EFFECTIVENESS OF CASE-BASED LEARNING INSTRUCTION ON STUDENTS' UNDERSTANDING OF SOLUBILITY EQUILIBRIUM CONCEPTS

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EFFECTIVENESS OF CASE-BASED LEARNING INSTRUCTION ON STUDENTS' UNDERSTANDING OF SOLUBILITY EQUILIBRIUM CONCEPTS

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ABSTRACT

EFFECTIVENESS OF CASE-BASED LEARNING INSTRUCTION ON STUDENTS' UNDERSTANDING OF SOLUBILITY EQUILIBRIUM CONCEPTS

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The main purpose of this study is to compare the effectiveness of case-based learning method instruction over traditional method instruction on eleventh grade high school students' understanding of solubility equilibrium concepts. In addition, students' attitudes toward chemistry as a school subject and students' epistemological beliefs were investigated.

Sixty-two eleventh grade students from two classes of a chemistry course taught by the same teacher in Atakent High School in 2007-2008 spring semesters were enrolled in the study. The classes were randomly assigned as experimental and control group. Experimental group students instructed by case-based learning method in which specific situations, generally real-life examples were discussed. On the other hand, control group students were instructed by traditional method.

Solubility Concept Test was administered as a pre-test to both groups. Moreover, Attitude Scale toward chemistry and Epistemological Belief Scale about chemistry were administered as a pre- and post-tests to all groups. Solubility Equilibrium Concept Test and Open-Ended Solubility Equilibrium Concept Test were administered as a post-test to all groups.

The results showed that case based learning instruction produced significantly greater achievement in understanding of solubility equilibrium than the traditional instruction. Also, there was a significant difference between the experimental and the control group with respect to their epistemological beliefs and attitudes toward chemistry as a school subject in the favor of experimental group.

Results obtained revealed that students have several misconceptions related to solubility equilibrium. Case based learning was effective for remediation of misconceptions and enhancing students' understanding in comparison to traditional method.

Keywords: case based learning, misconceptions, attitude toward chemistry, epistemological beliefs, solubility equilibrium.

ÖZ

ÖRNEK OLAY TEMELLİ ÖĞRENME YÖNTEMİNİN ÖĞRENCİLERİN ÇÖZÜNÜRLÜK DENGESİ İLE İLGİLİ KAVRAMLARI ANLAMALARINA ETKİSİ

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Çalışmanın temel amacı örnek olay temelli öğrenme yönteminin onbirinci sınıf lise öğrencilerinin çözünürlük dengesi ile ilgili kavramları anlamalarına etkisinin geleneksel yöntem ile karşılaştırmaktır. Ayrıca, öğrencilerin kimya dersine karşı tutumları ve epistemolojik inançları araştırılmıştır.

Bu çalışmaya 2007-2008 ilkbahar döneminde Atakent Lisesinde aynı kimya öğretmenin iki ayrı onbirinci sınıfındaki 62 öğrenci katılmıştır. Sınıflar kontrol ve deney grubu olarak rastgele seçilmiştir. Deney grubu öğrencileri; belirli durumların, genellikle günlük hayat örnek olaylarının tartışıldığı örnek olay temelli öğrenme yöntemi ile öğrenim görmüşlerdir. Buna karşılık, kontrol grubu öğrencileri geleneksel yöntemle öğrenim görmüşlerdir.

İki gruba da çözünürlük kavram testi ön test olarak uygulanmıştır. Ayrıca iki gruba kimya dersine karşı tutum ölçeği ve epistemolojik inanç ölçeği ön test ve son test olarak verilmiştir. Çözünürlük dengesi kavram testi ve Açık uçlu çözünürlük dengesi kavram testi son test olarak iki gruba da verilmiştir.

Sonuçlar örnek olay temelli öğrenme yönteminin geleneksel yönteme göre çözünürlük dengesinin anlaşılmasında daha etkili olduğunu göstermiştir. Aynı zamanda deney grubu ve kontrol grubu arasında onların epistemolojik inançları ve kimya dersine karşı tutumları göz önüne alındığında da deney grubundan yana istatistiksel bir fark bulunmuştur.

Elde edilen sonuçlar öğrencilerin çözünürlük dengesiyle ilgili kavram yanılgılarının olduğunu açığa çıkarmıştır. Örnek olay temelli öğrenme, kavram yanılgılarının giderilmesinde ve öğrencilerin anlamalarını pekiştirmek açısından geleneksel yönteme göre daha etkindir.

Anahtar Kelimeler: Örnek olay temelli öğrenme, kavram yanılgıları, kimyaya karşı tutum, epistemolojik inançlar, çözünürlük dengesi.

To my family

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CHAPTER 1

INTRODUCTION

Students come to classes with their attitudes, abilities and experiences; and these properties influence students' learning in instruction. According to Ausubel (1968) the most important indication of learning is what the learner already knows since an image or an example directs the learner to relevant prior experience or learning and also points forward to new material. In line with this view Shapiro (2004) and Dochy, Segers, and Buehl (1999) stressed the importance of prior knowledge in learning. Thus, students shape their own meaning accordingly. Errors are characteristics of initial phases of learning because students' existence knowledge is insufficient and supports only partial understanding. However, many researchers revealed that students' views about an image or an example are not match with scientific views. Even after formal instruction, students learn concepts different from scientific consensus, and these wrong ideas are called "misconceptions". Misconceptions mean the difference between learner's understanding and scientifically accepted understanding of the concept. However, they do not mean the lack of knowledge, factual errors or incorrect definitions. They are the demonstration of the constructed explanations of students in response to their prior knowledge and experience. They are resistant to change with traditional instruction because of instruction's inefficiency on constructing consistent relations among concepts and developing conceptual frameworks. Thus, misconceptions hinder students' learning, and as Ausubel (1968) states the formation of relations between ideas, concepts and information and also linkage between concepts are interrupted. Thus, students could not establish meaningful learning.

In chemistry instruction, many researchers mentioned that students could not establish meaningful learning because of ignoring the presence of misconceptions. Chemistry is considered as abstract and difficult for students (Nieswandt, 2001; Chittleborough, Treagust & Mocerino, 2002). To get rid of this, students must actively seek out knowledge, acquire it, and construct it to obtain a deeper understanding of the chemistry concepts. Therefore, researches concerned on students' misconceptions are very important. The chemistry topics investigated on students' misconceptions are mole concept (Duncan & Johanstone, 1973), entropy (Frazer, 1980), chemical equilibrium (Camacho & Good, 1989; Gussarsky & Gorodetsky, 1990; Chiu, Chou & Liu, 2002), covalent bonding (Peterson & Treauguest, 1989), electrochemistry (Garnett & Treaguest, 1992a; 1992b), acid-base chemistry (Ross & Munby, 1991), solubility equilibrium (Önder & Geban 2006). Solubility equilibrium is a complex topic since it integrates solubility, molarity, physical, chemical equilibrium and Le Chatelier's principles concepts. Also, it interacts with biology concept such as osmotic pressure and osmosis. Thus, instruction eliminating students' misconceptions should be found out. While considering the teaching method students' prior conceptions, development of meaningful learning should be taken into account. Constructivist learning theorists emphasized the role of mind in learning, meaningfulness of learning thing, and active involvement in learning process (Bruner, 1966). Lockwood (1992) defined that learner should be encouraged for constructing their own learning by using many forms of activities and so they will be willing to respond instruction. Thus, the role of learner is to solve nonroutine problems related to the subject area.

According to constructivist approach multiple perspectives of learning environments is required. Learning environments should include 'reality, knowledge construction and context-rich, experience based activities' (Jonassen, 1992, p.137). Thus, real life examples and case based learning environments facilitate constructivist learning (Jonassen, 1994). Case based learning instruction promotes students' active participation and constructs their own learning in class.

In fact, cases are stories with a message, these stories are firstly used in the law, business, and medical schools and afterwards they are used in undergraduate classrooms. Students analyze and consider solutions of cases. Students' higher order thinking skills and teamwork abilities are improved (Herreid, 1994). Teachers make use of cases through questioning, discussion in class by starting lesson with a open-ended question having definite and simple answer; this could be trouble but students could answer that question and then discussion is proceed and a product should be produced (Herreid, 1994). While conducting case- based instruction using small group discussion, students make groups of students and they are examined and interpreted that case together and then whether they solve the case related questions by theirselves (Herreid, 1994). Cases benefit teacher for taking attention of students because students like stories, but teacher should be careful about losing the control of purpose of transforming desired purpose of the case. Cases could be used in many forms so the class environment will be interactive by using this instruction in chemistry subject, students' chemistry achievement will be enhanced. Inquiry can be done using case- based learning and with this using real life scenarios and stories enhance students learning through the impact of active participation in instruction (Fasko, 2001). In the classroom setting, teacher should create an environment fostering students' inquiry skills. Instructors can do this by generating cases or counter- examples to learners for producing hypotheses, predictions, and revealing their misconceptions and ideas (Smith & Murphy, 1998).

Challenging learning environments involving negotiation, questioning of students' own ideas, teachers' ideas are developed in case-based learning instruction. Researchers investigated the relation between students' beliefs and their characteristics and learning outcomes (Jehng, Johnson & Anderson, 1993; Qian & Alvermann, 1995) and also the changes beliefs over time (Schommer, Clavert, Gariglietti, Baja, 1997) and found out the structure and specificity of students' knowledge beliefs. Schommer (1994) stated that real life connectional ideas should be included in the instructions for development of students from naïve belief that knowledge is certain and simple to sophisticated beliefs that knowledge is interwoven and complex. Thus, students' epistemological understanding about science is improved using case based learning instruction. The focus on epistemology in education encompasses beliefs about "the definition of knowledge, how knowledge is constructed, how knowledge is evaluated, where knowledge resides, and how knowing occurs" (Hofer, 1994). Millar (1989) stated that students' epistemologies are affected by both formal education focusing on rote memorization and the perception of science as a body of absolute facts or received knowledge (as cited in Tsai, 1998). Thus, case-based learning instruction focusing on students' active involvement could be very effective tool for enhancing students' epistemological beliefs. In this study case based learning instruction was used with small groups as Herreid (2000) stated. Thus, cases were analyzed in small groups since students will willing to participate in class and by using small group discussion students' achievement and attitudes toward chemistry was promoted. In this study, case based learning instruction was used with small groups and in each group students discuss the case together.

Attitude is the one of the important affective variables in science education since it is correlated with achievement positively. Researchers are interested in teaching methods improving students' attitudes. Case based learning instruction is considered as effective for enhancing students' attitudes since it emphasizes students' ideas, demonstrates real life situations and uses their knowledge and share their ideas with peers. Thus, students are active in the learning process and it is helpful for students to developing positive attitudes.

To sum up, misconceptions are important obstacle affecting students' learning in chemistry topics. Due to its difficulty, multiply integrated and abstract nature, solubility equilibrium is analyzed by case-based learning instruction for eliminating students' misconceptions and developing meaningful learning. Case-based learning instruction is interactive and includes students' active participation in class. Thus, it affects students' epistemological beliefs and attitudes toward science.

1.1 Purpose

The purpose of the study was to compare the effectiveness of case based learning instruction and traditional instruction on understanding of solubility equilibrium concept, attitude toward chemistry and epistemological beliefs.

1.2 Significance of the Study

Students should relate new knowledge with previously learned one to establish meaningful learning. Solubility equilibrium is one of the subjects which students have some preconceptions contracting with the scientific view. The remediation of the misconceptions would be helpful for science educators. Therefore, a teaching method helping remediation of misconceptions is important. Using case based learning method, students will get chance to study in real life cases and they will learn by engaging in the concept. Moreover, in this study case based learning used with small group discussion, thus students will willing to participate in class.

When students come into the class, they had already some conceptions related to the topic since they could interact with related issues in their daily life. Thus, they will interpret the topic according to their everyday knowledge. However, students' everyday knowledge was usually different than the scientifically accepted conceptions. This means students have misconceptions on that topic. In order to establish meaningful learning, the misconceptions of the students should be remediated. Thus, students could construct their knowledge. If students' misconceptions could not be remediated, students could construct wrong conceptions again.

Solubility equilibrium is important subject in chemistry because this concept is linked to other subject areas such as solubility, molarity, chemical equilibrium and Le Chatelier's principles concepts Also it interacts with biology concept such as osmotic pressure and osmosis. Thus, students have several misconceptions related to this concept. It is relatively difficult to integrate all of the concepts stated above. Using case- base learning in solubility equilibrium subject, students will visualize and discuss this topic and so they actively involved in the learning process and they construct their own learning.

Case based learning involves challenging learning environments in which negotiation and questioning of students' own ideas and case based learning can help students to remediate misconceptions. Students work together in the group so students start to learn to share their ideas with other people. Also, they get chance to learn respect others contrasting ideas and they start to evaluate the situation. In Turkey, case- based learning instruction is less studied in chemistry subject, researchers generally concentrated on natural sciences.

The reason of studying case- based learning is that this subject has relatively lower number of studies in chemistry education topic. Besides this case- based learning method is important and effective method for enhancing students' learning and developing their knowledge and their abilities. Using this method, students' problem solving skills and inquiry skills might be developed and they are easily understood and gathered information. Thus, this method could be beneficial for students' comprehending subjects (Wassermann, 1994).

This method is helpful for education because teachers use cases by variety of formats such as lecturing, questioning, discussion or cooperative learning method. Cases are stories so students love stories, so teacher could take attention of students to the topic which is presented and also teacher could apply these cases in variety of formats. Therefore, cases were helpful for both teachers and students.

When teachers use case method, students will ready to move on more complex skills. Since teachers plan the process of how to approach a case, students will get the opportunity to practice that process. Each case presents a different set of details, so students may apply a similar type of analysis.

The uniqueness of a case method lies not so much in the methods employed and their relationship to the end product. Stake (1995) claim that knowledge learned from case- based leaning method is different from other research knowledge in four important ways. Firstly, in that knowledge is more concrete this means case method knowledge is related with our own experience because it is more apparent, clear, and concrete. Secondly, case method knowledge is more contextual. This means the basis of our experiences is context, while in case method it is knowledge. This knowledge distinguish from abstract knowledge, formal knowledge is derived from other research designs. Thirdly, using case method reader interpretation is developed. Readers bring to case method their own experience and understanding. Thus, generalizations are occurring when new data for the case are added to old data. Finally, case method knowledge is based more on reference populations determined by the reader. In this case reader is assumed have some population in mind. Unlike traditional research, the reader participates in extending generalizations to reference populations.

1.3 Definition of important terms

The following terms are defined in relation to the study:

Case based learning: the instructional method in which students are actively engaged in real-life examples. The real life examples are cases and they are stories with educational message. Students study together to examine cases and so they come to conclusion at the end of the analysis (Herreid, 1994).

Traditional method: the instructional method in which students were passive listeners and teacher's role was to transmit the facts and concepts to students. Textbook and worksheet are used for teaching.

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

Epistemological Beliefs: beliefs about knowledge and knowing (Charles, 2003).

CHAPTER 2

REVIEW OF RELATED LITERATURE

In this study, the effect of case based learning instruction on students' understanding and remediation of misconceptions on solubility equilibrium concept, students' attitudes toward chemistry and epistemological beliefs were investigated. Case based leaning instruction is one of the constructivist teaching methods since students construct their knowledge with their colleagues and using real life examples. In this chapter, the review of the related literature of the important concepts, which are used in the research problem, are presented. Literature related to misconceptions, constructivism, solubility equilibrium, case based learning, attitudes and epistemological beliefs are presented.

2.1 Misconceptions

Learning is influenced by students' attitudes, abilities and experiences because students have these properties before they come to the instruction. Thus, students' prior knowledge is important for learning process (Shapiro, 2004; Dochy, Segers & Buehl, 1999). Students have some conceptions about concepts which are taught in class. However, these conceptions are usually different than scientific conceptions. Thus, teachers and researchers investigated some instructional methods for establishing conceptual change (Carey, 1985, Thagard, 1991, Hewson & Hewson, 1992). To establish conceptual change, students should meet Piaget's disequilibration (i.e. assimilation and accommodation) conditions (Piaget, 1952). When students use existing concepts dealing with new phenomena this process is called assimilation, whereas when students replace their existing concepts dealing with new phenomena this process is called accommodation. When students' existing conceptions and the results of an event does not fit, this process is called disequilibration. Meaningful learning was promoted by conceptual change approach by accommodation. Ausubel (1968) stated that what students already knows is the most significant indicator for learning development, because an image or an example directs the learner to relevant prior experience or learning and also points forward to new material .

Students' conceptions sometimes are different than the scientifically accepted conceptions. The difference between students' understanding and scientifically accepted understanding of the concept is called "misconceptions". However, they do not mean the lack of knowledge, factual errors or incorrect definitions. Even after formal instruction, students sometimes learn concepts different from scientific consensus, and they hold misconceptions after instruction. The reason for resistance of misconceptions is that instructions are not efficient for the construction of consistent relations among concepts and the development of conceptual frameworks. Misconceptions indicate the students' constructed explanations in reaction to students' prior knowledge and experience.

2.1.1 Misconceptions in Chemistry

In chemistry instruction, many researchers mentioned that students could not establish meaningful learning because of ignoring the presence of misconceptions. Chemistry is considered as abstract and difficult for students (Nieswandt, 2001; Chittleborough, Treagust & Mocerino, 2002). To get rid of this, students must actively seek out knowledge, acquire it, and construct it to obtain a deeper understanding of the chemistry concepts. Therefore, researches concerned on students' misconceptions are very important. The chemistry topics investigated on students' misconceptions are mole concept (Duncan & Johanstone, 1973), entropy (Frazer, 1980), chemical equilibrium (Camacho & Good, 1989; Gussarsky & Gorodetsky, 1990; Chiu, Chou & Liu, 2002), covalent bonding (Peterson & Treauguest, 1989), electrochemistry (Garnett & Treaguest, 1992a; 1992b), acid-base chemistry (Ross & Munby, 1991), solution (Uzuntiryaki & Geban 2005) and solubility equilibrium (Önder & Geban 2006).

2.2 Solubility Equilibrium

Solubility equilibrium is defined as the equilibrium between the dissolved salt and undissolved salt existing in a saturated solution or sparingly soluble salt solution (Ebbing, 2001). When soluble ionic solid put in the water, at first the rate of dissolving of the solid is high; as time goes, the dissolution continues and the chance of collision of ions increases and the precipitation increases. At equilibrium, the rate of dissolving is equal to the rate of precipitation. Solubility equilibrium includes dissolution, stoichiometry, chemical equations, ionic compounds, chemical equilibrium characteristics, solubility, common ion effects and Le Chatelier's principle (Raviolo, 2001). Thus, solubility equilibrium misconceptions were determined while looking at previous related literature.

Some studies related to find out solubility and solubility equilibrium misconceptions and the way for the remediation of these misconceptions are given below.

Önder and Geban (2006) investigated 10th grade students' understanding of solubility equilibrium. Also, the conceptual change texts oriented instruction was implemented for enhancing students' understanding. Experimental group was instructed with conceptual change texts oriented instruction. Control group was instructed with traditional methods. Traditional instruction includes lecturing and questioning method but students' misconceptions didn't considered. Teacher gave major concepts, equations and definitions and students listened and took notes. In other words, control group students were instructed with teacher centered instructional methods. Conceptual change texts included analogies, examples and graphic organizers thus the topic became more concrete and easily understood. In conceptual change texts oriented instruction; students asked questions, discussed the topic with their friends and demonstrated the understanding of the concept. Students' preconceptions were activated by creating conflicting conditions about the topic. Teacher prepared these conditions so students realize that they had some preconceptions which were inconsistent with the scientific explanations. Thus, students' misconceptions were activated; teachers explained the reasons of their misconceptions were wrong. While explaining concepts teacher used analogies, demonstrations and daily life examples. Results obtained showed that the performance of the experimental group was better for remediation of misconceptions and enhancing understanding of solubility equilibrium. However, after treatment some experimental group students hold misconceptions such as, "there is no relationship between Ksp and solubility, the temperature has no effect on solubility and the concentration of ions will remain constant although common ion added". They explained this result by the length of the treatment was low, three weeks.

Forbes (2004) investigated the college chemistry students' misconceptions about density, solubility and phase changes and found out the effectiveness of traditional lab activities for promoting students' conceptual understanding on these topics. Students implemented with three lab activities, experiments, related to the above topics. They were instructed with one topic in each week so the duration of the treatment is three weeks. The pre and post test multiple choice tests was given and these tests had similar items but their order was different. Also, at the end of the treatment students were required to define some terms related to the above concepts. Students were compared within each subject area and overall test, and based on tests results six students, who had difficulty with these concepts, were interviewed. The results of the study demonstrated that students had misconceptions which are the same as literature cited. Most of the students stated incorrectly that "particles in solution disappear with the addition of solvent" and none of the interviewed students had a concept of solubility equilibrium. They suggested that particles move in and out of the solution but they couldn't explain the reason of this. Students couldn't explain how the motion of particles determines the solubility process. The traditional lab activities did not promote students' conceptual understanding. There was no significant improvement on students' understanding of above concepts.

Demircioğlu, Özmen and Demircioğlu (2004) investigated the effectiveness of 5E learning cycle model on solubility equilibrium. Forty six high school students from two classes participated in the study. Experimental group students (N=22) was treated with prepared activities related to 5E learning cycle model and control group students (N=24) was treated with teacher centered approach. 5E learning cycle model consisted of five sequences; Engage, Explore, Explain, Elaborate and Evaluate. Activities were prepared based on these sequences. The treatment lasted for six weeks. Both groups received Concept Achievement Test. The results revealed that experimental group students were more successful than control group students. The authors explained the reason of this result by in experimental group students linked the events to daily life, thought their friends' and their own understanding, did experiments, and participated in the arguments for determining students' preconceptions. Activities used in experimental group were helpful for recognition and remediation of students' misconceptions.

Raviolo (2001) evaluated conceptual knowledge about solubility equilibrium and diagnosed the difficulties in relation to previous concepts, such as dissolution, stoichiometry, chemical equations, the particular nature of matter, ionic compounds, chemical equilibrium characteristics, solubility, the common ion effect and Le Chatelier's principle. One problem was given at the macroscopic level (experiments), the microscopic level (atoms, molecules, ions) and the symbolic level (symbols, formulas, equations) and students were required to connect all of three for adequate conceptual understanding. This problem was developed for secondary school students and first year university students. While using this problem, it is proposed that students' misconceptions of identifying the species would be remediated. For example; it was stated that while applying Le Chatelier's principle or the common ion, students failed to maintain neutrality of the solution. In microscopic level of the problem, students were expected to be able to connecting the particles with models and analogies and students could discuss what the model was about and what their limitations were. The result of the study proposed that students became highly motivated and actively participated in the discussions.

Ashkenazi and Weaver (2007) designed a lecture demonstration, in which over-generalized or over-simplified concepts were discussed, for solvent miscibility and its relation to intermolecular interactions. First year general chemistry students from two universities were instructed during two lecture sessions; in the first session students were given theoretical concepts about the topics, that is background lecture; in the second session students were presented with interactive presentations of the demonstrations. The results of the demonstration were given by either generating a conflict with existing concepts (confrontation) or by enhancing discrimination and contextualization of scientific concepts (refinement). While using refinement and confrontation demonstrations, the encouragement of students in discussion was not enhanced much. The refinement demonstrations were helpful for enhancing students' reasoning skills. They concluded that effectively designed lecture demonstrations were useful for discussing the relevant concepts in context for understanding scientific concepts' applications.

Powell, Pettit, Town and Popov (2000) developed CD-based package of tutorials for teaching equilibria to undergraduate students. This package included the principles and applications of acid-base, redox, solubility and metal-ligand chemistry. It was used for supporting lecture and laboratory courses on environmental chemistry, coordination chemistry and analytical chemistry. The purpose of this package was developing problem solving and promoting students' motivation. Students were informed about the package then seven weeks they studied alone and they used the computer, thus student centered instruction was implemented. The results of the study demonstrated that motivations of the students were increased since the instruction linked theory and its applications to problems in real systems. Students also stated that the package was technically satisfactory and they used this package on their leisure time.

Pereira, Alcalde, Villegas and Vale (2007) emphasized the common characteristics of four kinds of ionic equilibria: acid-base, redox, precipitation, and complexation. Then they investigated the unified treatment to the solubility equilibrium and describe the usefulness of this consideration. According to unified treatment, the equilibria problems were solved with diagrams in which the logarithm of the concentration of the exchange particle was used. One application of the unified treatment was ionic reactions produced an exchange of protons, electrons or ligand particles between a donor and an acceptor. Solubility equilibrium was presented with particle exchange reactions which is called unified treatment of aqueous ionic reactions. Solubility problems were solved with predominance interval diagrams and they were helpful for solving problems. While using this method, students gained new and more meaningful way for solving solubility equilibrium problems.

Cacciatore, Amado, Evans and Sevian (2008) developed a novel experiment in which chemical equilibrium, solubility and chemical periodicity was linked for high school or undergraduate first-year undergraduate students. In this study, solubility equilibrium was implemented while considering the chemical periodicity concept. Students first found out the trend of solubility in their lab results and then they predicted the solubility of similar compounds which were not studied in the lab. Students were required to learn and apply principles of green chemistry and develop scientific inquiry. This experiment was called green because students used less toxic substances in the experiment and then they found their Ksp values, after that they approximated the Ksp of more toxic substances. Also, after the experiment students were asked why this experiment was called green. Most of the students answered properly. Students planned and did their experiments by their selves using a partially incomplete sample lab report rather than cook book style lab manual. Students could discuss with each other to do experiment and solve problems. Students were required to integrate solubility, periodicity and equilibrium concepts and then according to the findings of the integration study, students understood and explained how green chemistry is related to their study. Thus, students developed scientific inquiry since students they achieved to integrate new and preexisting knowledge.

Kelly and Jones (2008) demonstrated two video animations, in which molecular representation of sodium chloride dissolution was presented, to college level general chemistry students. Then, students' ability to transfer their understanding of salt dissolution to the description of a precipitation formed from aqueous sodium chloride as a reactant was investigated. Before watching animations related to the dissolution of sodium chloride, students did hands on activity on the same event. Students demonstrated fewer misconceptions than the previous situation of the dissolution of sodium chloride. After these animations, one week later students viewed the video related to the macroscopic precipitation reaction individually. In the second video, the solutions of sodium chloride and silver nitrate were mixed and then the precipitation formed. Students were required to explain the precipitation process by directing questions. For example, students were required to draw the aqueous reactant solutions of sodium chloride and silver nitrate from macroscopic and microscopic level. Most of the students draw the macroscopic representation of sodium chloride that they watched from previous video. Students were asked while drawing the picture of chemical reaction, whether they thought previous video or not. Most of the students stated that they thought previous video. Students could not interpret the animations well; even they discussed the animations after watching it. The conclusion of the study was that students had difficulty for transferring understanding of salt dissolution to drawing the aqueous reactant solution of sodium chloride in the chemical reaction. Thus, students need help for processing new information and making meaningful connections to other chemical systems.

Kabapınar, Leach and Scott (2004) investigated the effect of the simple particle model on students' understanding of solubility. Students formed two groups; experimental and control group. Experimental group students were instructed with designed teaching sequence, in which teacher followed the teaching sequence providing some evidence about students' learning, and the control group was instructed with the typical teaching. The experimental group intervention explained the solubility particles based on macroscopic and quantitative perspectives. The disagreements among students' explanations were developed and students evaluate their ideas without teacher correcting them. Teacher encouraged students for challenging the everyday ideas they exposed. Thus, teacher prepared challenging questions about solubility and then teacher promoted students for formulating scientific explanations. Students were required to develop social language in the classroom and students reviewed and criticized in the class. While using questioning, evaluation and explanation, students constructed their own knowledge. Students were given questions measuring macroscopic and quantitative perspectives of the solubility. The results of the study demonstrated that there is not much difference in terms of students' conceptual understanding in comparison to non treatment group. Experimental group students were better for explaining the dissolution process using simple particle model and they were also better for explaining the difference between dissolving and melting. Also, experimental group students answered macroscopic and microscopic questions more than the control group students.

Pınarbaşı, Canpolat, Bayrakçeken and Geban (2006) investigated the effect of conceptual change text-oriented instruction on students' understanding of solution concepts and students' attitudes toward chemistry. Two classes assigned as control and experimental group. The experimental group students were instructed with conceptual change text-oriented instruction and the control group students were instructed with traditional instruction. Traditional instruction included lecturing and the discussion methods. Students were instructed without considering students' misconceptions. Teacher's role is to describe and define the concepts and then students discussed with teacher directed questions. Conceptual change text-oriented instruction was implemented with considering students' misconceptions. Conceptual change texts were developed for providing special learning environment in which common misconceptions were identified, students' alternative conceptions were activated by giving examples, descriptive evidence were given for students' misconceptions were incorrect and then scientifically correct explanation were given to students. A traditional and a refutational text were developed. A traditional text was taken from textbook used in the school. A refutational text was prepared with the helpful related literature and students' interviews. The result of the study demonstrated that experimental group students had better understanding of solution concepts. There was no significant difference between experimental and control students in terms of attitudes toward chemistry.

O'Sullivan and Crouch (2009) stated that students had difficulty related to the calculations of soluble salts. They also stated that students could not conceptualize the differences for varying thermodynamic solubility product constants, Ksp, of solids' concentration in the solution. Students could not perform the calculations related to solubility of species of different Ksp values. They developed a visual demonstration for several copper salts of different molar solubilities and connected these calculations to the solubility equilibrium computations of these salts. In the demonstration, students visually observed the molar solubility of sparingly soluble salts of varying solubility product constants. Also, effectiveness of common ion on the solubility of salt was demonstrated. The demonstration had two parts: qualitative and quantitative demonstration. In the qualitative part, students were presented solutions with different concentrations and different colors. They observed that saturated solutions above the precipitate were colorless, means no copper was present; however, other than saturated solutions were colorful, means copper was present. In the quantitative part of the demonstration; firstly, they calculated the expected concentrations of copper in solution. Then, the solution forces and crystal forces which were related to dissolution phenomena were discussed. Students generated the calibration curve and measured the absorbance. Students determined the minimum detectable copper concentration by using the molar absorptivity and sensitivity of the spectrophotometer. At the end of the demonstration students recognize that there was a difference between Ksp values which were calculated from quantitative demonstrations and using equations. This was occurred since there was a secondary equation in the reaction. Students was not required to consider that reactions. The authors suggested that in the qualitative part of the demonstration, students will developed their understanding of the magnitude of the solubility product constant. In the quantitative part, students performed the absorbance measurement by using spectrophometer, thus students comprehended the quantitative perspective of solubility and solubility equilibrium.

Coleman and Fedosky (2006) developed computer simulations for determining the differences in the solubility of salts. This was used for demonstrating equilibrium concepts qualitatively. This simulation could be used for high school and college introductory chemistry courses. Computer simulations provided visual interpretations of different solubilities of salts. The solubility of salt was varying because of configurational disorder and thermal disorder. The authors proposed that students' conceptual understanding of chemical equilibrium could be promoted by using this animation, without doing any quantitative interpretation about equilibrium constant. The simulations used in the study were qualitative and thus there was no calculation regarding entropy change. When equal amounts of two salts were dissolved in the same amount of water, the computer program illustrates the before and after the dissolution process. While performing these simulations, students should be informed about the small number of particles and large spaces representation which was used in the study was not realistic. Also, in the simulations the exchange process of water molecules of hydration sphere did not demonstrated.

2.3 Constructivism

Constructivism has so much influence on education over the past twenty years. Constructivism is a learning theory in which nature of knowledge and the way of learning is explained (Berg, 2006). Constructivism is defined as constructing new knowledge into already existed knowledge and making sense of them (Lorsbach & Tobin, 1992). People construct their knowledge by actively creating their own understanding rather receiving knowledge from others. Environment is viewed as “black box” in which people know “what is going on” (p.374) in their minds, however; the relation between “mental structures” and “real world” can only be predictable (Bodner, 1986). According to Bodner (1986), knowledge is constructed and tested continually in the construction process. Knowledge does not existed outside from knowers and knowing, and people could not search for truth, means discovering theories, laws and principles related to reality. Instead people “try to make sense of what is taught by trying to fit it with his/her experiences” (p.2). People use their senses to interact with environment and construct world picture (Lorsbach, Tobin, 1992). However, people could not construct knowledge freely, the knowledge must be “viable” and “work” (Bodner, 1986).

There are many versions of the constructivism in which each form has different characteristics (Berg, 2006). Geelan (1997) described the six forms of the constructivism in which each has some supporters and opponents and they emphasize teaching and learning differently. These are personal constructivism, radical constructivism, social constructivism, critical constructivism, contextual constructivism, social constructionism.

Personal constructivism closely associated with Kelly and Piaget. They focused on the individual construction of the knowledge by making sense of experiences of individual within the world. They also emphasize that knowledge cannot be transmitted from person to another; instead knowledge is constructed by the learner (Geelan, 1997).

Radical constructivism is advocated by von Glasersfeld. He emphasized the direct transfer of knowledge from environment or other person to learner is not possible, instead learner constructs their knowledge in his/her mind. People construct their knowledge for enhancing viability of knowledge by making sense of the experience (Geelan, 1997). Personal constructivism and radical constructivism are slightly same to each other (Ferguson, 2007).

Social constructivism is advocated by Solomon. Solomon (1987) emphasized that social effects, such as peer approval and agreement, is the most single significant factor for science learning. Thus, according to this principle, knowledge is constructed by a group of people.

Social constructionism is advocated by Gergen. According to this form of constructivism learner cannot make sense of their knowledge by theirselves and by a group of people; instead they stated that knowledge is held within societies and thus language and meaning making processes made that knowledge.

Critical constructivism is advocated by Taylor. Teaching and learning processes are socially constructed, however social myths could cause deficiencies in the constructivism. Social reconstruction is important so Taylor stated that collaborative groups should be used in the class in which the social structures of the class were formed and these deficiencies could be eliminated (Geelan, 1997).

Contextual constructivism is advocated by Cobern. Culture is the most important factor for development of ideas, rather than social interactions (Cobern, 1993). According to this view, people learn if the relation between culture of science and culture of learner explored and understood.

Among these forms of constructivism, personal constructivism and social constructivism are commonly used, explained in the literature and they are compared and contrasted by most of the researchers (Bodner & Orgill, 2007). Ferguson (2007) stated that it could be more beneficial to emphasize the commonalities of both personal and social constructivism since both of them share theoretical underpinning.

Berg (2006) concluded that constructivists focus on the knowledge making rather than knowledge transmission, and engagement of students to the world is emphasized in the learning so learner could construct knowledge.

The influence of Piagetian theory in science education is declined in which research on domain general reasoning skills in science learning (Scott, Asoko, Leach, 2007), however; some researchers are also interested in this area (Koslowski, 1996, Kuhn, 1993). There is a sharp and significant gap from Piaget's approach in Ausubel studies. Ausubel (1968) stated that learners' existing knowledge has the most important effect on their conceptual development in the target domain. Driver and Easley (1978) called students' domain specific reasoning as students' alternative conceptions. In this study students' understanding of solubility equilibrium, students' domain specific reasoning, was investigated.

Piaget emphasized that people make meaning only by their cognitive processes, however; Vygotsky stated that people make meaning in social context (family, school). Thus, there is a tendency from individual construction of knowledge to social construction of knowledge. Language and social interactions is included in the construction of knowledge. He developed the "zone of proximal development" idea. The ZPD is the region between learners' actual skills or knowledge and learners' potential skills or knowledge. Learners' potential knowledge is the knowledge gained by outside aid, such as teacher (Wellington, 2006).

Case based learning instruction is one of the constructivist oriented teaching approach (Sudzina, 1997). Students studied cases in groups in which they learned from each other in the group and in the class. Also, they investigated the case and possible solutions of it by searching internet, library, parents and other resources. Teacher's role is facilitator to students for helping them to examine the cases in wide perspectives. The student construct own knowledge with the help of friends, teacher and other resources. Thus, in this study case based learning was based on the social constructivism approach.

2.4 Cased Based Learning

Cases are stories to educate and they are used for improving decision making and also learners are encouraged to identify problems and relation between concept and the story (Herreid, 1994). Cases are used firstly in law schools (Merseth, 1991), medical schools (Herreid, 1994), undergraduate (Brink, Goodney, Hudak & Silverstein, 1995) and secondary schools (Tippins, Koballa & Payne, 2002). To improve teaching and learning process case studies and case based learning were used in the education literature since the early 1900s and in the 1950s there is an increasing demand toward case based learning (Fasko, 2001).

Case is an actual description of events occurred in the past. Case based learning method, fictional stories have some pedagogical objectives, but they do not have adequate intellectuality. Case should include specific pedagogical or research objectives of writer, so sufficient material related to the situation and environment should be provided in the case (Naumes & Naumes, 1999).

Cases which are used in law schools have one correct answer and students are forced to find out this answer, and they are called Socratic questioning. This is also continued in medical schools in which students reach an answer through general principles. In 1997s, medical schools used clinical cases and this is the first example of problem based learning in medical schools. In 1940s, Conant started to implement "case- study teaching" using lecture method (Herreid, 1998). After that time business schools started to use cases, but these cases have not one correct answer, and used with discussion.

The difference between law, medical cases and business cases is that law and medicine cases grounded on well- defined knowledge base; however in business cases knowledge is in flux, conditions are changing; and business cases focus on human condition and subjective view (Merseth, 1991).

2.4.1 Types of Case Studies

Herreid (1994) stated that cases could be used in eight different ways: lectures, discussions, debates, public hearings, trials, problem based learning, scientific research teams and team learning. Then, he (1998) reclassified the case study methods in four different ways: individual assignment, lecture, discussion and small group activities. The definition of the case is the same in all of the forms; however, the students and the teacher roles' are chancing in each case forms. For example, in the individual assignment format students mostly work by their selves; in the lecture format teacher mostly work by their selves; in the discussion format the teacher and the students are working together but the teacher has control in the discussion; in the small group activities the teacher and the students are working together but in contrast to previous format students have control for analyzing cases.

2.4.1.1 Individual Assignment Format

Teacher gives individual assignments to students, which is generally used format in teaching. However, students construct a story line including stories with a message. For example; assigning to write historical account of events, theses, book reviews which include the case of story with a message.

2.4.1.2 Lecture Format

Conant used lecture format in case method in the 1940s (Herreid, 1994). Instructors while using lecturing method in class tell stories to students. Students role is to listen to the case and if it is needed take notes. Also, in one class two instructors could use cases for debating and dialoguing some subjects. One of the teachers tells the story line of one perspective and the other teacher tells the other perspective. Teachers could argue the related to story line on different side of the problems.

2.4.1.3 Discussion Format

This is the best known format for conducting case based learning method. It is mostly used by business and law schools. Instructor's role is to question the students' perspectives on the case. However, students could not feel they over the learning when they finished the cases, thus teacher should be skillful for eliminating this fault. Most business cases are dilemma cases in which decisions must be made. The problem of this format is that science teachers usually do not know how to use dilemma cases in class. Teachers are accustomed to lecturing format and usually they are not skillful for being discussion leader.

2.4.1.4 Small Group Format

According to Johnson and Johnson cooperative learning strategies in small groups is the best method for learning (Herreid, 1994). Thus, cooperative learning strategies could be used with case based learning method for enhancing learning. Team learning strategies, in which the group of students received individual and group test, solved the problem and without using formal lectures students analyzed the case, could also be used with this method. Problem based learning is also successful for using cases. Students work in the small group and teacher works as a facilitator. Students work the one case in three sessions. In one session, students were given case and they investigated the case using books and internet and students found out the important issues with the help of teacher. Students searched the internet and library on these issues. Next session, students share their findings to group and teacher gave additional information related to the problem. The final session, students gave their report including for the problem.

In this study, case based learning instruction is studied with small group format since students could learn more each other. Also, the learning of solubility equilibrium topic is difficult since it is integrated to other concepts such as dissolution, stoichiometry, chemical equations, ionic compounds, chemical equilibrium characteristics, solubility, common ion effects and Le Chatelier's principle. Thus, small group format is suitable for promoting learning.

2.4.2 Advantages and Disadvantages of Case- Based Learning

Case- based learning is a method which improves students' higher order thinking skills by allowing students to evaluate a situation or identify problems in different ways. Also, cases which are used in conducting case method in class may establish relationship between a setting and organization, and they are helpful for observing changes over time.

Another advantage is that students’ decision making process is developed by deciding on alternative solutions using appropriate criteria. Then, alternatives are extended and so reached a conclusion. Also, cases are useful for developing decision process from analysis to implementation.

The case method is active pedagogical process contrary to the lecturing method which is passive process (Sudzina, 1999). Therefore, students learn by doing analyzes and activities themselves, instead of being told how it is done. Most students learn more by doing than learning through lectures.

Disadvantages of case- based learning method is the taking of considerable time for design and develop, thus it could be more helpful for preparing these cases with content specialist, and instructional designers. For developing cases it requires the collection and storage of a large quantity of resources.

The one of the disadvantages of case-based learning is that, from the perspective of content coverage, cases are rather inefficient. Given this disadvantage, a relevant question is whether in-depth learning experiences with cases lead to transfer of learning into classroom teaching practice. This transfer may occur in situations that are very similar to the situation depicted in the case.

Woods (1994) stated two main disadvantages of case- base learning. First, because of previous educational approaches used in prior study habits, there maybe a persistent impression of accepting change. Secondly, there is a perception that more depth of study and understanding may have ensured from a subject- based study.

According to Herreid (1994) the case method cannot solve all of the problems in the science teaching. Also, he states that some devotees admit that for delivering plenty of facts, figures, and principles case method is not the best method. However Herreid (1994) claim that this method is ideal for developing higher order reasoning skills. He also suggests that both teachers and students will not be comfortable when this method is used with only occasionally. When cases become predominate in the instruction, there could be a problem of information covered in the course. Then, he suggest to teachers for keeping the discussion on the science, evidence and analysis side.

2.4.3 Applications of Case Base Learning

Business and law schools have used real or simulated stories known as cases in long times. Other disciplines such as medicine, psychology and teacher's education have used this method to take attention of students.

Cornerly (1998) used case based instruction and she used cases in biochemistry courses. Different cases were given to groups of three to five students. She conducted this study to 51 students in a one semester course. Instructor identified cases and students asked questions to understand cases. Then, groups found a solution while using course textbook and library. After that students wrote a report for case study questions and report was presented in class. Using case method, students worked cooperatively with each other. Students were evaluated by 30 statements concerning the course requesting whether they were agreed or not. For example, one of the statements was "The case study was a valuable exercise" and then there was a four scale in which strongly agree, agree, neutral, disagree. Of the 51 students, 45 % was the "strongly agree" with that statement, 31 % was the "agree" with that statement, 18 % was the "neutral" with that statement, 6 % was the "disagree" with that statement. Then, researcher was concluded that they actively involved in biochemistry courses and also this study showed that students enjoyed the case method. According to these results, researcher had used four- scale measurement for evaluating and generally there could be five- scale for valid evaluation.

Smith and Murphy (1998) used case study in biology courses. They demonstrated some uses of the cases and the degree of students' involvement. The cases were designed in different formats, such as cases were presented to the students in lecture, laboratory, report writing, stimulating individual students and engaging entire group discussion. In one class, the case including a patient with a variety of symptoms related to the topic was given, and questions were presented after the case. Students worked by their own or in groups. Then students discussed the case by comparing other groups' responses. The result of the study demonstrated that students linked real life to the concept presented. Students' developed the sense of accomplishment, and they thought that cases were helpful, interesting and they stated that they enjoyed the course. They promoted their thought process using cases. Students viewed the cases as challenging, interesting and they saw these as rewarding.

Jones (1997) did case study to 200 students in the honor sections of general chemistry at university. The purpose of the study was to promote students' awareness of the relevance of science. He used a classroom jury trial to reinforce their science perception in their lives. They met four times per week for lecture section and one hour per week for small group discussions. First week, roles were given to students as judges, dependent, jury, witnesses and reporters. The aim of the study was presented to the class and students worked in their groups outside of the first class for identifying individual tasks. Students whose role were witnesses, dependent or lawyer implemented research in the library related to the topic. Next two weeks the trial was carried out. Forth week, students having same kind of roles met and discussed the case and prepared group reports and then they were presented in the class. Students prepared both oral and written report and students were evaluated based on both. One of the students in each group, means one member of jury, were required to ask question and each reporter in the group summarized the activities in the last trial day. The result of the study demonstrated that students enjoyed the case based instruction and they stated that the topic was interesting and controversial. Also they stated that cases made the science more relevant to their lives.

Cliff & Curtin (2000) stated that directed case study was helpful for students because student understood main concepts of course and the critical thinking of students was developed. While implementing direct case method, teacher prepared short, dramatic case stories and they were extended into the traditional lecture. Each case followed didactic questions in which students could answer these only studying textbook and listening lecture. The objective of the case stories and the questions was to promote students' thinking of facts, figures and principles under theory. Case story and case questions were prepared while considering learning objectives that encourage students to consider facts, figures and principles in the subject. The case stories provided students to the application of their knowledge for solving the important problem or issue and so students deeply understood the underlying facts and concepts. In the one story, more than one topics were interrelated each other. Firstly, students analyzed the case outside of the class alone or in groups and then they submitted their answers before coming to class review of the case. During one class session, each student presented their answer to the class by discussing the each answer of the other students. Thus, students clarified the misunderstandings, strengthen and reemphasis the topic. Students worked together and discussed the problem with the teacher guidance. The result of the study demonstrated that directed case method was helpful for students to understand fact and concepts deeply.

Herreid (1994) used cases in general education course. His results were consisted with Jones (1997) who conducted study in honors class of general chemistry course. Also, he stated that in case studies, students' learning of concepts were improved, their analytical and decision making skills were developed, their management through hard real life issues were enhanced, and their communication with each other was developed. Case method teaching included both to teach of content and also to teach how science process was developed. Students showed higher order learning skills and their attendance rate in class was increased from 50-65 % to 95 %. Also, he stated that he applied the trial format in evolutionary biology class. The conflict case was presented in which the conflict of preservation of animals and lumber industry. Each side had positive and negative sides, thus “witnesses” with different views were presented. Students were given case including different perspectives of the problem. Team leader and attorney were determined in the class. The script was developed for witnesses for essential points. Attorneys of the two sides were presented their research results and they gave evidence. For example, for proponents of the lumber industry, the students whose role was “scientist” described the owl and basic problem. Both sides presented with witnesses and after that attorney summed up their position. Students prepared position papers on favoring each topic and at the end of the trial students wrote reaction paper. The result of the study demonstrated that students enjoyed this method.

Brink, Goodney, Hudak & Silverstein (1995) mentioned that case based learning method is useful for chemical principles and application. In that study, they used case studies in introductory chemistry. Two course curriculums on same concepts are developed. Then, first semester lecturing method is applied, and second semester cases related to concepts are introduced. In the lecturing part, the textbook were prepared by modifying existing textbooks. In the case study part, many fundamental concepts were integrated and applied. While progressing one case to another, students restated the ideas. The cases were based on the textbooks which were prepared for lecturing part and they kept the case studies generic. Thus, the explanation part of the case got smaller and theory was not given within the case so the flow of the case didn’t interrupted. The cases included concepts deeply and emphasized the mathematical sophistication. The results of this study showed that case study approach was applicable and successful in teaching chemical principles and applications. Also, students enjoyed case based approach. Students were evaluated by survey questions in that according to these questions, students enjoyed all of the cases.

Brink, Goodney, Hudak & Silverstein (1995) results were also consisted with the Cheng (1995) who used case studies on teaching Environmental Chemistry. Firstly, he developed a teaching program for removing industrial pollutions, then he used case study while transmitting traditional to case based learning instruction. Teacher gave the facts and opinions mentioned in the case. Students evaluated the feasibility of the methods for removing pollutions. Then students' written and verbal analysis of the case was evaluated. Students identified the problem and made decisions about the solution. Students worked in a group thus team working skills were enhanced. At the end of the each case students couldn't reach a solution for industrial pollution. Students were evaluated qualitatively means instructor gave some value to each skill for example decision making skill. The result of the study demonstrated that students actively involved in class discussions and they were enthusiastic about the learning; however, they couldn't develop verbal presentation skills since the time of the treatment was short. Thus, students' achievement in that course was increased.

Barden, Frase, & Kovac, (1997) used case study in high school to teach science ethics, and their results were similar with the undergraduate students' results. They developed cases related to Laboratory safety, working with other, reporting results, using computer and computer software. The characters of these cases were people. Discussion questions were presented, small group discussions were conducted and report was prepared. Students identified and analyzed the ethical problems, after that some solutions were proposed and evaluated. The purpose of the case study was to increase students' decision making process in ethical problems. After each case, questions were presented and so students discussed and commented about the issues. The case format of the study was small group discussion and group writing assignments. In small group discussion, students were energetic and concerned about the cases. In group writing assignments, students stated that they had not previously thought their behavior in the lab was related to ethics. This study showed that case method was useful for discussing science ethics with high school science students. Students understood science concepts and research process. They practiced the ethical decision making skills.

Guilfoile (1999) used cases in understanding of scientific information. Firstly, data was collected and hypothesis was formed for each cases. The cases were developed for how the scientific research was carried out. Cases demonstrated the progression of the scientific information. The cases were presented in the lectures for integrating facts in the textbooks. In this study students understood the process of science research. Students learned to work as a team member, they listened to other's ideas, they actively involved in class discussions and they made links between concepts. They understood the reason of their learning and the reason of their importance. Students developed deep understanding about how scientific research was actually carried out.

Gallucci (2006) discussed case based learning method with considering how students learn in the class. Firstly; she discussed while considering students' prior knowledge and possible misconceptions, how teachers could accomplish conceptual change by using cases. Secondly, how cases could be used for developing connections among concepts was discussed. Thirdly, while using cases students developed metacognition means whether students "think about thinking" or not was discussed. While using cases how students could become effective learners and how they could set learning goals to themselves and whether they assessed the goals were achieved or not was discussed. Students must control their learning for become educated people.

Tarhan, Kayalı, Urek and Acar (2008) investigated the effectiveness of problem based learning on 9th grade students' understanding of intermolecular forces, their misconceptions about the topic and their beliefs about the problem based learning. Seventy-eight students involved in the study, and firstly they were stratified according to cognitive levels, then they randomly assigned to experimental, in which problem based learning was implemented, and the control group, in which lecture method was implemented. In experimental group, students formed groups of five or six students in each group. Students were given roles as leader, recorder, timekeeper and reflector. The problem was given and students discussed it by activating their prior knowledge and teacher guided students about encouraging their hypothesis about the problem. Then student developed their research questions and after class, students did research and next class student presented the information to the class and discussed these. At the final session, students found the solution of the problem and they concluded the case. In control group, students listened and took notes and students instructed with teacher centered method. Results demonstrated that experimental group had better understanding of the topic and they eliminated their misconceptions and developed social skills. Experimental group students used scientific and critical ideas properly than the control group students. Students showed increasing interest toward the topic, but 75 % of the students stated that they did not want to be responsible for their learning.

Knight, Fulop, Magana and Tanner (2008) developed cases for teaching a senior cell and molecular biology laboratory course in the university. In the case-based format, they included experiments, Internet research, class discussion, written exercises, brief student presentations, and occasional short lectures. They presented the case into four phases. Firstly, one of the students read the case to the class, and secondly students formed groups and students in each group brainstormed the case. Thirdly, questions were given and students in each group discussed these questions and finally each group reported their results to the class. Then, students did research related to case and these results also reported. Students were evaluated by written and verbal assessment techniques to measure students' learning outcomes and attitudes toward case based learning instruction over two semesters. The results demonstrated that students learned the laboratory techniques, problem solving skills were developed and students developed intellectually and socially. Also, students' attitudes toward case based learning were positive.

Rybarczyk, Baines, McVey and Thompson (2007) investigated the learning outcomes of the students on cellular respiration topic. 157 students from two classes of a university, both non-biology and biology majors, participated in this study. Both classes were randomly assigned as control and experimental group. The control group students were taught with traditional lecture and the experimental group was taught with case base learning instruction. Students were introduced with interrupted case study format. The case was divided into four parts in which firstly students read the case scenario, brainstormed for causes of the event in the case, analyzed the data given in the case and integrate the knowledge to the event in the case. They found that case based learning group gained better learning than the traditional method group. However, they could not get sufficient evidence for case based learning were better for clarification of misconceptions. In contrast to traditional lecture, case based learning group stated that their peer collaboration is promoted. Case based learning group demonstrated better higher order thinking skills than traditional method.

McNaught, Lau, Lam, Hui and Au (2005) investigated the suitable transmission process from traditional method to case based learning method on university students in the physical science programs. They were planning to convert tradition instruction to case based learning instruction, thus they examined the students' current conceptual understanding and their perceptions about traditional method. 38 students involved in this study and they were taught on surface analytic techniques, which are vacuum technology, scanning electron microscopy, secondary ion mass spectroscopy, X-ray photoelectron spectroscopy, ultra-violent photoelectron spectroscopy and Auger electron spectroscopy. They collected base information for supporting and inhibiting case based learning method. The results demonstrated that students were motivated to solve practical problems but they do not want to be responsible for their own learning. Thus, they concluded that case based learning instruction would be implemented according to students' above expectations and beliefs. They also state that this result could be the conclusion of the culture factor since Asian people generally prefer to traditional instruction.

Romero, Eriksen, Haworth (2004) investigated the effectiveness of problem based learning method in pharmaceutics course. They implemented problem based learning over 10 year and they refined methodology by using feedbacks from students and faculty. The treatment took about four weeks. Firstly, students formed groups and the case was presented to the class. Then introduction and required information related to the case was given and then objectives of the case provided, and the aim of the case study was to enhance critical thinking and problem solving abilities. At the end of the study each group was interviewed on the specific area of the case study. The result demonstrated that group work had the significant effect on enhancing the exchanging of information and ideas among students. They stated that highly motivated students having strong backgrounds for the course showed better performance of learning others. They concluded that problem base learning was effective for learning, but in this study only one group was used so the comparison between traditional and problem based learning could not be made.

Srinivasan, Wilkes, Stevenson, Nguyen, Slavin (2007) compared the perceptions of medical students and faculty on traditional problem based learning with case based learning. Both instructional methods were implemented with small group teaching. 286 students and 31 faculty in two medical school were involved in the study. These schools were taught with problem based learning firstly, but currently they changed their methodology to case based learning. In the problem base learning format, students were given a clinical case and they identified their learning issues and brought these materials to their group for informing them. Students were promoted for finding outside sources. When students did mistakes, it was understood as the part of the learning. Faculty provided guidance only when asked. In the case based learning format, students were given a clinical case and they were given reading assignment related to the case. In the class, students shared their experiences and students started to discuss the case. Faculty could meet with students for helping students to solve the problem. The result of the study demonstrated that students and faculty of the two institutions preferred case based learning. The reason for this finding for students was explained by inefficient time for sufficiently implementing open inquiry (problem based learning). Faculty preferred case based learning since they involved in the discussion without dominating, their role was facilitator so they balanced the discussion among students and they could give feedback to students.

Gallucci (2007) investigated the effectiveness of case based learning instruction on biology non-majors understanding of some biology topics (genes, biodiversity and evolution). She also examined the effectiveness of case-based learning on students' conceptual change and attitude regarding the science and learning about science. Students used stories, narratives, scenarios, or articles as a case and the cases were used for homework, in class and on exams. The results of the study revealed that the case based learning is interesting, motivating and relevant, thus students' understanding of the topics was enhanced and students probably retain this knowledge more. Students remediated their misconceptions on these topics. There was no effect on students' attitude toward science but students' attitude about learning science was promoted. She concluded that case based learning is a teaching strategy in which promoting students' engagement in learning science and making development toward conceptual change.

2.5 Attitude

"An attitude is composed of affective, cognitive and behavioral components that correspond, respectively, to one's evaluations of, knowledge of, and predisposition to act toward the object of the attitude" (Wagner, 1966 cited in Gable and Wolf, 1993). Attitude is defined as a learned state creating a tendency ‘to respond in a particular ways to particular objects’ (Bricheno, Johnston & Sears, 2000). Attitudes demonstrate whether learner dislikes or likes the objects. Students’ attitude toward science demonstrates whether students dislike or like science. Thus, students’ attitudes about learning and teaching could be helpful for promotion or inhibition of their learning. For example, statement ‘I like reading books related to science’ express students’ attitudes toward science since it includes positive feelings toward science. Instruction should be conducted for considering students’ needs since the teaching methods affect students’ attitudes toward the subject taught.

Freedman (1997) revealed that high school students’ achievement was positively and negatively correlated with achievement. Extensive research results related to the relation between attitude and achievement demonstrated that achievement does not be predicted by attitude, attitude explains only moderate amount of variation in achievement (Ingram, Nelson, 2006).

Case based learning is active instructional method in which students work in small group and they study the cases with their friends. Flynn and Klein (2001) investigated the effectiveness of the case based learning with small group discussion format. They formed two groups; one group was instructed with cases but students work alone, the other group was instructed with cases but students work in small groups. The results demonstrated that students like to work in small groups more than to work by their selves and students believed that their learning is promoted while working in group in comparison to working alone.

Students who is working case based learning instruction with small group format, perceived that they could develop meaningful learning by engaging the exchange of ideas and information about subject matter among students. Students actively engage in the learning process and they understand the subject matter actively. Thus, case based learning have a positive effect on students’ attitudes toward chemistry.

2.6 Epistemological beliefs

Students' epistemological beliefs are defined as personal and implicit beliefs' systems or students' assumptions about nature of knowledge and learning (Schommer, 1990). The focus on epistemology in education encompasses beliefs about "the definition of knowledge, how knowledge is constructed, how knowledge is evaluated, where knowledge resides, and how knowing occurs" (Hofer, 1994). Sandoval (2005) described scientific epistemology from philosophical perspective as "a description of the nature of scientific knowledge, including the sources of such knowledge, its truth value, scientifically appropriate warrants, and so forth" (p.635). Epistemology is defined as *personal epistemology* by psychologists as "the set of beliefs that individuals hold about the nature of knowledge and its production (Sandoval, 2005, p.636).

Schommer's views on epistemological beliefs were used in this study since it integrates learning and epistemology and considers epistemological beliefs as multidimensional. Early studies are related to assuming epistemological belief as unidimensional and accordingly research is conducted for students' learning (Ryan, 1984); after that epistemological beliefs are considered as complex and thus, Schommer (1990) suggested multidimensionality of epistemological beliefs and characterize these as; Simple knowledge dimension includes the beliefs that "knowledge is organized as isolated bits and pieces" to "knowledge is organized as highly interwoven concepts". Certain knowledge dimension includes beliefs that "knowledge is absolute" to beliefs that "knowledge is tentative". Fixed ability dimension includes beliefs that "the ability to learn is fixed at birth" to beliefs that "the ability to learn can be changed". Quick learning dimension includes beliefs that "knowledge is acquired quickly or not at all" to beliefs that "knowledge is acquired gradually" Each factor of the EBQ measures a distinct belief dimension and each dimension have different effect on learning. Each dimension is independent of each other and the beliefs in each dimension do not need to develop at the same time. For example, a student could think that knowledge is acquired gradually, but at the same time he or she could think that knowledge is organized as isolated bits and pieces (Schommer, 1990).

Epistemological beliefs of the students can be directly examined and developed. While using practice, epistemological beliefs of the students manifest. Sandoval (2005) proposed that students' own beliefs about nature of knowledge science making should be examined, by investigating their practice and their expressed beliefs. He discriminated epistemological beliefs as "practical epistemologies" and "formal epistemologies" and he stated that the difference between them is the responsible for insufficiency of the inquiry in schools. Practical epistemologies are defined as the "…epistemological ideas that students apply to their own scientific knowledge building through inquiry" (p.635). Formal epistemological beliefs are defined as "…students' expressed beliefs about professional or formal science" (p.635). Scientific claims are evaluated by whether they are accepted by social communities or not. Thus, scientific knowledge is socially constructed, by cooperation, collaboration and competition.

The development of epistemological beliefs of students was investigated with interviews and questionnaires. Perry (1968) revealed that when undergraduate students entered the college they thought that knowledge is absolute and handed down by authority; when they were become seniors they thought that knowledge is tentative. Mackay (1971), Ryan and Aikenhead (1992), Leach, Driver, Millar and Scott (1997) and Driver, Leach, Millar and Scott (1996) reported that students' ideas about formal science got sophisticated through adolescence (as cited in Sandoval, 2005), remain naïve through high school (Sandoval, 2005). Students often hold inconsistent epistemological beliefs in different contexts (Sandoval & Morrison, 2003).

Schommer (1993) carried out cross sectional study for investigating the development of high school students' epistemological beliefs. She used her questionnaire for measuring students' epistemological beliefs (Schommer, 1990). The results revealed that high school students' beliefs on simple knowledge, certain knowledge and quick learning were decreased from freshman to senior year. Also, she found that the students believing less in quick learning tends to get higher grades. This is supported by stated that junior college students demonstrated the similar mecognitive abilities of high school students. Schommer, Calvert, Gariglietti and Bajaj (1997) investigated the development of epistemological beliefs of high school students from first grade to forth grade by doing longitudinal study. Students were selected from the study in Schommer (1993). Then the same instrument which was used in 1993 was given to these students. The result of the study demonstrated that high school students' beliefs in fixed ability to learn, simple knowledge, quick learning and certain knowledge changed to more sophisticated as they became forth year. Also, students believing knowledge is acquired quickly tend to get lower grades. The results of the two studies (Schommer, 1993 and Schommer et al. 1997) revealed that high school students' epistemological beliefs were changed as they became senior.

Students' scientific epistemological beliefs have a significant effect on students' learning orientations, and organization of scientific information (Tsai, 1998). Millar (1989) stated that students' epistemological beliefs are affected by both formal education focusing on rote memorization and the perception of science as a body of absolute facts or received knowledge (as cited in Tsai, 1998). Challenging learning environments involving negotiation, questioning of students' own ideas, teachers' ideas can improve students' epistemological understanding about science. To achieve learning, students' beliefs about knowledge and their epistemological beliefs are important component. Most of the research on epistemological beliefs related to students' intellectual development during the college years. These researches focused on students' improvement through stages, phases, or positions from progressively more mature to sophisticated epistemological beliefs (Paulsen, Feldman, 1999).

There are more research investigating the relationship between students' epistemological beliefs and various cognitive learning processes and outcomes (Qian & Alvermann, 1995). Qian and Alverman (1995) stated that simple and certain knowledge made the strong contribution for explaining conceptual change learning whereas innate ability made less contribution. For instance, there are some studies investigating the epistemological beliefs and relationships between belief in simple knowledge and mathematical text comprehension, students' perception toward knowledge is "collection of isolated facts", show lower sophistication in their study than students' perception toward knowledge is "complex and well-integrated" (Schommer, Crouse, & Rhodes, 1992). Thus, students' beliefs could have an effect on their process and interpretation of information.

Yang and Chang (2009) explored the three types of personal affective traits of high school students namely; personal preferences about web-based learning environment, personal epistemological beliefs and beliefs about web-based learning. Then they found out the effect of these affective traits on web based concept learning. Each personal affective trait was measured with three different questionnaires. Web based concept learning measured with an online test and flow-map technique. The flow-map technique described as the procedure in which firstly students were required to write and explain the concepts when they called the subject matter, then researcher developed concept map related to these concepts. The results obtained were that students preferences about web-based learning environment was inquiry based and outwardly interactive web based environments. They preferred more pragmatic and problem based learning styles. Students' belief toward the web based learning was conservative and they believed that it is difficult. Students showed more sophistication on quick learning and simple knowledge dimensions. After the implication of web based curriculum, students showed significant concept achievement. Students did not develop sophisticated epistemological beliefs tend to get moderate preference of explorative and interactive web based learning environments and they became conservative about the effectiveness of new type of learning.

Trautwein and Lüdtke (2007) carried out longitudinal study and examined the relationship between high school students' beliefs on certainty knowledge and their school achievement. Also, the relationship between their beliefs on certainty knowledge and their choice of college majors was investigated. Students were measured by questionnaire related to the certainty beliefs, cognitive ability, final school grade, family SES, cultural capital and fields of study. Structural regression analysis was conducted for analysis of the study. The results of the study demonstrated that when students' intelligence and family backgrounds were controlled, students who thought knowledge is absolute and certain showed lower school achievement at the beginning of the high school. Also, certainty beliefs predicted students' choice of college majors. Thus, they supported the students selected their major by their selves and by socialization.

Kienhues, Bromme and Stahl (2008) investigated the effect of a short intervention on students' domain specific epistemological beliefs. Students were randomly assigned control and experiment groups. The experimental group was instructed with challenging refutational epistemological instruction and the control group was instructed with non-challenging informational instruction. Students were given pre and post scoring on different layers of epistemological beliefs and students' epistemological beliefs were measured with two instruments. The control group students emphasized the facts and did not focus any controversial events. The experimental group students were instructed with two sided refutational texts in which analogies were formulating in it. Students introduced with a concept and then this concept was refuted by presenting alternative and more satisfactory theory. According to one kind of instrument, students in the naïve group of experimental group developed more sophisticated view, on the hand students in sophisticated group of control group developed more naïve view. According to other instrument, only naïve experimental group students developed sophisticated view. They concluded that the students' domain specific epistemological beliefs could be changed by short term intervention. However, there was no evidence for stability and elaborateness of those domain specific epistemological beliefs.

Valanides and Angeli (2005) investigated the impact of critical thinking principles on epistemological beliefs of university students, whether these effects were related to the teaching approaches and whether there was interaction between teaching approach and the epistemological beliefs of the students. Students were randomly assigned to three different groups; namely General, Infusion and Immersion approach was applied in these groups. Each student enrolled in these groups. General part of the intervention students were explained the purpose and procedure of the study. Then students took debate issue article and students read the article and summarized it and returned it to the researchers. In Infusion part of the study, students discussed the previous article together and they were required to find a common position on the article. Then students completed some parts of the epistemological beliefs questionnaire. The critical thinking principles were instructed with one of the teaching methods used in the study. Immersion part of the study, firstly students thought the previous article then developed an outline. After that students were required to write their rules for good critical thinking. The result of the study demonstrated that students performed better in post assessment. There were no interaction between intervention and students' epistemological beliefs.

Hofer (2004) investigated the epistemology of instructional practices of two classes of introductory-level college chemistry students. Classroom observations and students interviews were implemented for contextualization of the dimensions of the beliefs: certainty of knowledge, simplicity of knowledge, source of knowledge, and justification for knowing. Thus, evidence was collected from multiple sources and this contributes to the triangulation of data. In this study, undergraduate students' experience, perceptions and meaning making were emphasized. In this study case study is a qualitative research method, in which developing interpretative understanding of the interrelationships was conducted. In this study the relation between classroom practices and student beliefs were investigated. Chemistry class was observed in order to investigate the how students use beliefs about knowledge and knowing in the classroom and they situate these in classroom interaction. Observations were written as field notes, and they were interpreted according to dimensions of epistemology. Interview questions were prepared by using these field notes. Interviews were carried out toward the end of the semester and during the final month. Students' personal epistemologies were investigated. The study revealed students who were instructed with constructivist learning approaches, in which student centered approach was used, developed the epistemological beliefs dimensions more than the teacher centered group. This study proposed that students while using their epistemological assumptions interpret the perceptions of instructional practices. Thus, it is suggested that teachers should be aware of this finding and arrange instructional practices for considering students' epistemological beliefs.

Tsai (2008) investigated the effectiveness of Internet based inquiry oriented instructional activities on improvement of students' epistemological beliefs. In the study, 10^{th} grade students were required to search in internet for examining further scientific knowledge which was taught in the class and students also required to find out the answers of the controversial issues. Students involved in online discussions and debates. Students were given two instruments. One of them measured the standards of students for evaluating online information and the other instrument measured the epistemological beliefs toward science. These instruments were given as pre and post test to the students. The result of the study demonstrated that after internet based inquiry oriented instruction, the judgment standard of students for assessing online information got sophisticated. In addition to this, students' epistemological beliefs toward science were promoted. However, while some of the students' responses to the survey on judgment standards were investigated, in some items students showed not sophisticated view. The author concluded that students might use frequently sophisticated view in the study for assessing online information but they might hold also less sophisticated view. In addition to this, students developed constructivist epistemological beliefs and students' believes about knowledge was scientific exploration is theory-laden and the scientific knowledge is always changing. He suggested that students' preference for online information and for epistemological beliefs toward chemistry should be analyzed by using qualitative techniques to obtain deeper understanding of the results of the study.

Browlee, Purdie and Boulton-Lewis (2001) developed a teaching program for the reflection and development of epistemological beliefs of preservice graduate teacher education students. This study had experimental and the control groups. Experimental groups instructed with teaching method in which reflecting the content related to the epistemological beliefs and their own epistemological beliefs. Thus, students connected the tutorial to the epistemological beliefs frameworks, students were instructed by methods in which linking the relational and objectivist ways of knowing. They wrote articles for journal on specific educational psychology topics. Experimental groups were interviewed about their beliefs about knowledge at the beginning and at end of the teaching program. Students used journal reflections and inquirer feedback. Control groups instructed with not emphasizing epistemological beliefs and journal reflections, instead they implemented with the inquiry. Small group and large group discussions and activities related to the tutorial were conducted. Schommer's epistemological beliefs questionnaire were given to each group at the beginning and at the end of study. Control group students were interviewed for asking students to fill the blank in the statements which are written statements on their beliefs about knowledge at the beginning and at the end of the study. Results of the study demonstrated that experimental group students developed their epistemological beliefs. Students became sophisticated on quick learning and certain knowledge dimensions.

Case based learning instruction is active learning method in which real life stories (the case) is presented, and students' beliefs about nature of knowledge is promoted by using real life connections in the instructions (Schommer, 1990). Thus, using case based learning method students developed their naïve belief that knowledge is simple to sophisticated and knowledge is absolute to knowledge is tentative and the ability to learn is fixed at birth to ability to learn can be changed and knowledge is acquired quickly to knowledge is acquired gradually.

2.7 Summary

Students have some conceptions on some concepts but they are sometimes different than the scientific conceptions. Students also have some misconceptions related to chemistry which is abstract and difficult subject. Thus, students have difficulty for constructing meaningful learning. Solubility equilibrium is one of the fundamental concepts in chemistry since it integrates more than one concept such as solubility, chemical equilibrium, particular nature of matter, ionic compounds, stoichiometry, dissolution, the common ion effect and Le Chatelier's principle. To promote students learning in solubility equilibrium concept students construct new knowledge into already existing knowledge. Students construct their knowledge by interacting with the environment such as friends, teachers and materials. While using case based learning method, students work in groups for discussing the case and analyzing the case problems. While discussing the case and engaging in the concept, students started to enjoy the topic which is taught by case based learning method. Students promote the beliefs about the knowledge by discussing and evaluating the cases and so students could bridge between real lives to the concept taught. Thus; in order to promote students' understanding, to remediate students' misconceptions, to increase enjoyment to science and to make sophisticated students' beliefs about knowledge, case based learning method appears to propose valuable benefits for students while studying in solubility equilibrium.

CHAPTER 3

PROBLEMS AND HYPOTHESES

Before this chapter, the purpose, the significance of the study and literature related to the study was reviewed. This chapter presents the main problem and sub-problems and hypotheses of the study.

3.1 The Main Problem and Sub-problems

The study has the main problem and the sub-problems. There is one main problem and ten sub problems. Sub problems make easy to solve the main problem.

3.1.1 The Main Problem

The purpose of the study is to compare the effectiveness of instructions, one based on case based learning instruction and the other based on traditional instruction on eleventh 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 case based learning method and the other based on traditional method on eleventh grade students' understanding of solubility equilibrium concept?

2. Is there any difference between girls and boys with respect to understanding of 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 a significant mean difference between students taught with case based learning method and traditional method with respect to their attitudes towards chemistry as a school subject?

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

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

8. Is there a significant mean difference between students taught with case based learning method and traditional method with respect to their epistemological beliefs about chemistry?

9. Is there a significant mean difference between girls and boys with respect to their epistemological beliefs about chemistry?

10. Is there a significant effect of interaction between gender difference and treatment with respect to students' epistemological beliefs about chemistry?

3.2 Hypotheses

H_o1: There is no significant mean difference between post-test mean scores of students taught with instruction based on case based learning 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 girls and boys on their understanding of solubility equilibrium concept.

H_o3: There is no significant effect of interaction 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 mean difference between students taught with case based learning and students' taught with traditional instruction with respect to their attitudes toward chemistry as a school subject.

H_o6: There is no significant mean difference between boys and girls with respect their attitudes toward chemistry as a school subject.

H_o7: There is no significant effect of interaction between gender difference and treatment with respect to students' attitudes toward chemistry as a school subject.

H_o8: There is no significant mean difference between students taught with case based learning and students' taught with traditional instruction with respect to their epistemological beliefs about chemistry.

H_o9: There is no significant mean difference between boys and girls with respect their epistemological beliefs about chemistry.

H_o10: There is no significant effect of interaction between gender difference and treatment with respect to students' epistemological beliefs about chemistry.

CHAPTER 4

DESIGN OF THE STUDY

The purpose, the importance of conducting this study, the problems and the hypothesis of the study were given, and the literature related to the study was reviewed in the previous chapters. This chapter composed of experimental design of the study, population and subjects, the variables of the study, instruments which were used in the study, learning materials used in the class, treatment, analysis of data, treatment fidelity and treatment verification, ethical concerns, threats to internal validity, assumptions and limitations of the study.

4.1 Experimental Design of the Study

This study was designed to determine and compare the effects of the two instructional methods, traditional instruction and case-based learning instruction, on students' understanding of chemistry. In this study, students cannot be selected randomly from population because most of the school schedule cannot be changed. Thus quasi experimental study is conducted; treatments were randomly assigned two groups, as an experimental group (EG) or control group (CG). The research design of the study is presented below.

Solubility equilibrium subject was instructed to students in experimental group by case-based learning (CBL) while to students in control group by traditional method (TM). Before the experiment Solution Concept Test (SCT), Attitude Scale towards Chemistry (ASTC), Epistemological Beliefs Questionnaire (EBQ) were administered to all students as a pre-test. After six weeks of treatment period, Solubility Equilibrium Concept Test (SECT), Open ended Solubility Equilibrium Concept Test (OSECT), Attitude Scale toward Chemistry (ASTC), Epistemological Beliefs Questionnaire (EBQ) were administered to all groups as a post test. The research design of the study is presented in Table 4.1.

Table 4.1 Research Design of the Study

Groups	Pre-test	Treatment	Post-test
Experimental Group (EG)	SCT ASTC EBQ	CBI	SECT OSECT ASTC EBQ
Control Group (CG)	SCT ASTC EBQ	TI	SECT OSECT ASTC EBQ

Five kinds of measuring tools (SCT, SECT, OSECT, ASTC and EBQ) were used in this study. SCT and SECT were developed by Önder and Geban (2006). EBQ was developed by Schommer(1990) and translated into Turkish by Deryakulu and Büyüköztürk (2005). ASTC and OSECT were developed by researchers.

Lesson plans and cases to teach solubility equilibrium to the students by using case-based learning instruction (see Appendix F) were prepared. Before the study high school chemistry teachers and several prospective chemistry teachers were reviewed these. The pilot study was conducted on 43 students in different high school. Thus, according to the students', teachers' and prospective teachers' view the original form of the cases were developed.

Teaching methods were randomly assigned to two groups. One of the classes was instructed by case based learning and the other was traditional method. Instruction time of each class was 45 minutes per week and treatment carried out six weeks. The administration of tests took one week before and one week after the treatment.

Before the treatment, teacher participated in the study was trained and informed about what case based learning and the way of teaching with cases in the class was informed to teacher. Teachers were given to lesson plans and cases; teacher and researcher negotiate these. During treatment teacher and researcher were in contact, also researcher observed both experimental and control group several times.

4.2 Population and Subjects

All eleventh grade students in Istanbul, which is the largest city of the Turkey, were identified as the target population of the study. However, since it is too big population to conduct an experimental study, the accessible population is chosen as all eleventh grades in Ümraniye district.

Atakent High School was chosen as a convenient sampling from the schools in Ümraniye district. Two science classes were chosen and these classes were randomly assigned as control and experimental group since it is difficult to select students randomly. The data analyzed in this research study were taken from 27 students participated in instruction based on cased based learning and 35 students participated in instruction based on traditional methods. The experimental group consisted of 27 students and the control group consisted of 35 groups. Therefore, in this study in total 62 eleventh grade students participated. The study was carried out during the Spring Semester of 2007-2008.

4.3 Variables

The study included six variables, in which some of then categorized as independent variable and some categorized as dependent variable. Independent variables composed of two variables, dependent variables four variables. These are identified below.

4.3.1 Independent Variables

The independent variables were two types of instructional methods which are instruction based on case based learning and traditional methods and gender of students. Both of the variables were considered as categorical variable and measured on nominal scale.

The control group was coded as 1 and the experimental group coded as 2. The gender of students was coded as 1 for female and 2 for male.

4.3.2 Dependent Variables

The dependent variables are students' understanding of solution concept which was measured by solution concept test, understanding of solubility equilibrium concept which was measured by solubility equilibrium concept test, their attitudes toward chemistry as a school subject which was measured by attitude scale toward chemistry and their epistemological beliefs which was measured by epistemological beliefs questionnaire.

Table 4.2 Description of variables

Name of the Variable	Type of the Variable	Nature of the Variable	Type of the Data
SCT	Dependent	Continuous	Interval
SECT	Dependent	Continuous	Interval
OSECT	Dependent	Continuous	Interval
ASTC	Dependent	Continuous	Interval
EBQ	Dependent	Continuous	Interval
Gender	Independent	Categorical	Nominal
Instructional Method	Independent	Categorical	Nominal

4.4 Instruments

In this study, individuals were not assigned randomly to control and experimental group; thus before the treatment researcher administered SCT to both groups for controlling preexisting difference in each group. That is, students' understanding of solution concept before the study was treated as a covariate thus difference result from nature of groups were prevented. SECT and OSECT were administered to both groups as a post test to assess the understanding of students' in solubility equilibrium concept after the treatment. In addition ASTC and EBQ were administered before and after the treatment to both groups.

In this study five instruments were used to collect data. They were namely: Solution concept test (SCT), Solubility Equilibrium Concept Test (SECT), Open ended Solubility Equilibrium Concept Test (OSECT), Attitude

Scale toward Chemistry (ASTC) and Epistemological Beliefs Questionnaire (EBQ).

In addition to instruments, teaching materials which were the cases used in the experimental group is presented.

4.4.1 Solution Concept Test (SCT)

This instrument was developed by Önder and Geban (2006) for measuring students' understanding of solution and solubility concept. It includes 20 multiple choice items and most of which requires students to reflect misconceptions and others requires computations. The reliability coefficient was found to be .72. This instrument was administered to both experimental and control groups as a pre-test to measure their background knowledge with respect to understanding of solubility concepts. Solubility Concept test was administered as a pretest other than solubility equilibrium concept test is that to prevent testing effect and students didn't get familiar with the solubility equilibrium concept test. At the beginning of the instruction students were not familiar with the solubility equilibrium concept instead SCT were given as a pretest since they learned this subject before solubility equilibrium. The test is given in the Appendix A.

4.4.2 Solubility Equilibrium Concept Test (SECT)

This instrument was developed by Önder and Geban (2006) for measuring students' understanding on solubility equilibrium considering misconceptions. It includes 30 multiple choice items and each item rated as one point. Each item has one correct answer and other choices are distracter and usually students' misconceptions which were stated in the literature. The reliability of the instrument is 0.66. This instrument was administered to both experimental and control groups as a post-test after the treatment. This test is given in the Appendix B.

Table 4.3 Misconceptions investigated by the items in SECT and their corresponding items numbers

Misconceptions	**Corresponding Item Number**
Believing that at equilibrium there is no precipitation and dissolution.	2, 3, 10, 11, 16, 18, 26
Believing that at equilibrium dissolution stops.	2, 11, 13, 18, 25
Believing that at equilibrium the concentrations of the ions produced is equal to the concentration of the salt.	9, 10, 16, 20, 24, 26
Believing that mass can be used instead of concentration in Ksp calculations.	8, 16, 21
Believing that coefficients in solubility equilibrium equations have no other meaning then equating the solubility reaction.	5, 9, 21
Believing that at a given temperature Ksp can change.	13, 19, 22
Believing that ion product (Qi) can be used interchangeably with Ksp.	23
Believing that compounds in solid form should be included while writing Ksp equations.	5, 21, 24
Believing that the rate of dissolving increases with time from mixing the solid with solvent until equilibrium establishes.	25
Believing that amount (moles) can be used instead concentration (molarity) in Ksp calculation.	8, 21
Believing that at a given temperature the value of Ksp changes with the amount of solid or ions added.	13, 14, 19, 26
Believing that the value of Ksp always decreases as temperature decreases.	27
Believing that temperature has no affect on solubility.	17, 22, 27
Believing that at equilibrium addition of salt affects the equilibrium.	1, 14, 19
Believing that at equilibrium the concentrations of ions will remain constant although common ion is added.	3, 6, 11, 12, 14, 19

Table 4.3 (continued)

Believing that solubility of sparingly soluble salts is effected by change made in pressure and volume.	7, 28
Believing that in all situations one can compare solubility of salts at equilibrium by just looking at Ksp values.	4
Believing that if system is at equilibrium no other solute that doesn't contain common ion can dissolve.	13, 29
Believing that before the system reaches equilibrium there was no precipitation reaction.	1, 18, 25, 26
Believing that large Ksp implies very fast dissolution	30
Believing that there is no relation between Ksp and solubility.	14, 15

4.4.3 Open ended Solubility Equilibrium Concept Test (OSECT)

This instrument was developed by researchers for measuring students' understanding on solubility equilibrium concept considering misconceptions. It includes 12 open-ended questions, which requires students to understand, predict and evaluate given situations. The test measures misconceptions, difficulties and essential concepts to be learned in the solubility equilibrium topic. The items were developed from examining related literature such as textbooks, journals and books (Ebbing, 2001, Brecevic & Kralj, 2007, Romero, Eriksen & Haworth, 2004). This test assessed students' knowledge related to solubility equilibrium by solving nonroutine questions including real life inferences and so they are able to understand the concepts which are root of solubility equilibrium and also they are able to interpret chemical equilibrium which is related to solubility equilibrium subject. Science educators, science teachers, prospective science teachers examined the test for content, grade level and context. The reliability of the instrument was .87.

At the beginning of the development stage of the test, the instructional objectives of the solubility equilibrium were stated, based on the national curriculum (see Appendix C). Then, students' misconceptions in solubility equilibrium were classified by examination of related literature and interviewing with experienced teachers. At the end, test items were developed considering misconceptions on solubility equilibrium concept. Then the instrument was applied to students in the other high school students. After that students' difficulties while understanding of the items were examined and then the final version of the test was administered to the treatment groups. The content validity and the appropriateness of the test items were examined by experts of chemistry and chemistry education and chemistry teachers. This instrument was given to both groups for determining students' understanding of solubility equilibrium.

Table 4.4 Misconceptions investigated by the items in OSECT and their corresponding items numbers

Misconceptions	**Corresponding Item Number**
Ksp and solubility are not related to each other.	1
The solubility of solution at equilibrium determined by only comparing Ksp values.	1
The coefficients at solubility equation were used for only balancing equation.	1
Water soluble ions do not be discriminated.	2
There is no relationship between the magnitude of Ksp and their degree of solubility.	3
Ksp is calculated for both saturated and unsaturated solutions.	4

Table 4.4 (Continued)

There was no precipitation reaction before the system reaches equilibrium.	5
Adding common ion does not change the solubility of solution.	6,7
Precipitation happens when the ion product of sparingly soluble salts is equal to or smaller than the solubility product constant.	8
The solubility of sparingly soluble salts is affected by change made in pressure and volume.	9a
The solubility of solid changes with pressure.	9b
The value of Ksp always decreases as temperature decreases.	10
The molecular diagram of unsaturated solution, saturated solution and super saturated solution are not discriminated.	11
Believing that the rate of dissolving increases with time from mixing the solid with solvent until equilibrium establishes.	11
Believing that before the system reaches equilibrium there was no precipitation reaction.	12

Content validity of the instrument was determined by experts in chemistry education and chemistry teachers. This test was given as post test for determining the effect of treatments on students' understanding of solubility equilibrium. The purpose of given open-ended solubility equilibrium concept test was to reveal students' underlying reasoning in each question.

4.4.4 Attitude Scale toward Chemistry (ASTC)

This instrument was developed by Geban and Ertepınar (Geban et al, 1994) for measuring students' attitudes toward chemistry as a school subject. The scale contains 15 items with five-point Likert type (strongly agree, agree, undecided, disagree, and strongly agree) in Turkish. The reliability of the instrument was .83. It was administered to the experimental and control group before and after the treatment. It is given at Appendix D.

4.4.5 Epistemological Beliefs Questionnaire (EBQ)

This instrument was originally developed by Schommer (1990) for measuring students' epistemological beliefs. The reliability of the instrument was .73. EBQ items are rated on a five-point Likert type scale with 1 equalling to fully disagree to 5 equalling to fully agree (fully agree, agree, undecided, partially agree, fully disagree). Schommer (1994) identified the dimensions of the instrument: Simple knowledge dimension includes the beliefs that "knowledge is organized as isolated bits and pieces" to "knowledge is organized as highly interwoven concepts". Certain knowledge dimension includes beliefs that "knowledge is absolute" to beliefs that "knowledge is tentative". Fixed ability dimension includes beliefs that "the ability to learn is fixed at birth" to beliefs that "the ability to learn can be changed". Quick learning dimension includes beliefs that "knowledge is acquired quickly or not at all" to beliefs that "knowledge is acquired gradually" Each factor of the EBQ measures a distinct belief dimension and each dimension have different effect on learning (Schommer, 1990). Thus, students' score of each factor is evaluated and the overall score of students are not used so much. The higher score on each factor indicates that student has sophisticated belief whereas the lower score is the indication of naïve belief of student on that factor. All of the dimensions of the instrument was analyzed separately since the dimensions of the instrument was independent to each other. This instrument was given to experimental and control group students before and after the treatment.

This instrument has also four factors. The reliability of the fixed ability dimension was 0.74., quick learning was 0.70, simple knowledge was 0.65 and certain knowledge was 0.75.

4.4.6 Teaching/Learning Materials

Students were instructed with the cases in case based learning group. Cases were developed by researchers before the study was conducted. They were developed from the literature review and interviews conducted by chemistry teachers and prospective chemistry teachers and arranged according to students' culture and misconceptions. Cases were designed to help students to learn by doing and learn how to grapple real-life problems. Each case followed questions which were integrated to related issue in case and misconceptions. Cases firstly discussed in small group and then students discussed with class. Then, they came to conclusion about each case.

The case was given to students one week prior to the lesson. After students analyze cases before class, possible solutions were found. Then, in class, case was presented to the class and small group discussion (in each group 4 or 5 students and students make their own groups) was proceeded to analyze it. Firstly, each group discussed the case questions. When teacher observed class during solving this question, she took attention of some responses. After all of the questions were discussed in group, all class started to discuss the case. While doing these, follow up questions were directed toward students for enhancing consideration and understanding of the important concepts but these questions were not directly give the correct response of the questions. At the end of the all class discussion, students found out the important concepts and summarized the case. Thus, students solve the questions about the case and comprehend the common ion effect, temperature effect on solutions.

Thus, cases directed students toward a conclusion or provide resources and context to discuss and debate issues dynamically. Researcher with teacher prepared an outline of concepts and subconcepts to be discussed through the case. Also teacher was trained about case- based learning instruction by researcher. In this study six cases was given to the students and three of them given in the Appendix F.

4.5 Treatment

High school chemistry teachers and several prospective chemistry teachers were interviewed before the study. The interviews were semi-structured and conducted individually. Semi-structured interviews held for eliciting specific answers to several questions. The researcher prepared several questions for finding out misconceptions about solubility equilibrium. Thus, they are asked which kind of misconceptions were observed in the class and also misconceptions found from literature were presented to participant and they were asked whether students had the same kind of misconceptions. In addition, a copy of the cases were given and they were read and were indicated whether the content and grade level is appropriate or not to students. Participants' suggestions were considered and the final form of the cases was developed. The researcher then developed OSECT which was used as a post test. OSECT and SECT were used as only for post test because at the beginning of the instruction students were not familiar with the solubility equilibrium concept, instead SCT were given as a pretest since they learned this subject before solubility equilibrium. The validity of OSECT is investigated before the administration by faculties in chemistry science education and by chemistry teachers. Moreover, before the study lesson plans and cases were developed by researcher and they were examined by teachers, prospective teachers and a faculty in chemistry education for appropriateness of content, grade level and context. Cases were developed based on Herreid's small group discussion (1994). These were used to make engagement to instruction and easy to understand. Teacher participated in the study was trained and she was informed about constructivist learning and case based learning. The way of teaching with cases in the class was informed to teacher.

This study was conducted over six weeks in a public high school during the spring semester of 2007-2008 academic years. Total 62 eleventh grade students participated in this study. Both classes were taught with the same teacher to prevent teacher effect. Each of the teaching methods was randomly assigned as control and experimental group. The experimental group consisted of 27 students and the control group consisted of 35 groups. Solubility equilibrium subject was instructed to students in experimental group by case-based learning (CBL) while to students in control group by traditional method (TM). Before the treatment, teacher was trained about case-based learning by using teacher guide, and then instructional materials prepared by researcher were explained to her. The teacher was already using the traditional method in her classes so the researcher explained more the case based learning method.

To verify treatments and to control teacher effect, researcher observed the classes several times at different occasions. Teacher didn’t know when the observation time was. It was observed that in both classes, the teacher fulfilled the requirements of the each method. During the treatment, solubility equilibrium topics were covered as a part of regular classroom instruction in the chemistry course. The classroom instruction was three 45 minute periods per week for both groups.

Before the treatment, both groups received Solution Concept Test (SCT), Attitude Scale towards Chemistry (ASTC) and Epistemological Beliefs Questionnaire (EBQ) as a pretest. SCT was given to determine whether there was any difference at the beginning of the treatment between two groups with respect to understanding of solubility equilibrium. ASTC was given to determine students’ attitudes toward chemistry as a school subject at the beginning of the treatment. EBQ was given to determine students’ beliefs about knowledge at the beginning of the treatment.

The “solubility equilibrium” topic is covered the self ionization of the water, acid and base dissociation equilibrium, neutralization reactions, dissolution and precipitation equilibriums, formation and separation of complex equilibrium, titration. This study focused on the dissolution and precipitation equilibriums. The concepts which were studied in this study were: dynamic equilibrium, saturated solution, supersaturated solution, the conditions for precipitation, crystallization, and the common ion effect.

Students in control group were instructed by traditional instruction in which lecturing method, discussion and sometimes students performed the laboratory activities in that students were passive listeners and teacher’s role was to transmit the facts and concepts to students. Also, before lesson students were required to read related topic in the textbook. Textbooks do not mention misconceptions. During lesson teacher emphasized main ideas of the topic and gave some definitions in textbooks. Also, she gave the formulas of concept verbally and by using chalkboard. If students had questions about topic, teacher answered them. After that a question was written to chalkboard and students were required to solve it. During that time, teacher walked around the class and looked at some students’ answers and also students could ask questions to teacher. Then, one of the students solved the question on the chalkboard. After the lesson worksheets were given to students and students responded them. Questions in worksheets were direct questions related to topic. Teacher did not give emphasis on students’ misconceptions. Students were passive listeners and they were taking notes. In the laboratory activity section, students were required to do experiment by using the handout. The handout was like “cookbook”, described the all steps of the experiment.

Students in experimental group were instructed with case-based learning instruction by small group discussion as described by Herreid (1994). In that method, the cases were used as an active learning tool. The cases which were used in the study were given in the Appendix C. Moreover, students were given an opportunity for critical learning, comprehending concepts and real world problem solving skills by dealing cases with studying together. In this study, six cases related to real life scenarios related to solubility equilibrium were used. Each case followed questions which were integrated to related issue in case and misconceptions. Firstly, students were required to form groups in which five students per group. Before the class, students were given the case to read it and to do research for answering case questions. Before class, group members did meeting for analyzing and interpreting the case. In the class, the case was discussed first in the group and in the group students exchange their ideas related to the case and the questions given in the class. After all of the groups finished their own work, all of the students started to talk about this case for understanding the case. After that they understood and came to conclusion about the case. Each group solved the questions related the case, all of students in the group contributed for solving the problem and then one of the member of the each group gave the answer of the question to the class. After that all of the students, means all groups, provided a consensus about the answer of the each question and then they got one answer to each question. While solving questions, teacher guided students; students could ask questions to the teacher however the teacher didn't give answers to the questions. The teacher was careful about students' misconceptions; the conceptual change was established by using cases. While actively participating in the class, students discussed and interpreted the real life cases related to the topic, thus students misconceptions were remediated. The teacher reminded students to read the case and did some research to understand the case and solve the problems.

Researcher attended as an observer to the control and experimental groups several times. In these sessions, researcher observed the class for ensuring about the topic was presented as unbiased. Also, students' participation in each class and their interaction to teacher was observed.

After six weeks of treatment period, Solubility Equilibrium Concept Test (SECT), Open ended Solubility Equilibrium Concept Test (OSECT), Attitude Scale toward Chemistry (ASTC) and Epistemological Beliefs Questionnaire (EBQ) were administered as a post test to all groups.

4.6 Analysis of Data

All raw data were recorded into the computer and then analyzed statistically into two parts, including the descriptive and inferential statistics, by using SPSS.

4.6.1 Descriptive Statistics

Experimental and control group students' mean, standard deviation, skewness, kurtosis, range, minimum and maximum values and charts were performed as descriptive statistics analyses.

4.6.2 Inferential Statistics

As inferential statistics, independent t-test, Two-way Analysis of Covariance (ANCOVA), Analysis of Variance (ANOVA) and Repeated Measures Analysis of Variance were carried out to address the research questions. Prior to the treatment, independent t-test was used to determine whether there was existed a statistically significant difference between the experimental and control group students' understanding of solubility concepts, attitude toward chemistry. Also, at the beginning of the treatment MANOVA was conducted to determine whether or not there was a significant difference between experimental and control group with respect to students' epistemological beliefs dimensions. The results of the study demonstrated that there was no statistically difference between mean scores of experimental and control group students with respect to epistemological beliefs dimensions. Two way ANCOVA was used to compare the effectiveness of two different instructional methods and gender on students' understanding of concepts related to solubility equilibrium (using multiple choice concept test) by controlling the effect of students' prior understanding about solution concept. Also, one more two way ANCOVA was used to compare the effectiveness of two different instructional methods and gender on students' understanding of concepts related to solubility equilibrium (using open ended concept test) by controlling the effect of students' prior understanding about solution concept. The contribution of prior knowledge was also determined by using this analysis. Two-Way Analysis of Variance was carried out to compare the effectiveness of two different instructional methods and gender on students' attitudes toward chemistry as a school subject. Repeated measures of ANOVA was carried out to compare the effectiveness of two different instructional methods on students' epistemological beliefs dimensions.

4.7 Treatment Fidelity and Treatment Verification

Treatment fidelity is helpful for finding out the observed differences in the dependent variable was due to the implementation of the treatment, not other factors which were presented before the study was conducted (Detrich, 1999). Therefore, materials and assignments were investigated by the help of an expert in chemistry education to evaluate the obtained data and observed differences were not the result of the other factors than the treatment. The appropriateness of the instruments was ensured by an expert in chemistry education.

Treatment verification is helpful for deciding whether treatment was done as defined in the study (Shaver, 1983). Thus, researcher participated to several classes and observed teacher and students while conducting the study.

4.8 Ethical Concerns

Participants in this study did not have any trouble through the process. This means there was no risk for teacher and students. The teacher were observed and informed of rational for observing her. However, the behavior of the teacher may be affected and she can behave according to researcher's expectation. Thus, the researcher mentioned clearly the purpose of this study was not investigating teacher and her teaching style, and the purpose of the study was to investigate the two different teaching methods and no specific information would be given such as students and the teacher name. Also, students were informed that names of the subjects would not be used in the publication and any other places, and it was stated that all students in the study could withdraw from study if they want or they can request for their data will not be used in the study. For eliminate the question of deception subjects, students will be informed that the results will not be used for their following chemistry achievement scores and this is the only study and this is not influence their scores in the school. Thus, researcher could eliminate the students' deceptions.

4.9 Threats to Internal Validity

Internal validity is achieved by the observed difference on dependent variable only due to variation in independent variable (Fraenkel & Wallen, 2001). Thus, controlling threats to internal validity is important. Some of the treats to internal validity were presented by Fraenkel and Wallen (2001). They are subject characteristics, mortality, location, instrumentation, testing, history, maturation, attitude of students, regression and implementation.

In this study the prior achievement of students in experimental and control group were treated as a covariate in the analysis of data to prevent prior differences that exist in each group for revealing the actual difference related to treatments. The grade level of the students in each group was the same so they were almost the same age. Thus, these variables do not change the observed difference on dependent variable. However, control and experimental group students were not assigned these groups randomly from population, so the other variables may correlate with dependent variable.

All of the students in the experimental and control group was ensured to participate to pre test and post test. All of the students participated to both tests. However, there were some items that were left marked, that is each student participated to the study but didn't mark all of the items. Thus, mean replacement was done.

Both experimental and control group students were given pre and post test and instruction at the same place. Thus, the location of the test and treatment kept constant.

Open-ended instrument was used and the results could be interpreted differently and this could be cause instrument decay threat. To prevent this threat the researcher other than main researcher evaluates the same questions at different times and they became about 70 percent consistency with each other. Data collector characteristics are another threat and data was collected from the same teacher. To control this threat the teacher trained for standard test administration procedures. The researcher also observed the teacher during data collection so teacher obeyed the test administration procedures.

The pretest effect could be the other threat to the internal validity. To prevent this threat post tests were given six weeks later to allow time students for desensitization. For measuring students' understanding, students were given solution concept test rather than solubility equilibrium concept test.

History could be the other threat to the internal validity. External events which effects internal threat were identified by researcher and they were told to the teacher. Researcher interviewed the teacher and asked her while conducting the treatment, whether there was special events or not. Also the same question was asked to the students in both classes. However, there were no such event happened during the study.

Maturation can not affect internal validity of the study. All of the students were the same grade and the study lasted for six weeks so this is not enough time to observe maturation effect.

Attitude of students toward the study could have an affect on the dependent variable. Each group were given different kind of materials, in which experimental group students received cases based on case based learning and the control students received traditional methods. Thus, students ensured about the treatment just a regular part of the instruction and part of the experiment. Thus, the attitude threat was reduced. Hawthorne, John Henry and Demoralization effects could be eliminated.

Regression threat was not observed in this study since there were no extremely low or high achievers in both groups.

Implementation threat could be observed when treating experimental group intentionally for providing advantages to experimental group. To prevent this threat the same teacher conducted both groups and also the required implementation of the experimental group were informed to the teacher. Also, the researcher observed the both groups for preventing implementation threat. There were no implementation threat was observed.

4.10 Assumptions

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

1. Theoretical basis of the study is valid.

2. Experimental and control group students were not affected by each other.

3. All of the students in the study were ready for comprehension of the subject.

4. The teacher had an experience work with 11^{th} grade students.

5. The teacher was not biased.

6. The tests were administered under standard conditions.

7. Students answered the questions in the instruments honestly.

4.11 Limitations and Delimitations

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

1. Random assignment of students to the groups can not be applied.

2. The sample of the study is small.

3. Two classes from one school participated into the study.

4. Only 11^{th} grade students from general high school participated to the study.

5. Solubility equilibrium is the only subject which is studied.

CHAPTER 5

RESULTS AND CONCLUSIONS

This chapter is related to data analysis from the instruments and data collection techniques described in Chapter 4 for the research questions of the study. The hypotheses of the study were tested at 0.05 significance level 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.

Analysis of covariance (ANCOVA), analysis of variance (ANOVA), repeated measures of analysis of variance and independent t-test was used to test the hypothesis. In this study, treatments were randomly assigned to groups. Hinkle, Wiersma and Jurs (1998) stated that using ANCOVA preexisting differences that may exist among groups were adjusted and error variance was reduced and precision of the research was increased.

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

5.1 Statistical Analysis of Pretest Scores

At the beginning of the treatment Solution Concept Test, Attitude Scale toward Chemistry and Epistemological Beliefs Questionnaire were administered to both groups. Solution Concept Test was administered to determine students' understanding of solubility concept, since students' understanding of solubility concept is the predictor of students' solubility equilibrium concept and also this test was administered to prevent testing effect. Attitude Scale toward Chemistry was administered to determine students' attitudes toward chemistry. Epistemological Beliefs Questionnaire was administered to determine students' beliefs about knowledge.

5.1.1 Statistical Analysis of the Solubility Concept Test, Attitude Scale toward Chemistry (pre-test)

Independent sample t test analysis was used to find out whether or not there was a significant difference between experimental and control group with respect to students' pretest scores on understanding of solubility concept test. Independent t test results showed that at the beginning of the treatment there was no statistically significant difference between mean scores of the experimental and the control group students with respect to their understanding of solubility ($t= 1.30$, $df=60$; $p>0.05$).

Independent sample t test was used to investigate whether or not there was a significant difference between experimental and control group with respect to students' pretest scores on attitude toward chemistry. The results showed that at the beginning of the treatment there was no statistically significant difference between mean scores of the experimental and the control group students with respect to their attitude toward chemistry ($t= 0.429$, $df=55$, $p>0.05$).

5.1.2 Statistical Analysis of the Epistemological Beliefs

Simple knowledge, certain knowledge, fixed ability and quick learning are dimensions of the epistemological beliefs. MANOVA was used to investigate whether or not there was a significant difference between experimental and control group with respect to students' pretest scores on epistemological beliefs dimensions.

Table 5.1 shows the descriptive statistics of pretest epistemological beliefs dimensions.

Table 5.1 Descriptive Statistics of Epistemological Beliefs Constructs

Constructs	Mean		Standard deviation		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG
Simple Knowledge	2,46	2,61	0,75	0,50	1,180	0,318	1,221	1,790
Certain Knowledge	2,47	2,64	0,72	0,51	-0,032	0,622	0,723	0,051
Fixed Ability	2,69	2,74	0,58	0,38	-1,153	0,128	3,050	0,653
Quick Learning	2,60	2,85	0,66	0,47	-0,117	-0,357	1,692	0,138

Skewness and kurtosis values showed that there were not problem related to normality assumption. Box's test is interpreted for homogeneity of variance and covariance matrices assumptions. Box's test is significant ($F (10, 14765) = 2.49$, $p< 0.05$). Thus, homogeneity of variance and covariance matrices assumption was met.

Table 5.2 shows MANOVA results of the pretest scores on epistemological beliefs dimensions.

Table 5.2 MANOVA results of the pretest scores on epistemological beliefs dimensions.

Source	Wilks' Lambda	F	Significance (p)
Treatment	0.89	1.79	0.142

The results demonstrated that there was no significant difference between mean scores of the experimental and the control group students with respect to epistemological beliefs dimensions. Also, there was no significant difference between mean scores of each epistemological beliefs dimensions; simple knowledge ($F(1, 60) = 2,14$, $p>0.05$), certain knowledge ($F(1, 60)= 2,31$, $p>0.05$), fixed ability ($F(1,60)=0,6$, $p>0.05$) and quick learning ($F(1,60)=0,16$, $p>0.05$).

Finally, there were not significant differences in terms of students' understanding of solubility concept, their attitude toward chemistry and epistemological beliefs at the beginning of the treatment.

5.2 Statistical Analysis of Posttest Scores

Dependent variables of the study were students' understanding of solubility concept, solubility equilibrium concept, their attitudes toward chemistry as a school subject and their epistemological beliefs about chemistry. The independent variables are two types of instructional methods which are instruction based on case based learning and traditional methods and gender of students. Both of the variables were considered as categorical variable.

5.2.1 Solubility Equilibrium Concept Test

Hypotheses and statistical analysis are presented below.

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

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

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

H_o4: There is no significant contribution of previous learning in solubility concept to understanding of solubility equilibrium concept.

For the above hypotheses Two-Way Analysis of Covariance (ANCOVA) was carried out with treatment and gender differences as the independent variables, students' solubility concept test scores as a covariate and students' performance related to solubility equilibrium concepts measured by multiple choice questions as the dependent variable. The Levene's test was not significant ($p > 0.05$), thus homogeneity of variance assumption was not violet.

Descriptive measures of Solubility Concept Test are presented in Table 5.3.

Table 5.3 Descriptive measures of solubility concept test

		Pretest		Posttest	
	n	Mean	Std. Dev.	Mean	Std. Dev.
Experimental group	27	8,9	2,9	23,6	3,81
Control group	35	9,8	2,4	20,9	3,73

Statistical analysis indicated that there was a statistically significant difference between the experimental and control groups' mean scores on the Solubility Equilibrium Concepts Test in favor of the experimental group ($F(1,58)=22{,}007$, $p<0.05$). The students in the experimental group who were engaged in case-based learning instruction demonstrated better performance compared to the control group students who were engaged in traditional instruction. Also, the results showed that the prior knowledge made a statistically significant contribution to understanding solubility equilibrium concepts ($F(1,58)=39{,}824$, $p<0.05$). However, there was no significant difference between the performance of males and females ($F(1,58)=0.151$, $p>0.05$). Also, there was no interaction between treatment and gender difference ($F(1,58)=0.036$ $p>0.05$).

The misconceptions reflected by the distracters of the solubility equilibrium concepts test items were the common misconceptions in a certain solubility equilibrium topic. The post-test average percent of correct responses of the experimental group was 78.7 and that of the control group was 69.7.

When the proportion of correct responses and misconceptions determined by the item analysis for the experimental and control groups was examined, significant differences between the two groups in favor of the experimental were indicated. For example, when students were asked what happens when a small amount of salt which does not form compound with original salt solution added to original salt solution, 92.6% of the students who instructed with case based learning answered it correctly by stating that the solubility of the original salt increases. However, 65.7% of the students who received traditional instruction answered the same question correctly after the instruction. The common misconceptions among control group students were that Ksp of the original solution does not change (17.1%), the solubility of the original salt decreases (11.4%), the added salt precipitates without dissolution (5.7%). However, 3.7% of the students held original solution does not change and the added salt precipitates without dissolution. Further, students were asked what happens when salt solution is at equilibrium at 25°C, then temperatures drops to 15°C and its dissolution process is exothermic. The desired response was that the ion concentrations increase. Although 85.2% of the students in the experimental group gave the correct answer, the percent of correct response for control group students was 68.6%. Some students (17.1%) in the control group held the misconception that temperature has no effect on solubility, the value of Ksp always decreases as temperature decreases. However 7.4% of the experimental group students held the same misconception. When students were asked what the rate versus time graphic of salt solution is, 85.2% of the students in the experimental group gave the correct answer that the rate of dissolution decreases and at the same time the rate of crystallization increases and at equilibrium the rate of dissolution and crystallization become equal. However, only 57.2% of the students in the control group answered it correctly. The common misconceptions related to this concept among control group students were that before the system reaches equilibrium there was no precipitation reaction (20%), the rate of dissolving increases with time from mixing the solid with solvent until equilibrium establishes (11.4%) at equilibrium dissolution stops (11.5%). However, 3.7% of the experimental group students held the misconception of before the system reaches equilibrium there was no precipitation. Most students in control group couldn't understand what happens at equilibrium. 31.4% students in the control group couldn't identify the equality of the rate of precipitation and the rate dissolution at equilibrium. However, 81.5% of the experimental group students responded to the same question correctly. 17.1% of the control group students answered that at equilibrium the concentration of solute and solvent became equal, 11.4% stated that at equilibrium there is no precipitation and dissolution, 3% stated that at equilibrium the mass of solute is greater than the mass of solution. For an item which assessed students' understanding related to the effect of pressure and volume on solubility of salts, 81.5% of the students in the experimental group identified correctly that the change of pressure and volume does not effect if there is some solute at the bottom of the beaker. Whereas 65.7% of the students' responses in the control group were correct. 5.7% of the control group students believed that Ksp value should be known to answer this. Another common misconception among control group students (14.3% and 14.3%) was that the solubility of salt changes as the volume and pressure changes.

Students in the experimental group still have misconceptions about solubility equilibrium because misconceptions are very resistant to change even with instruction designed to address misconceptions and students persist in giving answers consisted with their misconceptions after a large amount of instruction (Fredette and Lochhead, 1980; Osborne 1983; Champagne, Klopfer, Anderson, 1985; Anderson and Smith, 1987; Wandersee et al., 1994).

5.2.2 Open ended Solubility Equilibrium Concept Test

Open-ended Solubility Equilibrium Concepts Test was criterion referenced interpretation in that students' score with subjective standard of performance are compared and not students' score with the performance of norm group. The reason for using criterion referenced is that content was narrow and so students was be able to understand all detail of the subject in that the amount of their understanding were determined. Also, students' lack points were easily determined. Using this test, students mastered a skill and demonstrated minimum acceptable performance. Maximum performances of students were measured and formative evaluation was used for evaluation students' knowledge and they were able to transform solubility equilibrium concepts in to real life situations. While evaluating students' responses, score was between 0-3. Students got 3 if their responses include complete understanding statement(s). Students got 2 if their responses involve partial understanding statement(s). If students give the correct answer without any explanation or give some partial understanding statements(s) including some misconceptions. If students give correct answer but give wrong explanations (misconceptions), they got 1 score. 0 was given if both statements and reasoning were wrong; means students still hold misconceptions about concepts.

The two-way analysis of covariance with treatment and gender differences as the independent variables, students' solubility concept test scores as a covariate and post-test open-ended scores related to solubility concepts as the dependent variable. The Levene's test was not significant ($p > 0.05$), thus homogeneity of variance assumption was not violet. Statistical analysis indicated that there was a statistically significant difference between the experimental and control groups' mean post-test scores on the Solubility Equilibrium open-ended post-test scores in favor of the experimental group ($F(1,57)=26.679$, $p<0.05$). For example, when students were asked to graph and comprehend the solubility and precipitation rate of the salt at the beginning, before equilibrium and at the equilibrium. 70.4% of the students in the experimental group completely understand and gave desired answers; however, this kind of answer in the control group was 42.9%. Another question measuring students' understanding of common ion effect, in this question 66.7% of the experimental group students fully understand and mentioning the adding common ion changes the solubility. However, in the control group 37.1% of the students fully understand. 33.3% of the experimental group students showed partial understanding by giving only solubility changes with common ion but couldn't explain the rate of the solubility. However, this percentage was 57.1% in the control group. The students in the experimental group who were engaged in case-based learning instruction demonstrated better performance compared to the control group students who were engaged in traditional instruction. Also, the results showed that the solubility concept test scores means their prior knowledge made a statistically significant contribution to understanding solubility equilibrium ($F(1,57)=31,693$, $p<0.05$). However, there was no significant difference between the performance of males and females ($F(1,57)=3.230$, $p>0.05$). Also, there was no interaction between treatment and gender difference ($F(1,57)=3.688$, $p>0.05$). Both open-ended and multiple choice concepts test results indicated that experimental group students performed well in comparison with control group students.

5.2.3 Attitude toward Chemistry

H_o5: There is no significant mean difference between students taught with case based learning and students' taught with traditional instruction with respect to their attitudes toward chemistry as a school subject.

H_o6: There is no significant mean difference between boys and girls with respect their attitudes toward chemistry as a school subject.

H_o7: There is no significant effect of interaction between gender difference and treatment with respect to students' attitudes toward chemistry as a school subject.

After the treatment, Two-Way Analysis of Variance was carried out, with treatment and gender differences as the independent variables, and post-test scores related to chemistry attitude as the dependent variable. The Levene's test was not significant ($p> 0.05$), thus homogeneity of variance assumption was not violet. The analysis showed that there was a statistically significant difference between the mean scores of the students taught by case based learning ($X_{EG}=59.5$)and those taught by traditional method ($X_{CG}=55.0$) with respect to their attitudes toward chemistry as a school subject in favor of case based learning ($F(1,56)=7.842$, $p<0.05$). The students in the experimental group who were engaged in case-based learning instruction demonstrated more positive attitudes toward chemistry compared to the control group students who were engaged in traditional instruction. However, there was no significant difference between the performance of males and females ($F(1,56)=2.772$, $p>0.05$). The mean of the males was 55.5 and the mean of the female was 58.0. Also, there was no interaction between treatment and gender difference ($F(1,56)=0.048$ $p>0.05$).

5.2.4 Epistemological Beliefs

H_o8: There is no significant mean difference between students taught with case based learning and students' taught with traditional instruction with respect to their epistemological beliefs about chemistry.

H_o9: There is no significant mean difference between boys and girls with respect their epistemological beliefs about chemistry.

H_o10: There is no significant effect of interaction between gender difference and treatment with respect to students' epistemological beliefs about chemistry.

Table 5.4 shows the descriptive statistics about epistemological beliefs.

Table 5.4. Descriptive measures for epistemological belief questionnaire

	Experimental Group				Control Group			
	Pretest		Post test		Pretest		Post test	
Dimensions	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Fixed Ability	2,61	0,51	3,59	0,27	2,46	0,75	2,49	0,54
Quick Learning	2,64	0,51	3,48	0,46	2,47	0,72	2,38	0,55
Simple Knowledge	2,74	0,38	3,68	0,27	2,69	0,58	2,73	0,50
Certain Knowledge	2,86	0,47	3,81	0,31	2,60	0,66	2,66	0,45

Repeated measures analysis of variance was conducted and The Levene's test was not significant ($p > 0.05$), thus homogeneity of variance assumption was not violet. It showed that there were significant differences between experimental and control group students in the four subscales.

There was a significant difference between the fixed ability about chemistry in favor of case based learning group ($F(1, 56) = 147.5$ $p<0.05$). Control group students stated the ability to learn is fixed at birth but experimental group students stated that the ability to learn can be changed. There was a significant difference between the quick learning about chemistry in favor of case based learning group ($F(1,56)=151.5$ $p<0.05$). Thus, control group students stated that knowledge is acquired quickly or not at all but experimental group students stated that knowledge is acquired gradually. There was a significant difference between the simple knowledge about chemistry in favor of case based learning group ($F(1,56)=155.2$ $p<0.05$). Thus, control group students stated that knowledge is organized as isolated bits and pieces and experimental group students stated that knowledge is organized as highly interwoven concepts. There was a significant difference between the certain knowledge about chemistry in favor of case based learning method ($F(1,56)=193.0$ $p<0.05$). Control group students stated that knowledge is absolute; however, experimental group students stated that knowledge is tentative. Thus, case based learning instruction group students showed more sophistication about epistemological beliefs dimensions.

5.3 Conclusion

The following conclusions could be stated:

1. Case based learning method caused the better understanding of the solubility equilibrium concepts and remediation of misconceptions than traditional method.

2. Case based learning method produced more positive attitudes toward chemistry than traditional method.

3. Case based learning method produced more sophisticated epistemological beliefs dimensions than traditional method.

4. There was no significant effect of gender difference on the students understanding of solubility equilibrium concept and attitudes toward chemistry.

CHAPTER 6

DISCUSSION, IMPLEMENTATION and RECOMMENDATIONS

In this chapter, the results that are acquired in Chapter 5 of the study are discussed. Implementations of the findings are discussed and recommendations for future study are presented. Firstly, summary of the study is presented.

6.1 Summary of the Study

The literature related to case based learning instructional method, solubility equilibrium, attitude toward chemistry and epistemological beliefs were examined. Semi structured interviews with teachers were conducted to find out what kind of misconceptions related to the solubility equilibrium are observed in the class. Also, teacher was asked whether the misconceptions which were cited in the literature were observed in the students. After the results of the literature review and interviews, misconceptions were determined. After that test and the case was developed according to the considering the students' misconceptions.

Case based learning instruction used in experimental group considering students' misconceptions. Cases were developed with respect to students' misconceptions. The main purpose of the study is to find out effectiveness of case-based learning instruction using small group discussion on students' understanding of solubility equilibrium concepts, epistemological beliefs and attitudes toward chemistry as a school subject.

One of the two classes of the same teacher assigned as experimental and the other class assigned as control group randomly. Experimental group received instruction based on case-based learning and the control group received traditional instruction. Case based learning instruction group students used cases in which real life stories related to solubility equilibrium was presented and students studied cases by small group discussion. Students were required to read the case before coming to the class. In the class, students formed groups of four or five and they discussed the case and the related questions. Then all of the groups shared and discussed their findings and ideas about the case to the class. After then all of the questions were answered in the class. Traditional instruction group students were instructed by lecturing method and discussion in that students were passive listeners and teacher's role was to transmit the facts and concepts to students. Before the class students were required to read the chapter which will be presented. In the class, teacher told the topic by using board and sometimes asks questions about the topic. Then teacher asked similar questions which was solved in the class recently. One of the students solved the question on the board. The duration of each lesson took 50 minutes. The treatment took for six weeks.

Two classes were observed during the treatment by researcher for verification of the treatment. During this classroom observations students reaction to the cases, whether they were willing to participate in class and whether teacher performed the appropriately according to the requirements of each teaching method were observed.

At the beginning of the treatment, students were given epistemological beliefs questionnaire, attitude scale toward chemistry, solubility concept test. At the end of the treatment, students were given epistemological beliefs questionnaire, attitude scale toward chemistry, solubility equilibrium concept test and open ended solubility equilibrium concept test. Independent sample t test was carried out for determining whether there was a difference between experimental and control groups at the beginning of the treatment in terms of understanding of solubility concept, attitude toward chemistry. Also, MANOVA was carried out for determining whether there was difference between experimental and control group inn terms of students' epistemological beliefs constructs.

The pretest results demonstrated that there was no significant difference in terms of students' understanding of solubility concept and attitude toward chemistry at the beginning of the treatment. Also, there was no significant difference between experimental and control groups in terms students' epistemological beliefs at the beginning of the treatment.

After the treatment, two-way ANCOVA was carried out to find out the contribution of treatment to understanding of solubility equilibrium concept, with treatment and gender differences as the independent variables, students' solubility concept test scores as a covariate and students' performance related to solubility equilibrium concepts measured by multiple choice questions as the dependent variable. Also, two-way ANCOVA was carried out to find out the contribution of treatment to understanding of solubility equilibrium concept, with treatment and gender differences as the independent variables, students' solubility concept test scores as a covariate and students' performance related to solubility equilibrium concepts measured by open ended questions as the dependent variable. Two-Way Analysis of Variance was carried out to investigate the contribution of treatment to attitudes toward chemistry as a school subject, with treatment and gender differences as the independent variables, and post-test scores related to attitude toward chemistry as the dependent variable. Repeated measured Analysis of Variance was conducted to determine the contribution of treatment to epistemological beliefs since all of the dimensions of the epistemological beliefs were considered as independent to each other.

The result of the study demonstrated that there was a statistically significant difference between the experimental and control groups' mean scores on the Solubility Equilibrium Concepts Test in favor of the experimental group ($F(1,58)=22,007$, $p<0.05$). Case based learning instruction was helpful for promoting students' understanding of solubility equilibrium concepts. Also, the prior knowledge made a statistically significant contribution to understanding of solubility equilibrium concepts ($F(1,58)=39,824$, $p<0.05$). However, there was no significant difference between the performance of males and females ($F(1,58)=0.151$, $p>0.05$). Also, there was no interaction between treatment and gender difference ($F(1,58)=0.036$ $p>0.05$). The results for the open ended solubility equilibrium questions revealed that there was a statistically significant difference between the mean post-test scores of experimental and control groups on the Solubility Equilibrium open-ended post-test scores in favor of the experimental group ($F(1,57)=26.679$, $p<0.05$). Thus, case based learning enhanced students' understanding on solubility equilibrium concepts. Also, the results showed that the solubility concept test scores means their prior knowledge made a statistically significant contribution to understanding solubility equilibrium ($F(1,57)=31,693$, $p<0.05$). However, there was no significant difference between the performance of males and females ($F(1,57)=3.230$, $p>0.05$). Also, there was no interaction between treatment and gender difference ($F(1,57)=3.688$, $p>0.05$). According to the results of the multiple choice and open ended questions, case based learning method was performed well for understanding of solubility equilibrium in comparison to traditional method.

The results of the study revealed that there was a statistically significant difference between the mean scores of the students taught by case based learning and those taught by traditional method with respect to their attitudes toward chemistry as a school subject in favor of case based learning ($F(1,56)=7.842$, $p<0.05$). However, there was no significant difference between the performance of males and females ($F(1,56)=2.772$, $p>0.05$). Also, there was no interaction between treatment and gender difference ($F(1,56)=0.048$ $p>0.05$).

The results obtained demonstrated that there was a significant difference between the fixed ability about chemistry in favor of case based learning group ($F(1, 56)= 147.5$ $p<0.05$). Control group students believed that learning ability is fixed at birth but experimental group students believed that the ability to learn is not fixed and it can be changed. There was a significant difference between the quick learning about chemistry in favor of case based learning group ($F(1,56)=151.5$ $p<0.05$). Thus, control group students believed that knowledge is acquired quickly or not at all but experimental group students believed that knowledge is acquired gradually. There was a significant difference between the simple knowledge about chemistry in favor of case based learning group ($F(1,56)=155.2$ $p<0.05$). Thus, control group students believed that knowledge is organized as isolated bits and pieces and experimental group students believed that knowledge is organized as highly interwoven concepts. There was a significant difference between the certain knowledge about chemistry in favor of case based learning method ($F(1,56)=193.0$ $p<0.05$). Control group students believed that knowledge is absolute; however, experimental group students believed that knowledge is tentative. Thus, case based learning instruction group students showed more sophistication about epistemological beliefs dimensions.

Case based learning instruction was more helpful for promoting students understanding on solubility equilibrium concepts and remediation of misconceptions related to the solubility equilibrium than traditional instruction. Also, students' attitudes toward chemistry were increased more in the case based learning instruction than the traditional instruction. In addition, students' epistemological dimensions were getting more sophisticated than the traditional instruction. However, there was no difference between male and females in terms of their understanding of solubility equilibrium, attitudes toward chemistry and epistemological beliefs dimensions.

6.2 Discussion of results

Ausubel (1968) stated that "the most important single factor influencing learning is what the learner already knows". Students' prior knowledge is investigated whether this prior knowledge is helpful for constructing of meaningful learning or not. When students' preconceptions different than the scientific conceptions, it is called misconceptions. Misconceptions hinder students learning and students could not develop relations between ideas, concepts and information. The reason of students' inability to develop meaningful learning using misconceptions is that meaning is constructed by these not correct conceptions and they formed not correct conception after using misconceptions. Misconceptions are resistant to change since instructions are inefficient for constructing consistent relations among concepts and developing conceptual frameworks. Therefore, the purpose of this study was to investigate the effect of case based learning instruction on students' understanding and remediation of misconceptions on solubility equilibrium concept, attitudes toward chemistry and epistemological beliefs.

Students demonstrated misconceptions on most of the topics in science since science is related to life and so they usually develop some concepts without judging it scientifically acceptable or not. Chemistry is abstract subject and it includes mostly microscopic topics so it is also difficult to develop meaningful learning. Student could not observe some of the chemistry in the real world. Solubility equilibrium is one of the topics in which students could not develop meaningful connections among their connections and scientific conceptions. The reason of that could be that solubility equilibrium includes more concepts such as chemical equilibrium, solubility, molarity, nature of matter, Le Chatelier's principle. Thus, in order to construct meaningful learning for understanding of solubility equilibrium, students should first understand these concepts and then integrate these concepts for developing meaningful learning.

Teachers should aware of students' misconceptions and so they should implement some teaching methods for remediation of students' misconceptions. Constructivist approach is helpful for remediation of students' misconceptions since students involved in the learning process more and they construct their own knowledge by their selves. There are some teaching methods which involving constructivist approach. One of them is case based learning. In the case based learning method students work with their friends in the group and they discuss the case and the answers of the questions related to the case. Then, all of the students in the class discuss the case and they find out the answers of the questions.

In this study case based learning was implemented and their effect on students' understanding of solubility equilibrium and the remediation of students' misconceptions were investigated. In addition to this, students' attitudes toward chemistry and epistemological beliefs were examined. Also, the effect of students' prior knowledge on their understanding and the effect of gender on students' understanding were investigated.

At the beginning of the treatment, students' previous understanding of solubility equilibrium was determined by implementation of solubility concept test. The reason of using solubility equilibrium rather than solubility equilibrium concept test was test, students did not familiar with the solubility equilibrium concepts and their responses to the questions in solubility equilibrium could be related to the guessing of the answers without thinking underlying mechanism. In addition to the solubility concept test, students were given attitude scale toward chemistry for measuring students' attitudes toward chemistry at the beginning of the treatment. Also, epistemological beliefs questionnaire was distributed to the students for determining students' beliefs about knowledge at the beginning of the treatment.

The results of the pre tests revealed that at the beginning of the treatment there was no significant difference between two groups in terms of students' understanding of solubility equilibrium, attitudes toward chemistry and epistemological beliefs.

After the treatment students' understanding of solubility equilibrium was measured with the solubility equilibrium concept test and open ended solubility equilibrium concept test. Thus, while the understanding of students was determined by using two instruments, students' understanding was measured from different perspectives. The questions in the open ended test, students were required the give the reasoning of their answers, thus whether students still hold misconceptions or not were determined.

Students demonstrated misconceptions on some of the topics. Students' understanding of solubility equilibrium was measured by both multiple choice questions and open ended questions. Thus, students got chance to state their reasoning on open ended questions. When the proportions of correct responses and misconceptions in multiple choice questions determined by item analysis, there was a significant difference between experimental and control groups in favor of experimental group. For example, the common misconceptions among the control group students were the temperature has no effect on solubility, before the system reach at equilibrium there was no precipitation reaction, at a given temperature Ksp can change, Ksp and solubility are not related to each other, the solubility of solution at equilibrium determined by only comparing Ksp values, the coefficients at solubility equation were used for only balancing equation, water soluble ions do not be discriminated, there is no relationship between the magnitude of Ksp and their degree of solubility, Ksp is calculated for both saturated and unsaturated solutions, adding common ion does not change the solubility of solution, precipitation happens when the ion product of sparingly soluble salts is equal to or smaller than the solubility product constant, the solubility of sparingly soluble salts is affected by change made in pressure and volume, the solubility of solid changes with pressure, the molecular diagram of unsaturated solution, saturated solution and super saturated solution are not discriminated, the rate of dissolving increases with time from mixing the solid with solvent until equilibrium establishes, before the system reaches equilibrium there was no precipitation reaction.

The similar misconceptions were observed using the open ended questions. Using open ended questions researched could examine the students' reasoning for their answers in the multiple choice questions. Thus, students' understanding of solubility equilibrium could more deeply investigated by using open ended questions. Students showed misconceptions related to the molecular diagram of solution and the process of the formation of precipitation. Also, the experimental group students showed better performance for understanding and remediation of the solubility equilibrium.

However, some misconceptions about solubility equilibrium also observed in the experimental group students after case based learning instruction. This implies that misconceptions are very resistant to change even with instruction designed to address misconceptions and students persist in giving answers consisted with their misconceptions after a large amount of instruction (Fredette and Lochhead, 1980; Osborne 1983; Champagne, Klopfer, Anderson, 1985; Anderson and Smith, 1987; Wandersee et al., 1994).

The results of this study showed that case based learning instruction was more effective than traditional instruction in enhancing high school students' understanding, attitudes toward science and epistemological beliefs about science. The reason of poor performance of the control group was that traditional instruction was not focusing on students' misconceptions and concepts were presented in a logical sequence that is usually seen in textbooks. However, in experimental group, students' misconceptions were identified, conceptual framework was developed, and finally usage of metacognitive approaches was integrated into cased based learning instruction (Gallucci, 2006). These properties of the case-based learning instruction may have led to a better understanding of solubility equilibrium concepts when compared to the traditional instruction. As Gallucci stated case-based learning was helpful for remediation of misconceptions. Experimental group students were instructed with cases emphasizing students' possible misconceptions, their prior knowledge, underlying concept and expected outcomes. In order to deal with misconceptions, students exchanged and differentiated their prior conceptions with new conceptions. Thus, by using case based learning instruction students observed and discussed real life situations and constructed their conceptions.

Case-based learning was administered by considering students' prior knowledge in solubility equilibrium. Cases were developed for revealing students misconceptions and after they were identified, by using small group discussion students' conceptions were constructed (Gallucci, 2006). The study revealed that students' prior knowledge made a statistically significant contribution to their understanding of solubility equilibrium concepts. Meaningful learning was established by the construction of new knowledge on the basis of what they already know (Ausubel, 1968). Also, students' prior knowledge was a significant source of learning difficulties (Hewson & Hewson, 1983) and it is best predictor of students' achievement (Staver & Jacks, 1988). When students' misconceptions were not remediated, students could not develop meaningful learning since their preconceptions were not appropriate for constructing meaning learning. While using case based learning instruction, students' preconceptions were altered by using real life cases. Thus they could visualize the concepts and the concepts made sense easily since they most probably experienced before.

Students' attitudes toward chemistry also promoted by using case based learning instruction since students engaged in small group discussions. Thus, as Myers and Fouts (1992) stated that students' active involvement, small group discussion and lower level of teacher control promotes students' attitudes. Case based learning instruction includes students' active participation. Students worked in the groups for discussing the cases and answering the questions about the case. Thus, students share their ideas with each other and they discuss the opinions of each other. In the case based learning method, the role of teacher was the facilitator and students could ask questions but teacher gave answers for promoting students' thinking rather than giving direct answers to the student. Students were active in learning process and thus, this may have positive effect on development of students' attitudes toward science.

Case based learning instruction also enhanced students' epistemological beliefs about chemistry. Thus, the results implied that students understood the construction of knowledge. Thus, they developed their beliefs about knowledge about chemistry as Tolhurst (2007) stated. The reason of the changes in epistemological beliefs of experimental group was that using case-based learning students actively engaged in their own learning, they investigated cases by themselves and then they discussed their ideas in small group and then all class discussed the case. Hofer (2004) stated that students' beliefs were influenced by instructional practices and proposed that students interpret the perceptions of instructional practices by using epistemological assumptions. Her study revealed that students who were instructed with constructivist approach tend to develop epistemological beliefs than traditional approach. Students in the case based learning instruction actively involved in the class and they could connect link between other concepts, integrate other concepts and they thought tentativeness of the knowledge and they thought that knowledge was developed gradually.

Since the students' prior knowledge and misconceptions strong predictor of achievement in science, teachers should be aware of this and should examine why these misconceptions occur. The main concern of the science teachers is the search for the efficient and enjoyable way of communicating chemistry concepts to students. This can be accomplished by devising new strategies and for them case-based learning is the one of the instructions for this. Thus, case based learning and its teaching formats such as discussion formats, debate format, public hearing format, trial format, problem based learning format, scientific research team format, team learning format should be administered.

Case based learning method was effective for promoting students' understanding on solubility equilibrium since students experienced the concept from a new and different aspect (Smith & Murphy, 1998). Also, this method was implemented with the small group discussion thus students share their ideas about the cases with each other and interpret and discussed the case so students' understanding was promoted. Also the cases were real life stories thus students like stories, and they dealt with real issue. Thus, students became interested in events in the case and they started to like the chemistry. At the same time, while working in group, students' knowledge was developed since students challenged and discussed the topics. However, while implementation of that method, teachers should be careful since while discussing ideas students could pass another topic and the purpose of the intervention could be distorted and students could not understand the main purpose of the study. Thus, teacher should guide students by asking questions related to focusing students on the issue in the case.

Abd-El-Khalick and Lederman (2000) suggested that epistemological beliefs about science could be changed in two ways: firstly using group learning, discussions of different views and secondly explicit, utilizing elements from the history and philosophy of science. In this study by using case based learning method, students saw the different views of other students and discussed the case and related questions together. According to Abd-El-Khalick and Lederman (2000) view, one way of promoting students' epistemological beliefs were could be observed in this study.

While implementing of case based learning, students need more time and effort than the traditional method. Time of the implementation is limited thus the retention of students' understanding on solubility equilibrium is not clear.

Students' epistemological beliefs were improved on all of the dimensions of the epistemological beliefs in the experimental group.

6.3 Implications

Students' prior knowledge was important since it integrated with their learning and influences their meaningful learning of the concepts. Thus, teacher should be aware of students' prior knowledge and should develop teaching materials according to students' prior knowledge level.

The remediation of the misconceptions is really difficult but constructivist learning approaches is helpful. Students could construct their knowledge by their selves or with the help of environment and so they actively involve in the learning process.

Some misconceptions were observed not only from students but also teachers and textbooks which teacher used in the class. Thus, teachers should be careful for preparing instruction materials and also they should use proper language in the class for formation of misconceptions in students' mind.

Case based learning method, which is one of the constructivist approaches, is helpful for promoting students' understanding and remediation of students' misconceptions. This method was applied according to Herreid (1994) procedures. Thus, teacher could use these kinds of teaching methods for remediation of students' misconceptions and promoting students' understanding. However, while using this kind of teaching methods, teacher should be careful for losing of the objective of the lesson. Thus, teacher should guide students by asking questions for focusing students to the aim of the lesson.

The results of the study demonstrated that after treatment students in traditional method held misconceptions related to solubility equilibrium. Thus, teachers should be aware of this finding and arrange the classroom for presenting other methods. Teacher should be educated for these issues in in-service education.

All of the students in the class are different than each other. Thus, teacher could be instructed according to middle level of students, however, teacher should observe and if necessary teacher should give special emphasis to these students. Thus, teachers should be careful for arranging instruction.

Teachers should be aware of the positive effect of case based learning method on enhancing students' attitudes toward chemistry. Therefore, while using this method students like the chemistry much and so teachers should use methods which promote students' enthusiasm.

Teachers should be aware of the positive effect of case based learning method on enhancing epistemological beliefs. Therefore, teachers should find some ways for sophistication of students' beliefs about knowledge. Teacher should design instruction for making students to become sophisticated about their beliefs about knowledge.

While implementing case based learning, students worked in the small group and then share their findings to the class. Thus, students should be trained about how they will work in small group discussions. Students should aware of the importance of the sharing of their ideas in the group and respect of others' views. Also, students should learn to take the responsibility of their own and their friends' learning. Each student should work equally and their role in the role should be determined.

Students should come to the class as prepared, but sometimes in this study some students did not come to the class prepared because of other responsibilities of students.

Teacher implementing the method should be experienced on case based learning method. Since teacher's role is facilitator, means teacher could answer students' questions without giving correct answer directly. Teacher should only give information for finding out that correct answer.

6.4 Recommendations

The similar study can be carried out in different grade levels and in different topics.

The similar study can be carried out with larger sample.

The other case methods for example, problem based learning could be compared with case based learning.

The duration of the treatment can be extended.

The similar study could be carried out with different subject characteristics.

The similar study can be carried out on different chemistry topics.

The students' understanding of solubility equilibrium concept, attitudes toward chemistry and epistemological beliefs could be measured after some time later.

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APPENDIX A

ÇÖZELTİLER TESTİ

Bu test 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 tuzu 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.

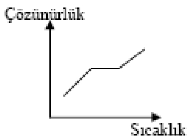
III. Buhar basıncı azalır.

yargılarından hangileri doğrudur?

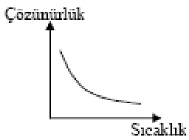
A. Yalnız I B. Yalnız II C. I ve II D. I ve III E. II ve III F. I, II ve III

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

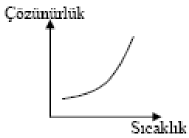
A.



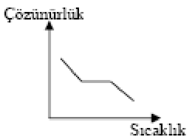
B.



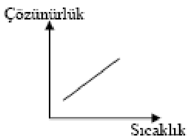
C.



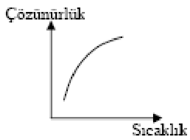
D.



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.

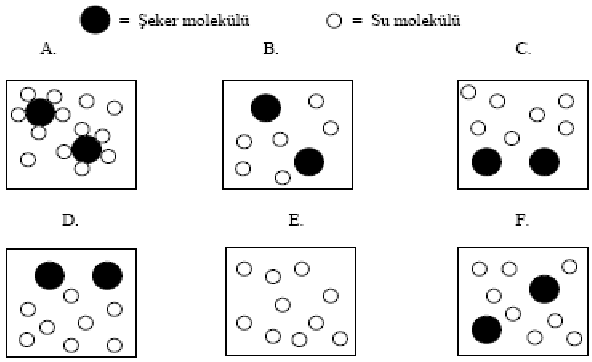
B. Mol sayıları farklı, molar derişimleri aynıdır.

C. Mol sayıları ve yoğunlukları aynıdır.

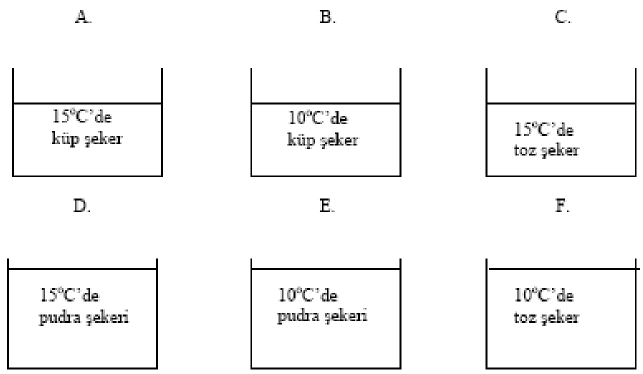
D. Yoğunlukları farklı, molar derişimleri aynıdır.

E. Mol sayıları ve molar derişimleri aynıdır.

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



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



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,

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

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

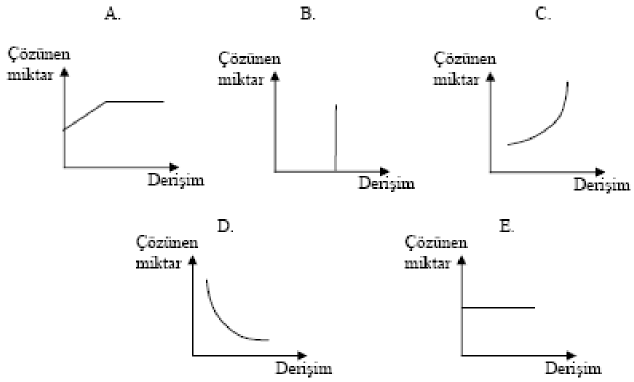
III. Sıcaklık

IV. Basınç

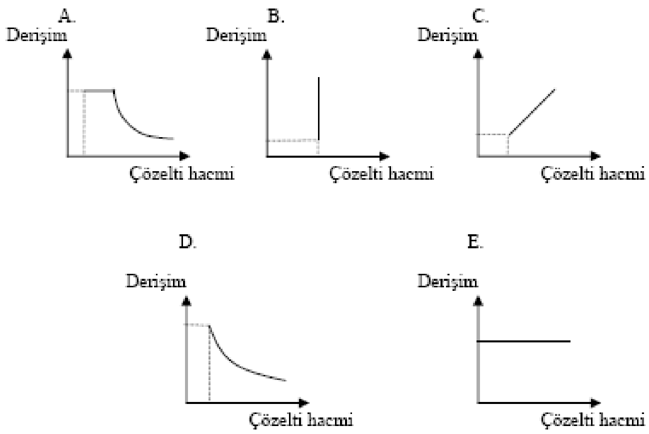
özelliklerinden hangisi etki eder?

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)



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



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 B

ÇÖZÜNÜRLÜK DENGESİ TESTİ

Bu test 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 $^{\circ}$C'de doygun AgCl çözeltisine bir miktar AgCl katısı ekleniyor. Buna göre aşağıdaki seçeneklerden hangisi doğrudur? ($K_ç$ = 1.8 x 10^{-10})

A. Klor iyonu derişimi doygun çözeltideki klor iyonu derişiminden daha büyük olur.

B. Klor iyonu derişiminde değişme olmaz.

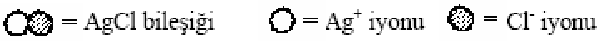
C. Klor ve gümüş iyonu derişimi doygun çözeltideki klor ve gümüş iyonu derişiminden daha büyük olur.

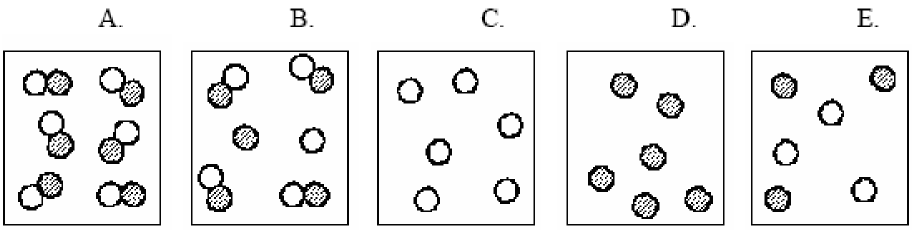
D. Klor ve gümüş iyonu derişimi doygun çözeltideki klor ve gümüş iyonu derişiminden daha küçük olur.

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. $BaCl_2$: $K_ç = 1.1 \times 10^{-10}$

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 $^{\circ}$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 x 10^{-21})

A. $[S^{-2}]$ = 4 x 10^{-21} M

B. $[S^{-2}]$ = 4 x 10^{-20} M

C. $[S^{-2}]$ = 2 x 10^{-10} M

D. $[S^{-2}]$ = 6 x 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 x 10^{-7} M

10. 25 $^{\circ}$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.

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

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°C'de doymuş KNO_3 sulu çözeltisi katısı ile dengededir. Çözelti 40°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-]	Kç
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. $40^{\circ}C$'de $CuCO_3$ sulu çözeltisi katısı ile dengededir. Bu çözelti $30^{\circ}C$'ye kadar soğutulup bir müddet bekleniyor. Daha sonra da aynı çözelti $40^{\circ}C$'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. $25^{\circ}C$'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.

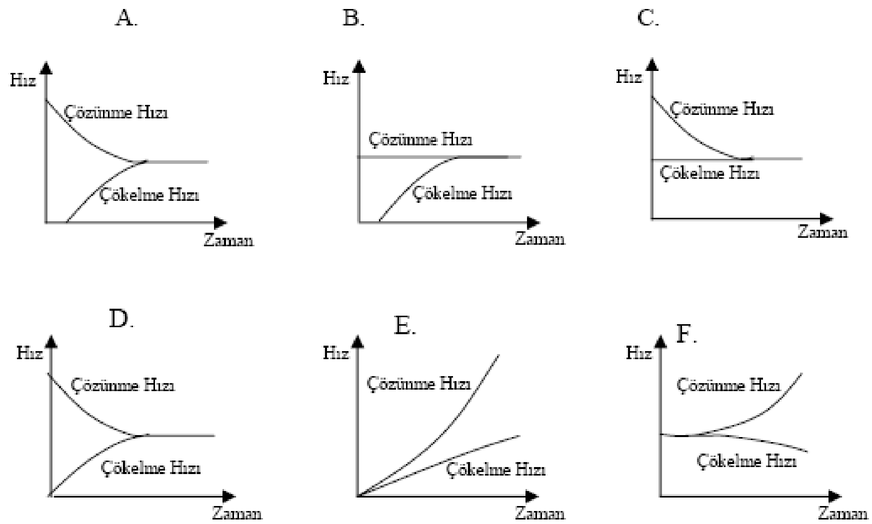
A. $[MgF_2]$, Kç denkleminde yer almamaktadır çünkü $[MgF_2]$ = 1 kabul edilir.

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?



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.

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

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?

MgCO3'ün çözünürlüğü	[Mg+2]	[CO3-2]
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 C

AÇIK UÇLU ÇÖZÜNÜRLÜK DENGESİ TESTİ

Bu test sizin Çözünürlük Dengesi Konusundaki başarınızı ölçmeyi ve değerlendirmeyi amaçlamaktadır. 13 tane açık uçlu sorudan oluşmaktadır. Aşağıdaki her bir soru için uygun açıklamayı soruların altındaki boşluğa yazınız.

Başarılar.....

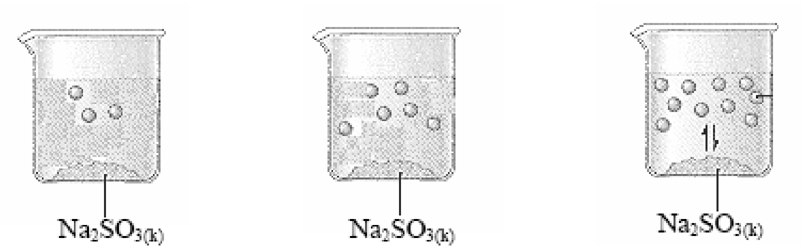
1. (5 puan)Kurşun bileşikleri boya pigmenti olarak kullanılmaktaydı, ancak kurşun (II) iyonu toksik olduğundan kurşun içeren boyaların evlerde kullanılması yasaklanmıştır.
Aşağıda aynı miktarda suya atılıp hazırlanan kurşun (II) bileşikleri verilmiştir. Bunlardan hangisi evde kullanıldığında en fazla zarar verir? Cevabınızın sebebini açıklayınız.
$PbCrO_4$, $PbSO_4$, PbS, PbI_2
(Kç değerleri: $PbCrO_4$: 1.8 X 10^{-14} , $PbSO_4$:1.7 X 10^{-8} , PbS : 2.5 X 10^{-27} , PbI_2 : 8.7 X 10^{-9})

2. (5 puan)Size iki mineral örneği veriliyor. Bunlardan biri halite, yani NaCl; diğeri ise fluorite, yani CaF_2. Fluorite mineralini belirlemek için basit bir test öneriniz ve bu testi açıklayınız. **(Elementlerin gruplarını dikkate alabilirsiniz.)**

3. (5 puan)Bazı katıların çözünürlük çarpımı çok küçüktür. Bazılarının ise çok büyüktür. Bunun sebebi nedir?

4. (5 puan)Doymamış $Mg(OH)_2$ çözeltisi için Kç hesaplanabilir mi? Cevabınızın sebebini açıklayınız.

5. (5 puan)Aşağıda Na_2SO_3 katısının çözünmesi ve çözeltinin katısı ile dengeye gelişi gösterilmektedir.



Şekil 1 **Şekil 2** **Şekil 3**

Na_2SO_3 çözeltisi, katısı ile dengeye gelmeden önce çökelme olur mu? Cevabınızı sebebiyle açıklayınız.

6. (5 puan)Eşit hacimlerde doymuş $NaNO_3$ (sodyum nitrat), Na_2SO_4 (sodyum sülfat) ve PbS (kurşun sülfat) çözeltileri veriliyor.

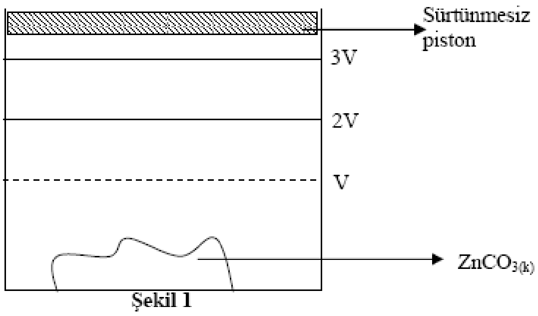
Bu çözeltilerinden hangisi $PbSO_{4(k)}$ (kurşun sülfat)ı <u>en fazla</u> çözer? Cevabınızı sebebiyle birlikte açıklayınız.

7. (5 puan)0.1 M $NaCl_{(suda)}$, doymuş $PbS_{(suda)}$, 0.1 M Na_2SO_4 çözeltileri veriliyor.

Bu çözeltilerden hangisi doymuş $PbCl_2$ çözeltisine eklendiğinde <u>en fazla</u> çökelek oluşturur? Sebebiyle açıklayınız.

8. (5 puan) Gümüş nitrat ($AgNO_3$) ve potasyum iyodür (KI) çözeltileri karıştırıldığı zaman çökelek oluşup oluşmadığını nasıl belirlersiniz? Bunu belirlemek için hangi bilgilere gereksinim vardır?

9. (10 puan)



Şekil 1

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

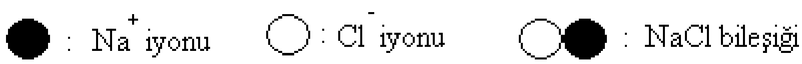
Şekil 1'deki kapta *V* hacminde katısı ile dengede olan doymuş $ZnCO_3$ çözeltisi vardır. Bu çözeltiye sıcaklığı sabit tutarak 3*V*'ye kadar su doldurulduğunda dipteki katının bir kısmının çözünmediği gözlemleniyor.

a) Yeni durumda $ZnCO_3$ ün çözünürlüğü için ne söyleyebiliriz? Cevabınızı sebebiyle açıklayınız.

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

10. (5 puan)Sıcaklık azaldıkça Kç her zaman DÜŞER mi? Cevabınızın sebebini açıklayınız.

11. (5 puan)Aşağıda verilen kaba doymamış NaCl çözeltisinin çok az bir miktarının anlık görüntüsünü çiziniz. (Not: Çözücü moleküllerine şekillerde yer verilmemiştir.)



İyonları ve bileşikleri yukarıdaki gibi gösteriniz ve neden böyle çizdiğinizi açıklayınız.

12. (10 puan)Na_2SO_3 katısının çözünme ve çökelme hızının başlangıçta, zamanla ve dengedeyken ki hızlarının zamanla değişimini gösteren grafik çiziniz, çözünme ve çökelmenin zamanla nasıl değiştiğini yorumlayınız.

APPENDIX D

KİMYAYA KARŞI TUTUM ANKETİ

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 E

EPİSTEMOLOJİK İNANÇ ÖLÇEĞİ

Bu ölçekte, Kimya dersine ait bilgi ve öğrenme hakkındaki inancınıza ilişkin ifadeler ile her cümlenin karşısında KESİNLİKLE KATILMIYORUM, KATILMIYORUM, KARARSIZIM, KATILIYORUM, KESİNLİKLE KATILIYORUM olmak üzere beş seçenek verilmiştir.

Her cümleyi dikkatlice okuduktan sonra kendinize uygun seçeneği işaretleyiniz.

	Kesinlikle Katılmıyorum.	Katılmıyorum	Kararsızım	Katılıyorum	Kesinlikle Katılıyorum
1. Okullarda öğrencilerin ders çalışma becerilerini geliştirmeye yönelik ayrı bir ders verilmesi yararlı olabilir.					
2. Çoğu zaman Kimya öğretmenlerimin gerçekte ne kadar bilgili olduklarını merak ederim.					
3. En başarılı insanlar, kendi öğrenme yeteneklerini nasıl geliştirebileceklerini keşfetmiş insanlardır.					
4. Bana göre Kimya dersine çalışmak, ders kitabındaki ayrıntıları değil ana düşünceleri öğrenmek demektir.					

5. Bilimsel çalışmaların en önemli kısmı özgün (orijinal) düşünmedir.					
6. Kimya ders kitabındaki bir bölümü ikinci kez okuduğumda, ilk okuyuşumda öğrenmediğim birçok şeyi öğrenirim.					
7. Kimya ders kitabından ne kadar çok şey öğrenebilecekleri öğrencilerin kendi elindedir.					
8. Öğretmenlerin ve bilim adamlarının görüş birliği içinde olmadıkları konular üzerinde düşünmek bence zihni çalıştırıcı bir etkinliktir.					
9. Herkes, Kimya dersinde nasıl öğreneceğini öğrenmeye gereksinim duyar.					
10. Kimya dersinde iyi bir öğrenci olmak, genellikle bilgileri ezberlemeyi gerektirir.					
11. Kimya dersinde akıllı olmak, soruların yanıtlarını bilmek değil, yanıtları nasıl bulabileceğini bilmektir.					
12. Eğer Kimya dersinde biri bir şeyi kısa sürede anlayamıyorsa, anlamak için çaba sarf etmeyi sürdürmelidir.					
13. Öğrenciler, Kimya ders kitabındaki bilgilerin doğru olup olmadığını araştırmalıdır.					
14. Bilim adamlarının önerilerini bile çoğu zaman sorgulamak gerekir.					
15. Çevredeki dikkat dağıtıcı şeyleri ortadan kaldırır ve gerçekten üzerinde yoğunlaşırsam Kimya dersinde işlediğimiz zor kavramları anlayabilirim.					

16. Kimya ders kitabını anlamanın gerçekte en iyi yolu, içindeki bilgileri kendinize göre yeniden düzenlemektir.					
17. Kimya dersini öğrenme, bilginin zihinde yavaş yavaş birikmesiyle gerçekleşir.					
18. Bilimde bugün doğru olan, yarın yanlış olabilir.					
19. Kimya öğretmenlerinin anlattıklarını bazen anlamasanız bile, onları doğru olarak kabul etmek zorundasınızdır.					
20. Kimya dersinde bazıları iyi öğrenci olarak doğar ve başarılı olur, diğerleri yaşam boyu sınırlı bir yetenekle kalır.					
21. Gerçekten zeki olan öğrencilerin Kimya dersinde başarılı olmak için çok çalışmalarına gerek yoktur.					
22. Zor bir Kimya problemi üzerinde uzun zaman harcayarak çok çalışmak, ancak zeki öğrencilere bir yarar sağlar.					
23. Biri zor bir Kimya problemi anlamak için çok fazla çaba harcarsa, büyük olasılıkla sonuçta kafası karışır.					
24. Kimya ders kitabından öğrenebileceğim bilgilerin neredeyse tamamını onu ilk okuyuşumda öğrenirim.					
25. Kimya dersinde orta düzeyde başarılı olan öğrenciler, okul sonrası yaşamlarında da orta düzeyde başarılı olurlar.					

26. Kimya ders kitabındaki yeni bilgileri, daha önce öğrenmiş olduklarımla bütünleştirmeyi denediğimde kafam karışır.					
27. İyi bir Kimya öğretmenin görevi, farklı düşüncelere sahip öğrencileri "tek bir doğru düşünceye" sevk etmektir.					
28. Bilim insanları yeterince çaba harcarlarsa, hemen her konuda gerçeği (doğruyu) bulabilirler.					
29. Kimyada çoğu sözcüğün açık (anlaşılır) tek bir anlamı vardır.					
30. Kimyada doğru (gerçek) değişmezdir.					
31. Yaşamda ne zaman zor bir sorunla karşılaşsam anneme ve babama danışırım.					
32. Bitiminde belirli bir sonuca ulaşmayan sinema filmlerinden hoşlanmam.					
33. Açık-seçik ve kesin bir yanıtının bulunma olasılığı olmayan problemler üzerinde çalışmak zaman kaybıdır.					
34. Dersini titizlikle planlayan ve bu planına bağlı kalan hocaları takdir ederim.					
35. Kimya derslerinin en iyi tarafı, çoğu problemin tek bir doğru yanıtının olmasıdır.					

Anket bitti. Teşekkür ederiz!

APPENDIX F

CASES

SERT SU

Çamaşır makinesi kullanıcıları, makinelerini aldıktan bir yıl sonra makinelerinin rezistansında sorun olduğundan şikayet etmektedirler. Makine ilk alındığında herhangi bir sorun bulunmadığını ancak alındıktan belli bir süre sonra makinenin gürültülü çalışmaya başladığını ve çamaşırların da ilk alındığına kıyasla çok yüksek sıcaklıkta yıkanmasına rağmen iyi yıkanmadığını ve en sonunda da makinenin artık çalışmadığını söylemişlerdir. Çamaşır makinesinin üretici firma müdürü kullanıcıların bu sorununu çözmek için araştırma grubu kurmaya vermiştir.

Firma müdürü bu sınıfı fabrikasının araştırma grubu yapmaya karar verdi. Bunun için herkes dört veya beş kişilik gruplar halinde çalışacak, tüm grupların bu sorun hakkındaki cevapları tüm sınıf olarak tartışılacak.

Arka Plan Bilgi:

Çamaşır makinelerinde kullanılan su başlıca Ca^{2+} ve Mg^{2+} iyonları içeren sert sudur ve bu iyonlar makineye zarar vermektedir. Su doğada kayalarla temas halinde olduğu için bu iyonların çözünmesine neden olur ve su sertleşir. Bu iyonları uzaklaştırmanın yollarından biri olarak kalsiyum sülfat ($CaSO_4$) içeren suya sodyum karbonat (Na_2CO_3) eklemek olduğu araştırmacılar tarafından önerilmektedir. Böylece sert suyun makinelere verdiği zarar azaltılmış olacaktır.

1. $CaSO_4$ içeren suya sodyum karbonat (Na_2CO_3) yerine sodyum sulfat (Na_2SO_4) eklenirse su yumuşar mı? Neden (Na_2SO_4 suda çözünür.)

2. Sert suyun içerisindeki iyonların makineye zarar vermesinin sebebi nedir?

3. Çökelmenin sebepleri nelerdir?

4. Elimizi yumuşak suyla mı yıkarken yoksa sert suyla mı yıkarken sabun daha çok köpürür? Bunun sebebi nedir?

KURŞUN KİRLİLİĞİ

Bu sınıf, belediye başkanı tarafından suyun kalitesindeki sorunu çözmek için görevlendirilmiştir. Belediye başkanı sizden çevre kirliliğine yol açan maddeleri belirlemenizi ve bunları şehir şebekesinden çıkarmak için bir yöntem önermenizi istemektedir. Bu görevi gerçekleştirmek için zamanınız kısa olduğu için gruplar halinde çalışacaksınız. Sorun hakkında gerekli bilgi aşağıda verilmektedir ama bu görevi yerine getirirken öğretmeninize de soru sorabilirsiniz. Her grup dersin sonunda bulgularını sunmak için bir kişi seçecektir.

Bulgular birleştirilerek belediye başkanına sunulacak nitelikte olmalıdır.

<u>Gerekli Bilgi:</u>

Şehrin işlem tesisine gelen su bulanık ve yüksek miktarda kurşun içermektedir. Şehir şebekesindeki suya güvenilir demek için kurşun konsantrasyonunun 5 ppb den küçük olması gerektiği belirtilmiştir.

Birçok yerden şehir şebekesine kurşun karışabilmektedir. Bunlardan üçü; kimyasal tesisler, şehrin yakınındaki boya fabrikası ve yakın zamanda meydana gelen seldir. Su taşıyan borular kurşun içerir ve su çok asidikse borulardaki kurşunun büyük miktarı çözünür. Şehrin yakınlarındaki göle kontrolsüzce sülfürik asit atan bir sanayi şirketi vardır. Ayrıca, şehrin yakınlarında boyaları karıştırmak için yıllardır aynı reaktörü kullanan bir boya fabrikası vardır. Boyalar kurşun içermese de bu reaktörler kurşun içerebilir. Bu reaktörlerin sodyum fosfatla yıkanması sırasında kullanılan su kontrolsüzce atılırsa suda yüksek konsantrasyonda kurşun meydana gelebilir. Ayrıca, karayolu üzerindeki nehir yakın zamanda birkaç defa taşmıştır. Bu alandaki toprak kurşun içermektedir. Topraktaki kurşun önceden analiz edilmiş ve çoğunlukla kurşun hidroksit olduğu görülmüştür.

Kimyacılar şehir şebekesinden alınan suya çeşitli testler uygulamışlar.

Bu testler; ozmotik basıncın belirlenmesi, suda çöken bir maddede kurşun ve oksijenin ağırlıkça yüzde analizi, süzülmüş suya sodyum sülfit eklendiğinde çökeltinin ağırlığıdır.

Ozmotik Basınç Laboratuar Sonuçları

25°C de kurşun içeren suda doygun çözeltinin ozmotik basıncı 0.380 mmHg dir.

Gaz sabiti 0.08206 L atm K^{-1} mol^{-1} dir.

Bileşenlerin Ağırlıkça Yüzde Analizleri

Örnek % 85.9 kurşun içermekte ve bundan ayrı bir elementin daha bulunduğu bilinmekte ama ne olduğu bulunamamaktadır.

Süzülmüş suya sodyum sülfit eklendiğinde çökeltinin ağırlık analizi

10.0 L su içeren örneğe konsantrasyonu 0.01M olana kadar sodyum sülfit ekleniyor.

Siyah çökeltinin ağırlığı 0.010 g dır. Pb: 207 S: 33

Bazı kurşun tuzlarının Kç değerleri Tablo 1 de verilmiştir.

Table 1. Bazı kurşun tuzlarının Kç değerleri

Tuz	Kç	Tuz	Kç
$Pb_3(AsO_4)_2$	4.1×10^{-36}	$Pb(OH)_2$	2.8×10^{-16}
$PbBr_2$	6.3×10^{-6}	PbI_2	8.7×10^{-9}
$PbCO_3$	1.5×10^{-13}	$Pb_3(PO_4)_2$	3.0×10^{-44}
$PbCl_2$	1.7×10^{-5}	$PbSeO_4$	1.5×10^{-7}
$PbCrO_4$	1.8×10^{-14}	$PbSO_4$	1.8×10^{-8}
PbF_2	3.7×10^{-8}	PbS	8.4×10^{-28}

SORULAR

1. Göreviniz kurşunun su şebekesinde olma ihtimali bulunmayan bileşiklerini belirlemektir. O bileşiklerin çözünürlüğü çok düşük olduğundan önceden belirlenen sınırları aşamaz. Bu bileşikleri belirlemek için yukarıda verilen bilgiyi kullanınız.

2. Göreviniz suyun esasen kurşun bileşiğiyle doygun olduğunu varsayarak kurşun bileşiğinin Kç değerini belirlemek. Kirli suya sodyum sülfit eklenmesiyle oluşan çökeltinin ağırlığını veren veriyi kullanınız. Tablo 1 de verilen Kç değerlerine göre hangi kurşun bileşiğinin kirletici olduğunu belirleyiniz. Bunu belirlendikten sonra arka plan bilgiyi dikkatli bir şekilde okuyarak kurşunun kaynağını bulabileceksiniz.

3. Göreviniz yukarıda verilen Kç değerlerinden suda kurşun konsantrasyonunu azaltan en iyi ortak iyonu belirlemek. Kullanılan ortak iyonu belirlerken başka bakmamız gereken bir şey var mı?

4. Göreviniz kurşunun kabul edilen değerlerin altına indiği zamanı belirleyebilecek şehir tarafından kullanılabilecek bir test önermektir. Bu test, hızlı ve maliyeti az olmalı, aynı zamanda teçhizata gereksinim duymamalı, kimya bilgisi olmayan işçiler tarafından kolaylıkla yapılabilmelidir. Bu testi bulmak için Kç değerlerinden faydalanabilirsiniz.

KÖPRÜ

Mert Aydın, kurul toplantısını açtı.

23 Haziran tarihinde yapılan Kurul Toplantısında yapılanlar:

Üyeler:

Belediye Başkanı	Mert Aydın
Ulaştırma Bölümü Başkanı	Onur Doğan
İş Sahibi	Yalçın Gürbüz
Kadın Derneği Başkanı	Ayşen Yüksel
Eğitim Kurulu Başkanı	Selma Çalışkan
Muhtar	Ümit Pekcan
Mali İşler Müdürü	Fuat Çetin

Toplantı Mert Aydın tarafından saat 09.00 da düzenlendi. 9 Haziran tarihli toplantıda yapılanlar aşağıda belirtilmiştir.

Toplantıda Tartışılan Konular:

1. Geçen Hafta Yapılan Köprü Açılış Töreninin Özeti - Mert Aydın

1 Haziran tarihindeki kurdele kesme töreni ve köprü açılış törenini kutlama pikniği çok başarılıydı. Pek çok kişi parkın yakınına yapılan köprünün parkın güzelliğini azaltmayacağını düşünmektedir. Ayrıca, bu köprüyle şehir ile hastane ve diğer sağlık kuruluşlarının birleşmesinden memnundur.

2. Ana caddenin yolunun yeniden döşenmesi – Onur Doğan

Onur Doğan, ana caddenin yolunun kötüleştiğini ve yeniden döşenmesi gerektiğini belirtti. 2. ve 7. Sokağın arasındaki ana caddeyi yeniden döşemek için maliyetin 75.000 YTL olacağını söyledi. Yolun yüzeyinin on yıl olan beklenen ömrünün yedinci yılında olmasına karşın erken döşeme açık olarak gerekmekteydi. Bölge ulaştırma bölümüyle yaptığı görüşmeler sonucunda Onur, soğuk geçen kışın ve bol yapılan tuzlamanın yolun erken bozulmasına neden olduğunu öğrenmiştir. Mali işler müdürü şehrin bütçesinin bu maliyeti şimdiki mali yılda yapılabileceğinin teminatını vermiştir. Kurul, yol çalışmalarını yetkilendirilmek için çalışmaya başladı.

3. Köprü bakımı bütçesi – Fuat Çetin

Leylak sokağının genişlemesi ve köprünün yapılmasıyla ilgili yol bakımı için gerekli paranın kurul tarafından en yakın zamanda temin edilmesi gerektiğini belirtmiştir. En önemli maliyetin köprünün buzunun eritilmesi daha sonrakinin ise caddelerin tuzlanmasıdır. Onur, köprülerin yollardan daha çabuk buzlandığını ve bu nedenle de buzları eritmek için köprülere yollardan daha fazla tuz gerektiğini belirtmiştir. Bulvarın yeni köprünün yapılmasıyla birlikte artan trafik yüzünden eskisine göre daha fazla tuzlanması gerektiğini söylemiştir. Yeni köprünün üzerinde ve yakın yollarda kaya tuzlarının etkilerini göz önüne alarak ana cadde üzerinde erken döşemenin gerekli olduğunu belirtilmişir. Parkın yanındaki yolun kenarındaki bitki topluluğuna tuzlamanın etkileri de düşünülmelidir. Yalçın Gürbüz, şehirde ve akarsu kenarında yaşayan halk için su kalitesinin düşünülmesinin gerekli olduğunu söylemiştir. Onur, kaya tuzunun ve diğer olası eritici maddelerin etkilerini araştıracak ve gelecek toplantıda bunları sunacak. Fuat ise çeşitli seçeneklerin tahmini maliyetini hesaplamada ve uygun olanı belirlemede ona yardım edecek.

4. Pikniğin planlanması – Ayşen Yüksel

Köprü açılış kutlamaları Kadın derneği tarafından hafta sonu düzenlenecektir. Kutlama parkta yapılacak ve toplantının menüsü ve etkinliklere karar verilecek.

Toplantıya ara verildi.

Mert Aydın, toplantı tutanağını okudu ve üyelere eklenmesi gereken veya düzeltilmesi gereken birşey olup olmadığını sordu. Hiç kimseden ses çıkmayınca tutanak olduğu gibi kabul edildi.

Mert Aydın, yeni oturuma farklı bir konuyla başladı. “Bu toplantımızın büyük bir kısmını 1 Eylül’ de gelecek olan yeni mali yılın bütçesine ayırmamız gerekiyor. Geçen kurul toplantısında Fuat ve ben gelecek mali yıl için taslak bütçe hazırlamıştık, ancak bu iş düşündüğümüzden daha zor. Kutlamaların maliyeti, yükselen yol bakım maliyeti ve turizm kampanyalarına ayrılan paranın gelecek yılın bütçesine eklenmesi yüzünden ihtiyaçların öncelikleri ciddiyetle düşünülmelidir. Bu önemli konuyu görüşmeden önce Ayşen’den piknik hazırlıklarındaki gelişmeleri dinleyeceğiz.”

Ayşen,“ağaç dikme şenliğinin düzenlemeye karar verdik.” dedi. “Bu, şehrin başarısının ve gelişmesinin sembolü olarak hizmet edecek. Ayrıca ilköğretim okulunun 3. ve 4. sınıflarında tropik çiçek gösterimi düzenlenecektir.”

Mert, “Ayşen, teşekkürler. Detayları senden bekliyoruz.”. “Yeni köprüyle alakalı bütçe konularına dönelim. Onur, senin raporun nedir?”

“Geçen toplantımızdan bu yana tuzun ve yeni buz eritici olan CMA hakkında detaylı bir araştırma yaptım. Özellikle de geçen toplantıda kaya tuzunun etkilerini gördükçe öteki var olan buz eriticileri araştırmak istiyorum. Çevredeki yerleşim yerlerini inceledim ve yüksek tuzlanma sebebiyle kaya tuzunun yolları bozduğunu ve bitki örtüsüne zarar verdiğini gördüm. Açıkça, çam ağaçları tuz kirlenmesine karşı korumasızdır. Bu yüzden daha çevre dostu buz eriticisi olan CMA kullanımını araştırmaya başladım. Ancak, tuz kullanımı üzerine yazılan broşürler ve CMA kullanımı birbiriyle zıt olduğu görülüyor ve ikisinin de etkili bir ürün olduğu belirtiliyor. Bu çelişkiyi ortaya çıkarmaya çalıştım ancak her buz eriticinin çevreye etkisini inceleyemedim.”

Fuat “güzel, o zaman bu iki buz eriticisinin etkinliğini bulmaya ihtiyacımız var. Ben bu kimyasalların maliyetlerini kontrol edeceğim. Kaya tuzlarının tonu 30 YTL’ydi, CMA’nın tonu 640 YTL olacaktır. Ancak, hükümetin köprü yapısında ve yakınındaki yollarda CMA kullanımının maliyetini karşılamak için önemli bir

para yardımı yaptığını öğrendim. Çevresel etkilerini düşünmeden önce CMA ve kaya tuzunun kullanımının maliyetini araştırmalıyız.”
Yalçın tartışmaya karışarak “CMA ortamda ne oluyor? Zararlı bir kimyasalı akarsuya mı dökeceğiz?”

Onur sinirlenerek “CMA’nın biyolojik olarak parçalanabilen olduğunu okumuştum, ancak ne demek olduğunu ve detaylarını hatırlamıyorum. Bu yönü üzerinde daha fazla durmamız gerekiyor. Çevresel sorunları düşünmeden önce, yeni buz eriticiye geçişin ek donanım maliyeti ve kış yol işçilerinin de eğitilmesi gerektiği unutulmamalıdır.”

Mert tartışmayı sürdürerek; “Öncelikle halkı düşünmemiz gerekmektedir, CMA buz eriticisinin kullanılmasının maliyeti ağır gelebilir. Bu nedenle onun kaya tuzuna göre etkinliğini ve para yardımı için seçildiğimizi varsayarak en düşük ücretin belirlenmesi gerekmektedir.” Masasına döndü ve “üçümüz için bu yılın seçim yılı olduğunu hatırlayalım. Şimdi halka büyük bir harcama yükleyemeyiz. Köprü açılış kutlamaları için birçok harcama yaptık ve bunların boşa gitmesini istemiyorum. Bütün yaz şehirdeki iş sahiplerinin turist kampanyasının reklamlarını yapmaktayız. Bahar toplantılarımızın birinde gelecek yılın bütçesinden bu kampanya için fon ayrılmıştır. Halk, bu programda bizim sözümüzden dönmemizi istemeyecektir.”

“Bu halkın mümkün olduğu kadar çevre için iyi şeyler yapmaya kendilerini adadıklarını unutmayalım.” Eğitim Kurulu Başkanı olarak Selma Çalışkan okullardaki öğrencilerin çevre koruma ve temizleme hakkındaki öğretim programlarından haberdardı. “Dünyamızın ve vatandaşlarımızın geleceğini düşünmemiz gerekmektedir. Bu bizim asıl düşünmemiz gereken şeydir.”

Mert özetleyerek, “Bu kolay bir görüşme olmayacak. Mevcut teçhizatın gözden geçirilmesine çalışma kolu kurulmasını teklif ediyorum. Selma, bu kurulda buz eriticilerin çevresel etkilerini incelemek için görev almak ister misin? Onur, buz eritme programının maliyetini kontrol eder misin? Ayrıca bu sorunu araştırmak için bilim adamlarından da yararlanabiliriz.”

Mert, “Gelecek Cuma raporunuzu hazırlamanızı istiyorum, böylece gözden geçirip kurula gönderebilirim,” dedi. O toplantıda oylanması gerekmekte çünkü bütçe bu konu açıklığa kavuşmadan hazırlanamaz.”

CMA da Kalsiyum asetat ve magnesyum asetatin niteliksel analizi

CMA broşüründe yazanlar:
CMA, kalsiyum asetat ve magnezyum asetatın karışımından oluşur.
Çevreye zarar vermeden toprakta çözünen, paslandırmayan ve zehirli olmayan buz eriticisi çevre dostudur.
CMA nasıl çalışır?
Bütün yol buz eriticileri, donma noktası düşmesi prensibine göre çalışır. Donma noktası düşmesi, bir sıvının içinde bir madde çözündüğü zaman sıvının donma noktasındaki azalmadır. Donma noktasının düşmesi, sıvının içinde madde çözündüğü zaman oluşan tanecik sayısıyla orantılıdır. Bu nedenle, CMA kaya tuzundan (NaCl) daha etkindir.

Kaya tuzu broşüründe yazanlar:
Kaya tuzu, NaCl kimyasal bileşiğinin katı kristallerine verilen ortak bir isimdir.
Etkinliği:
Kaya tuzu, CMAdan daha etkindir. 1 kg NaCl, 1 kg CMAdan daha fazla aktif birim içerir.

Aktif birim: Maddelerin basit formülleri.

Sorular

1. Her iki broşür de kullanılacak iki buz eriticisi olan kaya tuzu ve kalsiyum magnezyum asetatın (CMA) buz eritme konusunda etkin olduklarını belirtmişlerdir. Sizden, bu bröşürlerde verilen bilgilerin doğruluğunu kontrol etmeniz istenmektedir.

Bu nedenle buz eriticilerini kimyasal açıdan değerlendirecek ve bu sonuçlara göre bir buz eriticisi tavsiye edeceksiniz.

CMA % 70 $Mg(CH_3COO)_2$ ve % 30 $Ca(CH_3COO)_2$ içerir.
Ma(NaCl) : 60 g/mol
Ma($Mg(CH_3COO)_2$) : 142 g/mol
Ma($Ca(CH_3COO)_2$) : 158 g/mol

2. Karbonat iyonu kaya ve toprakta bulunur. Eğer Ca^{+2} ve Mg^{+2} iyonları toprakta CO_3^{-2} iyonları ile karşılaşırsa hangi tepkimenin gerçekleşmesini beklersiniz? Buradan yola çıkarak çevrede Ca^{+2} ve Mg^{+2} iyonları serbest halde bulunup bulunmadığını belirtiniz.

3. Na^{+} ve CO_3^{-2} iyonları arasında hangi tepkimeyi beklersiniz? Çevrede Na^{+} iyonlarının serbest halde bulunup bulunmadığını belirtiniz.

4. Bu sonuçlardan yola çıkarak hangi buz eriticisinin kullanılmasını önerirsiniz. Neden o buz eriticisini seçtiğinizi açıklayınız. (Buz eriticisini seçerken çevre kirliliği ve buz eritme etkinliğini göz önüne almalısınız.)

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