; Tsai, 1996). Moreover, Treagust, Duit and Fraser (1996) discussed the importance of prior knowledge and added the importance of starting instruction by considering students' preconceptions. Moreover, Selley (1999) compared traditional and constructivist views of learning and stated that starting from what students already know about subject will likely to enhance the effectiveness of teaching. According constructivist theory of learning the learners' prior knowledge interacts with the new knowledge, and then it is apparent that knowledge about the structure of students' prior knowledge is very important in removing alternative conceptions. Therefore, if the science teacher wants to promote conceptual change, they must start instruction by diagnosing the prior conceptions of students. Therefore, if teachers know the students' conceptions that are not in harmony with scientific ones, they can easily design their lessons in order to promote conceptual change. In other words, teacher may help students to overcome their misconceptions.

Concept maps, interviews and multiple choice tests and word association tests can be used to determine students' pre conceptions.

Chiu (2005) used interviews in investigating the students' misconceptions. Ross and Munby (1991) conducted clinical interviews in order to understand students' conception of acids and bases.

Gussarsky and Gorodetsky (1988) used word association test to examine difficulties understanding the chemical equilibrium concept. Maskill and Cachapuz (1989) used word association tests to reveal the different representations that individual students had about the concept of chemical equilibrium.

Novak (1996) explained that concept maps are useful tools that can be used for identification of students' misconceptions to facilitate learning.

McCloskey (1983) used a multiple choice question in order to reveal students' misconceptions. Wheeler and Kass (1978) used a 30-item multiple-choice test to determine students' misconceptions of chemical equilibrium.

Interviews yield detailed information on students' understanding of chemical concepts. However, in most cases, it is not possible to investigate as many students as in paper-and-pencil tests.

In this study, the researcher searched through the literature and tried to obtain misconceptions related to solubility equilibrium and interviewed with several science teachers and prospective teachers for additional misconceptions students may hold.

2.4.3.2 Relevance of Content

Conceptual change can be promoted by making science content relevant to students' daily lives. Gabel (2000) indicated that the materials used in introductory chemistry course in most high schools are unfamiliar to the students. Moreover, Pauling (1983) criticized secondary and freshman college chemistry texts as having too much advanced materials.

Gabel (1983) analyzed the content of some secondary chemistry textbooks and found that textbooks are prepared so that fosters memorization instead of understanding. The textbooks are generally presenting elaborate theoretical models as established facts and presenting concepts with no basis in experimentation. Moreover, she recommends preparing texts by balancing four goals which are societal needs, personal needs, career education and salient knowledge.

Van Aalsvoort (2004) identified the lack of relevance as a problem of chemical education. Moreover, Van Aalsvoort (2004) identified four reasons of chemistry's lack of relevance in chemistry education. The reasons are;

a. Personal relevance: chemical education ought to make connections to pupils' lives;
b. Professional relevance: chemical education ought to offer pupils a picture of possible professions;
c. Social relevance: chemical education ought to clarify chemistry's purpose in human and social issues and;
d. Personal/social relevance: chemical education ought to help pupils to develop into responsible citizens.

Herron (1983) suggested modifying the textbooks so that textbooks will include greater attention to student ideas. Moreover, diagrams and illustrations should be used to provide a meaningful context.

Students' motivation and interest will increase by making the content relevant to students' lives and that may result in conceptual change. Therefore, students will try to learn the subject more deeply rather than surface learning where the knowledge is forgotten soon.

In this study, in order to increase students' interest some cartoons and figures were used.

2.4.3.3 Organization of Content

The topics in science course should be organized which will enhance students' understanding. In other words, the instructor should begin instruction with more concrete concepts which are closely related to student experiences and then should move gradually to more abstract concepts by enabling students to make connections with previously learned information.

2.4.3.4 Presentation of Content in Different Ways

Conceptual change can be promoted by presenting the information in different formats such as diagrams, sketches, pictures or animations. Moreover, to overcome misconceptions anomalous data (Shepardson & Moje, 1999), student-generated analogy (Cosgrove, 1995) and computer-based simulation (Carlsen & Andre, 1992; Ronen & Eliahu, 2000) can be used. Nakhleh (1992) recommended that more pictorial language should be built into chemistry courses. Moreover, visualization of chemistry by computer animations can help students' understanding of particulate and symbolic dimensions of chemistry. Copolo and Hounshell (1995) have suggested that using computational and physical models promote chemistry learning. Computer animations must be prepared to overcome students' misconceptions. This can be come true when these animations show or present conceptions which are contrary to misconceptions held by the students which will promote cognitive dishonest that results in change in concepts.

2.4.3.5 Language

The scientific definition of some words is different than their regular meaning which causes misconceptions. For example, the word "salt" is used by students to represent table salt NaCl; however, in chemistry there are many salts in addition to NaCl, referring to an ionic compound formed by the reaction of acids with bases. Therefore, teachers should be careful while using and instructing such terms and they should provide the difference in meaning between common definition and scientific definition.

2.4.4 Implications of Research on Misconceptions

Teachers must be aware of common misconceptions students hold so they can examine their instructional materials and teaching materials as well as their scientific knowledge for potential sources of difficulties for students trying to understand chemistry. Since these alternative conceptions predicts strongly the student achievement (Demircioglu, Ayas & Demircioglu, 2005).

Students' background beliefs can be identified by developing better assessment methods. By knowing the potential threat to instruction teachers can find solutions to overcome these threats. That is, by knowing students' misconceptions teachers can respond immediately to them when they arise in the classroom.

The awareness of misconceptions allows teachers to see their views in totally different ways which may lead to reconstruction of their science knowledge so as the instructional strategies used in the classroom (Duit, Treagust, & Mansfield, 1996).

Science teachers, after knowing the misconceptions, can select science content and design curricula to cover the interests, knowledge, understanding, abilities, and experiences of their students in order to increase student understanding.

Current science textbooks should be revised to in order to prevent formation of alternative conceptions (Demircioglu, Ayas & Demircioglu, 2005).

2.4.5 Summary of Misconceptions

The seven statements presented by Gaddis (2001) below summarize the findings of studies on misconceptions.

1. Chemistry is a complex, abstract subject that lends itself to many alternative conceptions.
2. Misconceptions are deeply held and persist even after instruction.
3. Misconceptions are ubiquitous, occurring in all age and educational levels.
4. Students' inability to visualize at the molecular level leads to common misconceptions about structure, bonding and other chemical principles.
5. Misconceptions are often internally consistent and coherent.

6. Misconceptions arise from a variety of sources.
7. Misconceptions are resistant to change (p: 46-47).

Before going further, it should be understood that misconceptions hinder learning and understanding chemistry in meaningful way. Therefore, remediation of misconceptions gains importance. Several instructional approaches which are consistent with constructivist view of learning are developed to remove and remediate misconceptions. These models stress the importance of conceptual change in remediation of misconceptions so that meaningful learning can be achieved. Therefore, if meaningful learning is desired it is important to understand what conceptual change is?

2.5 Conceptual Change

Piaget described conceptual change as he distinguished between assimilation and accommodation. As it is explained before, assimilation occurs when learners' can explain new information with existing knowledge, whereas accommodation requires changing or modifying existing knowledge.

Posner et al. (1982) initially identified two phases of conceptual change. They used the terminology that Piaget used to explain cognitive development, to describe these two phases. Assimilation is a process which uses existing concepts to deal with new information whereas accommodation is a process where new information can not be explained with existing conceptions which may result in the rejection and replacement of older conceptions.

Conceptual change is defined as a process of learning science in meaningful way that requires the learner to rearrange or replace existing misconceptions in order to accommodate new ideas (Smith et al., 1993). In other words, the term ''conceptual change'' is used to describe the kind of learning required when the new information to be learned comes in conflict with the learners' prior knowledge acquired on the basis of everyday experiences and this situation requires prior knowledge to be reorganized.

Conceptual change occurs when a learner changes misconceptions with scientifically accepted conceptions. That is, conceptual change involves restructuring of the learners' conceptions. However, all the information that is contrary to students' pre knowledge which is inconsistent with the currently accepted scientific viewpoint, not causes accommodation and as a result conceptual change. If for example, the learner has separate or isolated misconception within his or her existing knowledge structure, it is not easy to employ conceptual change process in order to correct that misconception. That is, conceptual change may not be as easy as helping the students to redefine a scientific term. Saunders (1992) explained that students have three options even if a student's ideas conflict with new phenomena. Students can maintain the schemata, restructure the schemata or disengage or skip themselves.

Students have already constructed a common sense understanding of the world based on their experience from everyday life, before coming to school. Therefore, they can not be considered as ''empty vessels'' when considering scientific knowledge since students are active builder of his/her knowledge (Mason, 2001). The prior knowledge students already have interacts with new information and if prior knowledge is incompatible with new learning, classroom learning requires students to reorganize their existing knowledge which is called conceptual change (Mason, 2001; Vosniadou, Ioannides, Dimitrakopoulou, & Papademetriou, 2001).

2.6 Conceptual Change Approach

The conceptual change approach was developed by science educators who saw a relation between theory of change and students' learning. According to Vosniadou (1999) conceptual change approach has its roots from both science education research tradition and the cognitive developmental research tradition. Moreover, Vosniadou (1999) added that both of the traditions mentioned above consider Kuhn's revolutionary account of scientific change where it is suggested that the process of how learning theories are revised when they face new evidence is subject to change, as an important topic. In science education tradition, Piaget's idea of accommodation and assimilation takes importance. On the other hand, in cognitive developmental research tradition, Piaget's thesis that cognitive development primarily involves changes in general logical capabilities and concept formation takes importance.

Students come to classroom with knowledge which can influence their further learning. This prior knowledge is generally inconsistent with that of scientists in a particular field. According to Bodner (1986), the students' conceptions that are different from that of scientist, are called "alternative conceptions". Moreover, the research showed that the misconceptions are very resistant to change (Treagust, Duit, & Fraser, 1996; Tsai, 1998; 1999). Therefore, it is difficult to overcome problematic conceptions. This results from the complexity of students' mental structures where concepts are highly integrated with each other. Therefore, changing alternative conceptions require modifying or restructuring existing schemata. The major concern of conceptual change approach research is to find ways that can help correct the misconceptions students already have.

2.6.1 Some Obstacles in Conceptual Change Approach

There are factors that can result in reconsideration of conceptual change approach in schools where it is applied. Therefore, the constituents of school are considered separately to deeply investigate the difficulties considered as an obstacle of using conceptual change approach.

2.6.1.1 Student

There may be students who are successful in classroom where traditional instruction methods are applied. Therefore, these students may feel themselves as threatened by new type of instruction which may affect their success. Moreover, Zirbel (n.d.) indicates that students may feel uncomfortable with lectures that are based on conceptual change approach since they share their ways of thinking with teacher and classmates. Therefore, these students may feel them more vulnerable. Moreover, Zirbel (n.d.) explains that in conceptual change model, prior knowledge of students is challenged and this will probably result in confusion in students' minds. Moreover, students do not like to be confused which is an uncomfortable feeling. Zirbel (n.d.) indicates that teachers should explain students that confusion is unavoidable and is part of learning. Moreover, if it is not told, students may feel frustrated and blame the teacher for that feeling. In addition, compared to traditional instruction, lectures that are based on conceptual change approach requires students to be more active and therefore requires more extra work which may cause students to resist of being told by new methods.

2.6.1.2 Teacher

Compared to lectures where traditional methods are applied, lectures that are based on conceptual change approach require more teaching preparation time, covering less content and letting an atmosphere where the structure is more flexible and the class is noisier (Shea, 1995). Sunal, Hodges and Sunal (1998) stated that the main reason for not changing teachers of their instruction is resource, time and turf conflicts. In addition, lectures that are based on conceptual change approach has no complete control over how the lecture is going since the students' answers and performance determines the direction and overall speed of the lecture. This situation may cause teacher to feel that they have lost the authority and make him or her more vulnerable (Zirbel, n.d.). Moreover, Zirbel (n.d.) stresses the difficulty of implementing that kind of lecture for the teachers that are not accustomed to lectures that are based on conceptual change approach before. In addition to factors mentioned above, the test or examination achievement or successes of students are the main concern for the most schools; therefore, teachers may be uncertain of implementing instructional approaches based on conceptual change (Yip, 2001).

2.6.1.3 Administrative

Administrators may question the use of conceptual change techniques if problems arise for the students or teachers (Herreid, 1998). The structure and the atmosphere of the schools applying constructivist teaching strategies are more flexible (Shea, 1995) and the administrators which are used to traditional methods can feel as if they lost the control which may then result in reconsideration of conceptual change approach. Moreover, some of the administrators may also complain from lost of the discipline.

2.7 Conceptual Change Models

There are many conceptual change theories which aim to replace or restructure misconceptions with that of scientific ones to facilitate learning. The major difference between the conceptual change theories is the way they explain the change. In other words, in order to clarify the concept of conceptual change various theories have offered different views of the central process. Some of them are presented below.

2.7.1 Posner, Strike, Hewson and Gertzog's Model

Posner, Strike, Hewson and Gertzog (1982) stated that learning is not acquiring memorized information but, in contrast, it is a process of conceptual change. This model explains "how concepts change under the impact of new ideas or new information" (p. 211).

The conceptual model takes its rotes from the Piaget's ideas of conceptual change through assimilation and accommodation. That is, according to that model process of learning needs two phases which are assimilation and accommodation. In assimilation, new phenomena are explained adequately by using existing concepts and if the current concepts do not explain the new phenomena, the learner must modify or change the existing concept. In other words, the main emphasis on this theory is on accommodation, the situation where understanding a new conception requires the initial rejection of some existing conceptions, with which the new conception contradicts (Thorely, 1990). Posner and his colleagues (1982) suggested that accommodation usually occur when four conditions exist;

1. "There must be dissatisfaction with existing conception" (p. 214). According to Posner et al. (1982) individuals do not accept the new conceptions easily until they realize that their alternative conceptions do not work anymore. In other words, when students face with new phenomena they try to explain it by the help of existing concepts. Moreover, if the learner does not have some prior knowledge about the phenomena the learner will not question the phenomena whether it has irrelevant or relevant features. Therefore, it is important students to have prior knowledge and realize that his or her current conceptions do not successfully explain the phenomena; therefore, they must be changed or modified to accept new concepts.
2. "A new conception must be intelligible" (p. 214). In other words, the learner must know what it means and find that it makes sense. Hewson and Hennessey (1992) explained that in order a concept to be intelligible, learners must know what concept means and they should be able to explain the concept with their own words. Moreover, they should be able to give examples and not related examples and should find ways such as drawing, talking, concept map, to represent ideas to others.
3. "A new conception must appear initially plausible" (p. 214). In other words, the learner must believe that it is reasonable and it is consistent with their world view. In order the concept to be plausible Hewson and Hennessey (1992) stated that the learner must find the concept intelligible and this concept should fit with their world view. Moreover, the concept must be consistent with other concepts related to it and the learner must see the concept in light of how they observe things to work.
4. "A new conception should suggest the possibility of a fruitful research program. It should have the potential to be extended, to open up new areas of inquiry" (p.

214). In other words, a new concept must achieve something of value for the learner. Hewson and Hennessey (1992) indicated that the concept should be intelligible, plausible, and useful and the learner should be able to apply it to other concepts and these concepts should be a better explanation of things.

Conceptual change depends on the above conditions. Moreover, conceptual changes do not occur without concurrent changes in the relative status of changing conceptions (Hewson & Hewson, 1991). For example, if more conditions are met then the conceptions status is raised, on the other hand if conditions that occur seldom then the conception status are lowered.

Posner et al. (1982) identified that students' conceptual ecology is the key to the conceptual change model because " without such concepts it is impossible for the learner to ask a question about the phenomenon, to know what would count as an answer to the question, or to distinguish relevant from irrelevant features of the phenomenon" (p. 212). The term conceptual ecology is used to describe how new learning is continually being integrated into, modified by, or rejected from a learner's conceptual framework. Strike and Posner (1985) developed the notation that learners' conceptions are adapted to a range of cognitive factors which include what they termed the learners conceptual ecology. The factors in the conceptual ecology according to Thorely (1990) are:

1. Anomalies: "arise from an existing conception can act to select for its successor".
2. Analogies and Metaphor: "can suggest new ideas or make them intelligible or plausible".
3. Epistemological Commitments: "including both subject-matter specific and more general beliefs about the character of knowledge, especially scientific knowledge".
4. Metaphysical Beliefs: "about science and the universe, and basic ontological categories assumed about the world".
5. Prototypical Exemplars and Images: "including thought experiments can serve to determine what a learner can understand or find reasonable".
6. Past Experience: "with which conceptions should be consistent".
7. Other Knowledge: "with which conceptions should be consistent" (p: 21-22).

These factors must be addressed in the classroom for conceptual change instruction to be effective (Beeth, 1998). According to Posner et al. (1982) teaching science requires creation of cognitive conflicts in students. Moreover, instruction should contain diagnosing errors in students' thought, helping them to make connections with prior knowledge and applying strategies to eliminate students' misconceptions.

Strike and Posner (1992) revised their theory and suggested several modifications to their theory. They stated that in order to describe learners' conceptual ecology several factors should be considered such as motives and goals and the instructional and social sources. Moreover, Strike and Posner (1992) extended the role of conceptual ecology where all parts of the conceptual ecology including scientific conceptions and misconceptions viewed as dynamic and in constant interaction and development. Moreover, they mentioned the importance of developmental and interactionist view of conceptual ecology.

2.7.2 Vosniadou's Model

Vosniadou (2002) stated that conceptual change is a process that lets students to synthesize models in their minds, beginning with their existing explanatory frameworks. Vosniadou and Brewer (1987) stated that there are two types of restructuring which are weak restructuring and radical restructuring. Weak restructuring allows new information to be accumulated and new relationship to occur between existing ideas, without changing the core concepts. This process is similar to Piaget's assimilation. On the other hand, in order to occur radical restructuring, a change in core concepts and structure of knowledge must take place. Moreover, learning is described as process that requires significant reorganization of existing knowledge structures (Vosniadou, 2003).

Vosniadou (2001) stated that humans pick up information from the physical world which makes it possible to them to function in it. "While this early competence forms the necessary foundation for further learning to occur, it may also hinder the acquisition of scientific knowledge. This happens because scientific explanations of physical phenomena often violate fundamental principles of intuitive physics, which are confirmed by our everyday experience. For this reason, learning science requires the radical reorganization of existing conceptual structures and not just their enrichment, and creation of new, qualitatively different representations".

As it is mentioned before, the learners assimilate new information with current concepts. According to Vosniadou (1994) the assimilation process is called “enrichment”. Moreover, learners must replace or modify existing schemata through accommodation. According to Vosniadou (1994) the accommodation process is called “revision”.

Vosniadou (Vosniadou, 1992; 1994; Vosniadou & Ioannides, 1998) proposed two levels of theories that control the learners’ beliefs which are framework and specific theories. “Framework theories are built easily in infancy and are based on some fundamental ontological and epistemological presuppositions that define a domain (for example, the presuppositions of performance, solidity, continuity, and so forth for the domain of matter)” (Mazens & Lautrey, 2003, p.161). Specific theories on the other hand are consciously accessible and built from everyday experiences. That is, specific theory is based on the individual observation of the world and as well as instruction to explain a limited range of phenomena. These two classes of theories come together to form mental models. Moreover, the distinction between theories mentioned above explains why some conceptual changes are more difficult then others. In other words, because framework theories are based on explanations that are obtained by everyday experiences and grounded in years of confirmation, conceptual change is difficult.

2.7.3 diSessa’s Model

diSessa (2002) stated that conceptual change is the reorganization of diverse kinds of knowledge into complex systems in student’s minds. Moreover, he argues that novice learners’ knowledge of physical phenomena is like knowledge in pieces. In addition, he named these pieces as phenomenological primitives and shortly they are called as p-prims which are abstracted from common experiences. These p-primes then combine to form individual concepts (diSessa, 1993). P-primes are considered as phenomenological since they are the responses to experienced and observed phenomena. They are considered as primitive since p-primes are individual dependent that is they are self-evident to their holders. Moreover, diSessa (1993b) indicates that one sees and explains the world by the help of p-primes which are the self explanatory interpretations of physical reality. The p-primes are small knowledge structures that contains configuration of a few parts. Moreover, p-primes account for structures called causal nets which can be described as what people intuitively expect of causality. Moreover, diSessa and Sherin (1998) indicated that “causal nets are, roughly, our replacement for the theories that lie behind observations. Or the theories implicated in theory-based notions of categories" (p. 1174).

Conceptual change is considered as reorganization that increases the internal coherence of p-primes. In this model knowledge increases by refining and restructuring p-primes. In other words, moving from intuitive knowledge to expertise needs developing, refining and differentiating p-primes. Therefore, instruction is considered as a cause for conceptual change.

Classes of concepts that are thought important in science learning are called coordination classes which determine learners' ability to understand. Charles (2003) states that coordination classes are composed of structural components that perform two activities:

1. "centered on gathering information through selecting what to "see" (referred to as "readout strategy"), and the other,
2. "based on…causal net activity" (p. 24).

Moreover, according to diSessa and Sherin (1998) coordination classes of concepts would increase understanding by providing systematically connected ways of obtaining information.

2.7.4 Chi's Model

Chi, Slotta and deLeeuw (1994) define conceptual change as change in category assignment since meaning of a concept is determined by its category assignment.

According to Chi, Slotta and deLeeuw (1994), entities in the world belongs to three ontological categories which are "matter" (or things), "processes" (this category further divided into events, procedures, and constraint-based interactions) and "mental states". Entities in the matter category have such ontological attributes as "being confinable," "storable," "having volumes and mass," "being colored," and so on. Entities in the procedure category have such attributes as "being carried out" and "having a sequence." Entities in the event category have such attributes as "being caused by" and "having a beginning and ending." Entities in the constraint-based interactions category have such attributes as "being dynamic," "changing," and "coexisting." Finally, entities in the mental state category have such attributes as "emotional" and "intentional." Moreover, these categories are seen as the root of a tree which is composed of several ontological subcategories. Moreover, categories within a given tree differ ontologically from any category on the other trees because they do not share any ontological attributes. Chi, Slotta and deLeeuw (1994) indicate that many scientific concepts belong to ontological category called "constraint-based-interactions" and this category is a subcategory of "processes". Moreover, they locate causal reasoning as a subcategory called "events" under the "processes" category. They indicated that many misconceptions results from students' incorrect assignment of many scientific concepts into correct ontological category. In addition, several studies in the area of chemistry indicated that students assign many scientific concepts in to category of matter although they should be placed somewhere else (Sanmarti, Izquierdo, & Watson, 1995; Watson, Prieto, & Dillon, 1997). This causes several difficulties for students in developing scientific concepts (Boo & Watson, 2001).

Chi and Roscoe (2002) understand conceptual change as repair of misconceptions. In other words, students must identify misconceptions and repair them. In this model, misconceptions are defined as miscategorization of concepts. In other words, misconceptions result because of mismatch between the ontological category to which one assigns a concept and the ontological category to which the concept usually belongs, the correct category. Therefore, reassignment of concepts to correct categories is defined as conceptual change.

Chi (1992) and Chi, Slotta, and deLeeuw (1994) proposed an incompatibility hypothesis which explains why some scientific concepts can not be changed easily. Moreover, since many science concepts require conceptual changes across trees, difficulties arise while learning them. Therefore, some conceptual changes are hard and some of them are easy. Boo and Watson (2001) indicate that "to evaluate whether the reaction is exothermic or endothermic, students need to consider the energy balance between that required to break bonds and that released when new bonds are formed (a constraint-based interaction), rather than considering energy as the driving force for the reaction (an event). According to Chi's Incompatibility Hypothesis, both of these conceptions are placed within the "process" category, so conceptual change between the subcategories of "events" and "constraint-based interaction" should be easier than conceptual change between the major categories of "matter" and "process" (p. 571). Charles (2003) presented comparison of four models discussed above in a table format.

2.8 Commonalities of Conceptual Change Models

Conceptual change models generally have three common features which are identification of misconceptions, cognitive conflict and practice (Gaddis, 2001).

2.8.1 Identification of Misconceptions

Teaching for understanding, cannot be achieved without a diagnosis of students' initial understanding of content knowledge (Carey, 2000). Many researchers realized that students bring to the classroom many misconceptions that are resistant to change and difficult to extinguish. Many researchers saw these misconceptions as theories that need to be replaced by the currently accepted, correct scientific views since many researchers believe that students' prior knowledge could highly influence subsequent learning (Ausubel et al. 1978, Novak 1977, Wandersee et al. 1994). Therefore, identification of misconceptions is very important and serves as a basis for conducting conceptual change strategies. Several methods can be used for identification of misconceptions such as interviews, concept maps and multiple choice tests. Although interviews may be effective in identifying students' misconception, they are time consuming, difficult (Gaddis, 2001) and require subsequent training. Duit, Treagust, and Mansfield (1996) indicated that many researchers used multiple choice items in order to examine students understanding of science. Moreover they added that "diagnostic test provide an opportunity for both teachers and researchers to diagnose students' learning without the need for interviews" (p. 27).

2.8.2 Cognitive Conflict

Scott, Asoko and Driver (1992) indicated that cognitive conflict strategies play a key role in approaches that focus on conceptual change. Cognitive conflict can be achieved by providing students with evidence that contradicts with their existing conceptions. According to Duit and Confrey (1996) the most important point in instruction is whether students will really understand or realize the conflict. Moreover, they added that although sometimes it may appear discrepant to teachers, it may appear not discrepant or discrepant to some extend to students. Moreover, some studies reported that cognitive conflict was not being able to achieve through using discrepant event which is a cognitive conflict strategy (Chinn & Brewer, 1998; Gorsky & Finegold, 1994; Mason, 2001). Moreover, Murray (1983) stated that although contradictory event is presented to students, it may be understood in several ways by students such as;

a. Unnoticed
b. Tolerated or explained as mystery or magic
c. Seen as independent event
d. Resolved trivially

Although some researchers have raised questions about the role of discrepant events, several researchers mentioned a significant correlation between cognitive conflict and conceptual change (Kang, Scharmann, & Noh, 2004; Levin, Siegler, Druyan, & Gardosh, 1990; Mason, 2000).

Limon (2001) stated that presenting contradictory data with explaining the points it differs from students' current conceptions could help them to realize the differences between preconceptions and scientifically accepted conceptions. This may be one of the reasons why discrepant events are still used by many researchers in conceptual change studies.

2.8.3 Practice

Practice is very important since it will facilitate learning. However, most school practice involves recitations of definitions and relationships that have no meaning to child which causes rote learning (Novak, 1996). Therefore, activities that involve presenting and developing ideas, discussing examples of them, applying them in other occasions, linking them to other ideas will help students practice and strengthen the conceptual understanding. In other words, activities accompanied with concept maps and analogies can be used to strengthen conceptual understanding. Therefore, teaching for conceptual change gains importance.

2.9 Teaching for Conceptual Change

Teaching for conceptual change first of all requires instructors to be aware and familiar with the misconceptions that students are likely to hold. Then it is important to know the diversity of views that students have about a particular topic which helps students to realize ideas that they had not thought before (Hewson, 1996). In other words, just teachers views should not be stated, as it is in traditional teaching, students' views should also be considered. It will probably help students to realize that they all have different views (Hewson, 1996). Then it is important to promote conceptual change by helping students to overcome their misconceptions. In other words, it is important students to realize that some of their ideas are different from teacher's explanations. Therefore, many strategies are developed and used to promote conceptual change. Zirbel (n.d.) stated that in order students to form new concept and change old ones they have to be let through several processes. The first step is students have to understand and notice what the problem is. Secondly they have to assimilate more information and try to fit it into current neural networks. Then, they have to analyze and criticize all the argumentation in his own words and reorganize his thoughts, that is, they have to accommodate new knowledge. Finally, they have to work toward obtaining fluency in the newly acquired and understood concepts. Moreover, Zirbel (n.d.) stated that a good teacher can facilitate conceptual change and explained how an instructor can achieve this goal in four steps which are explained below.

1. Hooking the Student (Acknowledging Information): the teacher should get the students attention so that they will be interested in learning more about the new ideas.
2. Suggesting Bridges (Assimilating Information): the instruction should be clear and materials should be presented in a simple way so that everybody can understand the topic. That is, what is taught should make sense to every student. In other words, students should be able to explain the new information to some extend with their existing concepts. Therefore, meaningful associations can be useful since they may help students to order and integrate new information in to correct place in their knowledge database.
3. Querying and Confronting the Student (Accommodating Information): teacher should help students to realize their misconceptions and help them to overcome these misconceptions. Moreover, "what is important here is that the student thinks aloud and articulates the problem in his own words. The instructor can guide the student by challenging the students with the right question, but without putting the words into his mouth" (Zirbel, n.d., p. 13).
4. Practicing and Constructing (Familiarizing Information): instructor should provide examples so that students can apply new information and transform it to the other areas. Therefore, "all a good instructor can do is to challenge the student to go beyond his limits (Zirbel, n.d., p. 13).

2.10 Conceptual Change Strategies

Some theoretical models (Posner, Strike, Hewson, & Gertzog; diSessa; Vosniadou; Chi) were developed to explain conceptual change. Moreover, many studies were conducted in attempt to apply these models in classroom situations. Three kinds of instructional strategies can help to summarize the instructional efforts made to promote conceptual change.

- Conceptual Change Text or Refutation Text
- Analogy
- Graphic Organizers

2.10.1 Conceptual Change Text or Refutation Text

Hynd, McWhorter, Phares and Suttles (1994) defined refutation texts as “texts that refute commonly held naive concepts. They are designed to make readers aware of the inadequacy of their intuitive ideas, directly stating that commonly held intuitive ideas do not explain certain phenomena” (p. 934). Moreover, Hynd (2001) stated that “a refutational text introduces a common theory, belief, or idea, refutes it, and offers an alternative theory, belief, or idea that is shown to be more satisfactory” (p. 700). Conceptual change text is defined by Çakır, Geban and Yürük (2002) as a text where “students are asked explicitly to predict what would happen in a situation before being presented with information that demonstrates the inconsistency between common misconceptions and the scientific conceptions” (p. 240). Although refutation text and conceptual change text looks similar they differ a little. According to Chambers and Andre (1997), the major difference of these two types of texts results from the situation whether they want students to make predictions about phenomena. In other words, one of these texts wants students to make prediction before presenting the information that contradicts with scientifically accepted ideas and the other does not. Chambers and Andre (1997) stated that “in the conceptual change model, students are asked to predict what would happen in a situation before being presented with information that demonstrates the inconsistency between common misconceptions and the scientific conception. In the refutational text model, common misconceptions are contrasted to scientific conceptions, but the students is not asked first to make a prediction about a common situation before the refutation is given” (p. 109-110).

According to Guzzetti (2000), refutational text can be either narrative (story) or expository in form. Moreover, refutation of the misconception can be placed at the beginning or at the end of the passage. In other words, the order of the refutation makes no deference in changing students' alternative ideas (Maria & MacGinitie, 1987).

Roth (1985) described the procedures in refutational text. According to Roth (1985) common misconceptions of students should be first identified. Then, a situation which is prepared to activate students' common misconceptions is presented to elicit prediction about the phenomena. Next, students' misconceptions are challenged by introducing common misconceptions followed by evidence that they are wrong. Finally, the correct scientific explanation is presented. In other words, refutational text presents the commonly associated alternative conception, refutes it by explaining why it is not scientifically accepted and provides an explanation of the scientific conception to help remediation of misconceptions. Therefore, in this study the conceptual change texts are prepared according to Roth's (1985) procedures.

Many educators argue that telling students how the world works in a text can not be as effective as having students experience scientific notions of the world through experimentation (Lloyd, 1990; Newport, 1990; Osborne, Jones & Stein, 1985). Although some of the researchers raised questions about refutational texts, many researchers stated the effectiveness of refutational texts (Dole & Niederhauser, 1990; Chambers & Andre, 1997). In addition, compared to other conceptual change strategies, refutational texts were found to be the most effective. Moreover, Chambers and Andre (1997) explained the effectiveness of conceptual change texts. They stated that most of the conceptual change approaches to instruction focus on using in-class teacher–student and student–student interaction to promote conceptual change. These methods are generally appropriate for small sized classrooms. They also added that in large classroom situations conceptual change texts can help students to construction of conceptions more consistent with those accepted by the scientific community. Therefore, conceptual change text strategy is used in this study since most of the science classrooms in high schools in Turkey are crowded.

Hynd (2001) indicated that students prefer refutational texts to other kinds of texts since refutational texts were found to be:

a) Moderately discrepant with belief: Students realize that there is a difference between the text belief and their own and this is the one of Posner et al.'s (1982) conditions for conceptual change and is one of the key features of texts that invite conceptual change.

b) Understandable: Refutation texts are designed so that students can easily understand the text, that is, in the text explanations are clear, understandable and explained deeply. This is in harmonious with Posner et al.’s (1982) notion that the new idea must be plausible and understandable.

c) Credible: Credibility is another key feature of refutation texts. Texts seemed credible when they presented explanations that related to students’ everyday experiences.

d) Useful: The information presented in the texts can be used for better understanding of the things happening around and an individual can explain something to somebody by reading it. Therefore the refutation texts are considered as useful. This feature is also in harmonious with Posner et al.’s (1982) notion of fruitfulness.

e) Repeated: Students believed that repeated messages were persuasive.

f) Related: Relatedness is another key feature of refutational text.

Guzzetti, Snyder, Glass and Gamas’s (1993) meta-analysis of studies of conceptual change in science showed that one of the most successful techniques analyzed was the use of refutational text.

Hynd, McWhorter, Phares and Suttles (1994) compared the effectiveness of demonstration, refutational text and discussion in isolation and in combination to promote conceptual change in physics. 310 ninth and tenth graders from two high schools in 26 separate classes participated to the study. However, just 168 students’ scores were used in the analysis. Students were randomly assigned within classes to eight groups: a) Demo/Discussion/Text; b) No Demo/ Discussion/Text; c) Demo/ No Discussion/Text; d) Demo/Discussion/Unrelated Text; e) No Demo/No Discussion/Text; f) Demo/No Discussion/ Unrelated Text; g) No Demo/Discussion/Unrelated Text; h) No Demo/No Discussion/Unrelated Text. The results showed that of the three instructional variables that were manipulated in the study, refutation text had the strongest overall effect which supports the result of meta-analysis of Guzzetti et al. (1993).

Cakir, Uzuntiryaki and Geban (2002) compared effects of concept mapping and conceptual change texts instruction over traditional instruction on 10th grade students’ understanding of acid and base concepts. 110 students from 6 classes of a chemistry course taught by the same teacher were enrolled in the study. There were four experimental group classes and two control group classes. Two experimental groups class were instructed with concept mapping instruction; and the other two experimental groups were taught with conceptual change texts instruction and the next two classes were assigned as control group students instructed with traditional instruction. The results showed that concept mapping instruction and the conceptual change texts instruction caused a significantly better acquisition of scientific conceptions related to acids and bases than the traditional instruction. Similar results were found by studies where the effectiveness of conceptual change text accompanied by concept mapping strategy is investigated on understanding of diffusion and osmosis concepts (Tekkaya, 2003), human circulatory system (Sungur, Tekkaya & Geban, 2001), and solution concept (Uzuntiryaki & Geban, 2005).

Chambers and Andre (1997) investigated relationships between gender, interest and experience in electricity and compared conceptual change text and traditional didactic text in conceptual understanding of electrical concepts in physics. 206 students participated in the study and they found that conceptual change text has been shown to lead to better conceptual understanding of electrical concepts than traditional didactic text.

Hynd, Alvermann and Qian (1997) investigated the changes in pre service teachers' conceptions about projectile motion brought about by a combination of reading and demonstration and an appeal to usefulness. 73 pre service teachers randomly assigned in to a combined demonstration–text or in a text-only group. The results show that the demonstration–text group learned counterintuitive science concepts better. However, the effect of demonstration–text was no greater than the effect of merely reading the text after 2 months. That is, the effect of demonstration lessened over time. It is concluded that text was the only factor that produced long term conceptual change. In other words, conceptual change occurred just by having students read a refutational text. Moreover, Çetin, Ertepınar and Geban (2004) investigated effectiveness of conceptual change texts oriented instruction accompanied by demonstration on 78 ninth grade students' understanding of ecology and concluded that conceptual change texts oriented instruction accompanied by demonstration within a small group increased students' achievement of ecology concept compared to traditional instruction.

Diakidoy, Kendeou and Ioannides (2002) investigated whether the text structure effects the acquisition of the concept of energy and remediate specific preconceptions associated with it. 215 six grade students from six schools participated in study. Some of them read a simple expository text that presents factual information, some of them read a refutational text and the remaining students received standard instruction. They found that six grade students who read a refutation text outperformed students who read simple expository text and students who received no text.

Guzzetti (2000) indicated that although refutation text is effective to some students, for remaining students it is need to implement discussion. That is, students with ineffective reading strategies and those who are not able to draw inferences from the text may need their reading to be supported by teacher directed discussion. Moreover, Guzzetti (2000) reminded that although refutational text causes cognitive conflict and dissatisfaction with prior beliefs, cognitive conflict alone can not produce conceptual change. That is, some of the students may not change their inadequate ideas although they read a refutational text. Guzzetti (2000) concluded that refutation text accompanied with teacher directed discussion is the most effective way of changing students' misconceptions.

Çakır, Geban and Yürük (2002) investigated the effect of conceptual change text oriented instruction over traditional instruction on students' understanding of cellular respiration concepts. 84 eleventh-grade students from four classes of a high school participated in the study. Two of the classes were assigned randomly to the control group where students are taught with the traditional instruction, and the other two classes were assigned randomly to the experimental group where students are taught with a conceptual change text-oriented instruction. They found that the conceptual change text-oriented instruction caused a significantly better acquisition of scientific conceptions and elimination of alternative conceptions than the traditional instruction. Moreover, they concluded that it is not easy to eliminate misconceptions just by employing traditional instructional methods. Similar results were found by studies where effectiveness of conceptual change text oriented instruction over traditionally designed instruction is investigated on students' understanding of electrochemistry concept (Yürük & Geban, 2001) and respiration concept in biology (Alparslan, Tekkaya & Geban, 2003).

2.10.2 Analogy

Duit (1991) defines analogy as comparison of structures between two domains. Analogies are composed of propositions of the form “A is to B as C is to D” where A and B are comparisons in the base or analog domain and C and D are comparisons in the target domain. The base domain is concept related to the topic of the analogy and the target domain is the concept associated with the unfamiliar phenomena.

According to Duit, Roth, Komorek and Wilbers (2001) analogy involves the mapping of two domains called base which is more accessible and familiar concept in the students prior knowledge, and target which is more difficult to conceptualize concept. They added that specific features of these domains are similar which constitute the analogical relation. Moreover, they indicated that in base and target domains two kinds of aspects may be similar:

a) Simple properties or surface features.
b) Deep features or structural properties.

Duit et al. (2001) indicated that the base and target domains can be viewed as analogy of each other. In other words, base domain for example can be an analogy of target domain or target domain can be an analogy of base domain. Moreover, they added that this relationship is important since base domain is also in some occasions equally unfamiliar to students. Therefore, this symmetrical relationship between base and target domains helps stepwise construction of mutually constitutive understandings of both domains. In other words, learning by analogy includes switching perspectives between the two domains.

In constructivism, every learning process includes a search for similarities between what is already known and the new and unfamiliar one. That is, new concepts are tried to be explained by concepts that students already have and it is done by establishing relationship between them. Therefore, learning process often requires major restructuring of students’ already existing conceptions. Analogy can play a central role in this restructuring of students’ conceptual frameworks (Brown, 1992; Duit, Roth, Komorek & Wilbers, 2001; Harrison & Treagust, 1993). Although many researchers stressed the positive effects of an analogy on learning, several studies however show no improvement in concept acquisition by using analogies (Friedel, Gabel & Samuel, 1990; Gabel & Samuel, 1986; Gilbert, 1989).

Hodgson (1995) indicated that analogies provide the means for exploring, describing and explaining scientific and mathematical ideas. Moreover, they help make science relevant and interesting. Interest is very important in learning since students will probably not engage with scientific ideas if they not find scientific ideas interesting and worth learning.

Analogies can help learners understand and remember concepts that learners have little prior knowledge. Analogies can be presented by teacher or students can develop their own verbal or visual analogies. Analogies can be used to simplify both concrete and abstract concepts. However, they may be most helpful in making abstract concepts more concrete which enhance learning (Smith & Ragan, 1999).

Harrison and Treagust (2000) indicated that teachers frequently use analogical models to make abstract concepts more accessible to the students. They added that analogical models are attractive since models explain abstract science concepts in familiar, visual and often concrete ways. Moreover, students prefer think about abstract processes and concepts in concrete terms (Harrison & Treagust, 1996). They added that analogical models increases students' curiosity and enhance their creative thinking, and in some occasions such as structure of an atom, there is no other way to explain scientific phenomena other than an analogy.

Duit et al. (2001) stated that analogies can be used as a tool for learning science in schools especially in cases where scientific conceptions and preinstructional conceptions of students are incompatible. However, they also reminded that analogies always do not help conceptual change and in some occasions may cause students to construct improper information which may mislead students learning process. Hence, analogies in school science may be "two-edged swords" (Glynn, 1991) that afford or constrain conceptual change depending on the circumstances. In addition, Harrison and Treagust (2000) also stated that some problems can be obtained in teaching by an analogy since how students interpret the analogy depends on students' prior experience, knowledge, language skills and thinking strategies. Therefore several reasons have been stated for lack of enhanced performance when analogies are used as a teaching tool.

1. Analogical domain may be unfamiliar to students (Friedel, Gabel & Samuel, 1990).
2. Insufficient time on task (Friedel, Gabel & Samuel, 1990).
3. To not explain where the analogy breaks down (Smith & Ragan, 1999).

Harrison and Treagust (1993) indicated that effective instruction using analogy involves ensuring the teacher and the student visualize the analogy similarly, developing the shared attributes of the analogy and the target concept, and clearly identifying the unshared attributes. Moreover, Glynn, Britton, Semrud-Clikeman and Muth (1989) proposed a model called "Teaching with-Analogies" for using analogies to enhance learning. The model includes six steps:

1. Introducing the target concept.
2. Recalling the analog concept.
3. Identifying similar features of the concepts.
4. Mapping similar features.
5. Drawing conclusions about the concepts.
6. Indicating where the analogy breaks down.

Although some researchers mentioned some precautions and limitations of using analogy (Duit et al., 2001; Glynn, 1991; Harrison & Treagust, 1993; 2000; Friedel, Gabel & Samuel, 1990; Smith & Ragan, 1999), many researchers indicated that analogies may be powerful tools for guiding students from their pre instructional conceptions towards science concepts (Brown, 1992; Duit, Roth, Komorek & Wilbers, 2001; Harrison & Treagust, 1993).

2.10.3 Graphic Organizers

Graphic organizers according to Smith and Ragan (1999) "can be of great assistance in the information processing of organized discourse learning" (p. 166). Moreover they added that graphing organizers can be used in learning facts and lists. Holley and Dansereau (as sited in Smith & Ragan, 1999) presented some graphic organizer strategies such as networking, concept structuring, schematizing and mapping. Smith and Ragan (1999) also mentioned that all graphic organizer "strategies are similar in that they require learners to identify and represent ideas presented in instruction and spatially indicate the relationships among these ideas" (p. 167). In this study, several graphic organizers are used to simplify and present the knowledge in more organized and clear way while developing conceptual change texts.

Concept mapping is another type of graphic organizer which is commonly used by several researchers in their studies. Although concept mapping strategy is not applied in that study it is deeply investigated to inform readers of importance of graphic organizers.

Concept map is a graphic means of portraying relationships among ideas (Smith & Ragan, 1999). According to Martin, Mintzes and Clavijo (2000) a concept map is a two dimensional, hierarchical, node-link representation that portray the major concepts and relationships in the knowledge structure. Roberts (1999) describe concept map as a diagram designed to illustrate the understanding of the relationships between concepts involved with a particular area of study.

While developing a concept map first a list of words describing important aspects of a topic is decided and written on a piece of paper. Then, words are listed and placed in a hierarchical order, from most general to most specific. After that, they are arranged so that similar terms are near each other. Finally, links are drawn between the concept words, and statements are written to describe or explain the links. Taber (2000) indicated that "concept mapping involves producing a graphical representation of ideas about a particular topic: often writing the key concepts in boxes connected with lines or arrows labeled with the relevant propositions".

West, Framer and Wolf (1991) described three types of concepts maps: spider, hierarchy and chain. Moreover, Ruiz-Primo, Schultz, & Shavelson (as cited in Uzuntiryaki & Geban, 2005) explained two types of concept maps which are "fill in the map" and "construct a map". In "fill in the map type", students are provided with a concept map in which some of the concepts or linking words are missing and students are expected to fill in the blanks with appropriate concepts. In "construct a map" type, instructors decide on the amount of information to be provided.

Roberts (1999) state that concept maps are designed to demonstrate the level of deep understanding of the mapmaker through the illustration of connections between concepts and indicated several outcomes of using concept maps as:

a) The initial process of drawing a map may help students' to clarify their understanding of a topic.
b) Teachers can use the maps to identify student misconceptions and hence provide feedback.
c) The maps can be used to assess student understanding (p. 707).

Concept maps can also be used as a research tool to represent knowledge structures, facilitation of meaningful learning, design of instructional materials, identification of misconceptions, evaluation of learning and facilitation of cooperative learning and help students and teachers to understand the constructed nature of knowledge (Novak, 1990a; 1990b; 1996; Novak & Wandersee, 1990).

Concept map activities allowed the students to organize their learning by constructing interrelationships among concepts, which enhances meaningful learning (Odom & Kelly, 2001). In other words, concept mapping requires students to identify and arrange concepts and interpret the relationships between them. Moreover, concept maps show the students' personal interpretation of subject content and help students to form links among concepts which promotes meaningful learning. However, much of the school learning involves arbitrary definitions or statements of principles without opportunities to observe the relevant events or objects which results in rote learning (Novak, 1996). In addition, in rote learning new concepts are not carefully integrated that is relationships between concepts are arbitrary and are not constructed by the student, into students' existing knowledge frameworks (Dykstra, Boyle & Monarch, 1992). Although classroom learning experiences involve hands-on activities to illustrate concepts, many students fail to construct concept that are appropriate with that of scientists' or mathematicians' (Novak, 2002). Therefore, rote learning is ineffective in restructuring concepts. In other words, rote learning is inappropriate in remediation of misconceptions that is, in replacing them with valid conceptions. Novak (1996) stated that concept maps can be used as diagnostic tool to identify students that suffers from rote learning. Concept maps can also help students to move from patterns of rote learning to patterns of meaningful learning. He also added that concept mapping improves science teaching and learning by meaning making. In addition, concept mapping is considered as an effective tool for fostering and assessing conceptual change by many researchers (Liu, 2004; Martin, Mintzes, & Clavijo, 2000; Novak & Musonda, 1991; Novak, 1998; Pearsall, Skipper, & Mintzes, 1997; Trowbridge & Wandersee, 1998; Wallace & Mintzes, 1990; White & Gunstone, 1992).

Tsui and Treagust (2004) examined conceptual learning of genetics in tenth grade students in Australia from an ontological perspective. They used concept maps to examine students' possible cognitive structure or declarative knowledge about a gene concept in biology. Moreover, concept maps that are used helped them to identify some forms of consistent conceptual change.

Murtonen and Merenluoto (2002) described four different ways of using the concept map technique when studying conceptual change in university students. They suggest that concept maps could be used both to study complex domain learning and to follow up the process of change. They added that concept maps seem to be helpful especially when studying more complex domains which are composed of many different kinds of knowledge or clusters of knowledge.

Roberts (1999) examined the use of concept maps to measure tertiary science students' understanding of fundamental concepts in statistical inference. 19 students participated in the study. It is suggested that valuable information can be obtained from an investigation of students' concept maps. Moreover, she added that qualitative information obtained from concept maps can help in identification of misconceptions which could not be obtained from traditional methods. In additions, contribution of concept maps to formal assessment is also mentioned.

2.11 Metacognition

The term metacognition was introduced by Flavell in the 1970s. Flavell describes metacognition (as sited in Hewson, 1996) as "knowledge concerning one's own cognitive processes and products". In other words, metacognition means learners' knowledge of their own cognition. Moreover, Baird (1990) formulated metacognition as "knowledge, awareness and control of one's own learning". The term metacognition is formed from terms "meta" and "cognition". The term "meta" has its roots from ancient Greek and means along with or among. The term "cognition" as mentioned before means mental process of knowing. Therefore, if these two terms come together, metacognition means thinking alongside of one's thinking.

Paris and Winograd (1990) mentioned that students' learning can be enhanced by becoming aware of their own thinking as they read, write, and solve problems in school. In other words, if students knew that knowledge was something that they develop themselves, they will be more motivated and more active in construction of their scientific knowledge.

Constructivism, conceptual change and metacognition are interrelated to each other. Metacognition is related to constructivism since every learner individually decides whether or not to construct knowledge. In other words, in constructivism every learner constructs his or her ideas and learners are described by Gunstone (as sited in Case, Gunstone & Lewis, 2001) as metacognitive "if they consciously undertake an informed and self-directed approach to recognizing, evaluating and deciding whether to reconstruct their existing ideas and beliefs". In addition, metacognition is related to conceptual change since recognizing, evaluating and considering whether to reconstruct one's conceptions are metacognitive processes. In other words, conceptual change involves learners to recognize his or her existing ideas and beliefs and decide personally whether or not to reconstruct these ideas and beliefs. Conceptual change according to Posner et al. (1982) model involves dissatisfaction with existing ideas and beliefs, and the decision to consider whether alternatives are intelligible, plausible and fruitful. Gunstone and Northfield (1994) stated that "dissatisfaction implies recognition, evaluation requires at least plausibility, and fruitfulness is an extremely helpful way to consider approaches to making the demanding task of reconstruction one which is personally valuable to the learner" (p. 525). Metacognitive learning is explained by Gunstone (as sited in Georghiades, 2004) as ability to recognize, evaluate and where needed reconstruct existing ideas. Therefore, conceptual change and metacognition are interrelated to each other.

Linder and Marshall (1997a) used several metacognitive strategies such as concept mapping, peer discussion and lectures where qualitative reasoning is enhanced. Linder and Marshall (1997b) indicated that students shifted to more sophisticated conceptions of learning when metacognitive strategies are applied.

Flavell (as sited in Georghiades, 2004) stated that metacognitive strategies may not be different from cognitive strategies but there is a distinction which differentiates them. The distinction results from the fact that cognitive strategies facilitate learning and task completion, on the other hand, metacognitive strategies monitors the process.

Gunstone (as sited in Case, Gunstone & Lewis, 2001) suggested some requirements for developing content which enhances metacognitive development.

1. The content needs to require real cognitive learning.
2. The content should be neither already understood nor totally unfamiliar.

Metacognitive strategies can be taught in science classroom. These strategies increase the transfer of science learning and they facilitate conceptual change (Case, Gunstone & Lewis, 2001). Therefore, conceptual change texts are developed to enhance metacognition in this study.

2.12 Attitude

Attitude is a mental state that influences a learner to choose to behave in a certain way (Gagne, 1985). Simpson, Koballa, Oliver and Crawley (1994) defined attitude as tendency to respond positively or negatively to things, people, places, events or ideas. In other words, attitudes influence the choice the learner makes. In other words, how students' feel toward science influences their performance and their choice of science as a career. For example, a student that dislikes chemistry can choose not to take courses that contains chemistry concepts or a student that likes chemistry can build his or her career on chemistry. Therefore, attitude plays a strong role in students' motivation to initiate and preserve in learning. That is, students' attitudes about learning, teaching and subject matter introduced could help or hinder his or her learning. Therefore, development of positive attitudes toward science should be a basic goal of science instruction since Simpson and Oliver (1985) indicated that favorable attitude generally accounts for between 20% to 25% of the variation in academic achievement. In addition, many researchers showed that positive attitudes toward science improve students' interest and achievement in science (Brown & Story, 1979; Cannon & Simpson, 1985; Fraser, Nash & Fisher, 1983; Lin, 1992; Simpson & Oliver, 1990; Schibeci & Riley, 1986). Therefore, it is important to design a classroom instruction that will address the individual students' needs. Since the way in which instruction is conducted generates attitude about the material being learned. Several researchers indicated that classroom instruction that is based on conceptual change strategies produced significantly higher positive attitudes toward science (Canpolat, 2002; Özdemir, 1998; Uzuntiryaki & Geban, 2005).

In this study it is also investigated whether conceptual change text oriented instruction produces positive attitudes toward science compared to traditional instructional methods since positive attitudes toward science increases students' achievement. Moreover, the attitudes of students toward conceptual change texts are also determined in order to investigate whether they increase students' interest and achievement.

2.13 Science Process Skill

Many science curricula developed nowadays emphasized that acquisition of the science process skills should be one of the major goals of science instruction (Ateş, 2004).

Science process skills are classified as basic skills and integrated skills. According to Lancour (2005) basic skills include:

1. Observing: becoming aware of an object or event by using any of the senses to identify properties. It is a description of what was actually perceived.
2. Communicating: giving oral and written explanations or graphic representations of observations. In other words, using words, symbols or graphics to describe an object, action or event.
3. Classifying: grouping, arranging or distributing objects, events, or information representing objects or events in classes according to some method or system.
4. Measuring: making quantitative observations by comparing to a conventional or non conventional standard. In other words, using standard measures or estimates to describe specific dimensions of an object or event.
5. Inferring: drawing a conclusion based on prior experiences or formulating assumptions or possible explanations based upon observation.
6. Predicting: making a forecast of future events or conditions expected to exist.

Student can use all of the skills mentioned above at various time. However, in the earlier grades students will mostly use skills such as observing and communicating. And as they get older students will start to spend more time using the other skills. Padilla, Okey, and Dillashaw (as sited in Ateş, 2004) "believe that basic skills provide a foundation for the acquisition of integrated process skills" (p. 277).

Ateş (2004) indicated that integrated science process skills include stating hypotheses, identifying and controlling variables, defining operationally, interpreting data, and experimenting. Lancour (2005) explained integrated science process skills:

1. Stating Hypothesis: stating the proposed solutions or expected outcomes which must be testable, for problematic situation.
2. Identifying and Controlling Variables: identifying variables that are tested and controlling other variables that can affect expected outcomes.

3. Defining Operationally: explaining actions and operations necessary to measure or identify the variable.
4. Interpreting Data: analyzing qualitative and quantitative data given to formulate a conclusion.
5. Experimenting: manipulating data so that results can be verified.

Therefore, it should be a goal of the instructor to encourage science process skills that will provide students with background and curiosity sufficient to prompt investigation of important issues in the world around them. Several researchers indicated that science process skill was a strong predictor in understanding the concepts related to science (Alparslan, 2002; Bayır, 2000; Canpolat, 2002; Özdemir, 1998; Pınarbaşı, 2002; Preece & Brotherton, 1997; Ünlü, 2000).

In this study science process skill test was administered to experimental and control groups to determine the difference between groups concerning science process skills since the variation in achievement may result from the difference in science process skills.

2.14 Secondary Education in Turkey

Turkish Education System has democratic, modern, secular and coeducation characteristics. The aims of the system are to increase prosperity and welfare of Turkish citizens and society, to support and accelerate economic, social, cultural development in accordance with national unity and integrity, and to make Turkish Nation contemporary civilization's constructive, creative and distinguished partner (Republic of Turkey Ministry of National Education, 2001).

Secondary Education covers general high schools, and vocational and technical high schools which provide at least three-year (nowadays became four years) education for the graduates of primary education. The aims of secondary education are to provide the students with common general culture and to prepare them for tertiary education, life and vocational fields in accordance with their interests and talents through various programs (Republic of Turkey Ministry of National Education, 2001).

Secondary education in Turkey is not compulsory and free of charge in public schools. When students came to the high school before deciding on their subject area, they had to take science courses such as chemistry, physics and biology. Demircioglu, Ayas and Demircioglu (2005) indicated that “the curricula for these three subjects comprise only textbook based syllabuses. There are no accompanied teacher guides, laboratory manuals or computer programs for simulations etc. Moreover, the worldwide problems of education such as overcrowding, lack of materials, inadequate laboratories, and poor teacher preparation are commonly faced” (p. 40) in secondary education. Ersoy (2002) also indicated that it is not possible to conduct effective science education without adequate science laboratories.

Morgil, Yücel and Ersan (2002) stated that teachers think that more time is needed for teaching chemistry concepts. Moreover they also indicated that teachers complained that the methods and strategies applied in lessons are inappropriate.

Dogan, Oruncak and Gunbayi (2002) indicated that most teachers in secondary education use commonly a classical teacher-centered teaching where students are subject to passive learning. Moreover, they presented some observations of physics teachers about how students’ view physics course. Teachers indicated that students see physics courses as unnecessary, meaningless and have negative attitudes toward physics. In addition, it is also maintained that students gave no importance to subjects that the Student Selection Test does not cover. In other words, the priority of students is to pass the Student Selection Test. Moreover, the need for a more thoroughly planned curriculum is mentioned.

Ayas (as sited in Demircioglu, Ayas & Demircioglu, 2005) indicated that “curriculum contains general purposes, topics of domain, special aims of topics, and behavioral objectives, teaching and learning activities, teaching tools, learning results, assessment tools and methods” (p. 40). Demircioglu, Ayas and Demircioglu (2005) stated however that “in Turkey, it only contains general purposes, topics of subject area and subtitles of each topic, with the remainder resting on the shoulders of teachers” (p. 40).

The concept of solubility equilibrium is taught in the tenth grade that is in the second year of high school. Before being taught of solubility equilibrium, students learn some concepts that help comprehension of solubility equilibrium, such as chemical reactions, chemical equilibrium and in ninth grade solutions. Moreover, solubility equilibrium concept is taught for three weeks that is the time devoted to the concept is 14 hours. The unit of solubility equilibrium contains solutions and equilibrium, factors that control solubility equilibria, application of solubility product principle and the significance of solubility product constant.

2.15 Solubility Equilibrium

Solubility equilibrium means the equilibrium established between the saturated slightly soluble salt and its solution. That is, equilibrium is established with the excess undissolved solute and its ions in solution (Ebbing, 1996). When a slightly soluble salt is placed in water it gradually passes in to the solution, that is cations and anions that form the salt live the solid and move into the solvent. If enough slightly soluble salt and time is allowed, the slightly soluble salt will dissolve to the limit of its solubility. At this point where the formation of ions that forms the salt is equal to formation of salt, the equilibrium is reached (Akbulut et al, 1990).

The principles of ionic equilibria are similar to those used in other chemical equilibrium systems (Akbulut et al, 1990). Therefore, while determining misconceptions related to solubility equilibrium both studies on chemical equilibrium and solubility equilibrium are investigated. While determining misconceptions, the researcher interviewed with high school chemistry teachers and prospective chemistry teachers. The list of misconceptions that students' have in concept of solubility equilibrium is presented in Appendix A.

Some of the studies investigated to determine misconceptions about solubility equilibrium in addition to studies that are investigated the effect of conceptual change approach on both solubility equilibrium and chemical equilibrium are presented below.

Raviolo and Alexander (2001) presented a chemistry problem that can be used to evaluate conceptual knowledge about solubility equilibrium and to diagnose difficulties in understanding of solubility equilibrium as well as previous concepts such as dissolution, stoichiometry, chemical equations, particulate nature of matter, ionic compounds chemical equilibrium characteristics, solubility, the common ion effect and Le Chatelier's principle. A problem about solubility equilibrium is suitable for both secondary school students and students that are in their first year of university study and is presented as a resource for the evaluation of students. It involves macroscopic, microscopic, and symbolic levels of representation, and allows one to assess whether students have gained an adequate conceptual understanding of the phenomenon and realize some difficulties students' encounter. The problem, which starts with a figure using numbered particles, is useful for judging the relationships that students' establish among the three levels. The difficulties students' encounters while solving the problem were discussed.

Wheeler and Kass (1978) tried to determine the nature and extent of students' misconceptions in chemical equilibrium. Moreover, they investigated the degree to which certain misconceptions are related to chemical achievement. Ninety nine 12^{th} grade chemistry students participated in the study. They developed a diagnostic test which requires students to predict the effect of changing certain variables, to determine the nature and extend of misconceptions in chemical equilibrium. They found that students had difficulty understanding the following areas of chemical equilibrium: mass and concentration, reaction rate and degree, constancy of chemical equilibrium, and Le Chatelier's principle. They indicated that students benefit from laboratory approach where they can predict and observe the effect of varying certain variables on chemical system at equilibrium. Moreover, they suggested that graphical representations can be used accompanied to teaching of the concepts such as constant concentration and equilibrium constant to overcome misconceptions.

Smith and Metz (1996) investigated five different chemical concepts which are matter, state of matter, stoichiometric ratios and limiting reagents, acid strength and solution chemistry, using microscopic representation. Seventy three undergraduate students, 22 graduate students and 11 faculties participated in the study. Participants were tested individually and were asked to voice their thoughts and reasoning aloud. They are given a chemical problem and asked to complete it. Drawings obtained are evaluated by considering whether students properly dissociated reactants and products, showed correct bonding and structure of reactants and products, and conservation of mass. The investigation showed that 45.4% of faculty, 36.4% of graduate students and just 6.8% of undergraduate students correctly mentioned the three criteria presented above. It is also presented that 30.2% of undergraduate students missed all the three criteria in their drawings. They noted that undergraduate errors are unique and highly varied. Moreover, they stated that many graduate students and faculty share the common errors. They indicated that although students solve mathematical problems, they fail to understand chemistry. They also remanded that students have misconceptions in chemistry concepts discussed and these misconceptions hinder learning. Therefore, they suggested using microscopic representations before applying mathematical calculations since these microscopic representations are considered to increase comprehension and allow students to picture the chemistry.

Camacho and Good (1989) investigated the differences of problem solving behaviors of experts and novices engaged in solving seven chemical equilibrium problems. They found that successful problem solvers perceived the problem, properly used the symbols appropriate to each problem and properly applied several principles including gas laws, Avogadro's principles, Le Chatelier's principle and thermodynamic laws. Also their questions reflected an interest in the purpose and state of their knowledge development rather than insecurity or lack of knowledge. By contrast most unsuccessful students did not exhibit these critical behaviors.

Voska and Heikkinen (2000) conducted a study to identify conceptions students use when solving chemical equilibrium problems that requires them to use Le Chatelier's principle. 95 students enrolled in general chemistry class participated in the study. They used 10 two-tier items test where second part of each item presented a blank space where students write their reasoning. Moreover, 9 students were interviewed. According to research results, they warned chemistry teachers of some misconceptions that students' commonly hold. Moreover, researchers presented that 57% of students have a misconception in application of Le Chatelier's principle, 40% of students have misconception of constancy of the equilibrium constant and 19% of students hold the misconception about the effect of a catalyst.

Pekmez (2002) discussed issue of changing students' ideas and presented several misconceptions students have related to chemical equilibrium. She also mentioned that students have many misconceptions about acid-base and solubility equilibrium. Therefore, she discussed ways of changing students' misconceptions. She presented a several misconceptions about chemical equilibrium and presented a brief explanation about each misconception. Moreover, she also presented some reasons that cause misconceptions. Everyday language, multiple definitions, rote application of concepts and overlapping similar concepts are presented as a cause of misconception.

Nakhleh (1992) stated that although many students try hard to learn chemistry, they are unsuccessful since the fundamental chemistry concepts are not constructed appropriately. Therefore, she suggested a cognitive model of learning and presented misconceptions related to fundamental chemistry concepts one of which was misconceptions concerning equilibrium. She deeply investigated the study of Gussarsky and Gorodetsky (1990) where some equilibrium misconceptions are presented. According to that study students do not perceive the equilibrium mixture as an entity; rather, they manipulate each side of the chemical equation independently. Moreover, the researchers presented that students also fail to understand the dynamic nature of equilibrium and indicated that equilibrium problems are generally abstract that can be solved by rote learning. Nakhleh (1992) suggested including questions that specifically probe for misconceptions. As a result, teachers will have a better chance to estimate students' cognitive structures and students will have a chance of better understanding the chemistry concepts.

Clark and Bonicamp (1998) investigated whether K_{sp} values presented in different sources vary or not. Therefore, they examine ten general chemistry textbooks and compared the K_{sp} values of several compounds. Moreover, they also noted that most of the K_{sp} values presented in the books were thermodynamic K_{sp} values. Therefore, they have used a computer program called EQUIL to calculate solubilities from thermodynamic K_{sp} values. They compared the values of 25 compounds that exist in most of the books and found that K_{sp} values presented in the textbooks vary in value. They also investigated concentration K_{sp} values and thermodynamic K_{sp} values in order to examine whether they differ a lot. They found that for 16 compounds both concentration K_{sp} values and thermodynamic K_{sp} values are in acceptable range that is they do not differ a lot. So they advised authors that prefer not to mention activity coefficients, to present K_{sp} values of these 16 compounds in separate table in general chemistry books while teaching the solubility equilibrium.

Thomas and Schwenz (1998) conducted a study where 16 volunteer students from undergraduate physical chemistry classes were interviewed. They have presented students' alternative conceptions and nonconceptions about equilibrium and thermodynamics. While determining these alternative conceptions they have presented a chemical problem and asked students several questions that probe misconceptions. Responses obtained were coded into 30 codes including macroscopic and microscopic explanations of the laws of thermodynamics and equilibrium, how temperature and pressure affects equilibrium and the definitions of terms students used. Each student's response was rated from 0 to 5 according to how well the response matched that of scientific explanation. They just presented the results of alternative conceptions that 25% (4 students) of students held about thermodynamics and equilibrium. Moreover, in the study 29 alternative conceptions and nonconceptions are presented with percentage of students having those conceptions.

Huddle and Pillay (1996) investigated students' responses to questions about stoichiometry and chemical equilibrium. 642 students participated in study where a chemical equilibrium problem is asked. The results obtained showed that just 7, 5 % of students were able to correctly answer the question. In another study where 156 students involved, similar results were obtained. In that study just 8% of the students were successful in answering the question correctly. In addition, they have presented most common 11 misconceptions related to chemical equilibrium. They concluded that results obtained in that study is in line with the studies that are carried out in other countries. In addition, they highlighted that the main problem with these topics is that they are highly abstract and therefore they have suggested using concrete examples when these topics are first introduced.

Gussarsky and Gorodetsky (1990) used word associations to map the conceptions of the high schools students concerning the concept "chemical equilibrium" and "equilibrium". Three hundred and nine students ranging in age from 17 to18 involved in the study. Preconceptions of students in two concepts were investigated by dividing students in three groups according to level of studying chemistry. It is obtained that preconceptions of two concepts were different since the concept of "equilibrium" was associated with everyday life experiences while the concept of "chemical equilibrium" associated with general chemical concepts. After studying the chemical equilibrium concept at school, students were again asked to produce free associations and it is observed that the two concepts merge towards one and becoming synonymous. They stated that transfer of static attributes from "equilibrium" to the dynamic "chemical equilibrium" may be a reason for misconceptions associated with chemical equilibrium.

Chiu, Chou and Liu (2002) tried to investigate students' mental models of chemical equilibrium using dynamic science assessment. Moreover, they have developed a test to determine students' misconceptions. 122 10th grade students participated into the study while determining the students' misconceptions and 30 students who did not understand the chemical equilibrium is selected for further study where treatment group (20 students) instructed based on the main features of cognitive apprenticeship such as coaching, modeling, scaffolding, articulation, reflection, and exploration; whereas, control group learned from the tutor without explicit cognitive apprenticeship support. The results showed that treatment group significantly outperformed the control group. Moreover, students in treatment group successfully constructed correct mental models of chemical equilibrium however; students in control group fail to construct correct mental models of chemical equilibrium. It is also obvious that students in treatment group successfully constructed correct mental models when percentage of understanding of chemical equilibrium is investigated. For example, few students understood in the pretest (10% of students) that all substances exist in a chemical equilibrium. When post test results are compared the understanding of fact in treatment group increases to 90%.

Tyson, Treagust and Bucat (1999) explored students' understanding of chemical equilibrium by the help of two tier test. They indicated that students use multiple explanations when predicting the effect of change to equilibrium mixture. In addition, the use and interpretation of language considered as an important factor in teaching and learning of the topic of chemical equilibrium. They also presented several misconceptions students have about chemical equilibrium and criticized some explanations made by chemistry teachers while teaching chemical equilibrium.

Wilson (1998) presented an analogical model for teaching the concept of equilibrium. The concept of equilibrium is made more concrete by the use of a box of matches. The class was divided into small groups and then each group was divided in to three where one of the group was representing "reactants", one of the group was representing "products" and the other group recorded the results. By the help of that analogical model they stated that dynamic nature of equilibrium can be taught more easily since it became clear and concrete.

Quilez-Pardo and Solaz-Portoles (1995) investigated reasons, strategies and procedures used by both students and teachers while they are solving some chemical equilibrium problems and questions. 170 students and 40 teachers participated into the study. Students' misconceptions related to chemical equilibrium and some problematic aspects of understanding that could impede students' learning were determined first. They then investigated whether teachers' conceptions effects problem solving strategies of students. They found that both teachers and students hold similar misconceptions and indicated that teacher's conceptions effects problem solving strategies of students.

Bergquist and Heikkinen (1990) reviewed the literature of misconceptions students held on chemical equilibrium and summarized them within four general areas of difficulty. First one is that students show confusion regarding amount and concentration, second one is that students show confusion over the appearance and disappearance of material, third one is that students show confusion over the meaning of K_e and last one is that students show confusion over the use of Le Chatelier's principles. The interview conducted by Bergquist on second semester general college chemistry students illustrate some of the common misconceptions mentioned above. Moreover, they have presented some sources of misconceptions such as traditional instructional language and common language. They concluded that although traditional instructional methods are effective in transmitting the mathematical skills associated with equilibrium, these methods fail to develop students' understanding of chemistry concepts.

Van Driel, de Vos and Verloop (1999) conducted a study to identify the types of reasoning students apply when reversible reactions and chemical equilibrium introduced to them. Therefore, they have presented an educational design in which students perform hands on experiments that clearly demonstrate the reversibility of chemical reactions and the possibility that chemical reactions do not proceed to completion. Then, dynamic nature of chemical equilibrium is offered as a model that explains the results of these experiments. They concluded that the experiments performed aroused students' interest and encourage them to search for adequate explanation. Moreover, the results showed that most of the students understand dynamic nature of chemical equilibrium although some of them perceived chemical equilibrium as static.

Canpolat (2002) conducted a study to compare the effectiveness of conceptual change approach on students' understanding of chemical equilibrium concept and their attitudes towards chemistry. 85 first year university students participated in to study while they are taking general chemistry course. One class is taught with conceptual change approach (experimental group) and the other class was taught with traditional teaching strategies (control group). They have found that the mean score of experimental group on chemical equilibrium concept test as 28, 58 however; the mean score of control group on test was found as 21, 08. That is, results indicated that conceptual change approach was significantly more effective than traditional teaching strategies. He also presented some misconception related to chemical equilibrium and compared the percentage of correct responses between experimental and control groups on post test scores in order to assess the effectiveness of both teaching strategies on students' understanding of chemical equilibrium concept. These investigations also supported that conceptual change approach is more affective than traditional teaching strategies on students' understanding of chemical equilibrium concept. Moreover, students' attitudes towards science were found significantly higher in class where conceptual change strategies are applied.

Niaz (1998) aimed to construct a teaching strategy that could facilitate conceptual change in students' understanding of chemical equilibrium. Sixty eight freshman students from two sections participated into the study. One of the section was randomly designed as control group (N = 32) and the other section was experimental group (N = 36). Students in experimental group were exposed to two teaching experiments which lead the students into situations in which they experience conflict or contradiction. Then, both groups were given problems related to chemical equilibrium. Results obtained showed that performance of the experimental group was better. The researcher concluded that several aspects should be considered while applying conceptual change strategies in classroom.

Harrison and De Jong (2005) designed a study in which multiple analogical models were used to introduce and teach chemical equilibrium. Eleven 12^{th} grade students participated in to the study. A case study approach was used and the data were collected from the observation of three consecutive lessons on chemical equilibrium, pre- and post lesson interviews, and delayed student interviews. They have used "school dance" analogy to highlight chemical reactions, but included several factors that influence reaction rate, namely, concentration, temperature, and surface area. Then they used "sugar in teacup" analogy to illustrate the dynamic nature of the equilibrium. After presenting the "sugar in teacup" analogy one of the students in the class offered a "pot of curry" analogy which was more easily related to daily experiences. Finally in order to summarize dynamic nature of chemical equilibrium "busy highway" analogy is discussed. The outcome of the study showed that most students learned that equilibrium reactions are dynamic, occur in closed systems, and the forward and reverse reactions are balanced. The researchers recommended the use of multiple analogies and remanded teachers of showing where the analogy breaks down and carefully negotiate the conceptual outcomes.

Piquette and Heikkinen (2005) explored the general-chemistry instructors' awareness of and ability to identify and address common student learning obstacles in chemical equilibrium. Fifty-two volunteer general chemistry instructors completed an interactive web-based instrument consisting of open-ended questions, a rating scale, classroom scenarios, and a demographic form. Then respondents were interviewed by phone to clarify their responses. All the chemistry instructors were able to report and identify common difficulties students' face in chemical equilibrium. Chemistry instructors suggested several strategies to address and attempt to remediate students' alternative conceptions. However, these strategies rarely included all four necessary conditions specified by Posner, Strike, Hewson, and Gertzog (1982) to stimulate conceptual change. Several implication and recommendations are presented at the end of the study.

Akkuş, Kadayıfçı, Atasoy and Geban (2003) investigated the effectiveness of instruction based on constructivist approach over traditional instruction on students' understanding of chemical equilibrium. Seventy one 10th grade students participated into the study. The teaching methods randomly assigned to two classes that is one class is thought with constructivist approach (experimental group) and the other with traditional instruction (control group). They have controlled science process skills and previous learning by assigning these variables as a covariate. Results indicated that post test mean scores of students instructed with constructivist approach (X = 30. 75) was higher than post test mean scores of students taught with traditional instruction (X = 19. 84). Moreover they indicated that the average percentage of correct responses of the experimental group was 68% however; in control group the average correct responses were 44 percent. Therefore, they have concluded that constructivist approach is better in removing misconceptions. They also presented several misconceptions sited in the literature and presented an additional one which is "when one of the reactants is added to the equilibrium system, the concentration of the substance that was added will decrease below its value at the initial equilibrium" (p. 209).

Özdemir (1998) compared the effectiveness of the conceptual change text instruction on 10th grade students' understanding of chemical equilibrium concepts. Moreover, students' attitudes towards science were also investigated. 55 students from two classes participated into the study. One of the classes where conceptual change texts are applied was experimental group and the other class where traditional teaching strategies are applied was control group. The results indicated that post test mean scores of experimental group (X = 23.15) and control group (X = 20.35) with respect to achievement were significantly different. The results indicated that conceptual change text instruction is significantly more effective than traditional teaching strategies. She also compared the percentage of correct responses students in experimental and control groups gave to each post test items in order to assess the effectiveness of both teaching strategies on students' understanding of chemical equilibrium concept. These investigations also supported that conceptual change text instruction is more affective than traditional teaching strategies on students' understanding of chemical equilibrium concept. Moreover, she indicated that students in class where conceptual change text instruction is applied had more positive attitudes towards science.

2.16 Summary

Students develop many concepts while they interact with environment and construct knowledge. How students construct knowledge is explained by Piaget's Cognitive Stage Theory and Information Processing Theory so that one can explain and understand how student learn which helps in comprehension of how restructuring of concepts or remediation of misconceptions are done in human mind. In addition, remediation of misconceptions requires conceptual change and many strategies are developed based on constructivist view of learning to promote conceptual change such as conceptual change texts or refutation texts, analogies and graphic organizers. Moreover, many researchers tried to explain conceptual change by different models in order to better understand concept formation and concept restructuring such as Posner et al's, diSessa's, Vosniadou's and Chi's Models. Many researchers also indicated that conceptual change texts are useful tools in remediation of misconceptions that hinders learning. Therefore, promoting meaningful learning in chemistry which is considered as a difficult subject by many students requires teaching strategies that are better than the traditional instruction which is considered as ineffective in remediation of misconception by many researchers. In this study, the researcher therefore, developed conceptual change texts based on Roth's (1985) procedures considering metacognitive strategies to facilitate meaningful learning in solubility equilibrium in which there are not many research studies. That is, although solubility equilibrium is fundamental concept in chemistry education the literature review showed that there are not many studies on it. Therefore, developing teaching methods which prevents misconceptions and enhances meaningful learning in the concept of solubility equilibrium is necessary. For these and numerous other reasons presented in the review of literature, conceptual change texts based on conceptual change approach prepared considering metacognitive strategies appear to offer valuable benefits for students as they study solubility equilibrium.

CHAPTER III

PROBLEMS AND HYPOTHESES

3.1 The Main Problem and Sub-problems

3.1.1 The Main Problem

The purpose of this study is to compare the effectiveness of instructions, one based on traditional method and the other based on conceptual change approach on tenth grade students' understanding of solubility equilibrium concept.

3.1.2 The Sub-problems

1. Is there a significant mean difference in effectiveness of instructions, one based on traditional method and the other based on conceptual change approach on tenth grade students' understanding of solubility equilibrium concept?
2. Is there any difference between girls and boys with respect to achievement in solubility equilibrium concept?
3. Is there a significant effect of interaction between gender difference and treatment on students' understanding of solubility equilibrium concept?
4. Is there any contribution of students' prior achievement to their understanding of solubility equilibrium concept?
5. Is there any contribution of students' science process skills to the variation in their achievement in solubility equilibrium concept?
6. Is there a significant mean difference between students taught with conceptual change approach and students taught with traditional instruction with respect to their attitudes towards chemistry as a school subject?
7. Is there a significant mean difference between males and females with respect to their attitudes toward chemistry as a school subject?

8. Is there a significant effect of interaction between gender difference and treatment with respect to students' attitudes toward chemistry as a school subject?
9. Is there any relationship between students' attitudes toward conceptual change texts and their achievement in solubility equilibrium concept?
10. Is there a significant mean difference between males and females with respect to their attitudes toward conceptual change texts?
11. Is there a significant mean difference in effectiveness of treatment on understanding of solubility equilibrium to experimental group students and control group students with respect to students' achievement in chemistry?

3.2 Hypothesis

H_o1: There is no significant mean difference between post-test mean scores of students taught with instruction based on conceptual change approach and students taught with instruction based on traditional methods in students' understanding of solubility equilibrium concept.

H_o2: There is no significant mean difference between post-test mean scores of males and females on their understanding of solubility equilibrium concept.

H_o3: There is no significant effect of instruction between gender difference and treatment on students' understanding of solubility equilibrium concept.

H_o4: There is no significant contribution of students' prior achievement to their understanding of solubility equilibrium concept.

H_o5: There is no significant contribution of students' science process skills to their understanding of solubility equilibrium concept.

H_o6: There is no significant mean difference between students taught with conceptual change texts and students taught with traditional instruction with respect to their attitudes towards chemistry as a school subject.

H_o7: There is no significant mean difference between males and females with respect to their attitudes toward chemistry as a school subject.

H_o8: There is no significant effect of interaction between gender difference and treatment with respect to students' attitudes toward chemistry as a school subject.

H_o9: There is no significant relationship between students' attitudes toward conceptual change texts and their achievement in solubility equilibrium concept.

H_o10: There is no significant mean difference between males and females with respect to their attitudes toward conceptual change texts.

H_o11: There is no significant mean difference in effectiveness of treatment on understanding of solubility equilibrium to experimental group students and control group students with respect to students' achievement in chemistry.

CHAPTER IV

DESIGN OF THE STUDY

4.1 The Experimental Design of the Study

In some schools, students can not be randomly assigned as individuals to experimental groups and control groups since the schedule can not be changed. Therefore, in this study knowing that the school can not change the schedule the researcher used quasi experimental research design where all students within any one classroom was randomly assigned as an intact group to serve as an experimental group (EG) or control group (CG). The research design of the study is presented below.

Table 4.1 Research Design of the Study

Groups	Pre-test	Treatment	Post-test
Experimental Group (EG)	SCT ASTC SPST	ICCA	SECT ASTC ASCCT
Control Group (CG)	SCT ASTC SPST	TM	SECT ASTC

The meanings of abbreviations in the table are presented below.

SPST: Science Process Skill Test

SCT: Solution Concept Test

ASTC: Attitude Scale toward Chemistry

ICCA: Instruction based on Conceptual Change Approach

TM: Instruction based on Traditional Methods

SECT: Solubility Equilibrium Concept Test

ASCCT: Attitude Scale toward Conceptual Change Texts

4.2 Population and Subjects

All tenth grade students in Ankara which is the capital city of Turkey, are identified as the target population of the study. However, since it is difficult to conduct an experimental study on such a big population, the accessible population is chosen as all tenth grade students in Çankaya district.

Kocatepe Mimar Kemal High School was chosen from the schools in Çankaya district. Four science classes where the chemistry course is thought in 2004-2005 spring semester were chosen randomly from the possible classes in Kocatepe Mimar Kemal High School. The classes were randomly assigned as control group and experimental group since it is difficult to arrange classes by selecting students randomly. The data analyzed in this research study were taken from 58 students participated in instruction based on conceptual change approach and 67 students participated in instruction based on traditional methods. In other words, the number of students in experimental group was 58 and the number of students in control group was 67. Therefore, in this study in total 125 tenth grade students (51 male and 74 female) participated.

4.3 Variables

4.3.1 Independent Variable

The independent variables are two types of instruction methods which are instruction based on traditional method and instruction based on conceptual change approach.

4.3.2 Dependent Variable

The dependent variables are students' understanding of solubility equilibrium concept, their attitudes toward chemistry as a school subject and their attitudes toward conceptual change texts.

4.4 Instruments

Random assignment of individuals to control and experimental groups were not possible; therefore, before the treatment researcher administered SPST and SCT to both groups to control preexisting difference in groups. That is, science process skills and achievement of students in both groups before the study were treated as a covariate to prevent researcher observe difference that can result from the nature of groups. SECT was administered to both groups as a post test to assess the achievement of students on solubility equilibrium concept after the treatment. In addition ASTC was administered before and after the treatment to both groups and ASCCT was administered to experimental group after the treatment.

4.4.1 Solution Concept Test (SCT)

The test was developed by researcher by examining related literature, textbooks and several test books (see Appendix B). Items in the test were related to solution and solubility concepts. There were 20 multiple choice questions. Most of questions in the test required students to think qualitatively; that is, without doing any calculation and predict the correct answer where the alternatives are designed so that they reflect students' misconceptions. In addition, there were questions that require easy computations. For the content validity, the test was investigated by faculties in chemistry, science education and by chemistry teachers. They reported that the questions were appropriate with solution content and the grade level of students. The item and test analysis program, ITEMAN (Version 3.00), was run. The mean proportion correct and mean biserial values were obtained as 0.645 and 0.468, respectively. The ITEMAN result indicated that the 65% of the items were correctly answered by the participating students and the discrimination of items in general was good. The reliability coefficient calculated for internal consistency is 0.607.

4.4.2 Science Process Skills Test (SPST)

The test was developed by Okey, Wise and Burns (1982) and translated and adopted by Geban, Askar and Ozkan (1992) into Turkish. The test contains 36 multiple choice questions with four alternatives. The reliability of the test reported as 0.85. Since the reported reliability coefficient is above 0.80, the researcher decided to use it. The test measures the intellectual abilities of students related to identify variables, identifying and stating hypothesis, designing investigations, graphing and interpreting the data (see Appendix C). The test was administered to all students before the study.

4.4.3 Solubility Equilibrium Concept Test (SECT)

The SECT was developed by the researcher considering misconceptions that students hold about solubility equilibrium (see Appendix D). The misconceptions that students have with respect to solubility equilibrium were obtained from the literature related to solubility equilibrium and interviews made by chemistry teachers and prospective chemistry teachers. The test was consisted of 30 multiple choice questions. The distracters in the test were arranged in a way that they reflect students' misconceptions obtained from literature review and interviews and presented in Appendix K. All of the items were related to solubility equilibrium and developed from the data bank of Student Selection Test (ÖSS and ÖYS) in Turkey and several test books to assess students' understanding of solubility equilibrium. For the content validity, the test was investigated by faculties in chemistry, science education and by chemistry teachers. They reported that questions were appropriate to solubility equilibrium content and to students' grade level. The item and test analysis program, ITEMAN (Version 3.00), was run. The mean proportion correct and mean biserial values were obtained as 0.435 and 0.353, respectively. The ITEMAN result indicated that the 44% of the items were correctly answered by the participating students and the discrimination of items in general was good. The reliability coefficient calculated for internal consistency is 0.658.

4.4.4 Attitude Scale toward Chemistry (ASTC)

The scale was developed by Geban and Ertepınar (Geban et al, 1994) to measure students' attitudes toward chemistry as a school subject (see Appendix E). The scale contains 15 items with 5 point Likert type scale (strongly agree, agree, undecided, disagree, and strongly agree) in Turkish. The reliability was found to be 0.83. The test was given to students in both experimental and control group before and after the treatment.

4.4.5 Attitude Scale toward Conceptual Change Texts (ASCCT)

In order to assess students' attitudes toward the distributed conceptual change texts, the scale developed by Yalvaç (1998) was used (see Appendix F). The scale consisted of 25 items with 5 point Likert type scale (strongly agree, agree, undecided, disagree, and strongly agree). The items of the scale covered five dimensions; like/dislike, attention, interest, anxiety and importance. The items were prepared in Turkish. The reliability coefficient of the test was reported as 0.90. This test was administered to experimental group at the end of the treatment.

4.5 Procedures

The ERIC, Social Science Citation Index and Dissertation Abstracts International databases are systematically searched with several descriptors which are the words the researcher uses to tell the computer what to search for (Frankel & Wallen, 2001). Moreover, national database in YÖK and several national journals such as Hacettepe Üniversitesi Eğitim Facültesi Dergisi, Eğitim ve Bilim Dergisi and Milli Eğitim Dergisi were searched. In addition, search engines such as Yahoo, Google and Altavista were searched periodically. The descriptors are used together by the help of Boolean operators such as “and” and “or”. The keywords used are; constructivism, traditional teaching and learning, learning theories, conceptual change models, cognitive conflict, conceptual change approach, misconception, alternative conception, concept, conception, solubility equilibrium, ionic equilibrium, ionic equilibria, solubility equilibria, conceptual change text, chemical equilibrium, equilibrium, equilibria, solutions, refutation text, analogy, graphical organizers, attitude, science process skill, metacognition.

4.6 Activities

Conceptual Change Texts (CCTs) were developed by the researcher before study was conducted. CCTs were developed in order to remediate students’ misconceptions obtained from the literature review and interviews conducted by chemistry teachers and prospective chemistry teachers. In other words, each CCT was designed to help students realize their misconceptions; that is, made them to realize inadequacy of their prior knowledge and help them to remediate these misconceptions. CCTs were prepared according to Roth’s (1985) procedures considering metacognitive strategies. At the beginning of each text students are presented with a question and are asked to answer it. This question reflects a conflicting situation that helps students to realize something is wrong. In order to develop conflicting situations, the researcher examined interviews conducted with chemistry teachers and prospective teachers on students misconceptions. Students’ most common misconceptions were determined from these interviews and then used in constructing the conflicting situations. After that, it is explained that many students have misconceptions and why these misconceptions are inconsistent with scientific view is also explained. Then, correct explanation to conflicting situation is presented and several examples, analogies and graphical organizers are used to make content more concrete and easy to understand and support the scientific explanation. In summary, CCTs were designed so that students are convinced that the scientific explanation is more accurate than the preconceptions. Moreover, in order to gain students' interest several cartoons are used. Each activity was designed considering students' grade level and their prior knowledge. Moreover, activities were easy to read and the content was prepared appropriate to solubility equilibrium concept. Several teachers, prospective teachers and a faculty investigated appropriateness of each activity to grade level of students and the content. They have indicated that the activities were appropriate to grade level and solubility equilibrium content (see Appendix G).

4.7 Methods

Subject of solubility equilibrium was instructed to students in the experimental groups by conceptual change approach (CCA) while to students in control groups by traditional method (TM). Three teachers participated to the study. One teacher taught both an experimental and a control group. The control groups were instructed with lecturing method where students were passive listeners and the teacher was transmitting the facts and important concepts to students. Moreover, the teacher was presenting the "right" way to solve a problem without giving any opportunity of students to think critically. In addition, there was no emphasis on misconceptions while teaching. The experimental group was instructed by a method which was based on conceptual change approach where conceptual change texts (CCTs) were used. In that method, the teacher tried to help students realize that some of their preconceptions are wrong and help them to overcome these misconceptions by introducing conceptual change texts during the sessions. In addition, students were given an opportunity to think critically while solving the problems related to solubility equilibrium by letting them discuss problems critically with their friends (see Appendix H). Moreover, both experimental and control groups received instruction on solubility equilibrium twice a week during two-hour class periods for three weeks (12 consecutive chemistry lessons).

4.8 Research Methodology

High school chemistry teachers and several prospective chemistry teachers were interviewed before the study. The interviews were semi-structured and conducted individually. According to Fraenkel and Wallen (2001) semi-structured interviews consist of several questions designed to elicit specific answers on respondents. The researcher therefore, prepared several questions to find out misconceptions students hold about solubility equilibrium. Therefore, participants were asked whether they have observed any misconception related to solubility equilibrium and they have also presented with misconceptions obtained from literature review and were asked whether their students have such misconceptions. All misconceptions mentioned by participants were written and discussed for possible reasons of obtaining these misconceptions. In addition, participants were handed a copy of the CCTs and were asked to read these materials and indicate whether the content is appropriate to grade level of students and solubility equilibrium content. Suggestions of participants were considered and final form of CCTs were then prepared. The duration of interviews ranged from 50 to 70 minutes. The researcher then developed SCT and SECT which were used as a pre test and a post test before study begins. The researcher did not use SECT as pre test since the students were not familiar with the concept of solubility equilibrium. Therefore, the results will probably be affected much from the chance factor. In other words, students will probably respond to most of the questions by guessing. Therefore, the researcher developed SCT since students have already been taught of solution concept. The validity of the tests is investigated before the administration by faculties in chemistry, science education and by several chemistry teachers. As a result, the tests were used in the study. In addition, the researcher developed lesson plans and CCTs (see Appendices H & G) before the study and both of them was also examined by teachers, prospective teachers and a faculty in chemistry education for appropriateness of content, grade level and context. CCTs were developed based on Roth's (1985) procedure considering metacognitive strategies. In these text analogies, examples and graphic organizers were used to make content more concrete and easy to understand. Then, teachers and students that will participate in to the study were decided. Experimental group teachers received three hour training. In these training sessions, teachers were informed of constructivist teaching strategies, conceptual change approach and conceptual change texts. They are informed of how lessons will be taught and how CCTs will be used. All teachers were also trained of standard test administration. Meanwhile the experimental and control groups were decided. The study then conducted and it lasted in five weeks. Two of the science classes were assigned as experimental and two of the science classes were assigned as control groups. The control groups received materials and assignments based on TM and they are taught by TM. The experimental group received materials and assignments based on CCA and they were taught by CCA. Both groups were instructed on the same content which is solubility equilibrium in chemistry in coherence with the schools curriculum. Before the treatment both control and experimental groups received SPST, SCT and ASTC to determine whether there was any difference between two groups with respect to understanding of solubility equilibrium, students' science process skills and their attitudes toward chemistry as a school subject. In the control groups, students were instructed with traditionally designed chemistry teaching where the students were passive learners. That is, the students were there to listen and learn. The teacher generally used lecturing during the classroom instructions. Control groups received materials and assignments based on TM such as problems that the teacher have already presented the correct methodology of solving where the students were not questioning anything but just applying as they were doing usually in chemistry courses. In the experimental groups students were given an opportunity to ask questions, discuss and experience that everybody has different views. While teachers instructing on experimental group they used strategies such as conceptual change texts to make students realize that some of their previous ideas are not adequate to scientific literature by the help of cognitive conflicts. This is the first condition of conceptual change model that was developed by Posner at al (1982). While instruction, teachers explained why misconceptions that students hold are wrong. Moreover, they explained the scientifically correct answer by analogies, demonstrations and providing daily life examples. For example, to show that when the equilibrium is reached the process of dissolution and decomposition does not finish, teacher used the analogy of moving staircases. By the help of this analogy, students would probably realize that at equilibrium the rate of dissolution is equal to rate of decomposition and the process goes on if all the other things hold constant. In this stem, teacher tried to accomplish Posner et al's (1982) conditions of intelligibility and plausibility. However, they were reminded by the researcher of the importance of proper usage of analogies in order not to cause any misconception. In addition, some daily life examples were given to students such as formation of stalactites and stalagmites. Therefore, students would have an opportunity to realize that chemistry is important for explaining environment around us. They also saw the usage of new concept in different situations. Therefore, Posner et al's (1982) last condition was also achieved. At the end of treatment both groups received SECT and ASTC which were administered by the teachers to their classes in 40 minutes time in their regular classes. In addition, the experimental group also received ASCCT at the end of the treatment. Moreover, students' chemistry grades and teachers' opinion about each student's performance on chemistry is collected. The researcher collected these data in order to see how students in each classroom were arranged according to chemistry achievement. It is observed that all the classes were having students with varying grade levels. In other words, classes were heterogeneous when students' grade level is considered. In addition, teachers' opinion about each student's chemistry performance was obtained since some of the students might have low grades although they are good at chemistry because of some other factors. The correlation between chemistry grades and teachers opinion was very high as expected. The Pearson correlation coefficient is found as 0.922. In addition, these data was collected to investigate whether the students having different chemistry grades have effected differently from the treatment. In other words, the treatment may function better for some students then the others; therefore, it is crucial to investigate the performance of students with different chemistry achievement on understanding of solubility equilibrium. It is investigated deeply in Chapter V.

4.9 Treatment Fidelity and Treatment Verification

Treatment fidelity helps researcher to make sure that the difference in the dependent variable is not due to another factor than the treatment itself before the study is conducted (Borrelli et al., 2005; Detrich, 1999; Hennessey & Rumrill, 2003). Therefore, by the help of a faculty in chemistry education the lesson plans, materials and assignment are investigated to assess whether the desired data can be obtained by the help of these instruments and decide whether the observed difference does not result from other factors than the treatment. A faculty in chemistry education ensured that the instruments developed are appropriate for the purpose of the study.

Treatment verification helps researcher to decide whether treatment was done as defined in the study (Shaver, 1983). Therefore, while conducting the study researcher participated to several lessons and observed the teacher and students. In addition, anecdotal information obtained from teachers and their self reports of lessons are investigated. The researcher filled the observation checklist (see Appendix I) which was composed of several items that question how well something is done to rate. The scale consisted of 15 items with 5 point Likert type scale (Excellent, Above Average, Average, Below Average, Poor). Moreover, teachers were also presented of checklist (see Appendix J) that contains 17 questions designed to elicit teachers self evaluation of their instruction. The minimum requirement to say that the treatment was used as expected is to observe required behavior at least in average for most of the items in the checklist. That is, at least 75 percent of the items were expected to be marked as average or above.

4.10 Ethical Concerns

This study does not cause any possible harm to participants. That is, neither teachers nor students were placed under risk. The study and observations were an accepted part of school practice. The teachers were informed of rational for observing them. However, it should not be forgotten that this may affect behavior of teacher. In other words, teachers can behave as researcher expects. Therefore, the researcher reminded that the study does not aim to investigate the teachers and their teaching style, but just designed to investigate the two different teaching methods and the results of observation will just be mentioned in general that is no specific detail will be given such as their names. In other words, no one else had an access to the data.

4.11 Threats to Internal Validity

Internal validity means that any difference observed in dependent variable is directly related to independent variables and not to any other unintended variable (Fraenkel & Wallen, 2001). Therefore, it is important to control threats to internal validity. Some of these treats as presented by Fraenkel and Wallen (2001) are subject characteristics, mortality, location, instrumentation, testing, history, maturation, attitude of subjects, regression and implementation.

In this study the prior achievement and science process skills of students in EGs and CGs were treated as a covariate in the analysis of data to prevent prior differences that exist between the groups to effect observed difference in the post test mean scores of both groups. The students in EGs and CGs were at the same grade level which keeps age variable constant. Therefore, these variables do not effect the change observed in dependent variable. However, since the sample was not selected randomly from the population other subject characteristics may correlate with dependent variable.

Careful planning was done to ensure the participation of all students to pre tests and post test presented. However, there were students who did not participate to pre test presented. The data of students that did not participate to pre test (SCT) was handled and missing data analysis procedures were carried out. In addition, there were no items that were left unmarked, that is every student participated to the study marked all the items of the tests presented to them.

The location threat was controlled by holding location of test and treatment constant. In other words, students in EGs and CGs received both tests and instruction in their regular classes which were identical in physical arrangement.

Instruments were developed in multiple choice format (SPST, SCT, SECT) and in Likert scale (ASTC, ASCCT). Therefore, different interpretations of results were not possible which permits the instrument decay threat. Data collector characteristics is another threat to internal validity. In the study multiple collectors were used. In other words, all groups received instruments from their regular chemistry teachers. In order to control this threat all chemistry teachers participating to the study were trained of standard procedures of test administration. Moreover, in order to prevent data collector bias that can occur unconsciously, chemistry teachers were reminded of standard procedures of test administration before the instruments were provided to students. It is observed by researcher that all the teachers tried to obey standard procedures. In other words, before the administration of instruments the directions were read and necessary explanations were given by teachers. These procedures were adopted from procedures applied in Student Selection Test (ÖSS) in Turkey.

Pre test can also be one of the reasons of difference obtained in dependent variable. In order to prevent pre test effect which is students' awareness of possible treatment and tests, the researcher allowed sufficient time for desensitization (three weeks).

The researcher interviewed with teachers and some of the students in both groups to understand whether there are special events nowadays and at the time when tests are going to be administered. Researcher documented possible external events and while administering the tests the researcher observed the conditions of both groups. Moreover, contemporary control group was used in order to equate the effects of extraneous variables on dependent variable in both EGs and CGs.

Passage of time rather than the treatment itself can also unwillingly correlate with dependent variable. However, in the study testing procedures and treatments took place in students' regular classrooms approximately at the same time. In addition, all the students were at the same grade level. Therefore, maturation threat can not affect dependent variable.

Attitude of students toward the study and their participation also can create a threat to internal validity. In other words, Hawthorne, John Henry and Demoralization effects can affect students' performance on tests. Therefore, in order to control this thereat both groups received materials differing in philosophy. In the study control group students received material designed in traditional methods prepared by their teacher, however, experimental group students received texts based on conceptual change approach. Therefore, the effect of attitude thereat was reduced.

There was no regression thereat since the students were not selected on the basis of extremely low or high scores.

Implementation thereat may result from treating experimental group in unintended way which provides some advantage to experimental group. Since different teachers participated to the study implementation threat can occur because of difference in teachers' quality. Therefore, in order to control implementation threat one of the teachers was assigned to both experimental and control groups in order to equate treatment groups. Moreover, one of the remaining chemistry teachers was assigned to experimental group and the other teacher was assigned to control group in order to reduce the chance of an advantage to either method. In addition, experimental group teachers were trained before the study to ensure intended implementation of the treatments. Moreover, the EGs and CGs were observed to check whether teachers applied treatment as intended. Therefore, implementation threat was not likely to constitute a threat.

4.12 Assumptions

For the purpose of this research, the following assumptions apply:

1. It is assumed that the theoretical basis for the study is valid.
2. It is assumed that the students in control group were not affected by students in experimental group.
3. It is assumed that the conceptual change texts provide the context needed for students to alter their conceptions.
4. It is assumed that students were mentally prepared and intellectually mature enough to comprehend the concepts being taught.
5. It is assumed that instructors who used the conceptual change texts had the ability work with the 10^{th} graders.

6. It is assumed that teachers are not biased and the test scores are not affected by some external factors.
7. It is assumed that the students answered questions honestly.
8. It is assumed that students used metacognitive strategies in negotiating new information.

4.13 Limitations and Delimitations

For the purpose of this research, the following limitations and delimitations apply:

1. Random sampling can not be applied.
2. A small number of individuals were selected.
3. Just four classes from one school participated into the study.
4. Just 10^{th} grade students participated into the study.
5. Subjects are general high school students.
6. Content domain of the study is limited to the concept of solubility equilibrium.
7. Classes are intact groups.

CHAPTER V

RESULTS AND CONCLUSIONS

5.1 Results

This chapter presents the data analysis from the instruments and data collection techniques described in Chapter IV in order to answer the research questions. Qualitative results will be presented first and include a summary of findings from the high school chemistry teacher interviews and prospective chemistry teacher interviews. The quantitative results will be presented second and include the analysis of data gathered from instruments presented in Chapter IV. In other words, the results of analyses of hypothesis are presented.
The hypotheses were tested at a significant level of 0.05 since it is the most used value in educational studies. That is, the probability of rejecting the true null hypothesis was set to 0.05. In addition, the power of this study was set to 0.90. In other words, the probability of failing to reject the false null hypothesis was 0.10. The effect size was considered to be medium and the effect size index "f" is set to 0.30 (Cohen, 1977). In addition, medium effect size is observed in the results of previous related studies. Therefore, the necessary sample size is calculated as 58 for each EG and CG for a medium effect size and 0.90 power at 0.05 significance level.

Analysis of covariance (ANCOVA), analysis of variance (ANOVA), t-test and correlation analysis were used to test the hypothesis. Hinkle, Wiersma and Jurs (1998) presented two benefits of ANCOVA when using intact groups of subjects. In this study intact groups were used and treatments were randomly assigned to these groups. Therefore, for such an experimental arrangement there are two benefits of using ANCOVA. The first one according to Hinkle, Wiersma and Jurs (1998) is the adjustment for preexisting differences that may exist among the intact groups prior to the research study and the second one is the increase in the precision of the research from reducing the error variance.

The data were analyzed using SPSS (Statistics Package for Social Sciences, version 11.5) for personal computers.

5.1.1 Qualitative Results

Before high school students took the tests and the treatment, several high school teachers and prospective chemistry teachers were interviewed. The purpose of interviews was two fold. First, it was necessary to find out the misconceptions students hold about the solubility equilibrium concept since in the literature there was not many studies related to solubility equilibrium. Therefore, the researcher conducted the interviews in order to gain insight about the source, depth and details of students' misconceptions related to solubility equilibrium in addition to that found from the previous studies. Second, it was necessary to ensure that the prepared CCTs are appropriate to students' grade level and the solubility equilibrium content (see Table 5.1).

The interviews were semi-structured and conducted individually. Semi-structured interviews consist of several questions designed to elicit specific answers on respondents (Fraenkel & Wallen, 2001). First, the participants are informed of the purpose of the study and why the study is important. Then, they were asked several questions in order to obtain misconceptions students have about the solubility equilibrium and were presented of some misconceptions found from previous studies and asked to investigate and indicate whether they have observed these misconceptions. After that, they handed a copy of the CCTs and asked to read these materials and interpret whether the content is appropriate to grade level and solubility equilibrium content (see Table 5.1). They were asked to explain their answers to clarify their responses. The interviews each ranged from 50 to 70 minutes duration.

Most of the participants indicated that their students have difficulty in understanding the dynamic nature of the solubility equilibrium which may result from the misconceptions 1 and 2 presented in Appendix A. Students who believe that at equilibrium there is no precipitation and dissolution and at equilibrium dissolution stops, will not understand the dynamic nature of solubility equilibrium and therefore will fail to understand solubility equilibrium content in meaningful way. Participants also indicated that most of the students have difficulty in solving Ksp problems which may result from the misconceptions 3, 4, 5, 6, 7, 8, 10, 11, 12 and 17. Students who believe, for example, that at a given temperature Ksp can change and ion product can be used interchangeably with Ksp, will have difficulty in solving Ksp problems and therefore will fail to understand solubility equilibrium content in meaningful way. Another difficulty indicated is in understanding of graphs related to solubility equilibrium content and which may result from misconceptions 9, 13, 14, 15, 16 and 19. Some of the students who believe, for example, that the rate of dissolution increases with time from mixing the solid with solvent until equilibrium establishes or at equilibrium addition of salt affects the equilibrium, will have difficulty in both sketching and understanding graphs related to solubility equilibrium and therefore will fail to understand solubility equilibrium content in meaningful way. The other related misconceptions presented in Appendix A may also result in failing to understand graphs related to solubility equilibrium concept. Moreover, most of the participants indicated that the misconceptions presented are hold by most of the students. Therefore, the post test questions are developed so that they reflect these misconceptions (see Appendix K).

Table 5.1 Some of the Questions Asked in Interviews

Part 1. To Identify Students Misconceptions
• Do you think it is easy to teach solubility equilibrium concept? Why? • In your opinion, what problems do students have in understanding solubility equilibrium concept? Please explain. • Did you observe students to have difficulty in understanding solubility equilibrium? • What percent of the students (considering all your classes) you can say to have these problems? • In which parts of the solubility equilibrium content do students have difficulty in understanding? • In your opinion, what may be the reasons of observing such difficulties? Why? • Did you observe any student to have some of the misconceptions in the list given? • Which misconceptions are frequent? • Did you observe any other misconception not included in the list? Please specify. • Would you present any other misconception that students could probably have?
Part 2. To Ensure Appropriateness of CCTs
• Do you think that the CCTs given are appropriate to students' grade level? Why? • Is there any part that should be removed since it is not appropriate to students' grade level? • What would you suggest to make these texts more appropriate to students' grade levels? • Do you think that CCTs given are appropriate with solubility equilibrium content? • In your opinion are the CCTs given easy to read and understand? Why? • In which parts of the CCTs students may have difficulty in understanding? Why? • In your opinion, which parts of the CCTs should be revised? Why? • Do you think that analogies and graphic organizers used are appropriate? Why? • What would you suggest to make the content of CCTs more understandable? • What is your opinion about the effectiveness of the CCTs, I mean do you think CCTs are helpful and can remediate students' misconceptions? • What would you suggest to make these CCTs more effective?

5.1.2 Quantitative Results

Before explaining the analysis it is important to investigate how the number of individuals participated has changed. In total, 125 students participated to the study. All of the students participated to the post test. Three of the students did not participate to SPST which is 2.4 % of the total data. Since the data in variables SPST contain less than 5% missing value any procedure for handling missing data is appropriate therefore the missing data was replaced with the mean. 17 of students did not participated to SCT and pre ASTC which is 13.6 % of the total data and all of the students participated to post ASTC and ASCCT. The missing data was then analyzed to see whether they are distributed randomly in two groups. In other words, the pattern of missing data is more important than the amount of missing data. That is, missing values that are randomly scattered through the data, poses less serious problems. Therefore, the researcher investigated the pattern of missing values. From the results obtained, the distribution of the missing data was found to be random; that is, missing values were randomly scattered through the data. Consequently, missing values in SCT and pre ASTC were replaced with the mean of the each variable.

5.1.2.1 Solubility Equilibrium Concept Test (Post Test)

The proportion of correct responses to the questions in the post test for two groups is presented in Appendix L. Graphical representation of proportion of correct responses to the each question in the post test for experimental and control group is presented in Figure 5.1.

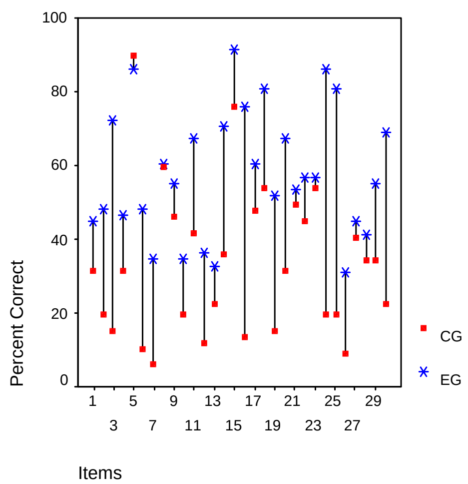

Figure 5.1 Percent Correct versus Post Test Items for EG and CG

If the data in Appendix L or Figure 5.1 is investigated deeply it can easily be seen that there is a difference in responses between the two groups (EG and CG) to the items in SECT.

The percent of correct responses to questions in SECT differs mostly between EG and CG in questions 2, 3, 6, 7, 10, 12, 14, 16, 19, 20, 24, 25, 26 and 30. In questions 8, 21, 23 and 27 the proportion of correct responses are almost equal. In question 5 the control group students performed better than that of experimental group. However, in this question the proportion of correct responses in both groups were very high. 89.6 % of the control group students and 86.2 % of the experimental group students correctly answered the question 5. In this question students are expected to remember that substances in solid state are not included in to the Ksp equation. This question is a simple question which asks for factual knowledge. Therefore, it is not surprising control group students to perform better than that of experimental group since in traditionally designed instruction factual knowledge is very important (Uzuntiryaki, 2003). Although questions 8, 21, 23 and 27 are almost equally answered correctly, the experimental group in these questions still performed better. The questions 8 and 21 are simple regular calculation questions; therefore, students who know the procedure of how these types of questions can be solved, can also easily answer the question correctly. Therefore, the control group student can also correctly answer these questions easily. In questions 23 and 27 students are expected to know the difference between Ksp and Qi and know that the Ksp values does not degreases always as temperature degreases, respectively. 53.7 % of the control group students and 56.9 % of the experimental group students answered the question 23 correctly and 40.3 % of the CG students and 44.8 % of the EG students answered the question 27 correctly. The results indicated that treatment has little effect on remediation of misconception 7 and 12 since both EG and CG performed equally after treatment on questions 23 and 27. In addition, the results also indicated that students have these misconceptions since half of the students participated to the study selected incorrect alternatives in these questions.

In the control group 19.4 % of the students and in the experimental group 48.3 % of the students correctly answered the question 2 in SECT. This question identifies several alternative conceptions students hold such as believing that at equilibrium there is no precipitation and dissolution and believing that at equilibrium dissolution stops. The results indicated that students have difficulty in understanding that at equilibrium the medium contains both the ionic compound and its ions which indicates that the process of dissolution and precipitation did not finish and goes on. The percentage and frequency of EG and CG students' selection of alternatives of item in SECT is presented below.

Table 5.2 Response Pattern of EG and CG Students on Question 2

	Control Group		Experimental Group	
Alternatives	Frequency	Percent Correct	Frequency	Percent Correct
A	14	21.0	14	24.1
B*	13	19.4	28	48.3
C	6	9.0	2	3.4
D	9	13.4	3	5.2
E	25	37.3	11	19.0
Total	67	100	58	100

(*) correct response

Question 3 was related to addition of common ion to equilibrium system. Only 14.9 % of the control group students gave correct answer whereas 72.4 % of the experimental group students correctly answered the question. This question identifies several misconceptions such as believing that at equilibrium the concentrations of ions will remain constant although common ion is added and believing that at equilibrium there is no precipitation and dissolution. The results indicate that CG students have difficulty in understanding what happens when common ion is added whereas most of the EG students have correctly answered the third question. The percentage and frequency of EG and CG students' selection of alternatives of item in SECT is presented below.

Table 5.3 Response Pattern of EG and CG Students on Question 3

	Control Group		Experimental Group	
Alternatives	Frequency	Percent Correct	Frequency	Percent Correct
A	15	22.4	4	6.9
B	13	19.4	1	1.7
C*	10	14.9	42	72.4
D	14	20.9	2	3.4
E	15	22.4	9	15.5
Total	67	100	58	100

(*) correct response

10.4 % of the CG students and 48.3 % of the EG students answered the question 6 correctly. This question investigates the effect of addition of common ion to solubility of a given salt. The percentage and frequency of EG and CG students' selection of alternatives of item in SECT is presented below.

Table 5.4 Response Pattern of EG and CG Students on Question 6

	Control Group		Experimental Group	
Alternatives	Frequency	Percent Correct	Frequency	Percent Correct
A	13	19.4	19	32.8
B*	7	10.4	28	48.3
C	15	22.4	3	5.2
D	14	20.9	6	10.3
E	18	26.9	2	3.4
Total	67	100	58	100

(*) correct response

Although majority of EG students gave correct response to the item there is still 32.8 % of students who selected the alternative which indicates that the addition of common ion does not affect the solubility of a given salt. Therefore some of the EG students after treatment may still hold misconception that at equilibrium the concentrations of ions will remain constant although common ion is added.

A similar difference between EG and CG is obtained for item 7 which is related to effect of change made in volume on solubility. Only 6.0 % of the control group students gave correct answer whereas 34.5 % of the experimental group students correctly answered the question. This question identifies the misconception of believing that solubility of sparingly soluble salts is affected by change made in pressure and volume. The results indicate that CG students have difficulty in understanding what happens when the volume changes. The percentage and frequency of EG and CG students' selection of alternatives of item in SECT is presented below.

Table 5.5 Response Pattern of EG and CG Students on Question 7

	Control Group		Experimental Group	
Alternatives	Frequency	Percent Correct	Frequency	Percent Correct
A	21	31.3	10	17.2
B	19	28.4	20	34.5
C*	4	6.0	20	34.5
D	23	34.3	8	13.8
Total	67	100	58	100

(*) correct response

If the alternatives of item 7 is investigated it is observed that although the EG students outperformed CG students in performance still 34.5 % of them are loaded in the alternative B. They think that since the volume of the system is reduced the concentrations should also be reduced. They forgot the relationship between the concentration and the volume. Therefore, after the treatment some of the EG students may still hold this misconception.

In the control group 35.8 % of the students and in the experimental group 70.7 % of the students correctly answered the question 14 in SECT. This question identifies several alternative conceptions students hold such as believing that at a given temperature the value of Ksp changes with the amount of solid or ions added, believing that at equilibrium addition of salt effects the equilibrium and believing that there is no relationship between Ksp and solubility. The results indicated that students have difficulty in understanding what happens when more salt is added to the solution. The percentage and frequency of EG and CG students' selection of alternatives of item in SECT is presented below.

Table 5.6 Response Pattern of EG and CG Students on Question 14

	Control Group		Experimental Group	
Alternatives	Frequency	Percent Correct	Frequency	Percent Correct
A	11	16.4	9	15.5
B	11	16.4	2	3.4
C	7	10.4	2	3.4
D*	24	35.8	41	70.7
E	14	20.9	4	6.9
Total	67	100	58	100

(*) correct response

If the alternatives of item 14 are investigated it is observed that 16.4 % of the students believes that when the salt of solution is added to equilibrium solution both solubility of the salt and Ksp increases which results from alternative conception of believing that at equilibrium addition of salt of solution effects the equilibrium. It is interesting to observe that 16.4 % of the students selected the alternative that when the salt of solution is added to equilibrium solution the solubility increases however Ksp decreases. This may results from the belief that there is no relationship between Ksp and solubility. 20.9 % of the students selected the alternative E of an item 14 which states that when the salt of solution is added to equilibrium solution solubility of a salt increases however the Ksp does not change. This also may results from the belief that there is no relationship between Ksp and solubility. When the performance of EG students are investigated it is clear that majority of them gave the correct answer which indicates the effectiveness of treatment on removing these misconceptions.

Question 16 was developed to investigate what solubility equilibrium is. Only 13.4 % of the control group students gave correct answer whereas 75.9 % of the experimental group students correctly answered the question. This question identifies several misconceptions such as believing that at equilibrium there is no precipitation and dissolution, believing that at equilibrium the concentrations of the ions produced is equal to the concentration of the salt and believing that mass can be used instead of concentration in solubility equilibrium calculations. The results indicate that CG students have difficulty in understanding what happens when equilibrium occurs whereas most of the EG students have correctly answered the question. The percentage and frequency of EG and CG students' selection of alternatives of item in SECT is presented below.

Table 5.7 Response Pattern of EG and CG Students on Question 16

	Control Group		Experimental Group	
Alternatives	Frequency	Percent Correct	Frequency	Percent Correct
A	17	25.4	7	12.1
B*	9	13.4	44	75.9
C	27	40.3	2	3.4
D	14	20.9	5	8.6
Total	67	100	58	100

(*) correct response

If the alternatives of item 16 are investigated it is observed that 25.4 % of the students believe that when solution is at equilibrium with its salt there is no dissolution and precipitation which results from alternative conception of believing that at equilibrium there is no precipitation and dissolution. 40.3 % of the students selected the alternative C that when solution is at equilibrium with its salt, the concentration of the salt and the solution is equal. This may results from belief that at equilibrium the concentrations of the ions produced is equal to the concentration of the salt. When the performance of EG students are investigated it is clear that majority of them gave the correct answer which indicates the effectiveness of treatment on removing these misconceptions.

A similar difference between EG and CG is obtained for item 19 which is related to effect of common ion on solubility and concentrations of ions. Only 14.9 % of the control group students gave correct answer whereas 51.7 % of the experimental group students correctly answered the question. This question identifies the misconception of believing that at a given temperature Ksp can change, believing that at a given temperature the value of Ksp changes with the amount of solid or ions added, believing that at equilibrium addition of salt effects the equilibrium and believing that at equilibrium the concentration of ions will remain constant although common ion is added. The results indicate that CG students have difficulty in understanding what happens when common ion is added at equilibrium system. The percentage and frequency of EG and CG students' selection of alternatives of item in SECT is presented below.

Table 5.8 Response Pattern of EG and CG Students on Question 19

	Control Group		Experimental Group	
Alternatives	Frequency	Percent Correct	Frequency	Percent Correct
A*	10	14.9	30	51.7
B	21	31.3	10	17.2
C	15	22.4	7	12.1
D	21	31.3	11	19.0
Total	67	100	58	100

(*) correct response

Question 24 was related to Ksp equation. Only 19.4 % of the control group students gave correct answer whereas 86.2 % of the experimental group students correctly answered the question. The results indicate that CG students have difficulty in understanding why the salt in solid state is not included in Ksp equation whereas most of the EG students have correctly answered the third question. The percentage and frequency of EG and CG students' selection of alternatives of item in SECT is presented below.

Table 5.9 Response Pattern of EG and CG Students on Question 24

	Control Group		Experimental Group	
Alternatives	Frequency	Percent Correct	Frequency	Percent Correct
A	32	47.8	2	3.4
B*	13	19.4	50	86.2
C	10	14.9	1	1.7
D	12	17.9	5	8.6
Total	67	100	58	100

(*) correct response

Majority of students in control group thinks that the salt in solid state is not included since the concentration of it is assumed to be 1. They confuse since the textbooks do not show that the concentration of the salt in solid state is constant therefore the multiplication of it with the equilibrium constant results in new constant which is Ksp. The textbooks and in traditionally designed lectures the teachers just remind students that the concentration of salt in solid state is constant therefore it does not appear in Ksp equation without showing why.

Therefore students may though that it should be one in order no to change the Ksp equation. However, when the performance of EG students are investigated it is clear that majority of them gave the correct answer which indicates the effectiveness of treatment.

In the control group 19.4 % of the students and in the experimental group 81.0 % of the students correctly answered the question 25 in SECT. This question identifies alternative conception of believing that rate of dissolving increases with time from mixing the solid with solvent until equilibrium establishes. The results indicated that students have difficulty in understanding what happens to rate of dissociation and precipitation. The percentage and frequency of EG and CG students' selection of alternatives of item in SECT is presented below.

Table 5.10 Response Pattern of EG and CG Students on Question 25

	Control Group		Experimental Group	
Alternatives	Frequency	Percent Correct	Frequency	Percent Correct
A	24	35.8	2	3.4
B	4	6.0	3	5.2
C	9	13.4	3	5.2
D*	13	19.4	47	81.0
E	11	16.4	1	1.7
F	6	9.0	2	3.4
Total	67	100	58	100

(*) correct response

If the alternatives of item 25 are investigated it is observed that majority of the CG students (35.8 %) selected the alternative A. These students may think that before precipitation occurs, some time should pass. However, after adding the solid into solvent dissolution starts and at the same time precipitation starts. In other words, at the beginning the rate of dissolution is much more than the precipitation. But after some time the rate of dissolution becomes equal to precipitation and the equilibrium is reached. When the performance of EG students are investigated it is clear that majority of them gave the correct answer which indicates the effectiveness of treatment on remediation of the misconception.

Question 30 is related to relationship between the magnitude of Ksp and the rate of solubility. For this question 22.4 % of the CG students and 69.0 % of the EG students gave correct answers. The percentage and frequency of EG and CG students' selection of alternatives of item in SECT is presented below.

Table 5.11 Response Pattern of EG and CG Students on Question 30

	Control Group		Experimental Group	
Alternatives	Frequency	Percent Correct	Frequency	Percent Correct
A*	15	22.4	40	69.0
B	13	19.4	4	6.9
C	28	41.8	12	20.7
D	11	16.4	2	3.4
Total	67	100	58	100

(*) correct response

Most of the CG students selected the alternative C in item 30 at SECT. In other words, most of the control group students believe that as the magnitude of the Ksp increases the rate of solubility should increase which results from the 21st misconception presented in Appendix A. However, in the experimental group majority of students selected the correct response. Therefore, it is clear that EG students performed better on that item which indicates the effectiveness of treatment on remediation of the misconception.

The performance of both EG students and CG students are investigated on each item and it is observed that the EG students outperformed the CG students on SECT. Therefore, the treatment performed helps students on remediation of misconceptions they have on solubility equilibrium concept.

5.2 Analysis of Hypothesis

5.2.1 Prior Differences

The researcher first of all investigated whether there was a significant mean difference between groups at the beginning of the treatment. The results presented that there was no significant difference between the CG and EG in terms of students' understanding of solution concept, $t\ (123) = 0.583$, $p > 0.\ 05$. The experimental group students' and control group students' pre test mean scores are, $X_{EG} = 12.88$, $X_{CG} = 12.63$, respectively. In addition, students' attitudes toward chemistry as a school subject and their science process skills are also investigated to see whether there was a difference between CG and EG. No significant difference was found between the two groups with respect to students' attitudes toward chemistry as a school subject, $t\ (123) = 1.316$, $p > 0.\ 05$. The experimental group students' and control group students' pre test mean scores are, $X_{EG} = 49.78$, $X_{CG} = 51.93$, respectively. However, there was a significant difference between the two groups with respect to students' science process skills, t (123) = 4.196, $p < 0.05$. Therefore, students' science process skills were treated as a covariate in the statistical analysis in order to control this preexisting difference. The EG and CG students SPST mean scores are $X_{EG} = 23.03$ and $X_{CG} = 20.10$.

5.2.2 Understanding

Hypothesis 1 which states that there is no significant difference between the post test (SECT) mean scores of students taught by traditionally designed instruction and those taught by instruction based on conceptual change approach with respect to understanding solubility equilibrium concept when science process skills and prior achievement (SCT) is controlled as a covariate, is investigated first. The results of ANCOVA analysis are presented below in Table 5.12.

Table 5.12 ANCOVA Summary Understanding

Source	df	SS	MS	F	p
Pre-test (SCT)	1	109.817	109.817	19.859	0.000
SPST	1	22.569	22.569	4.081	0.046
Group	1	597.130	597.130	107.985	0.000
Gender	1	0.038	0.038	0.007	0.934
Group*gender	1	0.949	0.949	0.172	0.679
Error	119	658.039	5.530		
Total	125	29447.000			

A one way analysis of covariance was conducted. The independent variable was instruction methods which are ICCA and TM. The dependent variable was the students' understanding of solubility equilibrium concept and the covariates were students' science process skills (SPST) and their prior achievement (SCT). The ANCOVA was significant, $F(1, 119) = 107.985$, MS = 597.130, $p < 0.05$, partial eta squared 0.476. The strength of relationship between instruction method and understanding of solubility equilibrium was very strong. Instruction method accounts for 47.6 % of the variance of the dependent variable when the SCT and SPST are controlled as a covariate.

The ANCOVA results presented above showed that there was a significant difference between the post test mean scores of students taught by traditionally designed instruction and those taught by instruction based on conceptual change approach with respect to understanding solubility equilibrium concept. The experimental group students scored significantly higher than control group students, X_{EG} = 17.78, X_{CG} = 12.39, respectively.

Hypothesis 2 which states that there is no significant difference between the post-test mean scores of males and females in their understanding of solubility equilibrium concept is investigated by the help of ANCOVA. Analysis of covariance results (see Table 5.12) presented that there was no significant mean difference between male and female students in terms of understanding of solubility equilibrium concept, $F(1, 119) = 0.007$, $MS = 0.038$, $p > 0.05$. The mean post test scores for males and females were, X_M = 13.92, X_F = 15.55, respectively.

Hypothesis 3 which states that there is no significant effect of interaction between gender difference and treatment with respect to students' understanding of solubility equilibrium concept was investigated by the help of ANCOVA results (see Table 5.12). The results revealed that there was no significant interaction effect between gender difference and treatment on students' understanding of solubility equilibrium $F(1, 119) = 0.172$, $MS = 0.949$, $p > 0.05$.

Hypothesis 4 which states that there is no significant contribution of students' prior achievement to understanding of solubility equilibrium concept was analyzed next. The results (see Table 5.12) indicated that there was a significant contribution of prior achievement on students' understanding of solubility equilibrium concept, $F(1, 119) = 19.859$, $MS = 109.817$, $p < 0.05$.

Hypothesis 5 which states that there is no significant contribution of students' science process skills to understanding of solubility equilibrium concept was analyzed next. The results (see Table 5.12) indicated that there was a significant contribution of science process skills on students' understanding of solubility equilibrium concept, $F(1, 119) = 4.081$, $MS = 22.569$, $p < 0.05$.

5.2.3 Attitude

Hypothesis 6 which states that there is no significant difference between students taught with traditionally designed instruction and students taught with instruction based on conceptual change approach with respect to their attitudes toward chemistry as a school subject, analyzed next by the help of ANOVA. The ANOVA results are presented below in Table 5.13.

Table 5.13 ANOVA Summary Attitude

Source	df	SS	MS	F	P
Group	1	185.751	185.751	2.515	0.115
Gender	1	400.676	400.676	5.426	0.021
Group*gender	1	14.597	14.597	0.198	0.657
Error	121	8935.303	73.845		
Total	125	355485.000			

The null hypothesis was not rejected at 0.05 significance level. Therefore, there was no significant difference between EG students and CG students with respect to attitudes toward chemistry as a school subject, $F(1, 121) = 2.515$, $MS = 185.751$, $p > 0.05$. Therefore, students taught with instruction based on conceptual change approach have almost similar attitudes toward chemistry as a school subject with students taught with traditionally designed instruction, $X_{EG} = 51.69$, $X_{CG} = 53.42$, respectively.

In order to analyze hypothesis 7 which states that there is no significant difference between post chemistry attitudes mean scores of males and females, analysis of variance (ANOVA) was run (see Table 5.13). The results indicated that there was a significant mean difference between male and female students with respect to attitudes toward chemistry as a school subject, $F(1, 121) = 5.426$, $MS = 400.676$, $p < 0.05$. Female students' mean post attitude score was 53.92 and male students' mean post attitude score was 50.73.

Hypothesis 8 which states that there is no significant effect of interaction between gender difference and treatment with respect to students' attitudes toward chemistry as a school subject was investigated next. The results (see Table 5.13) revealed that there was no significant interaction effect between gender difference and treatment on students attitudes toward chemistry as a school subject, $F(1, 121) = 0.198$, $MS = 14.597$, $p > 0.05$.

In order to analyze hypothesis 9 which states that there is no relationship between EG students' attitudes toward CCTs and their understanding of solubility equilibrium concept correlation analysis was conducted. The results of the analysis can be seen in Table 5.14.

Table 5.14 Correlation between SECT and ASCCT Scores of EG Students

Variables	N	Correlation coefficient	p
SECT	58	0.257	0.051
ASCCT	58		

The results indicated that there was no significant correlation between students understanding of solubility equilibrium concept and their views to CCTs ($p > 0.\ 05$).

In order to analyze hypothesis 10 which states that there is no significant difference between males and females with respect to their attitudes toward conceptual change texts, independent t-test was run. The results indicated that there was a significant mean difference between male and female students with respect to attitudes toward conceptual change texts, $t\ (24.153) = 2.421$, $p < 0.\ 05$. Female students mean attitude score toward CCTs was significantly higher than male students mean attitude score toward CCTs ($X_F = 89.70$, $X_M = 79.56$).

5.2.4 Chemistry Achievement

Hypothesis 11 which states that there is no significant mean difference in effectiveness of treatment on understanding of solubility equilibrium between experimental group students and control group students with respect to students' achievement in chemistry is investigated. The chemistry grade of students in both EG and CG is obtained. The chemistry grades range from 0 to 5. In addition, teachers opinion about each student is also obtained since some of the students may get low grades although they are good at chemistry because of some other factors. The teacher's opinion is also ranges from 0 to 5. The average of chemistry grade and teacher's opinion was taken for each student and the variable called chemistry achievement is constructed. The performance of students with different chemistry achievement for both EG and CG on post test (SECT) was investigated. Then, the mean of the post test scores for students with different chemistry achievement in both EG and CG was calculated. In other words, the mean post test scores for students with chemistry achievement 1, 2, 3, 4 and 5 for both EG and CG was calculated. In order to see the effect of treatment on students with different chemistry achievement for both EG and CGs with respect to understanding of solubility equilibrium the following graph was drown.

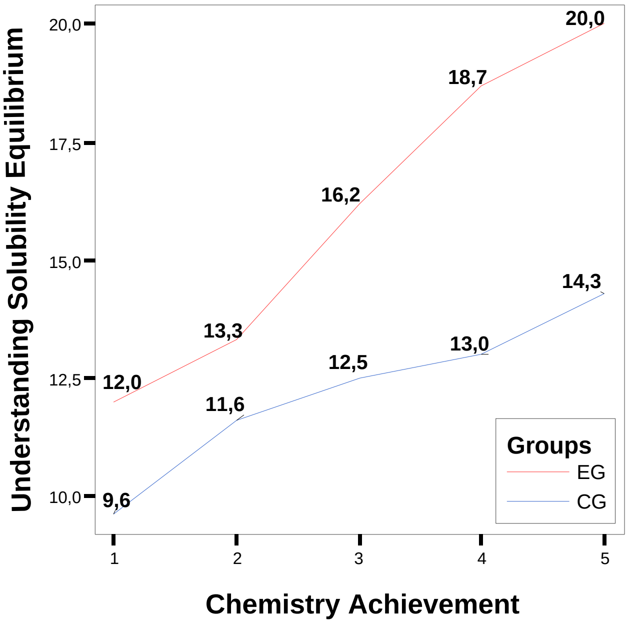

Figure 5.2 Understanding Solubility Equilibrium vs. Chemistry Achievement for EG and CG students

In general linear trend is expected between chemistry achievement and understanding of solubility equilibrium. However, students in EG with chemistry grade of 2 performed low and students with chemistry grade of 4 performed high when linear trend is considered. In other words, the treatment (ICCA) works better for students with high chemistry achievement. This may result from several factors. One of these factors can be the reading ability. High achiever students have high reading ability. Understanding CCTs require students to read them carefully; therefore, high achievers will perform better. Another factor can be students' attitudes toward reading and the new method. In ICCA students are more active and therefore, their contribution and participation to lesson is high compared to TM where students were just listening to teacher. Therefore, low achievers can have difficulty. As it is said before, linear trend is expected between chemistry achievement and understanding of solubility equilibrium. However, students in CG with chemistry grade of 2 performed high and students with chemistry grade of 4 and 5 performed low on post test (SECT) when linear trend mentioned above is considered. The deviation from linear trend in CG may result from several factors. Traditionally designed instruction is based on factual knowledge where students are supposed to recall simple facts (Uzuntiryaki, 2003). Therefore, low achievers can perform better.

5.3 Observed Effect Size and Power

The magnitude of effect size was calculated by looking to eta square value. Since the partial eta square for the factor is interpreted as the proportion of variance of the dependent variable related to the factor, holding constant the covariate (Green & Salkind, 2005). The observed value for eta square in the ANCOVA analysis is 0.476. Eta square value indicates that treatment accounts for 47.6 % of the variance of the dependent variable (students understanding of solubility equilibrium concept), holding constant the prior achievement and science process skills. The effect size index "f" is calculated by the help of eta square value and found to be 0.95. The observed power is calculated by the help of table presented by Cohen (1977, p 311-312) and found as greater than 0.995 which is larger than the predefined power.

CHAPTER VI

DISCUSSION, IMPLEMENTATION and RECOMMENDATIONS

This chapter presents discussion of results obtained in Chapter V. In addition, implications of the findings are discussed and recommendations for further studies are presented. The chapter started with a summary of the study in order to remind what has been done and to help understanding of discussions and findings better.

6.1 Summary of the Study

Before the study, semi structured interviews were conducted in order to determine students' misconceptions with several high school chemistry teachers and prospective chemistry teachers. Based on these findings CCTs which are used in EGs were prepared. Then the study in which quasi experimental research design is used, was conducted. In order to assess the effectiveness of teaching methods, four intact classes from possible science classes were assigned to experimental and control groups randomly. In other words, EG and CG were each composed of two science classes. EG contained 58 students and control group contained 67 students. EG students received instruction based on conceptual change approach where CCTs were used; on the other hand, CG students were instructed by instruction based on TM. Each group received instruction for three weeks and the study lasted in five weeks. Before the study begun, the students in each class received SPST and a pre test (SCT) which was related to solutions and solubility. After the treatment each class received a post test (SECT) related to solubility equilibrium. Post test items were designed so that these items reflect misconceptions students have about solubility equilibrium. The effectiveness of instructions were then compared by investigating post test results while controlling prior achievement and science process skills of students as a covariate in statistical analysis of data. Moreover, students' attitudes toward chemistry and CCTs were also investigated. Therefore, EG students and CG students received ASTC before and after the treatment. In addition, EG students received ASCCT after the treatment.

The sample of students who participated in this study was all tenth grade high school students. The age of students ranges from 16 to 18. In addition, 41% of the students were male and 59% of the students were female. All the students were attending to Kocatepe Mimar Kemal High School.

The teachers who participated in this study were all experienced chemistry teachers. One of the three teachers instructed both EG student and CG students. The remaining two chemistry teachers instructed students in remaining two classes where one of the classes was composed of EG students and the other was composed of CG students. The teachers who taught EG students were instructed by researcher on constructivist education, conceptual change approach and conceptual change texts. In addition all of the teachers received instruction on standard procedures of test administration.

6.2 Discussion of Results

Before coming to school students have many preconceptions. Some of these preconceptions are inconsistent with scientific views and are called misconception. Misconceptions hinder learning since students construct knowledge by the help of already existing conceptions. If some of these already exiting conceptions are wrong then students can not learn science meaningfully. Therefore identification of misconceptions which are very resistant to change and difficult to extinguish, and finding ways for remediation of misconceptions are very important. Therefore, the main purpose of this study was to determine misconceptions students held about solubility equilibrium, investigate the effectiveness of conceptual change texts and compare the effectiveness of conceptual change text instruction and traditional instructional on understanding of solubility equilibrium concept. In addition, students' attitudes toward chemistry before and after the conceptual change text instruction and traditional instruction, students' attitudes towards conceptual change texts, students' science process skills and understanding of solubility equilibrium of students with different chemistry achievement in both experimental and control groups were also investigated. In this study, the researcher therefore first of all tried to find misconceptions students have about solubility equilibrium concept by interviews conducted and by reviewing the previous studies. In other words, some of the misconceptions were obtained from literature review and the others were obtained from the interviews. Semi structured interviews were conducted with chemistry teachers and prospective chemistry teachers in order to identify students' misconceptions. The interview results indicated that many students have misconceptions relevant to solubility equilibrium. Most of the interviewers indicated that their students have difficulty in understanding the dynamic nature of the solubility equilibrium, solving Ksp problems and understanding and interpreting graphs related to solubility equilibrium concept. In addition, the researcher and the participants discussed the reasons of observing these difficulties and presented the taxonomy of misconceptions related to solubility equilibrium (see Appendix A). It is observed that like all chemistry concepts students have several misconceptions related to solubility equilibrium. In addition, literature review indicated that most of the high school students have misconceptions in various chemistry concepts including solubility equilibrium. However, there are not many studies related to solubility equilibrium concept. Therefore, the taxonomy of misconceptions presented in this study gains importance. Students have misconceptions related to solubility equilibrium which hinders understanding and learning solubility equilibrium concept and chemistry in meaningful way. Therefore, students consider chemistry as a difficult subject. Then, finding ways to enhance meaningful learning which requires remediation of misconceptions is important. Remediation of misconceptions requires understanding how individuals construct knowledge. Piaget's cognitive stage theory is a good source for understanding how cognitive development occurs from infants through adolescents. In this theory individuals learn through assimilation, accommodation and equilibration processes. In other words, students construct new concepts through assimilation and accommodation of new information while they are exploring the world and store these concepts in to correct mental categories in their minds. Therefore, prior knowledge they have affects their further learning. These prior conceptions however can hinder construction of new knowledge. According to information processing theories individuals construct knowledge by forming connections between newly organized knowledge and existing relevant knowledge. Therefore, if the prior knowledge is incompatible with the new information meaningful learning can not occur. Therefore, teaching for understanding requires identification of misconceptions. There are several sources that cause misconceptions such as prior experiences, textbooks, teachers' explanations, instruction, terminology, social interaction and everyday language. The new knowledge is constructed by the help of prior knowledge according to information processing theories. Therefore, if the prior knowledge is incompatible with the new information, the construction of the knowledge will be inappropriate. The everyday language can also lead misconceptions. There are words that people attribute different meaning from meaning that scientists attribute to same words. Instruction can be another source for misconceptions. For example, inappropriately prepared analogies may cause students by mistake to over generalize situations where base and target domains differ. Since teachers also have misconceptions related to several subjects and content areas they can also be a source of misconceptions. Terminology used can also result in misconception. In other words, the meaning of terminology may change over time and may cause students to interpret the meaning of the terms differently. Interaction with friends, parents and others in addition to media can also cause misconceptions. Another source is textbooks. Although textbooks are considered as authoritative information they may also contain several mistakes which will probably result in misconceptions. After realizing that there are various sources of misconception finding ways for remediation of misconceptions then becomes very important. Conceptual change approach therefore aims to help students on remediation of misconceptions they have.

Conceptual change is a process of learning science in meaningful way that requires learner to rearrange or remediate existing misconceptions in order to accommodate new ideas. In other words, conceptual change occurs when learner changes misconceptions with that of scientifically accepted ones. Therefore, changing alternative conceptions require modifying or restructuring existing schemata. The major concern of conceptual change approach research is to find ways that can help correct the misconceptions students have. Therefore, conceptual change texts (CCTs) are prepared in this study related to solubility equilibrium concept in order to remediate misconception students have. CCTs were prepared according to procedures described by Roth (1985). Misconceptions students have were first identified. Identification of misconceptions was necessary for conceptual change since students develop ideas about objects and events based on their experiences. Based on these misconceptions, situations which are prepared to activate students' misconceptions was presented to elicit prediction about the phenomenon. In other words, knowing students' misconceptions related to solubility equilibrium concept, several conflicting situations based on these misconceptions were prepared. Cognitive conflict where students are provided with evidence that contradicts with their existing concepts, is necessary in order to achieve conceptual change. By the help of these conflicting situations students will realize that something is wrong. Moreover, according to Posner and his colloquies (1982), in order to achieve conceptual change students must be dissatisfied with existing conception. That is, individuals do not accept the new conceptions easily unless they realize that their alternative conceptions do not work anymore. Cognitive conflicts used helped students to realize that something is wrong with their prior conceptions. Moreover, when students face with conflicting situations they try to understand these confusing situations. They ask several questions to themselves to resolve these conflicts in their minds. In other words, they try to explain and find answers to their own questions. These questions help them to monitor the level of their understanding. For example, when the activity where the relationship between temperature and Ksp was given to students, some of them asked themselves “What should I do?” and they directed their energies in to finding the relationships between temperature and Ksp. While this process, students monitored and self evaluated their comprehension which would probably enabled them to notice errors they have made and self correct them. These processes were considered to be metacognitive since they provided learners to check how well they comprehend what they were learning. Then, students’ misconceptions related to solubility equilibrium following by evidence that they are wrong are presented. It is explained to students that many students have several misconceptions like these. In addition, why students construct such alternative conceptions were also explained with correct scientific explanations. Moreover, in order to achieve conceptual change the new conception must be intelligible according to Posner and his colleagues (1982). That is, the learner must know what it means and easily understand the conception. Therefore, CCTs are prepared so that every student can easily understand and comprehend what is written. In addition, in order to make content concrete and enhance remediation of misconceptions analogies, examples and graphic organizers are used. In other words, activities that involve presenting and developing ideas helped students to practice and strengthen the conceptual understanding. This also satisfies the third condition that is mentioned by Posner et al. (1982) where the new conception must appear plausible in order conceptual change to occur. In other words, the learner must believe that it is reasonable and it is consistent with their world view. Some daily life examples are given to show that the solubility equilibrium concept is very important for understanding the nature. Students can then find some value for learning the new concept which is the last condition presented by Posner et al.(1982) for obtaining conceptual change. Therefore, it is clear that identification of misconceptions, cognitive conflict and practice was very important in conceptual change approach. In addition, the reading ability of some of the students may be low and the attitude of some of the students toward reading may be negative. Therefore in treatment, CCTs are discussed individually by each student and by groups of students in addition to reading them. Discussions helped students to evaluate and express their ideas about the solubility equilibrium concept. Therefore, every student had an opportunity to discuss and understand what is written in CCTs.

Although some researchers argue that telling students how the world works in a text is not so effective (Lloyd, 1990; Newport, 1990; Osborne, Jones & Stain, 1985), many researchers indicated the effectiveness of CCTs (Dole & Niederhauser, 1990; Chambers & Andre, 1997; Guzzetti et al, 1993; Hynd et al, 1994; Cakir, Uzuntiryaki & Geban, 2002; Tekkaya, 2003; Sungur, Tekkaya & Geban, 2001; Uzuntiryaki & Geban, 2005; Hynd, Alvermann & Qian, 1997; Diakidoy, Kendeou & Ioannides, 2002). Moreover, it is founded that CCTs are appropriate to large classroom situations which is the general truth for majority of high schools in Turkey. Classrooms in this study at least contained 26 students therefore can also be considered as crowded. In this study, students instructed by instruction based on conceptual change approach where CCTs were used outperformed students instructed with instruction based on traditional methods. In other words, the results obtained in Chapter V showed that instruction based on conceptual change approach caused significantly better acquisition of concepts related to solubility equilibrium compared to traditionally designed instruction. Moreover, when the proportion of correct responses given to each item by students in EG and CG is compared, it is obvious that conceptual change approach was better than traditionally designed instruction in elimination and remediation of misconceptions. The results of the study support the previous studies (Çakır, Geban & Yürük, 2002; Yürük & Geban, 2001; Alparslan, Tekkaya & Geban, 2003; Canpolat, 2002; Niaz, 1998; Dole & Niederhauser, 1990; Chambers & Andre, 1997; Cakir, Uzuntiryaki & Geban, 2002; Tekkaya, 2003; Sungur, Tekkaya & Geban, 2001; Uzuntiryaki & Geban, 2005; Çil, 2000; Pınarbaşı, 2002; Yürük, 2000; Yılmaz, 1998; Özdemir, 1998; Ünlü, 2000; Alparslan, 2002; Bayır, 2000; Uzuntiryaki, 1998; 2003).

Instruction based on CCA was more effective in understanding of solubility equilibrium concept and remediation of misconceptions compared to TM. In conceptual change approach students misconceptions are identified and Posner et al's (1982) four conditions necessary for achieving conceptual change is considered while preparing CCTs and these texts are used to remediate students misconceptions related to solubility equilibrium. However, in TM there was no emphasis on students' misconceptions. Therefore, students who have misconceptions related to solubility equilibrium concept would not construct appropriate knowledge since students construct new knowledge by relating it with already existing knowledge. If proper relationships are not formed, meaningful learning can not occur. It is also obvious that in TM there is no effort to prevent and remediate misconceptions.

Before students receive the treatment, the researcher and a faculty ensured that desired data can be obtained by the help of instrument prepared. In addition, the researcher observed the treatment and the administration of tests in order to decide whether treatment was done as defined in the study. Therefore, while conducting the study the researcher observed several lessons and completed the observation checklist (see Appendix I) prepared by the researcher. In addition, sometimes an instruction evaluation checklist (see Appendix J) was presented to teachers after their lessons. In addition, anecdotal information was also collected from teachers after their instructions. The checklists and anecdotal information collected were investigated while deciding whether treatment was done as defined in the study. At least 75% of the items were expected to be marked average or above average in the scale given in order to accept that the treatment was done as defined. The findings indicated that 86.7% of the items were marked average or above average. Therefore, the treatment in this study was accepted to be done as defined in the study.

It is important to control threats to internal validity since if they were not controlled the difference observed in the dependent variable would be affected by some other factors in addition to independent variable. Several threats presented by Fraenkel and Wallen (2001) were considered and careful planning was done in order to control these threats to internal validity. The procedures done and precautions taken in order to control these threats were given and discussed in Chapter IV. On the other hand, several limitations and difficulties were observed while trying to control these threats. For example, sample of the study was not selected randomly from the population therefore subject characteristics that were not controlled could correlate with dependent variable which is one of the limitations of this study. While treatment was applied in both EGs and CGs there were absent students (generally one or two) in both EG and CG whose post test performance would probably be affected. In addition, although contemporary control group was used and test administrations were observed to control extraneous variables, there could be some other extraneous variables that were not controlled that could affect the dependent variable. Moreover, although control group students were also provided with materials designed on TM, some of these students could realize that EG students received something different. Therefore, their attitudes could be affected either positively or negatively which then will affect their performance on post test.

When post test scores are considered, students in EG outperformed students in CG on understanding of solubility equilibrium concept. In addition, EG students did well compared to CG students on each item (see Appendix L), except the item 5, on post test (SECT). This difference is an evidence for the effectiveness of CCA.

When post test (SECT) results were deeply investigated it was observed that there were questions in which EG students and CG students performed almost equally, and there were questions in which EG students answers were generally loaded on one incorrect alternative. Therefore some of the EG students after the treatment might still have some of the misconceptions. For example, 53.7 % of the CG students and 56.9 % of the EG students gave correct answers to item 23. Similarly, 40.3 % of the CG students and 44.8 % of the EG students correctly answered the item 27. The results indicated that half of the students have misconceptions 7 and 12 (see Appendix A). Therefore, the treatment was not much affective on remediation of these misconceptions since both EG and CG students gave almost equal correct answers.

When frequencies of alternatives selected by EG students in each item were investigated, it was observed that in some of the items majority of students who selected the incorrect alternative were loaded in one or two alternatives. For example in question 2, 24.1 % of the students selected the alternative A and 19.0 % of the students selected the alternative E where both of these alternatives were incorrect. Moreover, in questions 6, 7, 14, 19 and 30 similarly 32.8 %, 34.5 %, 15.5 %, 19.0 % and 20.7 % of the students were loaded in an incorrect alternative, respectively. The results of this analysis indicated that after the treatment some of the students in EG were still holding several misconceptions. Several factors could cause obtaining such results. Some of the students in EG were absent when the treatment was being applied. Therefore, these students had no chance to remediate their misconceptions. In addition, some of the students with low reading ability could not benefit much from CCTs although CCTs were discussed individually and in a group work. The length of the treatment could be another factor since the study lasted in three weeks. In other words, the proportion of time spent on treatment was limited. Moreover, attitude of students toward CCTs and the new method could affect their participation to lessons and therefore their performance in remediation of misconceptions. If they believe that the treatment is meaningless and useless; then, they would probably not show any effort to remediate their misconceptions related to solubility equilibrium. Students' level of motivation when they respond to tests administered, could also affect the study. Because of ethical considerations students were told that their scores obtained on each test would not be included on their overall science grade. Therefore, some of the students were observed to respond tests administered not seriously. However, to minimize this effect the teachers in each group told students to answer the questions as best as they could. Moreover, students were reminded that although their scores would not contribute to their science grade, their scores on tests would be given to their teachers for the purpose of instructional planning.

Students' prior achievement were tested by SCT before the study in order to determine whether students in both EG and CG differ significantly with respect to understanding of solution concept. Prior achievement of students in the two groups according to the results did not differ significantly. In other words, before the study both students in EG and students in CG have similar achievement in solution concept.

Students' attitude toward chemistry as a school subject was investigated before the study in order to determine whether students in both EG and CG differ significantly with respect to their attitudes toward chemistry as a school subject. Results revealed that attitude of students in EG and CG toward chemistry did not differ significantly before the study. In other words, students in both EG and CG had similar attitudes toward chemistry before the study.

Students' science process skills were tested before the study in order to determine whether students in both EG and CG differ significantly with respect to science process skill. Science process skills of students in the two groups according to the results differ significantly. It is also found that students' science process skills contribute significantly to students' understanding of solubility equilibrium. Therefore, science process skills of students are controlled while investigating the effectiveness of ICCA. In other words, the results obtained from SPST were treated as a covariate in ANCOVA analysis.

Attitude of students in CG and EG before and after the treatment toward the chemistry as a school subject were investigated in order to determine whether treatment has an effect on students' attitudes toward chemistry. The results indicated that before the treatment mean attitude scores of EG and CG students were $X_{EG} = 49.78$, and $X_{CG} = 51.93$, respectively. After the treatment the mean attitude scores of EG and CG students were obtained as $X_{EG} = 51.69$, and $X_{CG} = 53.42$, respectively. The attitudes of students in both EG and CG increased at same magnitude. In other words, the treatment done did not cause any significant difference on students' attitudes toward chemistry compared to attitudes of CG students. This result can be obtained because of the length of the treatment. The length of the treatment was short; therefore, attitude of EG students did not change much. In addition, slight increase in EG and CG students' attitudes could probably be obtained because of their involvement to the study.

The post test mean scores of EG and CG students were investigated. The results revealed that there was a significant difference between the post test mean scores of students taught by traditionally designed instruction and those taught by instruction based on conceptual change approach with respect to understanding of solubility equilibrium concept. In other words, students in EG outperformed students in CG on post test (SECT) which indicates that ICCA was more effective in remediation of misconceptions and understanding of solubility equilibrium concept.

The relation between gender difference and understanding of solubility equilibrium concept is also investigated. It is observed that there was no significant mean difference between male and female students in understanding of solubility equilibrium concept. In other words, male and female students who were instructed by conceptual change approach and traditional method do not differ significantly with respect to understanding of solubility equilibrium concept.

The interaction between gender difference and treatment in terms of understanding solubility equilibrium was also investigated. No significant interaction was found.

The contribution of students' prior achievement to understanding of solubility equilibrium concept was analyzed and significant contribution of prior achievement was found which shows the importance of prior knowledge in further learning. In other words, the importance of correct and appropriate construction of concepts and necessity of remediation of misconceptions were seen.

The contribution of students' science process skills to understanding of solubility equilibrium concept was also analyzed. Significant contribution of science process skills to understanding of solubility equilibrium was found. Therefore, instruction based on developing students' science process skills gains importance if enhancing students' understanding of solubility equilibrium is desired.

Attitudes of students after the treatment toward chemistry were investigated. No significant difference was observed between EG and CG students with respect to their attitude toward chemistry. In other words, after the treatment EG and CG students had similar attitudes toward chemistry.

The relation between gender difference and attitude toward chemistry as a school subject is also investigated. It is observed that there was a significant mean difference between male and female students in their attitudes toward chemistry. In other words, male and female students who were instructed by CCA and TM differ significantly with respect to their attitudes toward chemistry. That is, female students had more positive attitudes toward chemistry. In addition, the interaction between gender difference and treatment with respect to students' attitudes toward chemistry as a school subject was also investigated and no significant interaction was found.

Students' attitudes toward CCTs were determined by ASCCT. The relationship between the student's attitudes toward CCTs and their understanding of solubility equilibrium concept was investigated by the help of correlation analysis. The results indicated that there was no significant correlation between these two variables. In other words students' understanding of solubility equilibrium concept does not depend on their attitudes toward CCTs.

The relationship between gender difference and students attitudes toward CCTs was also investigated. The results revealed that female students had more positive attitudes toward CCTs. Similar results were found in attitudes toward chemistry. That is, female students had more positive attitudes toward chemistry and CCTs compared to male students.

The results of the tests were investigated and findings indicated that instruction based on conceptual change approach where CCTs are used was more effective at preventing and remediation of students misconceptions compared to traditionally designed instruction.

It is also observed that ICCA was more appropriate to high ability students and the TM was more appropriate to low ability students (see Figure 5.2). The main reason for obtaining such a relationship is that in TM the instructional materials are highly organized and therefore demands less reasoning and interpretation. In other words, "the more the required information processing that the instruction performs for the learner, the better that instruction is for low ability learners. Conversely the more of the required information processing which is left to the learner the better the instruction is for high ability learners"

(Koran & Koran, 1984). However, in CCTs although they are verbal which is generally good for high ability students, several diagrams, figures and analogies are used to replace abstract interpretations to benefit low ability students. When the results are interpreted carefully it is observed that although low ability students performed poor compared to high ability students in EG when liner relationship between chemistry achievement and understanding of solubility equilibrium is considered they outperformed students with same ability level in CG. For example, the mean post test scores of students with chemistry achievement of 1 in EG are 12. These students have almost equal scores with students that have chemistry achievement scores of three in CG. In other words, students with lowest chemistry grades in EG scored almost equally with students that have an average chemistry achievement in CG. In addition, when the post test scores of students with lowest chemistry grades in EG and CG were compared, the EG students post test scores were higher than the CG students post test scores. In other words, these students outperformed CG students with same chemistry achievement. Moreover, when the students with highest chemistry achievement is compared, it is observed that CG students mean post test scores were poor than the EG students with average chemistry achievement.

One of the measures of the effect size is the eta square which was found to be 0.476. In other words, 47.6 % of the variance on dependent variable could be explained by treatment. The effect size index "f" calculated as 0.95 which could be categorized as large according to Cohen's (1977) classification. The power was calculated as greater than 0.995 which is higher than the predefined power.

6.3 Implications

Students' prior knowledge plays a key role in further learning since some of the prior conceptions are inconsistent with scientific views. Therefore, students can not form appropriate and correct associations between concepts so meaningful learning can not occur. Therefore, teachers should be aware of students' misconceptions and their harm to learning. While developing their instruction materials and planning, they should be aware of students' misconceptions.

Teachers often suffer from the same misconceptions students have. Therefore, teachers should receive courses that can help them recognize and remediate their misconceptions.

Teachers should also be aware of several sources that may cause misconceptions. One of the sources of misconception is teachers themselves. Therefore, they should be careful in planning their lessons and their instructions in order not to let students form any misconceptions. In other words, they should not forget that anything that was not explained enough can be a source of misconception therefore they should be very careful while their instructions. Another one is instruction itself. That is the examples and generalizations without explaining clearly can also lead misconceptions. For example, analogies can cause misconception if the pointes that differentiate base domain from target domain were not explained clearly. Therefore, teachers should be careful while they are using analogies.

Another source of misconception is terminology used by teachers and textbook authors. The meaning of some terms can change over time therefore these terms will contain both old and new aspects. Therefore, teachers and textbook authors should be aware of old and new meanings of terms used so that they will use these term appropriately.

Another source of misconceptions is textbooks used since it is possible to make errors while developing textbooks. Therefore, textbook authors should be careful and keep in touch with related research done in their fields. In other words, textbooks should be improved so that students' misconceptions can be minimized.

Textbook authors should also investigate research done on CCTs and should benefit while writing their textbooks.

It is difficult to distinguish and remediate misconceptions. Therefore, finding ways to remediate misconceptions is very important. Many previous studies and this study indicated that instruction based on CCA where CCTs are used, helps students in remediation of their misconceptions. Therefore, teachers should be aware of effectiveness of CCA.

Well designed CCT instruction can lead a significantly better acquisition of scientific concepts. Therefore, four conditions necessary for conceptual change mentioned by Posner et al. (1982) and Roth's (1985) procedures can be used while designing CCTs.

The results of this study presented that instruction based on traditional methods were ineffective in remediation of students misconceptions. Teachers should be aware that students will hold their misconceptions after traditional instruction. Therefore, teaching strategies that helps students learn science meaningfully should be presented to teachers by in-service teaching.

School administrators should encourage teachers to use CCTs in their instructions.

Curriculum designs based on constructivist approach could be used.

Curriculum developers and teachers should be aware that CCTs could be used in large sized classrooms.

Teachers should be aware of the effect of attitude toward achievement. Therefore, they should find ways to make students have positive attitudes toward science.

Science process skills of students are predictor of students' success therefore while planning instruction teachers should find ways to improve students' science process skills.

Every student does not benefit equally from a particular instruction. In other words, some of the instruction methods are good for high ability students and some for low ability students. Therefore, teachers should plan and design their instruction so that high and low ability students will both benefit from instruction.

6.4 Recommendations

A similar study can be conducted in different grade levels and in different subject areas.

Further studies can be conducted with large samples from different schools.

Other instructional methods can be used for further studies to compare the effectiveness of CCTs with instructional methods.

Further research should be conducted comparing instruction based on TM and instruction based on CCA over longer time periods.

A similar study can be conducted with a sample that differs in subject characteristics.

Different teaching strategies based on CCA can be employed to remediate students' misconceptions.

A similar study can be conducted in different chemistry concepts.

Longitudinal study that follows students throughout their university education could be useful in determining long term effects of CCA.

Alternative assessment strategies could be applied in order to assess students learning.

Further research in determining unpredicted misconceptions and effective techniques for changing these concepts could be done.

Further research could be done on students' metacognitive awareness.

6.5 Conclusion

This study indicated that students have several misconceptions related to solubility equilibrium and these misconceptions effects students understanding of chemistry concepts. Therefore, it is important to find ways to remediate these misconceptions in order to satisfy meaningful learning. The results of present study indicated that CCTs helped students in remediation of their misconceptions since students instructed by instruction based on CCA where CCTs were used outperformed students that were taught with instruction based on TM on understanding of solubility equilibrium. Therefore, it can be concluded that ICCA is more effective in remediation of misconceptions compared to TMs and helps more to achieve the goal of meaningful learning.

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APPENDIX A

MISCONCEPTIONS (SOLUBILITY EQUILIBRIUM)

1. Believing that at equilibrium there is no precipitation and dissolution.
2. Believing that at equilibrium dissolution stops.
3. Believing that at equilibrium the concentrations of the ions produced is equal to the concentration of the salt.
4. Believing that mass can be used instead of concentration in Ksp calculations.
5. Believing that coefficients in solubility equilibrium equations have no other meaning then equating the solubility reaction.
6. Believing that at a given temperature Ksp can change.
7. Believing that ion product (Qi) can be used interchangeably with Ksp.
8. Believing that compounds in solid form should be included while writing Ksp equations.
9. Believing that the rate of dissolving increases with time from mixing the solid with solvent until equilibrium establishes.
10. Believing that amount (moles) can be used instead concentration (molarity) in Ksp calculation.
11. Believing that at a given temperature the value of Ksp changes with the amount of solid or ions added.
12. Believing that the value of Ksp always decreases as temperature decreases.
13. Believing that temperature has no affect on solubility.
14. Believing that at equilibrium addition of salt affects the equilibrium.
15. Believing that at equilibrium the concentrations of ions will remain constant although common ion is added.
16. Believing that solubility of sparingly soluble salts is effected by change made in pressure and volume.
17. Believing that in all situations one can compare solubility of salts at equilibrium by just looking at Ksp values.
18. Believing that if system is at equilibrium no other solute that doesn’t contain common ion can dissolve.

19. Believing that before the system reaches equilibrium there was no precipitation reaction.
20. Believing that large Ksp implies very fest dissolution.
21. Believing that there is no relation between Ksp and solubility.

APPENDIX B

ÇÖZELTİLER TESTİ

ADI SOYADI:

Bu test siz öğrenci arkadaşların Çözeltiler Konusundaki başarınızı ölçmeyi ve değerlendirmeyi amaçlamaktadır. 20 tane çoktan seçmeli sorudan oluşmaktadır. Aşağıdaki her bir soru için size en uygun seçeneği işaretleyiniz. Başarılar.....

1. Bir katının sudaki çözünürlüğü aşağıdaki etkenlerden hangisi ile değişir?

A. Çözeltiyi karıştırmak.
B. Katıyı toz haline getirmek.
C. Su miktarını arttırmak.
D. Sıcaklığını arttırmak.
E. Katı miktarını arttırmak.

2. Bir bardak saf su içerisine az miktarda yemek tuzu (NaCl) atılıyor ve karıştırılıyor. Yemek tuzuna suda çözününce ne olur?

A. Yemek tuzu erir.
B. Yemek tuzu su içerisindeki boşluklara yerleşir.
C. Yemek tuzu elementlerine ayrışır.
D. Su molekülleri ile etkileşen yemek tuzu, iyonlarına ayrışır.
E. Yemek tuzu yeni bir maddeye dönüşür.

3. Doymuş tuz çözeltisine aynı sıcaklıkta bir miktar tuz eklenirse,

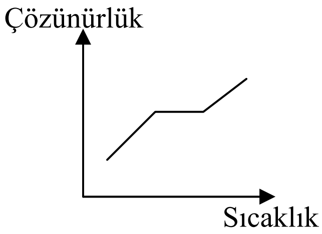
I. Derişimi artar.
II. Çözünen madde miktarı değişmez.
III. Buhar basıncı azalır.

yargılarından hangileri doğrudur?

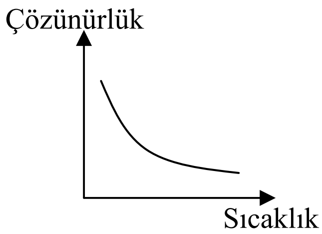
A. Yalnız I B. Yalnız II C. I ve II D. I ve III E. II ve III F. I, II ve III

4. Aşağıdaki grafiklerden hangisi çözünürlüğü sıcaklıkla azalan bir madde için çizilebilir?

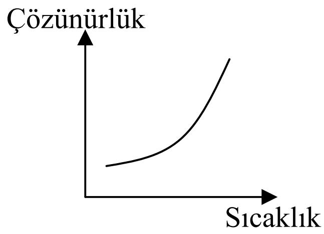
A.



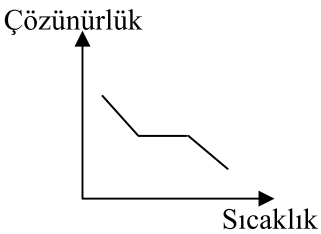
B.



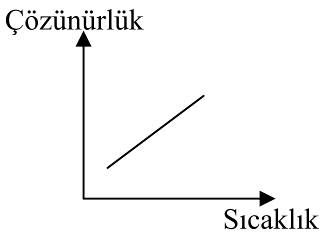
C.



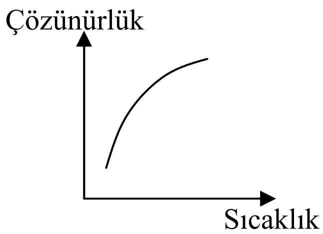
D.



E.



F.



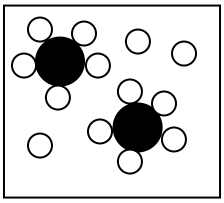
5. Bir litre çözeltinin içinde çözünmüş maddenin mol sayısına molar derişim denir. Buna göre, 1 molar tuzlu su çözeltisinden alınan iki örnekten, birinin hacmi 200 mililitre diğerininki ise 2 litredir. Bu iki çözelti için aşağıdaki ifadelerden hangisi söylenebilir?

A. Mol sayıları ve molar derişimleri farklıdır.
B. Mol sayıları farklı, molar derişimleri aynıdır.
C. Mol sayıları ve yoğunlukları aynıdır.
D. Yoğunlukları farklı, molar derişimleri aynıdır.
E. Mol sayıları ve molar derişimleri aynıdır.

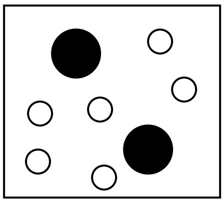
6. Aşağıdakilerden hangisi, şekerli su çözeltisinin çok az bir kısmının anlık bir görüntüsünü temsil etmektedir?

● = Şeker molekülü ○ = Su molekülü

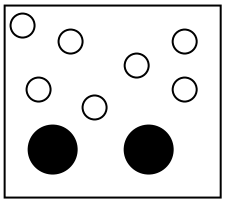
A.



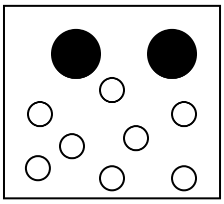
B.



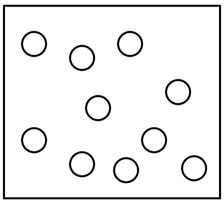
C.



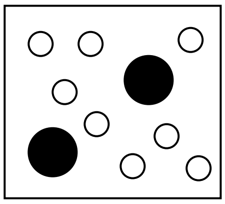
D.



E.



F.

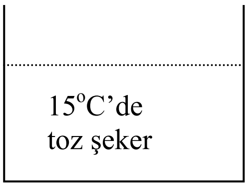


7. Her birinde 100 mililitre su bulunan aşağıdaki kapların herbirine, belirtilen sıcaklıklarda eşit miktarda şeker konuyor. Buna göre bu kapların hangisinde çözünme en hızlıdır?

A.

B.

C.



D.

E.

F.

8. Aşağıdaki madde çiftlerinin hangisinden çözelti elde edilemez?

A. Su, Amonyak
B. Su, Zeytinyağı
C. Sirke, Tuz
D. Sirke, Limon suyu
E. Su, Alkol

9. Aşağıdaki işlemlerden hangisi,

$$CaCl_{2(k)} \rightleftharpoons Ca^{+2}_{(suda)} + 2Cl^{-}_{(suda)} + \text{ısı}$$

denklemindeki $CaCl_{2(k)}$ sudaki çözünürlüğünü arttırır?

A. Bir miktar daha su ilave etmek.

B. Sıcaklığı düşürmek.

C. Çözeltiyi karıştırmak.

D. Bir miktar daha $CaCl_{2(k)}$ ilave etmek.

E. $CaCl_{2(k)}$'yi toz haline getirmek.

10. Aşağıdakilerden hangisi çözelti değildir?

A. Çeşme Suyu

B. Sodalı Su

C. Kolanya

D. Tuzlu Su

E. Etil Alkol

11. 4 gram NaOH'ın 500 mililitre suda çözünmesi ile oluşan çözeltinin molar derişimi kaç (mol/litre)'dir? (NaOH: 40 gram)

A. $2*10^{-4}$ B. 0.02 C. 0.20 D. 2 E. 20

12. 0,5 molar 200 mililitre $MgCl_2$ çözeltisinde kaç gram $MgCl_2$ çözünmüştür?
(Mg: 24 gram, Cl: 35.5 gram)

A. 2.37 B. 9.50 C. 1.05 D. 0.24 E. 38

13. Aşağıdaki örneklerin hangisinde KOH miktarı en fazladır?
(K: 39 gram, O: 16 gram, H: 1 gram)

A. 100 gram kütlece %10'luk KOH su çözeltisi.

B. 100 mililitre, 2 molar KOH su çözeltisi.

C. 0.2 mol KOH.

D. 12 gram KOH.

E. 2 litre 0.1 molar KOH su çözeltisi.

14. Aşağıdakilerden hangisi şeker su çözeltisi için doğrudur?

A. Şekerli su çözeltisinin ağırlığı, şekerin ve suyun ayrı ayrı ağırlıkları toplamından büyüktür.

B. Şekerli su çözeltisinin hacmi, şekerin ve suyun ayrı ayrı hacimleri toplamından büyüktür.

C. Şekerli su çözeltisinin ağırlığı, şekerin ve suyun ayrı ayrı ağırlıkları toplamından küçüktür.

D. Şekerli su çözeltisinin hacmi, şekerin ve suyun ayrı ayrı hacimleri toplamından küçüktür.

E. Yukarıdakilerden hiçbiri.

15. Kütlece %20'lik 100 gram X çözeltisi, kütlece %10'luk 300 gram X çözeltisi, 100 gram X ve 100 gram su karıştırılıyor. Karışımda kütlece % kaç X bulunur?

A. 20 B. 25 C. 27 D. 30 E. 33

16. %10'luk 150 gram tuz çözeltisine %25'lik yapmak için,

I. Bir miktar su buharlaştırmak.
II. Bir miktar tuz ilave etmek.
III. Bir miktar su ilave etmek.

işlemlerinden hangisi uygulanabilir?

A. Yalnız I B. Yalnız II C. I ve II D. I ve III E. I, II ve III

17. Katı bir maddenin çözünürlüğüne,

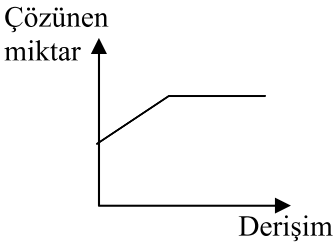
I. Çözücünün türü
II. Karıştırmak
III. Sıcaklık
IV. Basınç

özelliklerinden hangisi etki eder?

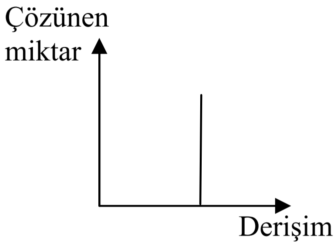
A. I ve II B. I ve III C. III ve IV D. I, II ve III E. II, III ve IV

18. İçerisinde yeterince katı bulunan sulu çözeltinin ısıtılmasına ilişkin çizilen çözünen miktar-derişim grafiklerinden hangisi doğrudur? (çözünme endotermiktir)

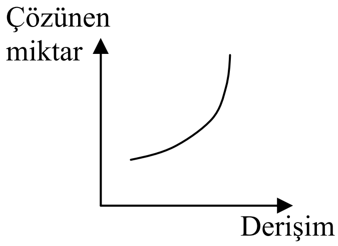
A.



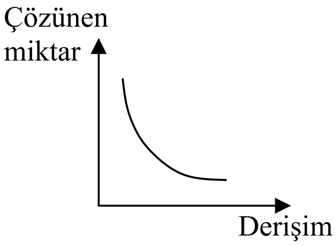
B.



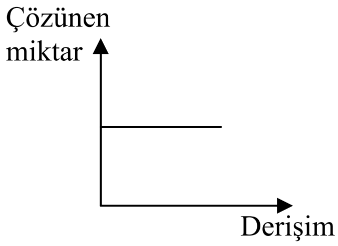
C.



D.

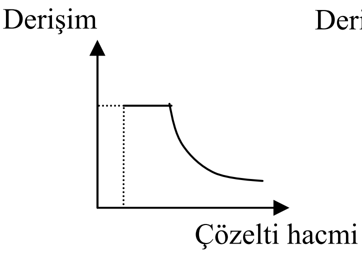


E.

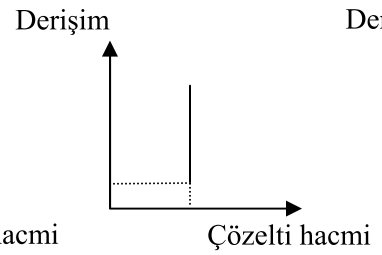


19. Katısı ile dengedeki doymuş bir çözeltiye bir miktar arı su yavaş yavaş eklenirse, çözelti hacmi ile derişim değişimini gösteren grafik aşağıdakilerden hangisi olabilir?

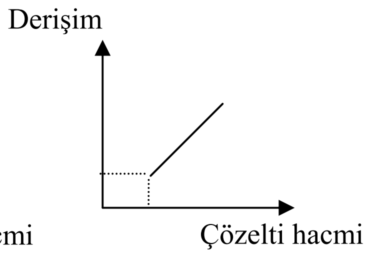
A.



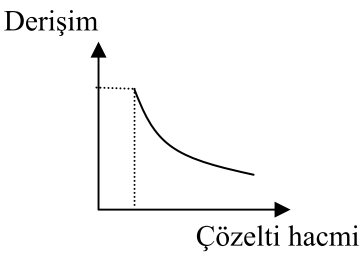
B.



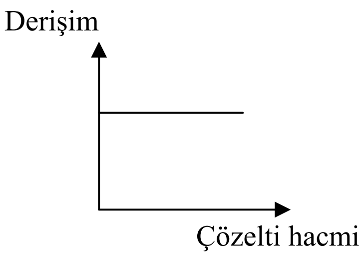
C.



D.



E.



20. Aşağıdaki işlemler sonucunda,

I. Doymamış tuz çözeltisine sabit sıcaklıkta bir miktar tuz eklemek.

II. Doymuş tuz çözeltisine sabit sıcaklıkta bir miktar tuz eklemek.

III. Doymuş tuz çözeltisine sabit sıcaklıkta toz halinde bir miktar tuz eklemek.

tuz çözeltilerinin derişimleri nasıl değişir?

	I. Çözelti	II. Çözelti	III.Çözelti
A.	Artar	Değişmez	Artar
B.	Artar	Artar	Değişmez
C.	Değişmez	Artar	Artar
D.	Değişmez	Değişmez	Artar
E.	Artar	Değişmez	Değişmez

APPENDIX C

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 ölçebilen sorular bulunmaktadır. Her soruyu okuduktan sonra kendinizce uygun seçeneği yalnızca cevap kağıdına işaretleyiniz.

Bu testin orijinali James R. Okey, Kevin C. Wise ve Joseph C. Burns tarafından geliştirilmiştir. Türkçeye çevrisi ve uyarlaması ise Prof. Dr. İlker Özkan, Prof. Dr. Petek Aşkar ve Prof. Dr. Ömer Geban tarafından yapılmıştır.

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.

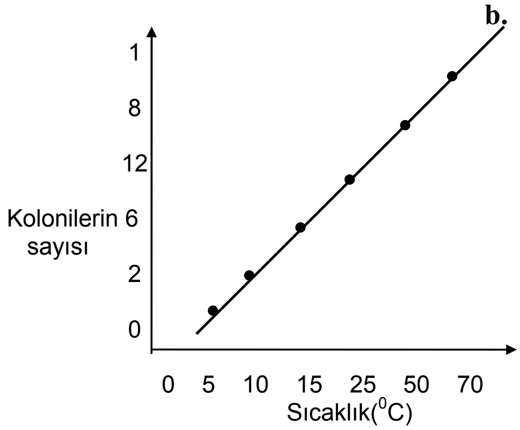
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir.

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

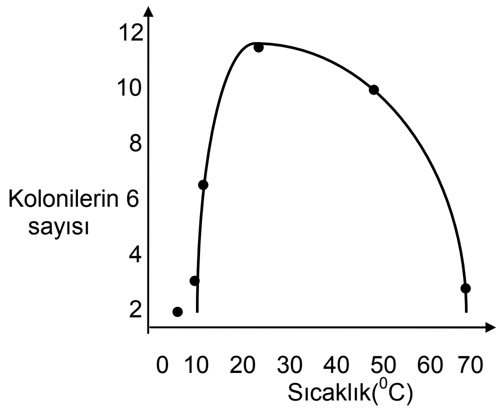
Deney odasının sıcaklığı (^{0}C)	Bakteri kolonilerinin sayısı
5	0
10	2
15	6
25	12
50	8
70	1

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?

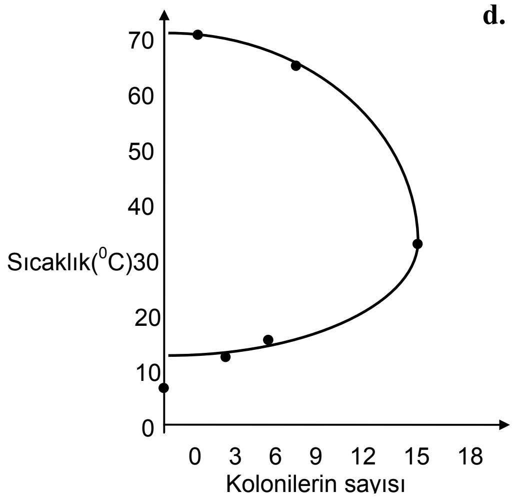
a.



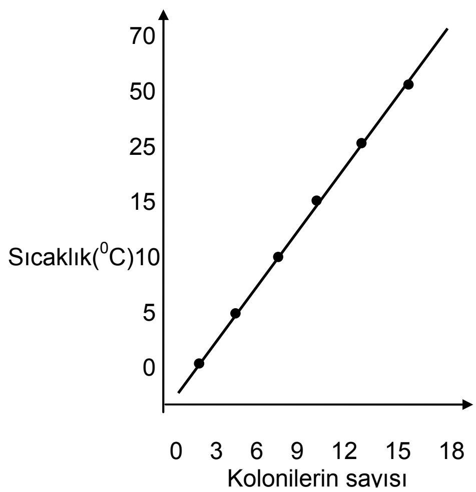
b.



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. Yollarde 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. Br oyuncak arabaya geniş yüzeyli tekerlekler takılır, önce bir rampadan (eğiik 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 genişlkleri 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?

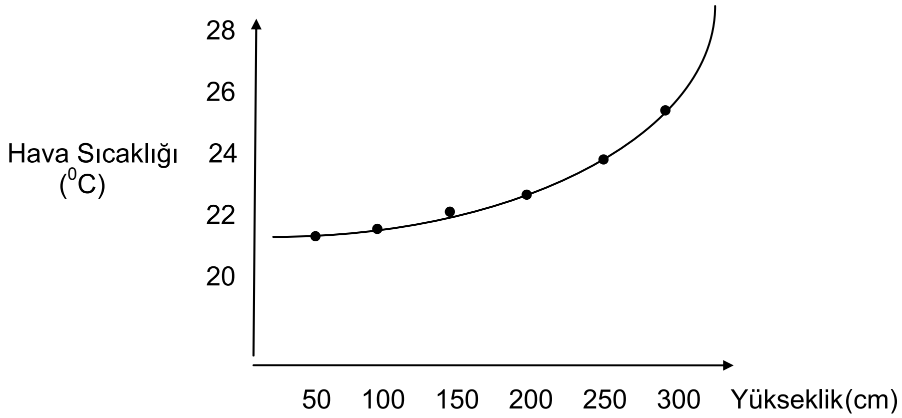
a. Tarlaya ne kadar çok gübre atılırsa, o kadar çok mısır elde edilir.

b. Ne kadar çok mısır elde edilirse, k**a**r 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 ilşki 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?

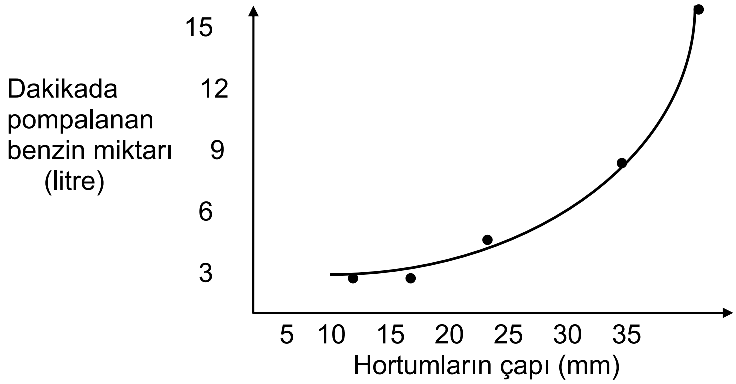
a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.

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 nbaşlar. 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. Kullanolan 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 alnlardaki 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.

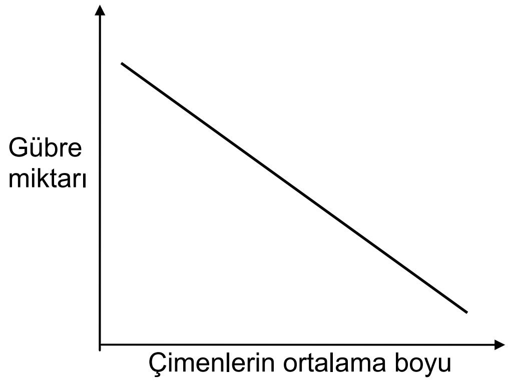
25. Bir araştırmacı yeni bir gübreyi denemektedir. Çalışmalarını aynı büyüklükte beş tarlad yapar. Her tarlaya yeni gübresinden değişik miktarlarda karıştırır. Bir ay sonra, her tarlada yetişen çimenin ortalama boyunu ölçer. Ölçüm sonuçları aşağıdaki tabloda verilmiştir.

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

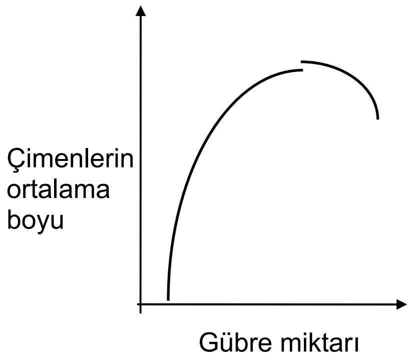
Tablodaki verilerin grafiği aşağıdakilerden hangisidir?

a.

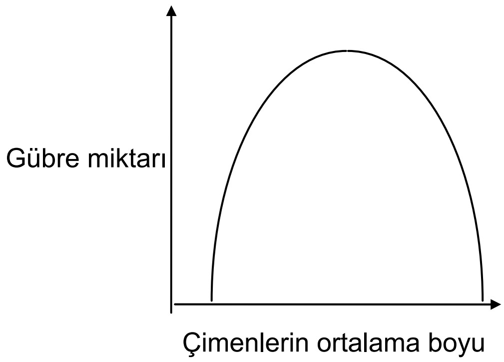
b.



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?

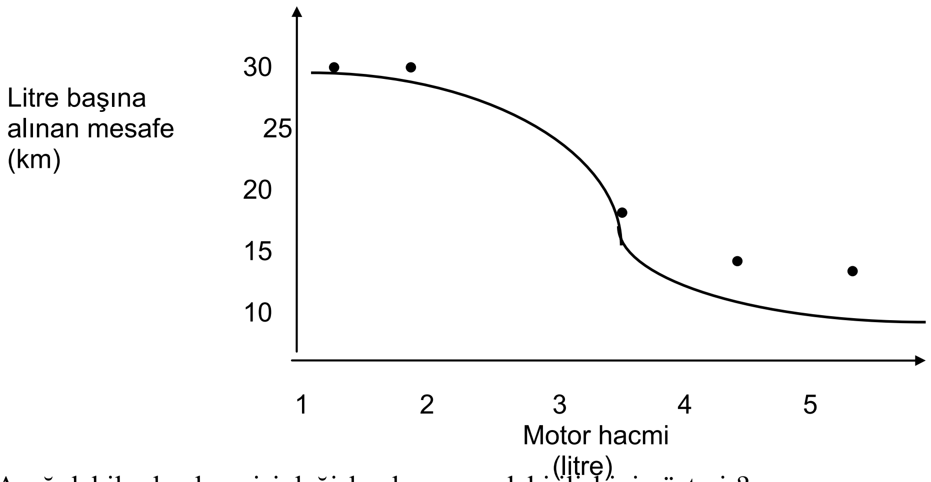
a. Daha fazla şekeri çözmek için daha fazla su gereklidir.

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.

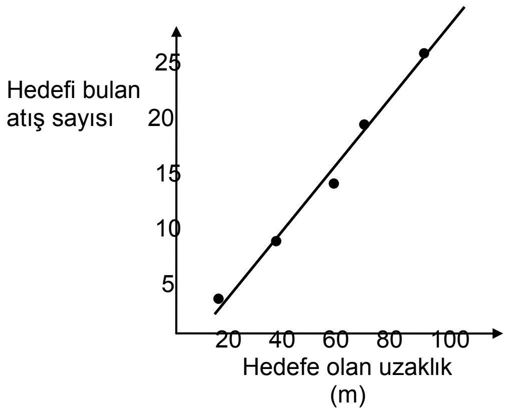
d. Çekilen demir tozlarının ağırlığı ile.

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

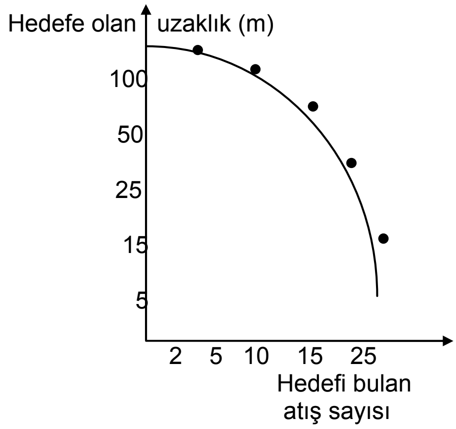
Mesafe(m)	Hedefe vuran atış sayısı
5	25
15	10
25	10
50	5
100	2

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?

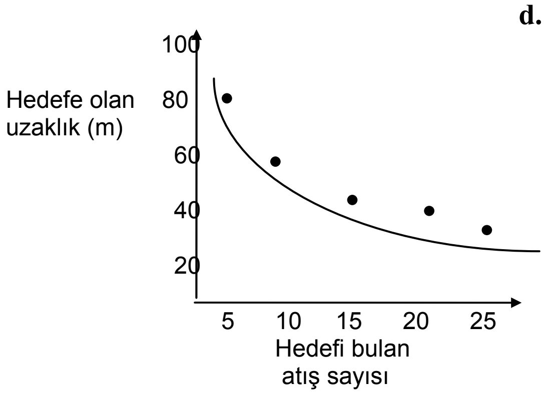
a.



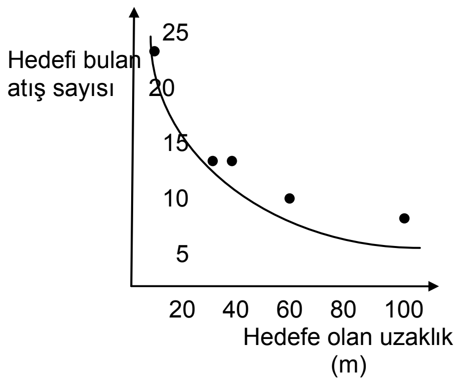
b.



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 electrikli 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 D

ÇÖZÜNÜRLÜK DENGESİ TESTİ

ADI SOYADI:

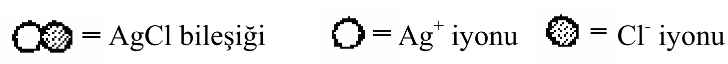
Bu test siz öğrenci arkadaşların Çözünürlük Dengesi Konusundaki başarınızı ölçmeyi ve değerlendirmeyi amaçlamaktadır. 30 tane çoktan seçmeli sorudan oluşmaktadır. Aşağıdaki her bir soru için size en uygun seçeneği işaretleyiniz. Başarılar.....

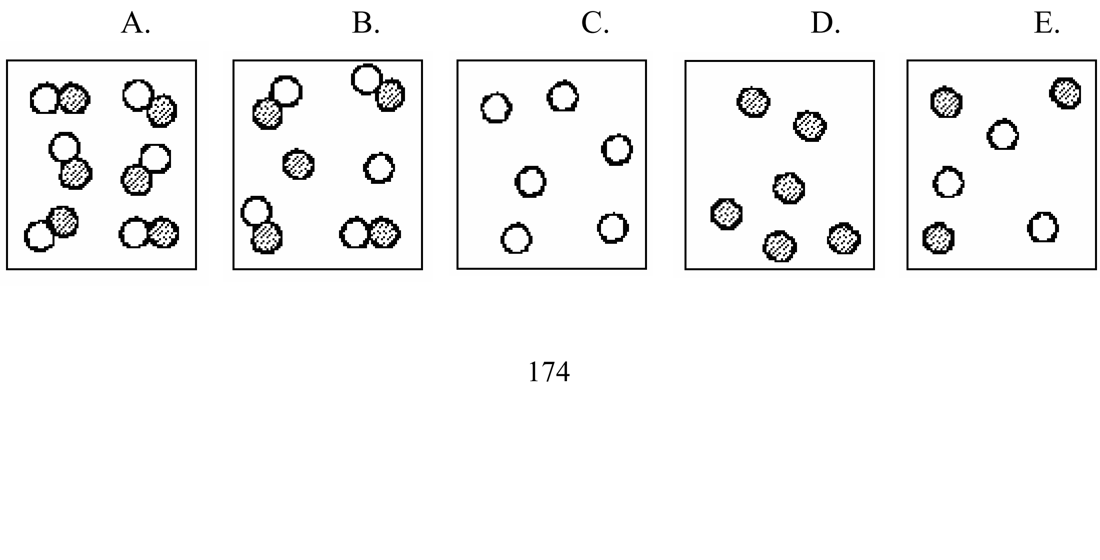
1. 25°C'de doygun AgCl çözeltisine bir miktar AgCl katısı ekleniyor. Buna göre aşağıdaki seçeneklerden hangisi doğrudur? ($K_ç = 1.8 \times 10^{-10}$)

A. Klor iyonu derişimi doygun çözeltideki klor iyonu derişiminden daha büyük olur.
B. Klor iyonu derişiminde değişme olmaz.
C. Klor ve gümüş iyonu derişimi doygun çözeltideki klor ve gümüş iyonu derişiminden daha büyük olur.
D. Klor ve gümüş iyonu derişimi doygun çözeltideki klor ve gümüş iyonu derişiminden daha küçük olur.
E. Klor iyonu derişimi doygun çözeltideki klor iyonu derişiminden daha küçük olur.

2. Aşağıdaki şekillerden hangisi, katısı ile dengede olan AgCl'nin doygun sulu çözeltisinin çok az bir miktarının anlık görüntüsünü temsil eder? (**Not:** Çözücü moleküllerine şekillerde yer verilmemiştir.)

$$AgCl_{(k)} \rightleftarrows Ag^{+}_{(suda)} + Cl^{-}_{(suda)}$$





3. 25°C'de doymuş CH_3COOAg (gümüş asetat) çözeltisine, çözeltinin hacminde değişme olmadığı kabul edilerek, bir miktar $AgNO_3$ çözeltisi yavaş yavaş ekleniyor. Buna göre aşağıdaki ifadelerden hangisi doğru olur?

$$CH_3COOAg_{(k)} \rightleftarrows CH_3COO^-_{(suda)} + Ag^+_{(suda)}$$

A. Bir miktar daha katı gümüş asetat çözünür.
B. Asetat iyon derişimi artar.
C. Bir miktar katı gümüş asetat çökelir.
D. $[CH_3COO^-]$ ve $[Ag^+]$ artar.
E. $AgNO_3$ eklemek denge durumunu etkilemez.

4. Aşağıdaki tuzlardan hangisi suda daha fazla çözünür?

A. $CuCO_3$: $K_ç = 2.3 \times 10^{-10}$
B. $BaCI_2$: $K_ç = 1.1 \times 10^{-10}$
C. AgCl: $K_ç = 1.6 \times 10^{-10}$
D. CaF_2: $K_ç = 3.9 \times 10^{-11}$
E. Bu soruyu cevaplayabilmek için daha fazla bilgiye ihtiyaç vardır.

5. Çözünme denklemi verilen $Ca_3(PO_4)_2$'ın çözünürlük çarpımı ($K_ç$) için aşağıdakilerden hangisi doğrudur?

$$Ca_3(PO_4)_{2(k)} \rightleftarrows 3\ Ca^{+2}_{(suda)} + 2\ PO_4^{-3}{}_{(suda)}$$

A. $K_ç = \dfrac{[Ca^{+2}]\ [PO_4^{-3}]}{[Ca(PO_4)_2]}$

B. $K_ç = [Ca^{+2}]^2\ [PO_4^{-3}]^3$

C. $K_ç = \dfrac{[Ca^{+2}]^3 [PO^{-3}]^2}{[Ca(PO_4)_2]}$

D. $K_ç = [Ca^{+2}]^3\ [PO_4^{-3}]^2$

E. $K_ç = 3[Ca^{+2}]\ 2[PO_4^{-3}]$

6. Belirli bir sıcaklıkta doymuş kalsiyum fosfat ($Ca_3(PO_4)_2$) çözeltisine aynı sıcaklıkta bir miktar kalsiyum nitrat ($Ca(NO_3)_2$) ekleniyor. Buna göre, $Ca(NO_3)_{2(k)}$ eklemek $Ca_3(PO_4)_2$ 'ün çözünürlüğünü nasıl etkiler?

A. Kalsiyum fosfat'ın çözünürlüğünü etkilemez.
B. Kalsiyum fosfat'ın çözünürlüğünü azaltır.
C. Kalsiyum fosfat'ın çözünürlüğünü artırır.
D. Kalsiyum fosfat'ın çözünürlüğünde beklenmedik değişmelere sebep olur.
E. Doğru cevap verilmemiştir.

7. 25°C'de katısı ile dengede olan $PbSO_4$'ın sulu çözeltisinin hacmini buharlaştırarak yarıya indirdikten sonra sıcaklık ilk duruma getirilirse, Pb^{+2} ve SO_4^{-2} ion derişimleri nasıl değişir?

A. Pb^{+2} ve SO_4^{-2} ion derişimleri artar.
B. Pb^{+2} ve SO_4^{-2} ion derişimleri azalır.
C. Pb^{+2} ve SO_4^{-2} ion derişimleri değişmez.
D. $K_ç$ değerini bilmeden bunu söyleyemeyiz.

8. 0.1 M Co^{+2} içeren çözelti içerisine yavaş yavaş $PbS_{(k)}$ ilave ediliyor. CoS'ın çökmeye başlaması için gerekli minimum S^{-2} iyon derişimi kaç M olur? (CoS: Kç = 4×10^{-21})

A. $[S^{-2}] = 4 \times 10^{-21}$ M
B. $[S^{-2}] = 4 \times 10^{-20}$ M
C. $[S^{-2}] = 2 \times 10^{-10}$ M
D. $[S^{-2}] = 6 \times 10^{-10}$ M

9. $Al(OH)_3$ suda çözündüğünde Al^{+3} ve OH^- iyon derişimleri ile $Al(OH)_3$'in sudaki çözünürlüğü (S) arasında nasıl bir ilişki vardır?

A. $S = [Al^{+3}] + [OH^-]$
B. $S = [Al^{+3}] + 3[OH^-]$
C. $[OH^-] = 3$ S, $[Al^{+3}] = S$
D. $S = [Al^{+3}] = 3\ [OH^-]$
E. $[S^{-2}] = 1 \times 10^{-7}$ M

10. 25°C'de doymuş AgCl çözeltisi için aşağıdakilerden hangisi doğru olabilir?

(AgCl: $K_ç = 1.8x10^{-10}$)

A. AgCl, %100 iyonlaşarak çözeltiye $Ag^+_{(suda)}$ ve $Cl^-_{(suda)}$ iyonları vermiştir.

B. Çözelti elektriği iletmez.

C. Çözeltide $Ag^+_{(suda)}$ ya da $Cl^-_{(suda)}$ iyonları yoktur.

D. Çözeltide çözünmemiş $AgCl_{(k)}$ vardır.

11. Katısı ile dengede bulunan $PbCl_2$ çözeltisine bir miktar $NaCl_{(k)}$ ekleniyor. Denge tekrar sağlandığında iyon derişimleri ilk durumlarına göre nasıl değişmiştir?

$$PbCl_{2(k)} \rightleftarrows Pb^{+2}_{(suda)} + 2\,Cl^{-1}_{(suda)}$$

A. Pb^{+2} ve Cl^{-1} iyonlarının derişimleri artmıştır.

B. Pb^{+2} ve Cl^{-1} iyonlarının derişimleri azalmıştır.

C. Pb^{+2} iyon derişimi azalmıştır ve Cl^{-1} iyon derişimi artmıştır.

D. Pb^{+2} iyon derişimi artmıştır ve Cl^{-1} iyon derişimi azalmıştır.

12. Belirli bir sıcaklıkta $BaSO_3$ çözeltisi katısı ile dengededir.

$$BaSO_{3(k)} \rightleftarrows Ba^{+2}_{(suda)} + SO_3^{-2}{}_{(suda)}$$

Buna göre aşağıdaki işlemlerden hangisi Ba^{2+} iyon derişimini arttırır?

A. Su ilave etmek.

B. $BaS_{(k)}$ ilave etmek.

C. $BaSO_{3(k)}$ ilave etmek.

D. $Na_2SO_{3(k)}$ ilave etmek.

13. Belirli bir sıcaklıkta doymuş AgCl çözeltisine bir miktar $Br^-_{(suda)}$ ilave ediliyor.

$$AgCl_{(k)} \rightleftarrows Ag^+_{(suda)} + Cl^-_{(suda)}$$

Buna göre, aşağıdaki seçeneklerden hangisi doğru olur?

A. Daha fazla AgCl çözünür ve $K_ç$'si artar.

B. Bir miktar AgCl çökelir ve $K_ç$'si azalır.

C. Daha fazla AgCl çözünür ve $K_ç$'si değişmez.

D. Bir miktar AgCl çökelir ve $K_ç$'si değişmez.

14. Belirli bir sıcaklıkta, doymuş AgBr çözeltisine bir miktar $AgBr_{(k)}$ ilave ediliyor. Buna göre, AgBr'nin çözünürlüğü ve Kç'si hakkında ne söyleyebiliriz?

	AgBr'nin Çözünürlüğü	Kç
A.	Artar	Artar
B.	Artar	Azalır
C.	Azalır	Artar
D.	Değişmez	Değişmez
E.	Artar	Değişmez

15. Çözünürlük ile $K_ç$'nin büyüklüğü arasındaki ilişki aşağıdaki seçeneklerin hangisinde doğru olarak belirtilmiştir?

A. İkisi arasında ilişki yoktur.
B. $K_ç$ küçüldükçe çözünürlük artar.
C. $K_ç$ büyüdükçe çözünürlük artar.
D. Çözünürlük her zaman Kç'nin kareköküdür.

16. Belirli bir sıcaklıkta bir çözelti katısı ile dengededir. Bu durumla ilgili aşağıdaki ifadelerden hangisi her zaman doğrudur?

A. Çözünme ya da çökelme gözlenmez.
B. Çözünme hızı çökelme hızına eşittir.
C. Çözünen katının derişimi ile çözücünün derişimi eşittir.
D. Çözünen katının kütlesi çözeltinin kütlesinden büyüktür.

17. $20^\circ C$'de doymuş KNO_3 sulu çözeltisi katısı ile dengededir. Çözelti $40^\circ C$'e kadar ısıtıldığında dipteki katısının tamamının çözünmediği gözlenmektedir. Yeni durumda oluşan çözelti ile ilgili, (KNO_3' ın çözünürlüğü endotermiktir)

I. Çözeltinin derişimi artar.
II. Çözelti yeni durumda da doygundur.
III. Çözeltinin özkütlesi artmıştır.

ifadelerinden hangisi ya da hangileri doğru olur?

A. Yalnız II B. Yalnız III C. I ve III D. II ve III E. I, II ve III

18. Katısı ile dengede olan her doymuş çözeltide çözünme hızı ....

A. Çökelme hızının yarısıdır.
B. Çökelme hızına eşittir.
C. Çökelme hızından azdır.
D. Çökelme hızından fazladır.
E. Bire eşittir.

19. Belirli bir sıcaklıkta AgCl çözelti katısı ile dengededir.

$$AgCl_{(k)} \rightleftarrows Ag^{+}_{(suda)} + Cl^{-}_{(suda)}$$

Aynı sıcaklıkta bir miktar NaCl ilave edildiğinde çözeltideki Ag^+, Cl^- iyon derişimleri ve Kç değeri nasıl değişir?

	$[Ag^+]$	$[Cl^-]$	$K_ç$
A.	Azalır	Artar	Değişmez
B.	Azalır	Azalır	Artar
C.	Artar	Azalır	Değişmez
D.	Artar	Artar	Artar

20. 25°C'de suda az çözünen $CuCl_{(k)}$ tuzu çözeltisi katısı ile dengededir. Buna göre,

I. $[CuCl_{(k)}] = [Cu^+] = [Cl^-]$
II. $[Cu^+] = [Cl^-]$
III. $[CuCl_{(k)}] = [Cu^+] + [Cl^-]$
IV. $[CuCl_{(k)}] = [Cu^+] - [Cl^-]$

ifadelerinden hangileri doğrudur? (CuCl: $K_ç = 1.9 \times 10^{-7}$)

A. Yalnız II
B. Yalnız III
C. I, II ve III
D. II ve III
E. I, II ve IV
F. I, II, III ve IV

21. 30°C'de 10 litrelik bir çözelti içerisinde en fazla 2,72 miligram $CaSO_4$ çözünebilmektedir. Buna gore CaSO4'ün 30°C'deki Kç değeri kaçtır? (Ca:40 g, S:32 g, O:16 g)

A. 4.10^{-4}
B. 4.10^{-8}
C. 4.10^{-10}
D. 4.10^{-12}
E. 4.10^{-14}

22. 40°C'de $CuCO_3$ sulu çözeltisi katısı ile dengededir. Bu çözelti 30°C'ye kadar soğutulup bir müddet bekleniyor. Daha sonra da aynı çözelti 40°C'ye kadar ısıtılyor ve $CuCO_3$ sulu çözeltisi yeni dengeye geliyor. Buna göre,

I. Kç artmıştır.
II. Kç azalmıştır.
III. $CuCO_{3(k)}$ katısı artmıştır.
IV. $[Cu^{+2}] = [CO_3^{-2}]$

ilk ve son denge ile ilgili verilenlerden hangisi doğrudur?

A. Yalnız I　　B. Yalnız IV　　C. I ve IV
D. II ve III　　E. I, II, III ve IV　　F. I , II ve III

23. 25°C'de 2.10^{-4} gram AgCl katısı 250mL suda çözünerek doygun olmayan AgCl çözeltisi hazırlanıyor. Buna gore,

I. $[Ag^{+}]$
II. Kç
III. Cl^{-} iyonlarının mol sayısı.
IV. AgCl katısının mol sayısı.

ifadelerinden hangisi hesaplanabilir? (Ag:108 g, Cl: 36 g).

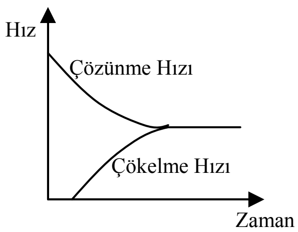
A. Yalnız II　　B. Yalnız IV　　C. I ve III　　D. I, III ve IV
E. II ve IV　　F. I, II ve III

24. 25°C'de katısı ile dengede olan MgF_2 sulu çözeltisinin çözünürlük çarpımı Kç= $[Mg^{+2}]$ $[F^{-1}]^2$ dir. Buna göre aşağıdakilerden hangisi ya da hangileri herzaman doğrudur.

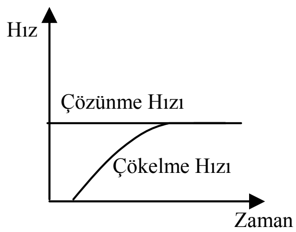
A. $[MgF_2]$, Kç denkleminde yer almamaktadır çünkü $[MgF_2]$ = 1 kabul edilir.
B. $[MgF_2]$, Kç denkleminde yer almamaktadır çünkü $[MgF_2]$ sabit kabul edilir.
C. $[MgF_2]$, Kç denkleminde yer almamaktadır çünkü $[MgF_2]$ yok kabul edilir.
D. $[MgF_2]$, Kç denkleminde yer almamaktadır çünkü $[MgF_2]$ =[Mg^{+2}]=[F^{-1}] kabul edilir.

25. 35°C'de katısı ile dengede olan CuS sulu çözeltisi hazırlanıyor. Buna göre hız-zaman grafiği nasıl olur?

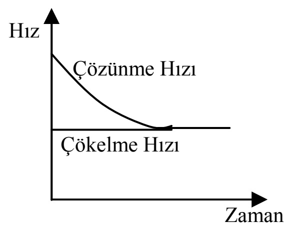
A.



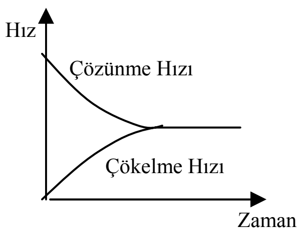
B.



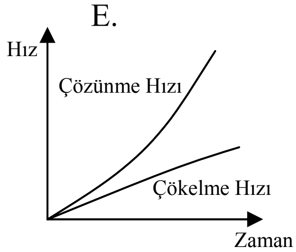
C.



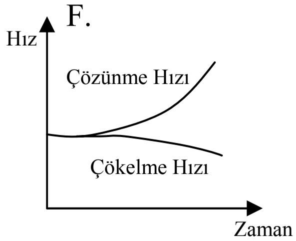
D.



E.



F.



26. 25°C'de bir miktar su içerisine yeterince $PbCO_{3(k)}$ ilave edilerek katısıyla dengede olan bir çözelti hazırlanıyor. Buna göre,

I. $[PbCO_{3(k)}]$ zamanla azalır.

II. Çözelti dengeye ulaşmadan önce $PbCO_{3(k)}$ katısı oluşumu gözlenmez.

III. Çözelti dengeye ulaştığında $Pb^{+2}_{(suda)}$ ve $CO_3^{-2}{}_{(suda)}$ iyonları oluşumu gözlenmez.

IV. Sistem dengedeyken $[PbCO_{3(k)}] = [Pb^{+2}_{(suda)}] = [CO_3^{-2}{}_{(suda)}]$ tir.

V. Hiçbiri.

ifadelerinden hangisi ya da hangileri doğrudur?

A. Yalnız II   B. Yalnız V   C. I ve II   D. II ve III
E. I, II ve IV   F. II, III ve IV

27. 25°C'de $CaCl_2$'ün sulu çözeltisi katısıyla dengededir.

$$CaCl_{2\,(k)} \rightleftharpoons Ca^{+2}_{(suda)} + 2Cl^{-}_{(suda)} \quad \Delta H<0$$

Bu çözelti daha sonra 15°C'ye gelene kadar soğutuluyor. Buna göre

I. $K_ç$ azalır.

II. $[CaCl_2]$ artar.

III. Bir miktar $CaCl_2$ katısı çöker.

IV. $[Ca^{+2}]$ artar.

ifadelerinden hangileri doğrudur?

A. Yalnız I   B. Yalnız IV   C. I ve II   D. II ve III
E. II ve IV   F. I, II ve III

28. 25°C'de $MgCO_{3(k)}$'ün sulu çözeltisi katısıyla dengededir. Buna gore çözücünün yarısının buharlaştırılması ve basıncının 3 katına çıkartılması $MgCO_3$'ün çözünürlüğünü, Mg^{+2} ve CO_3^{-2} iyonlarının derişimini nasıl değiştirir?

	$MgCO_3$'ün çözünürlüğü	$[Mg^{+2}]$	$[CO_3^{-2}]$
A.	Artar	Artar	Artar
B.	Artar	Azalır	Azalır
C.	Değişmez	Azalır	Azalır
D.	Değişmez	Değişmez	Değişmez
E.	Azalır	Değişmez	Değişmez
F.	Azalır	Azalır	Azalır

29. 25°C'de $CuCO_3$'ün sulu çözeltisi katısıyla dengededir. Bu çözeltiye aynı sıcaklıkta bir miktar (Cu^{+2} ve CO_3^{-2} iyonları ile bileşik oluşturmayan) X tuzu eklenirse aşağıdakilerden hangisi doğru olur?

A. X tuzu çözünmeden çöker.

B. $CuCO_3$'ün çözünürlüğü artar.

C. $CuCO_3$'ün çözünürlüğü azalır.

D. $CuCO_3$ çözeltisinin $K_ç$'si değişmez.

30. Çözünürlük çarpımı'nın ($K_ç$) büyüklüğü ile çözünme hızı arasındaki ilişki aşağıdaki seçeneklerin hangisinde belirtilmiştir?

A. Bir ilişki yoktur.

B. Düşük $K_ç$, yüksek çözünme hızını ifade eder.

C. Yüksek $K_ç$ yüksek çözünme hızını ifade eder.

D. Çözünme hızı daima $K_ç$ nin iki katıdır.

APPENDIX E

ATTITUDE SCALE TOWARD CHEMISTRY (ASTC)

ADI SOYADI:

Bu ölçekte Kimya dersine ilişkin tutumu belirleyici cümleler yer almaktadır. Her cümlenin karşısında TAMAMEN KATILIYORUM, KATILIYORUM, KARARSIZIM, KATILMIYORUM ve HİÇ KATILMIYORUM olmak üzere beş seçenek verilmiştir. Her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneği işaretleyiniz.

		Tamamen Katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Hiç Katılmıyorum
1.	Kimya çok sevdiğim bir alandır.	○	○	○	○	○
2.	Kimya ile ilgili kitapları okumaktan hoşlanırım.	○	○	○	○	○
3.	Kimyanın günlük hayatta çok önemli yeri yoktur.	○	○	○	○	○
4.	Kimya ile ilgili ders problemlerini çözmekten hoşlanırım.	○	○	○	○	○
5.	Kimya konuları ile ilgili daha çok şey öğrenmek isterim.	○	○	○	○	○
6.	Kimya dersine girerken sıkıntı duyarım.	○	○	○	○	○
7.	Kimya derslerine zevkle girerim.	○	○	○	○	○
8.	Kimya dersine ayrılan ders saatinin daha çok 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 daha iyi anlaşılmasında önemlidir.	○	○	○	○	○
13.	Dersler içerisinde Kimya dersi sevimsiz gelir.	○	○	○	○	○
14.	Kimya konuları ile ilgili tartışmaya katılmak bana cazip gelmez.	○	○	○	○	○
15.	Çalışma zamanının önemli bir kısmını Kimya dersine ayırmak isterim.	○	○	○	○	○

APPENDIX F

ATTITUDE SCALE TOWARD CONCEPTUAL CHANGE TEXTS (ASCCT)

ADI SOYADI:...

Açıklama:

Sizlere dağıtılmış olan "Kavram Değiştirme Metinleri" Kimya dersi konularından Çözünürlük Dengesi ile ilgili öğrencilerde sık rastlanan bazı yanılgılar hakkında sizleri uyarmak ve bilimsel temelli doğru kavramları edinmenize yardımcı olmak amacıyla geliştirilmiştir.

Bu ölçekte Kavram Değiştirme Metinlerine ilişkin tutumu belirleyici cümleler yer almaktadır. Her cümlenin karşısında TAMAMEN KATILIYORUM, KATILIYORUM, KARARSIZIM, KATILMIYORUM ve HİÇ KATILMIYORUM olmak üzere beş seçenek verilmiştir. Her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneği işaretleyiniz. İşaretsiz cümle bırakmayınız.

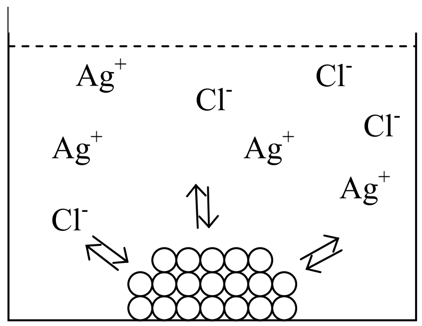
		Tamamen Katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Hiç Katılmıyorum
1.	Kavram Değiştirme Metinlerini okumak eğlenceliydi.	○	○	○	○	○
2.	Kavram Değiştirme Metinlerini çok dikkatli okudum.	○	○	○	○	○
3.	Diğer konularda da, benzer Kavram Değiştirme Metinlerinin geliştirilmesini isterim.	○	○	○	○	○
4.	Kavram Değiştirme Metinlerini okumak Çözünürlük Dengesi konusunu sevmeme yardımcı oldu.	○	○	○	○	○
5.	Kavram Değiştirme Metinleri beni korkuttu.	○	○	○	○	○
6.	Kavram Değiştirme Metinlerini okumak sıkıcıydı.	○	○	○	○	○

7.	Kavram Değiştirme Metinlerini anlamadan okudum.	○	○	○	○	○
8.	Kavram Değiştirme Metinlerinden konunun merak ettiğim yönlerini öğrendim.	○	○	○	○	○
9.	Kavram Değiştirme Metinlerini dikkatsizce okudum.	○	○	○	○	○
10.	Kavram Değiştirme Metinlerini birkaç kez okudum.	○	○	○	○	○
11.	Kavram Değiştirme Metinleri gerekliydi.	○	○	○	○	○
12.	Kavram Değiştirme Metinlerini okumak çok zordu.	○	○	○	○	○
13.	Kavram Değiştirme Metinlerinde verilen açıklamaları zaten biliyordum.	○	○	○	○	○
14.	Kavram Değiştirme Metinlerini okuduktan sonra Çözünürlük Dengesi konusunu daha iyi anladım.	○	○	○	○	○
15.	Kavram Değiştirme Metinleri, Çözünürlük Dengesi konusundaki başarımı arttırdı.	○	○	○	○	○
16.	Kavram Değiştirme Metinlerini hiç okumadım.	○	○	○	○	○
17.	Ders kitabının yanında Kavram Değiştirme Metinlerini okumak ilgimi çekti.	○	○	○	○	○
18.	Kavram Değiştirme Metinlerini anlamakta zorluk çektim.	○	○	○	○	○
19.	Kavram Değiştirme Metinlerini anlayana kadar okudum.	○	○	○	○	○
20.	Kavram Değiştirme Metinlerinde verilen yanılgı örnekleri ilginçti.	○	○	○	○	○
21.	Kavram Değiştirme Metinlerini kolayca okudum.	○	○	○	○	○
22.	Kavram Değiştirme Metinleri, Çözünürlük Dengesi konusunu anlamamda yardımcı olmadı.	○	○	○	○	○
23.	Verilen Kavram Değiştirme Metinlerini severek okudum.	○	○	○	○	○
24.	Kavram Değiştirme Metinleri, konunun zor olan yerlerini açıklayabiliyordu.	○	○	○	○	○
25.	Kavram Değiştirme Metinleri gereksizdi.	○	○	○	○	○

APPENDIX G

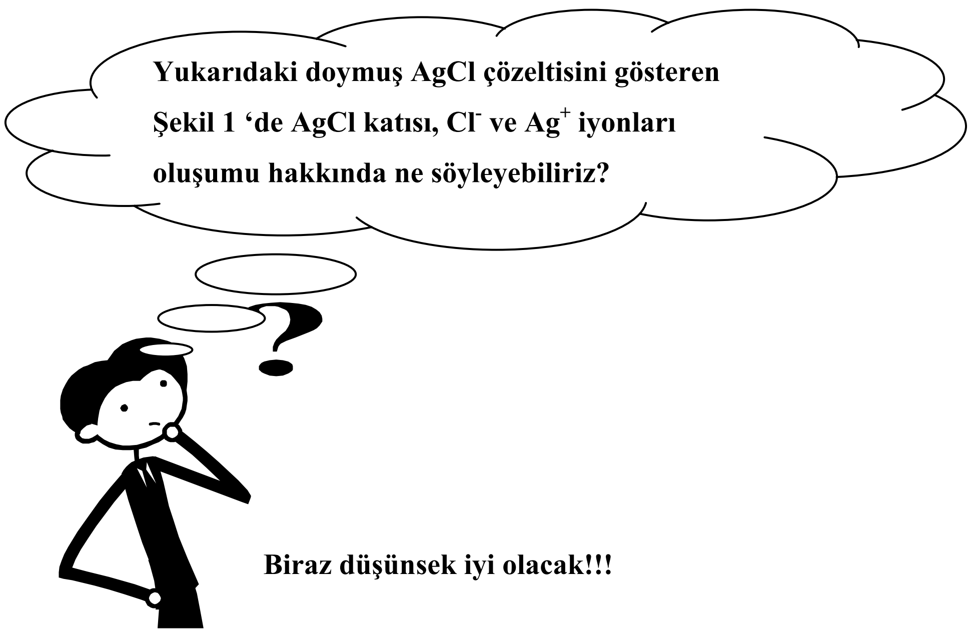
ACTIVITY 1

Şekil 1' de katısı ile dengede olan doymuş AgCl çözeltisini görüyoruz.



$$AgCl_{(k)} \rightleftarrows Ag^{+}_{(suda)} + Cl^{-}_{(suda)}$$

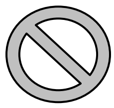
Şekil 1



Sonraki sayfada yazılanları okumadan önce aşağıda boş bırakılan kısma cevabınızı ve nedeninizi yazınız.

....

....

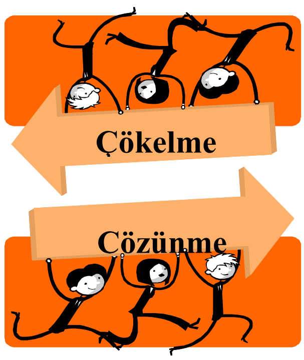


DİKKAT !!!!

Bazı öğrenciler denge durumunda çözünmenin ve çökelmenin durduğuna ya da sona erdiğine inanıyorlar ve dolayısı ile Şekil 1'e bakarsak çözelti katısı ile dengedeyken daha fazla $AgCl_{(k)}$'sının çözünmediğini ve yine $AgCl_{(k)}$ katısının oluşmadığını düşünüyorlar. Böyle düşünen öğrenciler genelde bu düşünceye kitaplarda denge durumu anlatılırken çizilen resimlerde sanki çözelti dengeye ulaştığında herşey bitiyormuş gibi ya da her şey durmuş gibi gösterildiği için sahip oluyorlar. Başka bir sebebi de dengeyi bazı öğrencilerin günlük yaşamda gözlemledikleri eşitliklere benzetmeleridir. Örneğin tahteravalli ya da terazi gibi. İki taraf birbirini dengelediğinde eşitlik ve de dolayısı ile denge sağlanmıştır kanaatine varıyorlar. PEKİ çözeltiler katıları ile dengede iken de aynı durum sözkonusu mudur? Yani dengedeyken herşey durmakta mıdır?

Çözünürlük dengesi bu mudur?

Aslında doymuş çözeltiler dengede iken (doymamış çözeltilerde denge durumundan bahsedemeyiz) çözünme ve çökelme devam etmektedir. Şekil 1'e bakarsak denge durumunda $AgCl_{(k)}$'sının çözünmeye devam etmekte ve dolayısı ile Ag^{+} ve Cl^{-} iyonlarının oluşumu da devam etmektedir. Aynı zamanda Ag^{+} ve Cl^{-} iyonları biraraya gelerek $AgCl_{(k)}$ katısı oluşmaktadır. İŞTE ÇÖZÜNÜRLÜK DENGESİ de bu çözünme ve çökelme hızlarının eşit olduğu durumda oluşur. Başka bir değişle denge durumunda hem bir miktar katı çözünmeye devam etmekte hem de bir miktar katı oluşmaktadır. Bu iki durumun HIZLARI EŞİT olduğunda da DENGE durumu söz konusu olmaktadır.



Çözünme ve çökelme hızlarının eşit olduğu durumda çözeltimiz katısı ile dengededir.

Doğru yoldasın, bu nedenle metnin devamını okumalısın

Denge durumunu şöyle örneklendirebiliriz; eğer AŞTİ (Ankara Şehirlerarası Terminal İşletmesi)'ne yolunuz düştüyse Ankaray girişinde yer alan yürüyen bantları görmüşünüzdür. Bu bantların bir tarafını gelen yolcular kullanırken diğer tarafını giden yolcular kullanmaktadır. Gelen yolcuların yürüyen banttan geçiş hızı ile giden

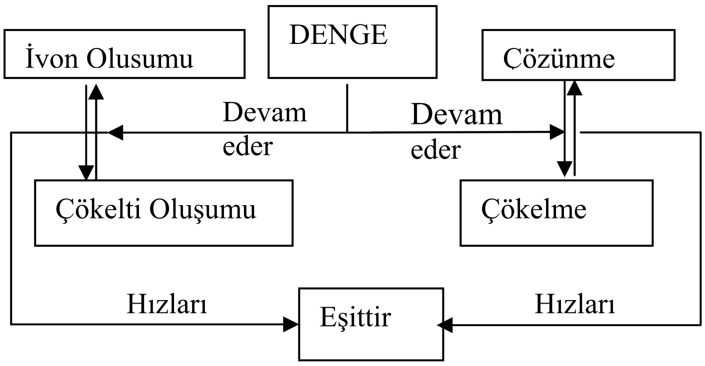
BRAVO!!!

Artık doğru cevabı biliyorsun!!

Dikkatlice incelemelisin.

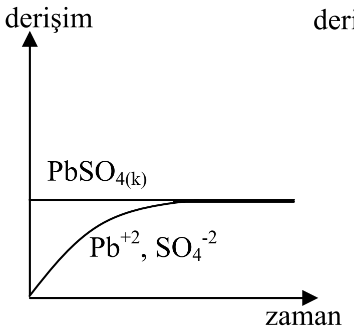
yolcuların yürüyen banttan geçiş hızı eşit olduğunda denge sağlanmaktadır çünkü iki tarafta da artış olmamaktadır yani sürekli birileri gidip diğerleri gelmektedir. Dolayısıyla da denge anında hiçbirşeyin durmadığı veya çözünmenin ve çökelmenin devam ettiğini söyleyebiliriz.

Sonuç olarak bir çözelti katısı ile dengede iken çözünme ve çökelme devam etmaktedir.

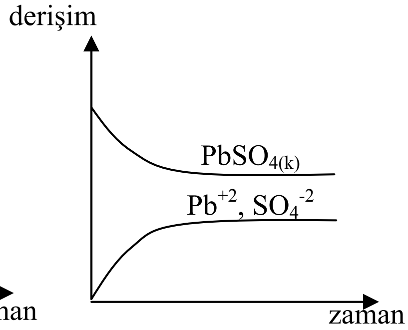


ACTIVITY 2

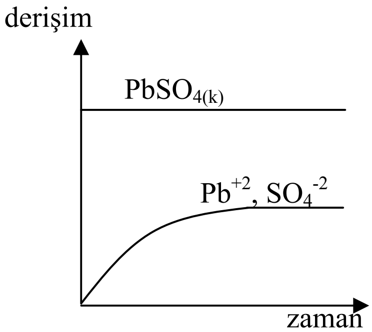
Aşağıda belirli bir sıcaklıkta katısı ile dengede olan $PbSO_4$ çözeltisine ait $PbSO_{4(k)}$ derişimi, Pb^{+2} ve SO_4^{-2} iyon derişimlerinin zamanla değişimini gösteren grafiklere yer verilmiştir.



Grafik I

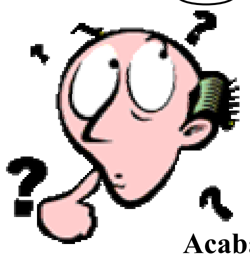


Grafik II



Grafik III

Yukarıda $PbSO_4$ çözeltisine ait $PbSO_{4(k)}$ derişimi, Pb^{+2} ve SO_4^{-2} iyon derişimlerinin zamanla değişimini gösteren grafiklerden hangisi doğru çizilmiştir? Neden?



Acaba hangisi ?

Sonraki sayfada yazılanları okumadan önce aşağıda boş bırakılan kısma cevabınızı ve nedeninizi yazınız...

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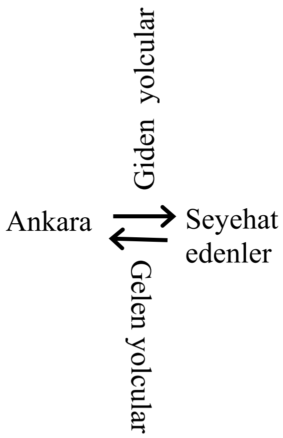
AMAN DİKKAT

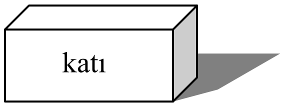
Kimi öğrenciler çözelti katısı ile dengedeyken her bir iyonun derişiminin katı tuzun derişimine eşit olduğunu düşünmekteler (Grafik I'i seçenler). Böyle düşünen öğrenciler genelde dengede olmanın iki şeyin eşit olmasını gerektiriyormuş gibi düşünmelerinde kaynaklanıyor olabilir. Başka bir nedeni de katıları denge denklemine yazmadığımıza göre katı tuzun derişimi iyonların herbirinin derişimine eşit olmalıdır yanılgısına düşmelerindendir. Kimi öğrenciler de dipte çözünmeden bulunan katının derişimini düşünmeden sadece çözücüde çözünen katının derişimini göz önünde bulundurarak katı tuzun derişiminin azaldığı yanılgısına düşmektedirler (Garafik II). Bu yanılgının temel nedeni de dipe bulunan katının bir kısımı iyonlaştığına göre derişimi de azalmıştır yanılgısına düşmelerindendir.

ASLINDA eğer bir çözeltinin dibinde katısı da varsa katı tuzun ve iyonların derişiminin eşit olduğunu düşünmek hatalı olur. Mesela, AŞTİ (Ankara Şehirlerarası Terminal İşletmesi) örneğinden yola çıkalım ve çözeltimizin katısı ile dengede olduğunu kabul edelim. Yani Ankara'ya gelen yolcuların ve Anklara'dan giden yolcuların geliş ve gidiş hızları eşit olsun. Ankara'daki bütün insanlar bizim katı tuzumuz ($PbSO_{4(k)}$) olarak düşünürsek bu insanların sadece belirli bir kısmı AŞTİ'yi kullanarak seyehat edecektir. Bu da suda ya da herhangi bir çözücüde çözünen tuz miktarı olacaktır. Bu da Ankara'daki bütün insanları düşündüğümüzde çok az bir miktar olacaktır ($PbSO_4$ suda çok az çözündüğü hatırlayalım). Dolayısı ile katısı ile dengede olan bir çözelti için katı tuzun derişiminin, her bir iyonun derişimine eşit olduğunu düşünmek hatalı olur.



Grafik II'yi seçen öğrenciler katı tuzun bir kısmının iyonlaşmış olmasının katı tuzun derişimini değiştireceği yanılgısına düşmekteler. ASLINDA katıların derişimi dış etkilerle değişmemektedir.

AŞTİ'ye hoş geldiniz...



Katıların derişimi dış etkilerle değişmez.

Gelin bunu bir örnekle anlamaya çalışalım. Mesela bir evde 4 kişi kalsın ve her biri ayda 300YTL kazansın. Bu evin aylık kişi başına düşen gelir miktarı 300 YTL olacaktır. Bu evden bir kişi ayrılırsa kişi başına düşen gelir miktarına ne olur? Değişir mi? Değişmeyecektir ve yine 300YTL olacaktır. Katıların derişimi de aynı şekilde bir mikatarı iyonlaşsa dahi değişmeyecektir. Çünkü miktardaki azalma hacimdeki azalma ile orantılıdır.

$PbSO_{4(k)}$ derişimi, Pb^{+2} ve SO_4^{-2} iyon derişimlerinin zamanla değişimi Grafik III'te DOĞRU olarak çizilmiştir. Katının derişimi değişmemekte fakat katının bir miktarı iyonlaştığı için Pb^{+2} ve SO_4^{-2} iyon derişimleri artmaktadır. Bu artış zamanla azalmakta ve dengede sabit bir değer almaktadır. Çünkü çözünme ve çökelme hızları eşitlenmekte ve bu nedenle de iyonların derişimi değişmemektedir.

YAŞASIN!! ☺

ACTIVITY 3

Şimdi düşünme zamanı...

$$MgF_{2\,(k)} \rightleftarrows Mg^{+2}_{(suda)} + 2F^{-}_{(suda)}$$

I) $K_ç = \dfrac{[Mg^{+2}]\,[F^-]}{[MgF_2]}$ **II)** $K_ç = \dfrac{[Mg^{+2}]\,[F^-]^2}{[MgF_2]}$

III) $K_ç = [Mg^{+2}]\,[F^-]^2$ **IV)** $K_ç = [Mg^{+2}]\,2[F^-]$

Yazının devamını okumadan önce aşağıda boş bırakılan kısma cevabınızı ve nedenini yazınız...

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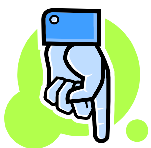
DİKKAT EDİN!!!



Kç bağıntısında KATILAR yer almaz....

Bazı öğrenci arkadaşlar çözünürlük çarpımını (Kç) yazarken derişimi dış etkiler ile değişmeyen katıların da yer aldığını düşünüyorlar. Nitekim aranızda I. ve II. denklemleri seçen varsa bu kavram yanılgısına onlar da sahip olabilirler. Bu nedenle yazının devamını dikkatlice okumanın faydasını göreceklerdir. Yukarıdaki yanlış düşünceye sahip olmanın temel nedeni kimyasal reaksiyonlarda denge bağıntısı yazılırken öğrencilerin genelde ürünlerin derişimleri çarpımını girenlerin derişimleri çarpımına bölerek bulmayı tercih etmelerinden kaynaklanmaktadır. Kimyasal reaksiyonlarda da denge bağıntısı yazılırken katılar DAHİL EDİLMEZ. Fakat genelde öğretmenler ve kitaplar örneklerini gaz tepkimelerinden oluşturduğu için öğrenci arkadaşlarımız sorgulamadan ürünlerin derişimleri çarpımını girenlerin derişimleri çarpımına bölerek denge bağıntısını bulmaktalar. Dolayısı ile her durum için de aynı şekilde denge bağıntısının yazılacağını yani katıların da yer aldığı denge denklemlerinde, gaz tepkimelerinde olduğu gibi ürünlerin derişiminin girenlerin derişimine bölünmesi ile denge bağıntısının ya da çözünürlük çarpımının bulunabileceği hatasına düşüyorlar.

DOĞRUSU nedir? Kç bağıntısı nasıl yazılır?

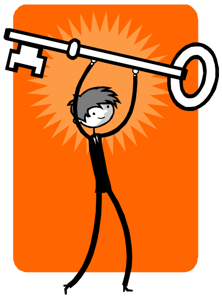
Sorudaki örneğimizi gözönünde bulundurursak, yani

$$MgF_{2\,(k)} \rightleftarrows Mg^{+2}_{(suda)} + 2F^{-}_{(suda)}$$

her denge denkleminde olduğu gibi bu denklemin denge bağıntısı; $K = \dfrac{[Mg^{+2}]\,[F^{-}]^2}{[MgF_2]}$ şeklinde yazılır. FAKAT saf katıların (örneğimizde $MgF_{2\,(k)}$) derişimi sabit olduğundan K∗ $[MgF_2]$ çarpımı, K ve $[MgF_2]$ değerleri sabit olduğu için sabit olacaktır. Başka bir değişle, hem K hem de MgF_2 katısının derişimi sabit olduğundan, iki sabit sayının çarpımı da yine sabit bir sayı olacaktır. Dolayısı ile yeni ifade, K∗ $[MgF_2]$ = Kç = $[Mg^{+2}][F^{-}]^2$ şeklinde yazılır ve kitaplarda her bir katı için yazılan Kç değerleri de BELİRLİ bir SICAKLIKTA böyle hesaplanır.

Dolayısı ile K_* $[MgF_2]$ çarpımı Kç değerine eşittir ve Kç değeri yazılırken katılar yeralmaz.

Peki, katıların derişimi neden sabit? Biraz düşünmekte yarar var?



Anahtar Cümle

Katıların derişimi bir miktarı çözünse bile değişmez.

Gelin bunu bir örnekle anlamaya çalışalım....

Örnek: Elimizde 40 gr $XY_{(k)}$ bileşiği olsun ve suya atıldığında 20 gr XY çözünmeden kalsın. Buna göre $XY_{(k)}$ bileşiğinin derişimi ilk ve son durumlarda nedir?

($M_{xy} = 40$gr, $d_{xy} = 2$)

XY bileşiğinin hacmi (V), $d = \frac{m}{V}$ 'den $2 = \frac{40}{V}$, V=20

XY bileşiğinin mol sayısı(n), $n = \frac{m}{M_{xy}}$ 'den $n = \frac{40}{40}$ n=1mol

XY bileşiğinin derişimi(M), $M = \frac{n}{V}$ 'den $M = \frac{1}{20}$ bulunur.

II. Durumda (katının 20 gramı çözünmemiştir)

XY bileşiğinin hacmi (V_2) $d = \frac{m}{V}$ 'den $2 = \frac{20}{V}$, V_2=10

XY bileşiğinin mol sayısı(n_2), $n = \frac{m}{M_{xy}}$ 'den $n = \frac{20}{40}$ n_2=1/2

XY bileşiğinin derişimi(M_2), $M = \frac{n}{V}$ 'den $M_2 = \frac{1/2}{10}$

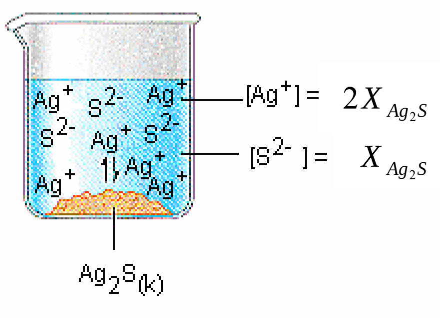
$M_2 = \frac{1}{20}$ bulunur.

Gördüğünüz gibi ilk ve son durumda da katının derişimi aynıdır ve dolayısı ile sabittir.

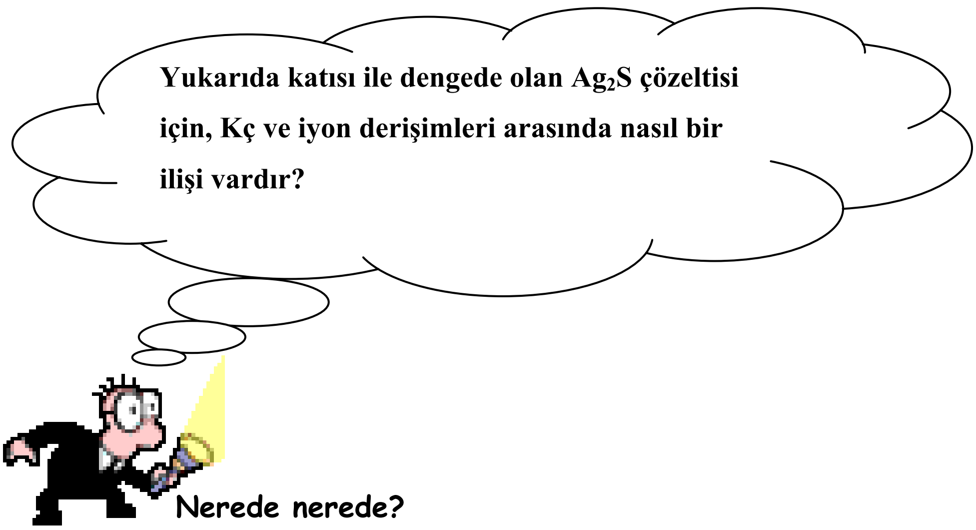
ACTIVITY 4

Aşağıdaki şekilde katısı ile dengede olan Ag_2S çözeltisi görülmektedir.

(Ag_2S: $K_ç = 6.3 \times 10^{-50}$)



$$Ag_2S_{(k)} \rightleftarrows 2Ag^+_{(suda)} + S^{-2}_{(suda)}$$



Sonraki sayfada yazılanları okumadan önce aşağıda boş bırakılan kısma cevabınızı ve nedeninizi yazınız.

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DUR ve BİRAZ DÜŞÜN

Bazı öğrenciler Kç ifadesinde, denge denkleminde katsayısı birden farklı olan maddelerin derişimlerinin (yukarıdaki örnekte Ag^+ iyonunun katsayısı mesela 2 dir) toplamının yazıldığı gibi yanlış bir düşünceye sahipler. Bu düşüncenin kaynağı denklemleri denkleştirirken zaten derişimleri de ayarlıyoruz yanılgısından kaynaklanmaktadır. Mesela yukarıdaki çözelti için Kç değerinin aşağıdaki haliyle yazılması gerektiği kanısına varıyorlar.

$$K_ç = 2[Ag^+][S^{2-}]$$

Genelde sorulan soru neden Ag^+ iyonu derişimini iki ile çarpıp daha sonra karesini alıyoruz ve zaten Ag^+ derişimini iki kere toplamıyor muyuz oluyor.

Bu sorunun kaynağı genelde öğrencilerin hesaplamalarda kullanılan sembolerin anlamını ve Kç bağıntısının tanımını tam olarak kavrayamamalarından kaynaklanmaktadır. Yukarıdaki çözeltiyi düşünürsek X_{Ag_2S}, Ag_2S'nin sudaki çözünürlüğünün mol/L cinsinden ifadesidir. Denkleme dikkatlice bakarsak her bir Ag_2S için iki tane Ag^+ iyonu ve bir tane S^{-2} iyonu oluşmaktadır. Bu nedenle dengede Ag^+ iyonunun derişimi Ag_2S'nin derişiminin iki katı, yani $2X_{Ag_2S}$ ve S^{-2} iyonu derişimi de Ag_2S'nin derişimine eşit, yani X_{Ag_2S} olur. Kç bağıntısı yazılırken Ag^+ iyonu derişiminin karesini almamızın sebebi ise Kç bağıntısının tanımından gelmektedir. Dolayısı ile yukarıda katısı ile dengede olan çözelti için Kç ifadesi

$$\boldsymbol{K_ç = [Ag^+]^2[S^{2-}]}$$

$$K_ç = [Ag^+]^2[S^{2-}]$$ şeklinde olur.

Bazı öğrenciler de çözeltide bulunan iyonların derişimlerinin birbirleri ile ilişkisi sorulduğunda daha doğrusu bir iyonun derişimini diğer iyonun derişimi şeklinde yazmaları istendiğinde, yanlış eşitlikler kurmalarıdır.

Mesela örneğimizde Ag^+ ve S^{2-} iyon derişimleri arasındaki ilişkiyi yazalım. Aşağıda boş bırakılan kısma cevabınızı yazınız.

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Doymuş Ag_2S çözeltisinin denge denklemine bakıp aşağıdaki denklemi yazmak işten bile değildir.

$[S^{2-}] = 2\,[Ag^+]$

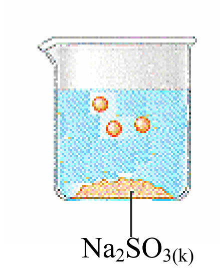
DİKKAT EDİN

Bu ifade çözeltideki Ag^+ iyon derişimi S^{2-} iyon derişiminin iki katı olarak düşünen bazı öğrenci arkadaşlar için çok mantıklı görünebilir. Fakat eşitlik yanlış kurulmuştur çünkü her bir S^{2-} iyonu oluşumu için iki adet Ag^+ iyonu oluşmaktadır. Dolayısı ile Ag^+ iyonu derişimi S^{2-} iyonu derişiminin iki katıdır ve aşağıdaki gibi bir eşitlikle ifade edilir.

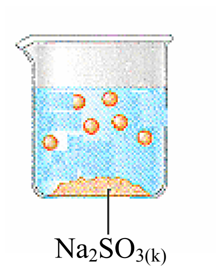
$$[Ag^+] = 2\,[S^{2-}]$$

ACTIVITY 5

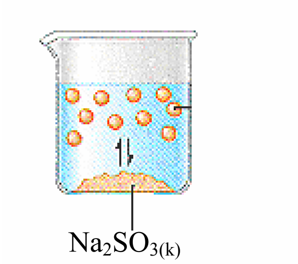
Aşağıda Na_2SO_3 katısının çözünmesi ve çözeltinin katısı ile dengeye gelişi gösterilmektedir.



Şekil 1



Şekil 2



Şekil 3

Our mu ki?

Sonraki sayfada yazılanları okumadan önce aşağıda boş bırakılan kısma cevabınızı ve nedeninizi yazınız.

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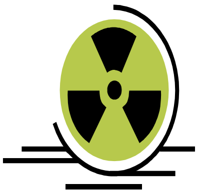


LÜTFEN DİKKAT EDELİM!!!

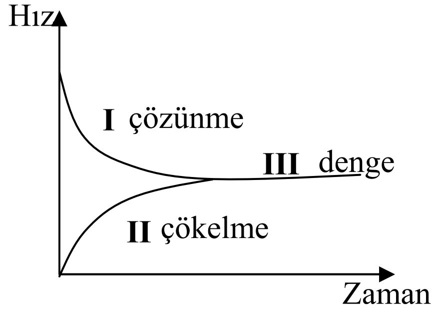
Bazı öğrenciler çözelti katısı ile dengeye gelmeden önce çökelmenin olmadığı kanısındalar. Bunu böyle kabul etmelerinin temel sebebi bir şeyin başlayabilmesi için diğerinin bitmiş olması gerktiği şeklinde düşünmeleridir. Yani, çökelmenin başlayabilmesi için çözünmenin bitmesi gerektiğini düşünmeleridir. Fakat gerçekten de çözelti doygunluğa ulaşmadan önce çökelme gözlenmez mi? Aslında tuz ($Na_2SO_{3(k)}$) çözünmeye başladıktan bir süre sonra çözeltide iyon sayısı artmaya başlar bu da iyonların birleşerek katı tuz oluşturma ihtimalini arttırmaktadır. Bu nedenle dengeden önce çözeltide katı tuz oluşur (örneğimizde $Na_2SO_{3(k)}$). Zaten çözünürlük dengesinin tanımı çözünme hızının çökelme hızına eşit olması değilmiydi. Tanımdan da anlaşıldığı üzere çökelme hızının çözünme hızına eşit olabilmesi için dengeden önce de bir miktar çökelmenin olması gerekir, değil mi?

AŞTİ örneğimiz.

Bunu gelin AŞTİ örneğimizle anlamaya çalışalım. AŞTİ'den giden yolcular iyonlaşan katıyı, gelen yolcular da iyonların birbiri ile çarpışması sonucu oluşan çökeltiyi temsil etsin. Denge anında ne demiştik? AŞTİ'nin Ankaray girişindeki yürüyen bantlardan giden ve gelen yolcuların geliş ve gidiş hızları eşitti değil miydi? Denge anında hızları eşitlendiğine göre denge anından önce nasıl olur? Denge anından önce de bir miktar yolcu gidecek ve bir miktar yolcu da gelecektir. Fakat giden yolcular denge anına kadar daha fazla olacak ve denge anında da gelen ve giden yolcuların geliş ve gidiş hızları eşit olacaktır. Dolayısı ile dengeden önce de bir miktar yolcu gelecektir. Bu da örneğimize geri dönersek bir miktar çökelmenin olması gerektiği anlamına gelmez mi? Dolayısı ile çözelti katısı ile dengeye gelmeden önce de bir miktar katı Na2SO3 oluşmaktadır.

Çözelti katısı ile dengeye gelmeden önce de bir miktar çökelme olacaktır.

Bunu gelin bir de hız-zaman grafiği üzerinde anlamaya çalışalım.



Grafik 1

Ama bundan önce aşağıdaki soruyu yanıtlamanızı istiyorum.

Cevabınızı aşağıda boş bırakılan kısma yazınız...

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DİKKAT EDELİM

Bazı öğrenciler çözünme hızının zamanla arttığını düşünüyorlar. Böyle düşünmenin temel sebebi öğrencilerin günlük hayatta karşılaştıkları bazı çözünme reaksiyonlarını yanlış yorumlamalarıdır. Mesela çaya şeker atıp karıştırılırsa çok çabuk çözünme gerçekleşir diye düşünüp çözünürlüğün zamanla arttığı yanılgısına düşmekteler. Aslında çözünürlüğü arttıran sıcaklık ve çözünenin çözücü ile temas ettiği alanı arttırmaktır ve bu da genelde toz haline getirerek ya da karıştırarak sağlanmaktadır.

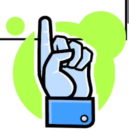
O zaman belirli bir sıcaklıkta çözünme hızının zamanla artıp artmadığı hakkında ne söyleyebiliriz? Biliyoruz ki bir çözücü belirli bir sıcaklıkta belirli miktarda katı çözebilir. Bu nedenle çözünme hızı zamanla azalır çünkü zamanla çözünen (katı tuz) ile etkileşim halinde olan su ya da çözücü molekülü sayısı azalacaktır. Çünkü bir kısmı çözeltideki iyonlarla etkileşim halindedir.

AŞTİ örneğimiz.

Bunu gelin AŞTİ örneğimiz ile açıklamaya çalışalım. AŞTİ'deki bütün şirketler çözücü molekülleri olsun. Bu şirketlerin taşıyabileceği yolcu sayısı da çözünürlüğün tanımı olacaktır. Öyleyse yolcu sayısı zamanla artarsa bu şirketlerin taşıyabileceği yolcu sayısı da azalacaktır. Yani çözeltimizde iyon sayısı artarsa, çözünme hızımız azalacaktır.

Sonuç olarak çözünme hızı zamanla AZALIR. Başlangıçta çözünme hızı çok hızlıdır ve dengeye gelene kadar azalır ve dengede çökelme hızıyla çözünme hızı eşitlenir.

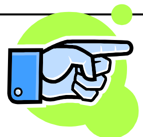
Başlangıçta çözünme hızı çok hızlıdır ve dengeye gelene kadar azalır.



Tekrar Gafik 1'e dönersek I numaralı çizgi çözünme hızının zamanla nasıl değiştiğini gösterirken, II numaralı çizgi çökelme hızının zamanla nasıl değiştiğini gösterir ve III numaralı çizgi de dengedeyken çökelme ve çözünme hızlarını göstermektedir. Yukarıda da açıkladığımız gibi çözünme hızı zamanla azalırken çökelme hızı zamanla artmakta ve dengeye ulaşıldığında çökelme ve çözünme hızları eşit olmaktadır. Grafikten de anlaşıldığı üzere sistem dengeye ulaşmadan önce de çökelme devam etmektedir.

Grafik 1'e dikkatlice baktığımızda, II numaralı çizginin sıfırdan başladığını göreceksiniz. Sizce bunun nedeni ne olabilir?

Konunun özeti, bu nedenle dikkatlice incelemelisin.

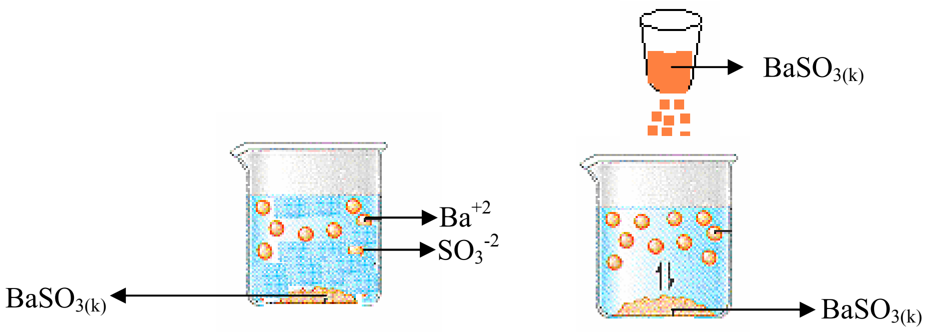


Sıfır noktasından başlar çünkü başlangıçta çözücüde çözünen iyon yoktur. Zamanla iyon sayısı artmakta bu da iyonların birbiri ile çarpışma ihtimallerini arttırmaktadır. Bu nedenle de çökelme hızı zamanla artmaya başlamaktadır ve denge anında çözünme hızına eşit olmaktadır. Çözünme hızı da tam tersi olacaktır. Yani zamanla azalacaktır çünkü çözeltideki iyon derişimleri zamanla artacak ve çözücünün o sıcaklıkta çözebileceği çözünen miktarı belirli olduğundan, çözünme hızı zamanla azalacaktır.

	Çözünme Hızı	Çökelme Hızı
Başlangıç	Çok hızlı	Çok yavaş
Zamanla	Azalır	Artar
Dengede	Çökelme hızına eşittir	Çözünme hızına eşittir

ACTIVITY 6

Belirli bir sıcaklıkta Şekil 1'de $BaSO_3$ çözeltisini görüyorsunuz. Bu doymuş çözeltiye aynı sıcaklıkta Şekil 2'deki gibi bir miktar $BaSO_{3(k)}$ katısı ekleniyor.



Şekil I **Şekil II**

Şekil I'deki denge durumundan Şekil II'deki duruma, yani doymuş $BaSO_3$ çözeltisine bir miktar daha katı $BaSO_{3(k)}$ eklersek, yeni durumda Ba^{+2} ve SO_3^{-2} iyonları derişimi ve Kç nasıl değişir?

Kim bilebilir...

Sonraki sayfada yazılanları okumadan önce aşağıda boş bırakılan kısma cevabınızı ve nedeninizi yazınız.

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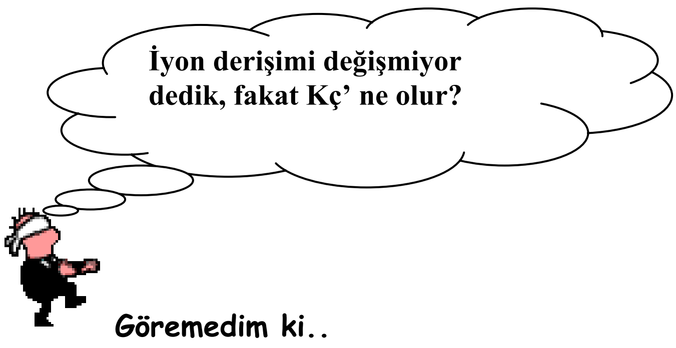
Bazı öğrenciler, doymuş bir çözeltiye bir miktar daha katısından eklemenin iyon derişimlerini artırdığını düşünüyorlar. Böyle düşünmelerinin temel sebebi denge denklemini düşünerek bir tarafa birşey eklersek denklemin diğer tarafında da bir artış olmalı ki denge sağlansın diye düşünmeleridir. Fakat bir çözelti dengedeyse çözebileceği maksimum katıyı çözmüştür ve biz ona daha fazla katı ilave etsek de bulunduğu sıcaklıkta daha fazla katı tuz çözemez. Daha fazla katı çözünmediği için de iyonların mol sayısı değişmez. Aynı zamanda hacim sabit olduğundan derişimleri de değişmez.

DAHA DİKKATLİ OLMALISIN

Gelin bunu yine AŞTİ örneği ile açıklamaya çalışalım. AŞTİ'deki bütün otobüs firmaları bizim çözücü moleküllerimiz olsun. Bu çözücü moleküllerinin taşıyabileceği maksimum yolcu sayısı da 1000 olsun (çözeltide bulunan iyonlar). Eğer AŞTİ'ye daha fazla yolcu gelirse firmaların taşıyabileceği yolcu sayısı değişir mi?

Doymuş bir tuz çözeltisine aynı sıcaklıkta katısından bir miktar daha eklemek, katı tuzun çözünürlüğünü değiştirmeyecektir.

HAYIR çünkü bu ancak otobüs sayısının artması ile mümkün olur. Dolayısı ile 2000 yolcu gelse de bunun sadece 1000 tanesi taşınabilecektir. Eğer bizim çözeltimiz dengede ise bu zaten elimizde 1000 yolcu olduğunu gösterir ki daha sonra eğer biz 2000 yocu daha koyarsak (sonradan eklenen $BaSO_3$) taşınabilecek yolcu sayısı değişmeyeceği için eklediğimiz katı miktarı kadar madde dipte çözünmeden kalacaktır. Bu nedenle doymuş $BaSO_3$ çözeltisine katı $BaSO_3$ eklemek iyon derişimini etkilemeyecektir.



Kimi öğrenciler belirli bir sıcaklıkta çözeltiye katısından eklemenin ve ya çözeltinin hacmi değişmemek koşulu ile ortak iyon eklemenin, Kç değerini değiştirdiğine inanıyorlar. Böyle bir inancın temel sebebi çözücünün DOYMUŞ bir çözeltide çözebileceği maksimum madde miktarını çözmüş olmasını anlamamalarıdır. Bu nedenle de çözeltiye katısından eklenmesi ile ortamdaki iyon derişiminin artacağı ve bunun da Kç değerini değiştireceğine sanıyorlar. Yine ortak iyon eklediğimizde çökelme tepkimesini unutup, mevcut durumda iyon derişiminin yine arttığını düşünüyorlar. Böyle düşünen öğrenciler yanılıyorlar, çünkü bir önceki örnekte bahsettiğimiz gibi DOYMUŞ bir çözelti zaten çözebileceği maksimum çözüneni çözmüştür. Bu nedenle aynı sıcaklıkta bir miktar daha katı ilave etmemiz iyon derişimlerini de dolayısı ile değiştirmeyecektir. Kç'de DOYGUN bir çözeltideki iyon derişimleri çarpımı olduğundan, o da değişmeyecektir. Sonuç olarak, başta sorduğumuz sorumuza geri dönersek; Şekil II'deki durumda (bir miktar $BaSO_{3(k)}$ ilave edildiğinde) Kç değeri değişmeyecektir.

Belirli bir sıcaklıkta, çözeltiye katısından ilave etmek Kç değerini değiştirmez

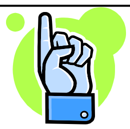
Ortak iyon eklediğimizde PEKİ neden Kç değişmiyor? Doymuş bir çözeltiye ortak iyon eklersek (örneğimizde $BaSO_3$ çözeltisine SO_3^{-2} iyonları eklersek) Le Chatelier prensibinden faydalanarak bir tarafa bir etki yapıldığında o etkiyi azaltmak için sistem diğer tarafa kayar. Bu durumda çökelme tepkimesi hızlanır ve sistem dengeye geldiğinde ortak iyon eklenen iyonun derişimi artmış fakat ortamdaki diğer iyonun ($[Ba^{+2}]$) derişimi de aynı oranda azaldığı için Kç çarpımı değişmez.

tepkime

$$BaSO_{3(k)} \rightleftarrows Ba^{+2}_{(suda)} + SO_{3\,(suda)}^{-2}$$

SO_3^{-2} iyon derişimini arttırırsak çözeltideki iyon sayısı artacak ve bu nedenle iyonların çarpışarak BaSO3(k) katısını oluşturma ihtimalleri de artacaktır.

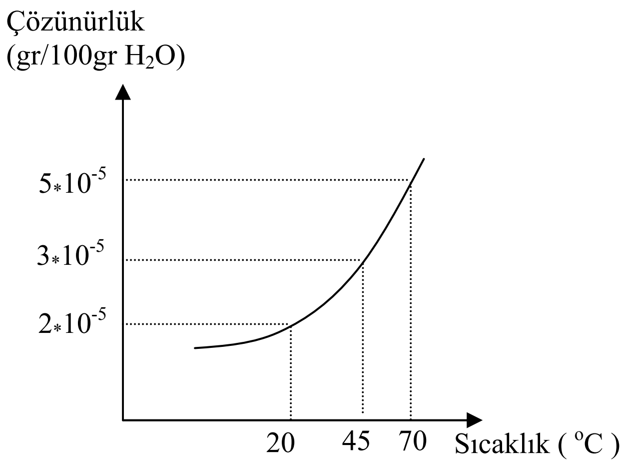
Belirli bir sıcaklıkta, çözeltiye çözeltinin hacmi değişmemek koşulu ile ortak iyon eklemek Kç değerini değiştirmez.



Dolayısı ile çökelme hızı çözelti katısı ile dengeye gelene kadar çözünme hızından daha fazla olacaktır. Aynı zamanda çözeltide Ba^{+2} iyonu derişimi sadece $BaSO_{3(k)}$ katısını çözünmesinden geldiği için, çözelti dengeye ulaştığında SO_3^{-2} iyon derişimi Ba^{+2} iyonu derişiminden büyük olacak fakat Kç değişmeyecektir. ÇÜNKÜ aynı SICAKLIKTA çözücünün çözebileceği madde miktarı aynıdır. Başka bir değişle çözeltide SO_3^{-2} iyon derişimindeki artma Ba^{+2} iyonu derişimindeki azalmayla dengelenmekte ve yine aynı Kç çarpımı elde edilmektedir.

ACTIVITY 7

Şekil 1'de X_2Y katısının çözünürlük-sıcaklık grafiği görülmektedir.



Şekil 1

45^oC'deki derişik X_2Y çözeltisini 20^oC'ye soğutup bir süre beklendikten sonra tekrar 45^oC'ye ısıtırsak; son durumdaki Kç değeri, ilk durumdaki Kç değerine göre nasıl değişmiştir?

Sonraki sayfada yazılanları okumadan önce aşağıda boş bırakılan kısma cevabınızı ve nedeninizi yazınız.

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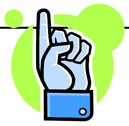
DİKKAT!!

Az çözünen tuzların Kç değeri, aynı sıcaklıkta sabittir.



Bazı öğrenciler suda az çözünen tuzların aynı sıcaklıkta farklı Kç değerleri olduğuna inanıyorlar. Bu görüşe sahip olanlar genelde bu yanlış yargıya ders kitaplarında ya da test kitaplarında aynı maddenin Kç değerinin sıcaklık belirtilmeden farklı verilmesi ya da Kç değerinin yuvarlanarak (örneğin $1,8 * 10^{-5}$ değerini $2 * 10^{-5}$ olarak yazmak) yazılması sebebi ile sahip oluyorlar.

Aslında Kç değeri AZ ÇÖZÜNEN tuzlarda aynı sıcaklıkta AYNI değere sahiptir. Örneğin 25°C'de AgBr'nin Kç değeri $7 * 10^{-13}$ dir. Çünkü belirli bir sıcaklıkta çözücünün çözebileceği katı miktarı belirlidir. Bu nedenle de Kç değeri de çözünen iyonların derişimleri çarpımı olduğundan belirli bir sıcaklıkta sabittir. Aynı sıcaklıkta Kç farklı değerler alsaydı yukarıdaki grafik çizilebilir miydi? Hayır çizilemezdi, çünkü o zaman Kç sabit bir sayı olmaktan çıkardı ve de dolayısıyla iyon derişimleri o sıcaklıkta farklı değerlere sahip olurdu.

Doğru Cevap

Başta sorulan soruya geri dönersek, katının 45°C'deki çözünürlüğü $3 * 10^{-5}$ tir. 20°C'ye soğutursak çözünürlük grafikte görüldüğü üzere azalıyor ve $2 * 10^{-5}$' e düşüyor, bu da bir miktar katının çökeldiği anlamına gelmektedir. Biz tekrar bu çözeltiyi 45°C'ye ısıtırsak ve de dengeye ulaşması için bir müddet beklersek yine çözünürlüğü $3 * 10^{-5}$ olacaktır. Bu nedenle de Kç değeri ilk ve son durumlarda değişmeyecek yani aynı kalacaktır.

Son olarak AZ ÇÖZÜNEN tuzların Kç değeri SICAKLIK ile DEĞİŞİR ve aynı sıcaklıkta aynı değere sahiptir.

ACTIVITY 8

Sonraki sayfada yazılanları okumadan önce aşağıda boş bırakılan kısma cevabınızı ve nedeninizi yazınız.

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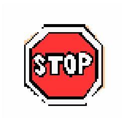
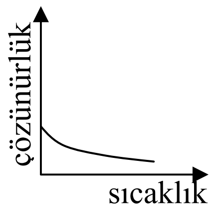
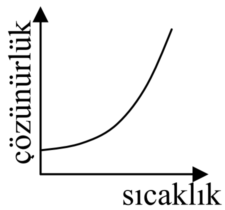


DİKKAT!!!



Ekzotermik



Endotermik

Bazı öğrenciler sıcaklık düştükçe çözünürlük azalır ve dolayısı ile iyon derişimleri azalır diye düşünerek, Kç değerinin her zaman azaldığı yanılgısına düşüyorlar. Bazı öğrencilerinin böyle düşünmesinin sebebi genellikle ders kitaplarında her zaman çözünürlüğü sıcaklık azalışı ile azalan ya da sıcaklık artışı ile artan çözeltilere yer verilmesidir. Böyle olunca da kimi öğrenciler böyle yanlış bir genellemeye varabiliyorlar. Aslında, sıcaklığın artması ile çözünürlüğün artması veya sıcaklığın düşmesiyle çözünürlüğün azalması SADECE ENDOTERMİK çözünmeler için doğrudur. Çözünmenin ekzotermik olduğu çözünmelerde sıcaklık arttıkça çözünürlük azalırken sıcaklık düştükçe çözünürlük artmaktadır. Görüldüğü üzere endotermik ve ekzotermik çözünmelerde SICAKLIK çözünürlüğe farklı şekillerde etki etmektedir.

Sıcaklık NEDEN ekzotermik ve endotermik çözünmelerde farklı etki yapar?

Nedennn?

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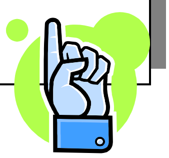
Öncelikle çözünmenin ekzotermik olduğu çözünmelerde dışarıya ısı verilmesi nedeniyle sıcaklığın arttığını; endotermik olduğu çözünmelerde ise dışarıdan ısı alınması nedeniyle ortamın sıcaklığının azaldığını hatırlamalıyız. Bu nedenle sıcaklık arttırılırsa sistem Le Chatelier prensibine göre bu etkiyi azaltacak bir tepki gösterir yani sıcaklığı düşürmek ister.

$XY_{(k)}$ + ısı $\rightleftarrows X^{+}_{(suda)} + Y^{-}_{(suda)}$ endotermik (ısı alır)

$BM_{(k)} \rightleftarrows B^{+}_{(suda)} + M^{-}_{(suda)}$ + ısı ekzotermik (ısı verir)

Isı alarak çözünen maddeler sıcaklık artışında daha fazla çözünürken, ısı vererek çözünen maddeler sıcaklık artışında daha az çözünecektir.



Endotermik çözünmelerde ortamın sıcaklığını arttırırsak sistem etkiyi azaltacak bir tepki gösterir yani sıcaklığı düşürmek ister. Başlangıçta da belirttiğimiz gibi endotermik çözünmelerde dışarıdan ısı alınması nedeniyle ortamın sıcaklığı azalır. Dolayısıyla artan sıcaklığı düşürmek için daha fazla çözünme gerçekleşecektir.

Ekzotermik çözünmelerde yukarıdaki denge denkleminde de gördüğünüz üzere ortamın sıcaklığı çözünme sırasında artmaktadır. Dolayısı ile sıcaklığı arttırırsak sistem bu etkiyi azaltmak isteyecek ve sıcaklığı düşürmek için çökelmenin lehine işleyecektir. Çünkü çökelme sırasında dışarıdan ısı alınmakta bu da ortamın sıcaklığı düşürmektedir. Kısacası ısı alarak çözünen maddeler sıcaklık artışında daha fazla çözünürken, ısı vererek çözünen maddeler sıcaklık artışında daha az çözünecektir.

Aşağıdaki örnek bu konuyu daha iyi kavramamızda yardımcı olacaktır.

Güneş enerjisi yardımı ile yol alan arabalarda güneş ışınları arttıkça daha fazla enerji elde edilmekte bu da daha fazla yol katetmek anlamına gelmektedir. Bulutlu havalarda ise daha az enerji elde edebildiği için çok uzun yol katedemez. Sizce bu endotermik çözünmelere mi yoksa ekzotemik çözünmelere mi bir örnektir?

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Endotermik, çünkü endotermik çözünmelerde sıcaklık arttıkça çözünme artmaktadır. Örneğimizde de güneş ışınları arttıkça enerjimiz artmakta ve dolayısı ile aldığımız yol artmaktadır (çözünürlük artmaktadır).

ACTIVITY 9

Sonraki sayfada yazılanları okumadan önce aşağıda boş bırakılan kısma cevabınızı ve nedeninizi yazınız.

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DİKKAT!!!

Bazı öğrenciler doymamış çözeltilerde de Kç değerinin hesaplanabileceği yanılgısına düşüyorlar. Bu yanılgının yegane sebebi kimya kitaplarında çözünürlük dengesi ile ilgili soruların genelde problem çözmeye ve işlem becerilerine yönelik olmasından dolayıdır. Çünkü sorular genelde, belirli bir sıcaklıktaki doymuş çözeltiler, başka bir deyişle katısı ile dengede olan çözeltiler için sorulmaktadır. Dolayısıyla bazı arkadaşlar bundan yanlış bir genellemeye varıp Kç'nin tüm durumlarda (doymuş, doymamış) hesaplanabileceği kanısına varmaktadırlar.

> Doymamış çözeltilerde Kç ‘den bahsedemeyiz.

Fakat şunu untmamalıyız ki, Kç BİR DENGE SABİTİDİR yani dengede olan bir çözeltinin iyon derişimleri çarpımıdır. Doymamış bir çözeltide denge durumundan bahsedebilir miyiz? Tabiki hayır. Çünkü çözebileceği maksimum çözüneni çözmemiştir, dolayısıyla da çözünme ve çökelme hızlarının eşitliğinden bahsedemeyiz. Çünkü doymamış çözeltilerde çözünme çökelmeden daha hızlı gerçekleşmektedir. Sonuç olarak eğer çözeltimiz doygun değilse denge durumundan bahsedemeyiz. Bu nedenle de Kç hesaplaması yapamayız.

İyon çarpımı (Q_i) dediğimiz ve Kç ile karşılaştırarak çökelmenin olup olmadığını tayin edebildiğimiz değeri hesaplamış oluruz.

1. Q_i = Kç
2. Q_i > Kç
3. Q_i < Kç

Eğer Q_i = Kç ise çözelti doymuştur; yani çökelme ve çözünme hızları birbirine eşittir ve çözelti dengededir.

Eğer Q_i > Kç ise çözeltideki iyon derişimleri denge derişiminden büyük olduğu için Q_i = Kç olana kadar iyonlar çökelti oluşturur.

Eğer Q_i < Kç ise çözelti doymamıştır. İyon derişimleri denge derişimlerinden küçük olduğu için çökelme olmaz. Çözeltide katı varsa Q_i = Kç eşitliği sağlanana kadar çözülür.

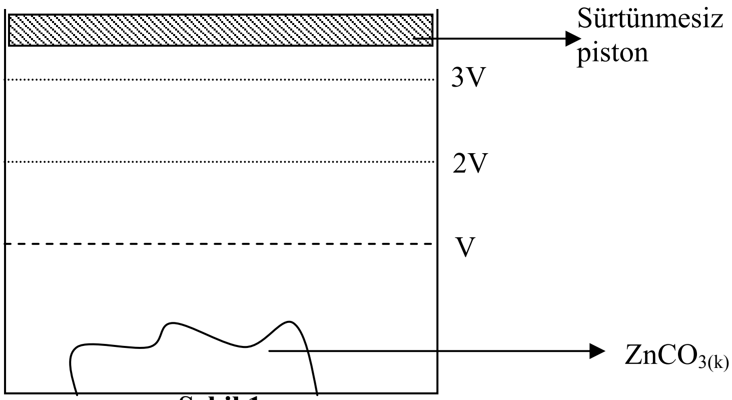
Sonuç olarak suda az çözünen bir tuzun herhangi bir anda hesaplanan iyonların derişimleri çarpımı için üç durum sözkonusu olabilir.

1. Çözelti doymuştur ve katısı ile dengededir (Q_i = Kç).
2. Çözelti doymamıştır ve denge durumundan bahsedemeyiz (Q_i < Kç).
3. Çözeltide bir miktar tuz katısı ile dengeye gelene kadar çökelir (Eğer Q_i > Kç).

ACTIVITY 10

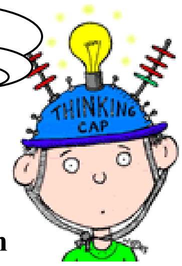
Şekil 1'de katısı ile dengede olan doymuş $ZnCO_3$ çözeltisi görülmektedir.

$$\mathbf{ZnCO_{3(k)} \rightleftarrows Zn^{+2}{}_{(suda)} + CO_3{}^{-2}{}_{(suda)}}$$



Şekil 1

Şekil 1'de görüldüğü üzere kapta *V* hacminde katısı ile dengede olan $ZnCO_3$ çözeltisi vardır. Bu çözeltiye 3*V*'ye kadar su doldurulduğunda dipteki katının bir kısmının çözünmediği gözlemleniyor. Yeni durumda $ZnCO_3$ ün çözünürlüğü için ne söyleyebiliriz?



Ehe, Ehe de kem küm

Sonraki sayfada yazılanları okumadan önce aşağıda boş bırakılan kısma cevabınızı ve nedeninizi yazınız.

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LÜTFEN DİKKAT EDİN!!!

Hacimin artması ve iyon sayısının da artması, aynı sıcaklıkta Kç değeri aynı olduğu için, iyon derişimini değiştirmeyecektir. Bu nedenle de çözünürlük değişmez.

Bazı öğrenciler suda az çözünen tuzların *çözeltilerinin dibinde, bir miktar katısından kalmak* koşulu ile hacminin arttırılması ya da azaltılmasının o tuzun çözünürlüğünü değiştirdiğini düşünüyorlar. Böyle düşünenler, hacmin değişmesi ile derişimin değişeceğini, bunun da çözünürlüğü etkileyeceğini düşünerek böyle bir yanılgıya düşmekteler. Oysa soruya dikkatlice bakıldığında, çözeltinin son durumda da dibinde bir miktar katı olduğunu görürüz. Yani yeni durumda da (SICAKLIK DEĞİŞMEDİĞİ İÇİN) Kç aynıdır. Çözeltimizin Kç si aynı olduğundan çözünürlük değişmeyecektir. Peki ama neden?

Bir miktar daha su eklediğimizde çözeltinin hacmi artacaktır. Fakat aynı zamanda o sıcaklıkta, çözeltinin dibindeki katının bir kısmı daha iyonlaşacaktır ve dolayısı ile iyon sayısı artacaktır. Fakat çözünen iyonların derişimi değişmeyecektir çünkü, çözünen iyonların mol sayıları ile hacim artışının oranı sabit kalacaktır. Sıcaklık değişmediği için, çözeltini çözebileceği maksimum madde miktarı da değişmeyecektir, bu da neden iyon derişimlerinin değişmediğini açıklamaktadır. Çözeltinin dibinde son durumda da bir miktar katı olduğuna göre, aynı sıcaklıkta, çözelti katısı ile yeniden dengeye gelecektir. Yani yeni durumda, çözünme hızı çökelme hızına eşit olduğunda denge tekrar kurulacaktır.

Sonuç olarak dibinde bir miktar katı kalmak koşulu ile çözeltiye çözücü eklemek, aynı sıcaklıkta, katı tuzun çözünürlüğünü değiştirmeyecektir.

Şekil 1'deki kabın basıncı (Piston aşağıya doğru bastırılarak) arttırılırsa $ZnCO_3$ 'ün çözünürlüğü için ne söyleyebiliriz?

Mıııın!!! ....

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LÜTFEN DİKKAT EDİN!!!

Basınç artışı, katıların çözünürlüğünü etkilemez.

Kimi öğrenciler suda az çözünen tuzların çözünürlüğünün basıncın değişmesi ile değiştiğini düşünüyorlar.Böyle düşünmelerinin temel sebebi gazların çözünürlüğünün basınca bağlı olarak değişmesini hatırlayıp katıların da çözünürlüğü basınç ile değişmeli gibi yanlış bir yargıya varmalarındandır. Biliyoruz ki gazlar sıkıştırılma özelliğine sahip olduklarından, uygulanan basınçla orantılı olarak çözünürlükleri artmaktadır. Oysa ki katıların ve sıvıların sıkıştırılamadığını biliyoruz, değil mi? Dolayısıyla da basıncın artması katıların (örneğimizde $ZnCO_3$) çözünürlüğünü etkilemez.

ACTIVITY 11

XY_2 ------ $K_ç = 3,2 * 10^{-6}$

XY ------ $K_ç = 5,2 * 10^{-5}$

X_3Y ------ $K_ç = 4,2 * 10^{-7}$

Sonraki sayfada yazılanları okumadan önce aşağıda boş bırakılan kısma cevabınızı ve nedeninizi yazınız.

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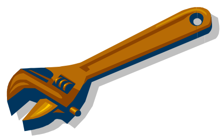


DİKKAT!!!

Kimi öğrenciler tuzların sudaki çözünürlüğünü sadece Kç değerlerine bakarak karşılaştırabileceklerini sanıyorlar. Bu fikre sahip olmalarının temel nedeni ders kitaplarında verilen örneklerin genelde Kç değerlerinin bu tür bir kıyaslamaya uygun verilişindendir. Peki Kç değerleri verilen tuzlar farklı katsayılara sahip iyonlar şeklinde çözünüyorsa yine de sudaki çözünürlüklerini Kç değerlerine bakarak karşılaştırabilirmiyiz? Tabiki hayır. Öncelikle denge denklemi yazılmalı ve ondan sonra da Kç ifadesi yazılmalıdır. Daha sonra da iyon derişimleri yardımı ile katının çözünürlüğünü hesaplayabiliriz.

Sorduğumuz sorudaki denge denklemi ve Kç bağıntılarını yazalım.

$XY_{2\,(k)} \rightleftarrows X^{+2}_{(suda)} + 2Y^{-}_{(suda)}$ $\quad$ $Kç=[X^{+2}][Y^{-}]^2$

$\qquad\qquad s \qquad\qquad 2s$ $\qquad$ $Kç = s.\,(2s)^2 = 4s^3$

XY_2 : $Kç = 3{,}2{*}10^{-6}$
XY : $Kç = 5{,}2{*}10^{-5}$
X_3Y : $Kç = 4{,}2{*}10^{-7}$

$XY_{(k)} \rightleftarrows X^{+}_{(suda)} + Y^{-}_{(suda)}$ $\quad$ $Kç=[X^{+}][Y^{-}]$

$\qquad\qquad s \qquad\qquad s$ $\qquad$ $Kç = s.\,s = s^2$

$X_3Y_{(k)} \rightleftarrows 3X^{+}_{(suda)} + Y^{-3}_{(suda)}$ $\quad$ $Kç=[X^{+}]^3[Y^{-3}]$

$\qquad\qquad 3s \qquad\qquad s$ $\qquad$ $Kç = (3s)^3\,.\,s = 27\,s^4$

Bu tuzların çözünürlüklerini sadece Kç değerlerine bakarak sıralasaydık $XY > XY_2 > X_3Y$ şeklinde olacaktı. Bu ifade sizce doğru mudur?

Yandaki ifade doğru mu?

Sadece Kç değerlerine bakarak tuzların çözünürlüklerini karşılaştıramayız.

Her bir denklem için tuzların sudaki çözünürlüğü (s) olarak kabul edelim. Bu nedenle Kç bağıntılarından yararlanarak her bir katının çözünürlüğünü bulabiliriz, değil mi?

I. Denklem için $4s^3 = 3{,}2{*}10^{-6}$ $\quad s = 9{,}3{*}10^{-3}$

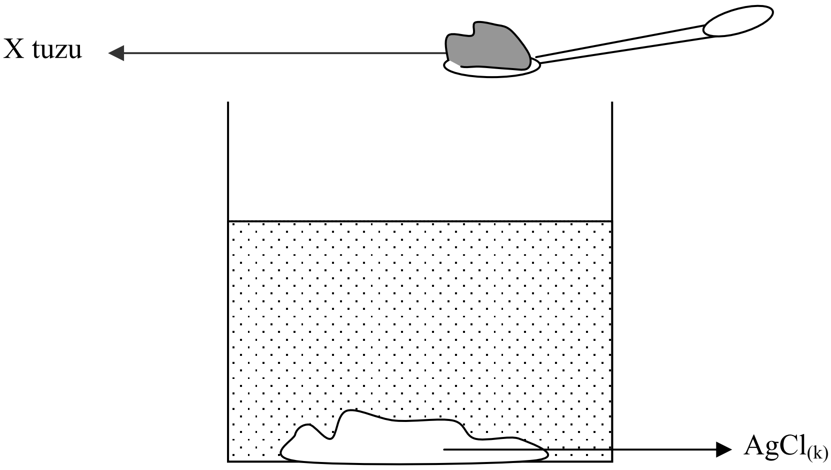
II. Denklem için $s^2 = 5{,}2{*}10^{-5}$ $\quad s = 7{,}2{*}10^{-3}$

III.Denkelem için $27\,s^4 = 4{,}2{*}10^{-7}$ $\quad s = 1{,}1{*}10^{-2}$

Görüldüğü gibi sıralama $X_3Y > XY_2 > XY$ şeklini aldı ve yukarıdaki suralamadan farklı olduğunu görmekteyiz. Bu nedenle sadece Kç değerlerine bakarak tuzların çözünürlüklerini karşılaştıramayız.

ACTIVITY 12

Şekil 1'de doymuş AgCl çözeltisine bir miktar, Ag^{+} ve Cl^{-} iyonları ile bileşik oluşturmayan, X tuzu ekleniyor.



Şekil 1

Sonraki sayfada yazılanları okumadan önce aşağıda boş bırakılan kısma cevabınızı ve nedeninizi yazınız.

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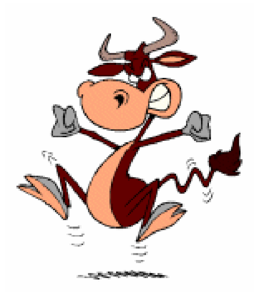

LÜTFEN DİKKAT EDİNİZ!!!

Kimi öğrenciler doygun bir çözeltide başka bir katı tuzun (çözeltideki iyonlar ile bileşik oluşturmayan) çözünmesi ile çözünürlüğün değişmeyeceğini düşünüyorlar. Bu düşüncenin temel nedeni çözeltide bulunan iyonlar ile ilave edilen tuzdan gelen iyonların bileşik oluşturmaması sebebi ile çözünürlüğün değişmeyeceğini sanmalarıdır. FAKAT gerçekten de çözünürlük değişmemekte midir?

ASLINDA, yabancı iyonlar (örneğimizde X tuzunun çözünmesi ile oluşan iyonlar) çözeltinin iyon şiddetini yükselterek (iyon sayısının, ilave edilen tuzdan gelen iyonlar nedeni ile artığını hatırlayalım) çözünürlüğü az olan madde iyonlarının o çözücüdeki çözünürlüğünü arttırmaktadır. Bunun da temel sebebi çözeltideki iyonların (eklenen yeni iyonlar nedeniyle) elektrostatik çekme ve itme etkisinin artmasıdır.

Dolayısı ile örneğimizde AgCl'nin çözünürlüğü eklenen X tuzu ile nasıl değişecektir? Artar mı yoksa azalır mı? Yukarıda belirtiğimiz nedenden dolayı AgCl'nin çözünürlüğü artacaktır.

Çok heyecanlı.

Kç ile çözünme hızı arasında doğrudan bir ilişki yoktur.

Kimi öğrenciler Kç değerinin büyüklüğü arttıkça katıların sıvılar içerisinde daha hızlı çözündüğünü düşünüyorlar. Böyle düşünenler bu genellemeye daha çok çözündüğüne göre daha hızlı çözünmeli yaklaşımı ile varmaktalar. Fakat Kç sadece çözünmenin miktarı ile ilgilidir daha doğrusu bir katının bir çözücüde nekadar çözündüğünü belirtir. Oysaki çözünme hızı sıcaklığa ve katının çözücü ile temas ettiği temas yüzeyine bağlıdır. Bu nedenle Kç ile çözünme hızı arasında doğrudan bir ilişki yoktur.

APPENDIX H

SAMPLE LESSON PLAN

Conceptual change texts were given to each student in experimental group before each lesson. In other words, every student before the lesson received related conceptual change texts. They were supposed to read these texts at home before they went through these texts in the lessons. Moreover, students were reminded not to forget bringing these texts to each lesson. When the lessons started the teacher asked several questions where conflicting conditions were presented, related to topic of interest in order to activate students' preconceptions and their ideas. Moreover, it was aimed students to realize that there is something wrong with knowledge they already have. In other words, conflicting situations were presented to make students realize that alternative conceptions they have do not work anymore. This is in agreement with Posner et al's (1982) first condition for conceptual change. They indicated that in order to achieve conceptual change first of all there must be dissatisfaction with existing conception since students do not easily accept new conceptions.

Teacher told students to read conceptual change texts individually. The teacher waited until all the students finished reading and asked whether everybody understood what is written in conceptual change texts. Then, groups were formed where each group was containing 4 or 5 students. While forming groups students with same chemistry achievement were placed in different groups. In other words, each group was containing students with different chemistry achievement in order to prevent forming groups that are consisted of students with all high ability or low ability. The groups were heterogeneous in chemistry achievement. Therefore every group had an opportunity to realize different explanations to the situations given. Each group went on conceptual change texts and discussed the conflicting situation written in these texts. While the discussion the teacher encouraged each student to participate discussions in group they belong in order to prevent domination of discussions by one or few students. Therefore students in each group had an opportunity to express their ideas and had a chance to realize the thoughts of their friends. In other words, each student in the group explained their ideas and thoughts related to conflicting situation. Than, students would realize that every student has different explanations to same concept. In addition, some of the students with low reading ability could not benefit much from conceptual change texts. Therefore, within group discussions would help these students to understand and comprehend what was written in conceptual change texts. After the discussions each group was supposed to give a common answer to the teacher. This is in agreement with Posner et al's (1982) second condition for conceptual change. They have indicated that a new conception must be intelligible. In other words, students should know what the new conception means. Therefore, within group discussions could help students to understand what the concept means and could explain it with their own words.

Each group explained their answers therefore; students in each group had an opportunity to see the thoughts of other students. They have realized that there are several explanations to the same situation. Then the teacher explained that some of these explanations are inconsistent with scientific view. In addition, the teacher explained why several students have misconceptions related to the subject of interest. The teacher presented the scientific explanation of the concept. In addition, in order to make content more concrete and easy to understand, the teacher used analogies. However, the analogies were presented with care, that is, the difference between base and target domains in analogy was clarified. In addition several examples were given by students and the teacher related to the concept. In order to strengthen the scientific explanation the teacher presented several daily life examples. These are in agreement with Posner et al's (1982) third and fourth conditions for conceptual change. They indicated that in order to achieve conceptual change the new conception must appear initially plausible and should suggest the possibility of a fruitful research program. Since the concept is explained as clearly as possible students could find it plausible and the daily life examples could help students to realize that what is taught is fruitful.

After that teacher told students to summarize what they have learned in the lesson in order to see whether there is any point left unclear and realize whether students still hold misconceptions. At the end of the lesson students were told to find daily life examples and explain the relationship of these examples to the topic of interest.

APPENDIX I

OBSERVATION CHECKLIST

GROUP : ……………………………………

DATE : ……………………………………

INSTRUCTOR : ……………………………………

This checklist is designed with the aim of guiding evaluator while evaluating the treatment. The scale given can be used while evaluating items.

Scale: Excellent (5), Above Average (4), Average (3), Below Average (2), Poor (1)

		Excellent	Above Average	Average	Below Average	Poor
1.	The teacher asked questions to reflect misconceptions that students hold about the solubility equilibrium.	○	○	○	○	○
2.	Students discussed questions presented individually.	○	○	○	○	○
3.	Students formed groups to discuss questions by using their prior knowledge about solubility equilibrium.	○	○	○	○	○
4.	The teacher did not interfere with students.	○	○	○	○	○
5.	The teacher asked appropriate questions that caused cognitive conflict.	○	○	○	○	○
6.	Each group's discussion results are listened, that is each group presented their explanations of conflicting situation.	○	○	○	○	○
7.	The teacher helped students to realize that some of the conceptions they hold are not with agreement with that of scientific explanation.	○	○	○	○	○
8.	Students read CCTs individually.	○	○	○	○	○
9.	The teacher asked whether students have alternative explanations presented in CCTs.	○	○	○	○	○
10.	The teacher adequately discussed why students' misconceptions are wrong.	○	○	○	○	○
11.	The teacher explained the scientific explanations of the conflicting situation appropriately.	○	○	○	○	○
12.	The teacher explained analogies presented in CCTs effectively.	○	○	○	○	○
13.	The teacher and students gave proper daily life examples.	○	○	○	○	○
14.	The teacher behaved as a facilitator.	○	○	○	○	○
15.	The teacher obeyed the lesson plan appropriately.	○	○	○	○	○

APPENDIX J

KONTROL LİSTESİ

SINIF : ……………………………………
TARİH : ……………………………………
KONU : ……………………………………

Açıklama:

Bu ölçekteki sorular Kimya dersinin işlenişini değerlendirmek amacıyla hazırlanmıştır. Bu nedenle soruları dersin işlenişini göz önünde bulundurarak değerlendiriniz. Her cümlenin karşısında "Çok İyi, İyi, Orta, Zayıf ve Çok Zayıf" olmak üzere beş seçenek verilmiştir. Her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneği işaretleyiniz. Teşekkürler......

		Çok İyi	**İyi**	**Orta**	**Zayıf**	**Çok Zayıf**
1.	Öğrencilerin çözünürlük dengesi konusunda sahip oldukları kavram yanılgılarını yansıtan ve kavramsal çelişkiye yol açan sorular soruldu.	○	○	○	○	○
2.	Öğrenciler sorulan soruları kendi başlarına incelemelerine izin verildi.	○	○	○	○	○
3.	Öğrencilerin önceki bilgileri ile çözünürlük dengesi konusunda sorulan soruları tartıştıkları gruplar oluşturuldu.	○	○	○	○	○
4.	Herbir öğrencinin grup içi tartışmalara katılımı sağlandı.	○	○	○	○	○
5.	Anlaşılmayan noktalar gerektiğinde açıklığa kavuşturuldu.	○	○	○	○	○
6.	Öğrencilerin grup içi tartışmaları sırasında, öğretmen tartışmalara müdahale etmedi.	○	○	○	○	○
7.	Herbir grubun tartışma sonuçları dinlendi ve öğrencilerin grup olarak kavramsal çelişkiye neden olan soru hakkındaki açıklamaları dinlendi.	○	○	○	○	○
8.	Öğrencilere, sahip oldukları bazı kavramların açıklamalarının bilim adamlarının kabul ettiği açıklamalarla ters düştüğü açıklandı.	○	○	○	○	○
9.	Her bir öğrenci kavramsal değişim metinlerini okumaya fırsat buldu.	○	○	○	○	○
10.	Öğrencilerin kavramsal değişim metinlerinde yazan yanılgılara sahip olup olmadıkları araştırıldı.	○	○	○	○	○
11.	Neden bazı kavramların yanlış öğrenildiği açıklandı.	○	○	○	○	○
12.	Belirtilen kavram yanılgılarının bilimsel açıklaması yapıldı.	○	○	○	○	○
13.	Bilimsel açıklamaları daha somut ve anlaşılır kılmak için benzetmelere yer verildi.	○	○	○	○	○
14.	Verilen benzetmelerin, konu ile farklılık gösterdiği noktalar açıklandı.	○	○	○	○	○
15.	Öğrencilerin benzetmeleri anlayıp anlamadıkları sorgulandı.	○	○	○	○	○
16.	Öğrenciler ve öğretmen konu ile ilgili uygun örnekler verdi.	○	○	○	○	○
17.	Konu, verilen ders planına uygun anlatıldı.	○	○	○	○	○

APPENDIX K

Table K.1 Misconceptions Reflected by Post Test Items

Questions	Misconceptions
2, 3, 10, 11, 16, 18, 26	Believing that at equilibrium there is no precipitation and dissolution.
2, 11, 13, 18, 25	Believing that at equilibrium dissolution stops.
9, 10, 16, 20, 24, 26	Believing that at equilibrium the concentrations of the ions produced is equal to the concentration of the salt.
8, 16, 21	Believing that mass can be used instead of concentration in Ksp calculations.
5, 9, 21	Believing that coefficients in solubility equilibrium equations have no other meaning then equating the solubility reaction.
13, 19, 22	Believing that at a given temperature Ksp can change.
23	Believing that ion product (Qi) can be used interchangeably with Ksp.
5, 21, 24	Believing that compounds in solid form should be included while writing Ksp equations.
25	Believing that the rate of dissolving increases with time from mixing the solid with solvent until equilibrium establishes.
8, 21	Believing that amount (moles) can be used instead concentration (molarity) in Ksp calculation.

Table K.1 (continued)

13, 14, 19, 26	Believing that at a given temperature the value of Ksp changes with the amount of solid or ions added.
27	Believing that the value of Ksp always decreases as temperature decreases.
17, 22, 27	Believing that temperature has no affect on solubility.
1, 14, 19	Believing that at equilibrium addition of salt affects the equilibrium.
3, 6, 11, 12, 14, 19	Believing that at equilibrium the concentrations of ions will remain constant although common ion is added.
7, 28	Believing that solubility of sparingly soluble salts is effected by change made in pressure and volume.
4	Believing that in all situations one can compare solubility of salts at equilibrium by just looking at Ksp values.
13, 29	Believing that if system is at equilibrium no other solute that doesn’t contain common ion can dissolve.
1, 18, 25, 26	Believing that before the system reaches equilibrium there was no precipitation reaction.
30	Believing that large Ksp implies very fest dissolution.
14, 15	Believing that there is no relation between Ksp and solubility.

APPENDIX L

Table L.1 Proportion of Correct Responses on Each Item

	Percent Correct (%)	
Question	Control Group	Experimental Group
1	31.3	44.8
2	19.4	48.3
3	14.9	72.4
4	31.3	46.6
5	89.6	86.2
6	10.4	48.3
7	6.0	34.5
8	59.7	60.3
9	46.3	55.2
10	19.4	34.5
11	41.8	67.2
12	11.9	36.2
13	22.4	32.8
14	35.8	70.7
15	76.1	91.4
16	13.4	75.9
17	47.8	60.3
18	53.7	81.0
19	14.9	51.7
20	31.3	67.2
21	49.3	53.4
22	44.8	56.9
23	53.7	56.9
24	19.4	86.2
25	19.4	81.0
26	9.0	31.0
27	40.3	44.8
28	34.3	41.4
29	34.3	55.2
30	22.4	69.0

CURRICULUM VITAE

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