CONCEPTUAL CHANGE TEXT ORIENTED INSTRUCTION TO FACILITATE CONCEPTUAL CHANGE IN RATE OF REACTION CONCEPTS

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ABSTRACT

CONCEPTUAL CHANGE TEXT ORIENTED INSTRUCTION TO FACILITATE CONCEPTUAL CHANGE IN RATE OF REACTION CONCEPTS

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The aim of this study is to investigate the effectiveness of conceptual change text oriented instruction accompanied with analogies over traditionally designed chemistry instruction on overcoming 10^{th} grade students' misconceptions, their understanding of rate of reaction concepts and their attitude towards chemistry as a school subject.

42 tenth grade students from two classes of a chemistry course taught by the same teacher at a public high school in Çanakkale involved in the study. The study was carried out in Spring Semester of 2005-2006 Education Year.

Two groups of students participated in the study. One group was called Experimental Group and instructed with conceptual change texts oriented instruction accompanied with analogies and the other group was called Control Group and was instructed with traditionally designed chemistry instruction over a period of four weeks.

To investigate the effectiveness of the treatment, Rate of Reaction Concepts Test and Attitude Scale Towards Chemistry as a school subject were administered to both groups of students at the beginning and at the end of the treatment period. To evaluate students' science process skills, Science Process Skills Test was administered to both groups of students before the treatment.

MANCOVA was used to test the hypothesis of the study. The results of the study indicated that students instructed with conceptual change texts oriented instruction accompanied with analogies gained higher average scores in Rate of Reaction Concepts Test than the students instructed with traditionally designed chemistry instruction.

Results and strategies that were developed for the present study may be used by science teachers to reduce and eliminate students' misconceptions about rate of reaction concepts.

KEYWORDS: Conceptual Change Texts Oriented Instruction Accompanied with Analogies, Traditionally Designed Chemistry Instruction, Misconception, Attitude Towards Chemistry as a school subject, Science Process Skills.

ÖZ

REAKSİYON HIZI KONUSUNDA KAVRAMSAL DEĞİŞİMİ KOLAYLAŞTIRMAK İÇİN KAVRAMSAL DEĞİŞİM METİNLERİNE DAYALI ÖĞRETİM

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Ekim 2006, 128 sayfa

Bu çalışmanın amacı benzetmelerle desteklenmiş kavramsal değişim metinlerine dayalı öğretimin lise 2. sınıf öğrencilerinin reaksiyon hızı konusunu anlamalarına, kavram yanılgılarını azaltmalarına ve kimya dersine olan tutumlarına etkisini incelemektir.

Çalışmada aynı kimya öğretmeninin eğitim verdiği 42 lise ikinci sınıf öğrencisi yer almıştır. Çalışma Çanakkale'de bir genel lisede 2005-2006 Eğitim-Öğretim yılı ilkbahar döneminde gerçekleştirilmiştir.

Çalışma için öğrenciler iki gruba ayrılmıştır. Deney grubunda reaksiyon hızı konusu işlenirken benzetmelerle desteklenmiş kavramsal değişim metinleri kullanılmıştır.

Kontrol grubunda ise aynı konu işlenirken geleneksel kimya öğretim metodu kullanılmıştır. Öğrencilerin reaksiyon hızı konusunda başarılarını belirlemek için reaksiyon hızı başarı testi, kimya dersine karşı tutumlarını belirlemek için kimya dersi tutum ölçeği, bilimsel işlem becerilerini ölçmek için ise bilimsel işlem beceri testi uygulanmıştır.

Çalışmanın hipotezlerini test etmek için Çok Yönlü Varyans Analizi istatiksel analiz yöntemi kullanılmıştır.Analiz sonuçları benzetmelerle desteklenmiş kavramsal değişim metinlerini kullanan öğrencilerin reaksiyon hızı konusundaki başarılarının geleneksel kimya öğretim metodunu kullanan öğrencilere göre daha yüksek olduğunu göstermiştir.

Bu çalışma için geliştirilen yöntemler ve elde edilen sonuçlar öğretmenlerce tepkime hızı konusundaki kavram yanılgılarını azaltmada ve gidermede kullanılabilir.

ANAHTAR SÖZCÜKLER: Benzetmelerle Desteklenmiş Kavramsal Değişim Metinleri, Geleneksel Kimya Öğretim Metodu, Kavram Yanılgısı, Kimya Dersi Tutum Ölçeği, Bilimsel İşlem Becerisi

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LIST OF SYMBOLS

SYMBOLS

t: Statistic

p: Observed significance level

SS: Sum of squares

df: Degrees of freedom

MS: Mean square

F: The ratio of of two mean squares

n: Number of sample observed

$\overline{X}$: Mean of the sample

s: Standard deviation

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LIST OF ABBREVIATIONS

ABBREVIARIONS

EG: Experimental Group
CG: Control Group
RRCT: Rate of Reactions Concepts Test
ASTC: Attitude Scale Towards Chemistry as a School Subject
SPST: Science Process Skills Test
CCTIA: Conceptual Change Texts Oriented Instruction Accompanied with Analogies
TDCI: Traditionally Designed Chemistry Instruction

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CHAPTER 1

INTRODUCTION

In the 1950's, behaviorism was influential in describing how people learn. According to behaviorism, learning is seen as a passive process. Behaviorists stated that learning could happen by giving certain stimuli in order to produce the desired response. In addition, behaviorists did not consider the learner's prior ideas and assumed the learners as empty vessels to be filled in with information. Therefore, the only role of the teacher is to give the necessary explanations with giving a certain stimuli according to this learning theory. However, at the time of early 1960's, Jean Piaget, genetic epistemologist, was interested in understanding how knowledge is constructed and put forward that learners were actively involved in the learning process and constructed knowledge through the interaction with their environment. In addition, he explained the importance of prior ideas of learners in the learning process (Schunk, 2000).

Afterwards, the cognitive psychologist Ausubel (1968) made the distinction between rote and meaningful learning and he stated that meaningful learning was related to previous knowledge and the new knowledge should be related to the existing knowledge for the meaningful learning to occur. On the other hand, the new knowledge exists as a piece of information in the rote learning. Since it is not linked to any of the pre-existing knowledge, it is like memorization and forgotten after a while. Ausubel (1968) stated: "If I had to reduce all educational psychology to just one principle, I would say this: The most important factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly." This statement also indicates the importance of prior knowledge in the learning process.

Many research studies had been conducted in order to understand how knowledge was constructed in the learner's mind after the second half of the 1980's. The view that students do not come to science classes as blank slates, rather with some conceptions, was accepted.

When students' conceptions do not match with the scientifically correct knowledge, these are called as misconceptions (Novak, 1988). Different terms such as alternative frameworks (Driver & Easley, 1978), alternative conceptions (Gilbert & Swift, 1985), and children's science (Gilbert & Osborne, 1985) are also used to represent misconceptions in several research studies. In this study, the term, *misconception* will be used.

There are different sources of misconceptions. One of them is the everyday experience (Driver, 1985). Another source of the misconception is the everyday language (Garnett, Garnett & Treagust, 1990; Nakhleh, 1992). In addition, instruction and textbooks were found to cause misconceptions (Osborne & Cosgrove, 1983; Cho, Kahle & Nordland, 1985; Blosser, 1987; Bar & Travis, 1991). Nieswantd (2000) stated that misconception limits students' understanding in science. Another feature of misconceptions is that they are often strongly resistant to traditional teaching method (Driver & Easley, 1978; Nussbaum & Novick, 1982; Novak, 1988).

Many research studies indicated that many students had many misconceptions in chemistry concepts; such as, equilibrium (Bonarjee,1991; Demircioğlu et.al.,2000), phase changes (Bar &Travis, 1991; Çelebi, 2004), chemical reactions (Barker & Millar ,1999), gases (Benson et.al.,1993; Azizoğlu, 2004), stoichiometry (BouJaoude & Barakat,2000), atoms and molecules (Grifffiths & Preston, 1992), acids and bases (Ross & Munby,1991; Nakhleh & Krajcik, 1993; Nakhleh, 1994), and covalent bonding (Peterson et. al.,1986). In the context of rate of reaction concepts, though there are very

few research studies conducted, they revealed that students had misconceptions in this topic as well (Mortimer,1989; Chuephangam, 2000; Wheeler & Kass, 1978; Bonarjee, 1991).

Since students' misconceptions limit their understanding in science, it is important to identify students' misconceptions about certain science topics and prepare a teaching scheme by taking these misconceptions into account (Griffiths & Grant, 1985; O-Saki & Samiroden, 1990; BouJaoude, 1992). How teachers should teach in order to prevent students' misconceptions and promote their learning is a difficult question to answer. However, it is certain that traditional view of teaching will not be appropriate to deal with these misconceptions since it does not consider students' prior ideas.

Constructivism is a theory of learning that considers the view that students come to science classes with some prior conceptions and these affect students' learning. According to constructivism, pupils actively construct knowledge as they interact with the environment and other people. This process is continuous. In addition, pupils' prior knowledge is influential in this construction. Another feature of the constructivist view of learning is that pupils are responsible for their learning (Driver & Bell, 1986). For this reason, the role of the teacher is to guide students and create suitable environment where students would construct knowledge.

Based on the constructivism principles, a conceptual change model was developed by Posner, Strike, Hewson and Gertzog (1982). Like constructivism, according to the conceptual change model, learning involves the interaction of the new ideas with the existing ideas (Strike & Posner, 1982). Hewson (1992) defined conceptual change as both conceptual extension and conceptual exchange.

The conceptual change model suggests four conditions to be satisfied for conceptual change (Posner, Strike, Hewson & Gertzog, 1982).These are;

1) There must be dissatisfaction with the existing conceptions.

2) A new conception must be intelligible.

3) A new conception must appear initially plausible.

4) A new concept should suggest the possibility of fruitful research program.

For the conceptual change to occur, these four conditions need to be reflected in teachers' teaching strategies. Several methods, such as, demonstration, cooperative learning strategies, hands-on activities, concept maps, analogies and refutational texts are used for conceptual change to occur. Conceptual change text is one of these methods in order to provide conceptual change. It identifies and analyses misconceptions, refutes these misconceptions that students have in their mind, illustrates inconsistencies between the misconception sand scientific knowledge (Kim & Van Dunsen,1998), and changes students' misconceptions with scientifically accepted ones (Chambers & Andre, 1997). Misconceptions are contrasted with the scientifically accepted conceptions by providing examples and explanations. In conceptual change texts students are asked explicitly to make prediction about a given situation and then the misconceptions and explanations about the given situation are presented. By this way, the four steps of the conceptual change model are provided by the conceptual change texts. Several research studies indicated that conceptual change texts promoted students' understanding of scientific concepts and were influential in remedying their misconceptions (Chambers and Andre, 1997; Mirjamaija, 2001; Sungur, et al, 2001; Uzuntiryaki & Geban, 2005).

Many chemistry concepts are difficult to learn due to their abstract nature. However, analogies help students visualize the abstract concepts and make them more understandable (Lawson, 1993). In addition, analogies help the link between the unfamiliar concepts with the pre-existing conceptual structure; thereby support the rapid learning of new information (Thiele & Treagust, 1991). When analogies used with the appropriate teaching strategy, students' understanding of scientific concepts can be enhanced as well as students' misconceptions could be reduced (Duit, 1991;

Harrison & Treagust, 1994; Lin, Shiau, & Lawrenz, 1996; Harrison & Treagust, 2000). Therefore, the use of analogies in the conceptual change texts would hinder students' misconceptions in the rate of reaction concepts by linking the new concept taught with students' existing knowledge.

Research studies found that students' attitudes were related to their learning and appropriate teaching strategies can enhance students' attitudes. For example, providing supportive environment, constructivist approach to learning, group work where students have the chance to discuss were among the teaching strategies that could enhance students' attitudes (Mulholland & Wallace, 1995; Weinburgh, 1995; Bandele et al, 1998). In this study, the effect of conceptual change text oriented instruction on students' attitudes towards science will also be evaluated.

Based on this literature, the purpose of this study is to compare the effect of conceptual change text oriented instruction accompanied with analogies over traditionally designed chemistry instruction on students' understanding of rate of reaction concepts and their attitudes towards chemistry. Conceptual change texts are used to activate students' misconceptions related to rate of reaction.

1.1 Significance of This Study

There are many research studies concerning students' misconceptions in science education. And there are different conceptual change methodologies to remove these misconceptions are mentioned in these researches; such as, conceptual change texts, concept maps, conceptual assignments, and analogies. In this study, conceptual change texts are allowed during the instruction, as these texts include some common student misconceptions and correct scientific knowledge about these misconceptions. Chambers and Andre (1997) stated that most of the conceptual change approaches were most commonly suitable for small classrooms whereas use of conceptual change texts can promote conceptual change even for a crowded class.

Students have some misconceptions in rate of reaction concepts and there is little knowledge about these concepts in the literature. Thus, this study will provide information about students' misconceptions in rate of reaction concepts, and their removal by conceptual change texts oriented instruction accompanied with analogies.

The results of this study will provide information to science teachers, especially to chemistry teachers and curriculum developers, as the results may be seen as an example study for the effectiveness of the conceptual change texts oriented instruction on students' achievement and understanding of rate of reaction concepts in chemistry education. In addition, this study would help chemistry teachers be aware of misconceptions students have about the rate of reaction concepts and how conceptual change texts can be used in chemistry classes.

CHAPTER 2

REVIEW OF RELATED LITERATURE

It is important that we should be aware of reasons for teaching science since it affects the way in which science is taught (DeBoer, 1991). Why teach science? What is the purpose of science education? Some of the main purposes of science teaching are to help students acquire scientific knowledge, develop their curiosity about the world, enhance their scientific literacy, develop their problem-solving and decision making skills and stimulate mental discipline (DeBoer, 1991; Millar & Osborne, 1998). The second crucial question is "How can we teach science effectively?" in order to fulfill these purposes of science education. For the answer of this question, we should have an idea about how students learn.

Learning is an active process in which students play an active role and construct their knowledge based on previous knowledge, ideas or experiences. During the learning process, students create their own personal meanings and the conceptual schemes are based on prior knowledge and experiences (Schunk, 2000).

Ausubel, Novak, and Hanesian (1978) stressed the importance of meaningful learning and distinguished rote and meaningful learning. Rote learning is like memorization and is not necessarily accompanied by any understanding of the terms.

The new learned information remains as discrete piece of information without linked to any previous knowledge in the mind. Therefore, students are unable to apply information that is learned by rote. On the other hand, meaningful learning is the learning that is related to previous knowledge, and it is understood well enough to be manipulated, paraphrased, and applied to novel stuations (Ausubel, 1968). The famous statement of Ausubel (1968), which is “the most important single factor influencing learning is what the learner already knows.” indicates the importance of students’ previous knowledge.

The constructivist theory also considers the importance of students’ pre-conceptions, which are deeply rooted in their cognitive structure on learning. In addition, constructivism is based on the principle that the student must be an active participant in the learning process, and employ meaningful learning strategies.

2.1 MISCONCEPTIONS

Many students are not able to develop an appropriate understanding of fundamental concepts despite instruction. One of the reasons is that students construct some ideas about scientific concepts through their experiences with the environment, the people they talk to or the media before instruction (Driver, 1985). In most cases, these prior conceptions are different from the scientifically accepted views and influence students’ learning. Nakhleh (1992) defined the term "misconception" as "any concept that differs from the commonly-accepted scientific understanding of the term".

There are five major types of misconceptions as *preconceived notions, non-scientific beliefs, conceptual misunderstandings, vernacular misconceptions and factual misconceptions. Preconceived notions* are popular conceptions rooted in everyday experiences. For example, the thought that water in underground must flow in streams may come from our daily expectations since people see the water flowing in streams in everyday life.

Nonscientific beliefs include views learned by students from sources other than scientific education, such as religious or mythical teachings. *Conceptual misunderstandings* arise when scientific information is taught in a way that does not challenge students’ prior knowledge and result in conflicting situations. As an example for this type of misconception, students may know the definition of matter but does not accept air as matter. Another example is that although students are taught water cycle, they may not believe evaporated water exists in air, rather than they think that evaporated water moves upwards the clouds since their mental model was never challenged. *Vernacular misconceptions* arise from the use of words that mean one thing in everyday life and another in a scientific context. For example, the meaning of the term “work” in science classes is different from its meaning in everyday life.

Factual misconceptions are falsities often learned at an early age and retained unchallenged into adulthood. For example, “lightining never strikes twice in the same place” is an idea which is embedded in one’s mind at an early age, but not correct (National Research Council, 1997).

According to Vosniadou (2002), children begin to acquire knowledge by organizing their sensory experiences under the influence of everyday culture and language into narrow, but coherent, explanatory frameworks and these frameworks may not be the same as currently accepted science. This indicates the importance of children’s experiences, everyday culture and language in knowledge construction.

Misconceptions are created by different sources, some of which are everyday experience, media and observation (Driver, 1985). Also, the perceptually dominated thinking is another source of misconceptions (Driver, 1985; BouJaoude, 1991). For example, when sugar dissolves in water, some students may think that sugar has disappeared since they do not see sugar anymore. Therefore, they cannot reason that sugar still exists in water.

In addition, diagrams or statements in textbooks (Blosser, 1987; Cho, Kahle & Nordland, 1985); and teachers and instruction (Osborne&Cosgrove, 1983; Bar &Travis, 1991) may be the reason for misconceptions.

Another common source of misconceptions is the everyday language. Some scientific terms are used differently in our everyday language than its scientific meaning. For example, the term “particle” is used in science classes in order to refer the inner structure of a matter. However, this term refers to small visible pieces of substances in everyday life. If this distinction is not made in science classes, students may think particles as visible small pieces of matter rather than its inner structure.

Students continue to hold these misconceptions in spite of the given instruction since students' misconceptions affect their observations of an experiment and even interpretations when they read a text or listen to the teachers' explanations. Therefore, their preknowledge conflict with the new knowledge taught and may not construct a relation between them. So the new conceptions may be misunderstood by the students. Different labels as preconceptions (Anderson & Smith, 1983), children's science (Osborne, Bell & Gilbert, 1983), naive beliefs (Caramazza, McCloskey & Green, 1981), and alternative frameworks (Driver & Erickson, 1983) have also been used in the literature instead of the term misconception. As mentioned before, conceptions which do not agree with accepted scientific view are referred as misconceptions (Nussbaum& Novick, 1982; Nakleh, 1992; Grifith, 1994).

During the past two decades, researches about students' preinstructional knowledge, misconceptions (Driver & Eeasley, 1978), preconceptions (Driver & Easley, 1978), alternative frameworks(Driver & Erickson, 1983) showed that these notions limited students' understanding in science and are often different from the commonly accepted scientific concepts (Nieswantd, 2000).

In addition, a review of the research relating to students' misconceptions of science concepts reveals that misconceptions are often strongly resistant to traditional

teaching method (Driver & Easley, 1978). If students' misconceptions can not be eliminated, they affect their further learning negatively. Therefore, it is necessary to overcome these misconceptions with the help of different instructional methods.

Because students have relied on these existing notions to understand their world, they may not easily discard their ideas and adapt a new way of thinking. Thus, simply presenting a new concept or telling the students that their views are inaccurate will not result in conceptual change. Teaching for conceptual change requires a constructivist approach in which learners take an active role in reorganizing their knowledge (Griffiths & Grant, 1985; O-Saki & Samiroden, 1990; BouJaoude, 1992).

2.1.1 Misconceptions in Rate of Reactions

It is known that chemistry is one of the most difficult subjects in secondary and high school. Therefore, many of the students have difficulties in understanding fundamental concepts (Kavanaugh & Moomav, 1981). Research on students' understanding of chemistry concepts has revealed that students have many misconceptions. The concepts examined include equilibrium (Bonarjee, 1991), phase changes (Bar & Travis, 1991), chemical reaction (Barker & Millar, 1999), gases (Benson et al., 1993), stoichiometry (BouJaoude & Barakat, 2000), atoms and molecules (Griffiths & Preston, 1992), acids and bases (Ross & Munby, 1991), and covalent bonding (Peterson et al.,1986). There is very little research about the students' understanding about the rate of reaction concepts.

Chemical kinetics is a branch of science that deals with the relationship between reaction rates and reaction mechanisms. It gives information about factors affecting reaction rates, how fast is a reaction and in what ways a reaction proceeds (Mortimer, 1989).

Justi and Ruas (1997) studied the influence of 16 years old Brazilian students' views about the nature of matter on their learning kinetics; they searched students' ideas
about the nature of matter, the concept of chemical reaction, and how a reaction occurs, held before instruction in chemical kinetics. Then, during the formal teaching of chemical kinetics, they investigated which ideas students used to explain why chemical reactions take place at different rates. By this, Justi & Ruas (1997) tried to identify how students' prior ideas influenced their learning. It was found that most students held continuous view of matter and similarly most students did not use the particulate model to explain the concept of chemical reaction before instruction. When students were asked to explain why different chemical reactions occur at different rates, most students did not refer the particulate nature of matter. However, when asked to explain the effect of concentration, temperature and catalyst on rate of reaction, they could use the collision particle theory appropriately. Justi and Ruas

(1997) concluded that having continuous view of matter could lead students have initial difficulties in understanding the different rates of chemical reactions, however, students overcame this difficulty during learning chemical kinetics since they could correctly use the particulate model in explaining the factors affecting the rate of reaction. Thus, Justi and Ruas (1997) claimed that teaching chemical kinetics can help students overcome the counter-intutiveness of the particulate nature of matter.

The idea of collision was one of the focuses of chemical kinetics studies. Cachapuz & Maskill (1987) investigated students' ideas about collision by means of word association tests. Firstly, students from two mixed ability classes were grouped into three according to their performances in a chemistry test. It was found that while the majority of the high achieving students associated words as 'reaction', 'atom', 'speed', and 'molecule' to the stimulus word 'collision', only 50% of the low achieving students associated 'molecule' with 'collision'. In the group of the low achievers, the words associated mainly originated from everyday meanings: 'accident', 'crash', 'bang', and 'car'. As a result, this study indicated that low achievers could not understand the micro-level collision model, instead associated the word collision with its use in everyday language.

In the study of Van Driel & De Vos (1989a), students performed experiments about the effects of temperature and concentration on reaction rates. To explain the effect of concentration, students most commonly reasoned that 'less particles (per unit of volume) would lead to less collisions (per unit of time)'. Other students emphasised that in a dilute solution particles are at greater distances from each other. To explain the increase of reaction rates at higher temperatures, most students related 'faster moving particles' with 'more collisions' or 'a higher probability of collisions'. However, another group of students reasoned that when particles that move very fast collide with each other, it is very likely that these particles will 'bounce back' without reacting.

In a review of the literature on students' alternative conceptions in chemistry, Garnett, Garnett & Hackling (1995) identified the main conceptions of 17-19 years old students concerning chemical kinetics:

-The forward reaction rate increases as the reaction 'gets going'.

-The forward reaction rate always equals the reverse reaction rate.

-The forward reaction is completed before the reverse reaction commences.

-A catalyst can affect the rates of the forward and reverse reactions differently and hence leads to a different equilibrium yield.

It was concluded in the study that these ideas could have arisen from the chemistry laboratory and from students' everyday life experience.

Van Driel & De Vos (1989b) investigated how the concept of catalysis in textbooks was introduced. The result of the study showed that the textbooks' definitions of catalysis focus on the effect of a catalyst on the rate of a chemical reaction and emphasise that a catalyst is not consumed during the chemical reaction, thus remaining 'unchanged'. Explanations of what a catalyst is and how it affects the course of a chemical process were usually very brief and simplistic as, for instance, a catalyst 'provides an easier way for particles to react' or 'increases the percentage of effective collisions'. By the authors this result was concluded as these textbooks could promote misconceptions because students might perceive a catalyst as a 'magic wand'.

In the study of Chuephangam (2000) carried out in Thailand, the students' misconception about rate of reaction concepts were identified by using a test. The results showed that students had some misconceptions about understanding the meaning of a reaction rate, the explanation of factors affecting reaction rate, and its reasons. In addition, Griffiths (1994) stated that most secondary school students did not understand the meaning of a reaction rate and held the misconcetion "Rate of reaction means the same as the extent of the reaction".

Even, prospective teachers were found to hold some misconceptions about rate of reaction concept. In the study of Nakiboğlu et. al., (2002) the misconceptions in chemical kinetics of candidates of chemistry teachers were examined by using V-diagrams. The study showed that some candidate teachers were not able to use collision theory in explaining the effect of concentration and temperature on reaction rate. Similarly, they thought that the effect of temperature on endotermic and exothermic reactions' rate was different. Another misconception they held was the thought of incresing the concentration of all reactants increases the reaction rate. They also thought that if the concentration increases, time of reaction process increases. They also confused the reaction rate with the time of reaction occurring.

In the study of Bozkoyun (2004) the effectiveness of conceptual change texts oriented instruction accompanied with analogies over traditionally designed chemistry instruction on overcoming 10th grade students' misconceptions, their understanding of rate of reaction concepts were investigated. The result of the study showed that conceptual change texts oriented instruction accompanied with analogies was more effective in elimination of misconceptions and better acquisition of scientific conceptions than traditionally designed chemistry instruction. However, nearly half of the students in both control and experimental groups still had the misconception as "Reaction rate can be increased by increasing the surface area of reactants".

Some studies examining the misconceptions about chemical equilibrium also indicated misconceptions about rate of reactions (Wheeler & Kass, 1978; Bonarjee,
1991). They indicated that students often do not discriminate between reactions that go to completion and reversible reactions; students may believe that the forward reaction goes to completion before the reverse reaction commences; students may fail to distinguish between rate (how fast) and extent (how far); students often think that the rate of forward reaction increases with time from the mixing of reactants until the equilibrium is established; students may believe that mass and concentration mean the same thing for substances in equilibrium systems.

2.2 CONSTRUCTIVISM AND CONCEPTUAL CHANGE APPROACH

Chemistry is difficult for many students because chemistry concepts are abstract and difficult to attach to real-world experience. When planning instruction in chemistry, for more effective teaching, teachers need to consider a broad range of issues which are (a) be aware of and take into consideration students' prior knowledge, (b) the multiple ways in which chemistry phenomena can be represented, (c) the meanings of the same and similar terms used in chemistry and in everyday life, (d) the chemistry of everyday life. When students are engaged in their own learning, they frequently have a better understanding of chemistry and of the role of chemistry in their daily lives. Furthermore, the lessons are more pleasing experiences both for teacher and students. In the study of Treagust and Mann (2000) research had revealed that many difficulties in learning and understanding chemistry appeared to be caused by a view of chemistry instruction that was academic and not related to the chemistry of everyday life. Smith et al. (1993) stated that science teaching needs to develop conceptual understanding rather than rote memorization. In addititon, an important goal of science teaching is to assist students as they come to understand important scientific concepts and relationships (Fellow, 1994). Therefore rote learning or simple addition of new knowledge to current knowledge is not enough to promote meaningful learning of science.

Jean Piaget asserts that knowledge can not be transmitted intact from one person to another; people must construct their own knowledge and their own understanding. Constructivism theory also supports this view. It supports the view that each child constructs his or her own meaning by combining prior information with new information in ways that make personal meaning. Constructivists believe that each learner must construct meaning for himself or herself. New learning must be connected to the individual's already existing knowledge. What children learn is not a copy of what you teach or what they observe, but rather it is a result of how they think about and process this information. Children begin their study of science with ideas about the world already in place. Some of these ideas are in line with currently accepted scientific understanding and some are not. Children have to experience for themselves events that contradict their currently held beliefs. A constructivist view of learning assumes that the student needs to construct meaning by the means of the interaction with the physical world and with their peers.

The role of the teacher in constructivism is different from the traditional teacher. The traditional teacher does not consider students' pre-existing knowledge and only transmits knowledge to students by means of lecturing. On the other hand, the constructivist teacher elicits students' initial beliefs and ideas about the subject to be studied and then sets up situations that will cause dissatisfaction with existing ideas. Realizing that students' expectations affect their observations and that multiple approaches to problem solving are beneficial, the teacher monitors students' understandings, requests from them evidence and justification, provides constraints for their thinking, and gives them opportunities to represent their knowledge in a variety of ways. In sum, it can be said that the constructivist teacher guides, supports students in the process of constructing meaning (Driver, 1995; Driver, Asoko, Leach, Mortimer, & Scott, 1994; Duit, 1995; Fosnot, 1996; Lewin, 1995; Rubin, 1995; Tobin & Tippins, 1993; Von Glasersfeld, 1995).

Based on the constructivism principles, the theory of conceptual change was developed in the early 1980s, by a group of science education researchers and science philosophers (Posner, Strike, Hewson, & Gertzog, 1982). Before explaining how conceptual change occurs, firstly it is necessary to define what conceptual change means. What does conceptual change mean? Different researchers explained what conceptual change meant differently. For example, Chi et al. (1994) assume that concepts belong to one of three ontological categories: matter, processes or mental states. Conceptual change occurs when a concept is reassigned from one ontological category to another. While radical conceptual change takes place a cognitive shift across different ontological categories, normal conceptual change occurs within ontological categories. Di Sessa (1988) suggests alternative knowledge as fragmental pieces resulting from primitive experiences. Di Sessa (2002) explains conceptual change as organizing fragmented knowledge in mind. Vosniadou (2002) states that conceptual change is a gradual process where students synthesize models in their minds, beginning with their existing explanatory frameworks. Hewson (1992) described the meaning of conceptual change by explaining what is meant by change. The meaning of change may be different for different situations. One may use the word “change” for extinction of the former state. For example, if a princess kisses a frog, the frog changes into prince. In that situation, the frog is no longer there and the change means extinction.

One may understand the change as an exchange of one entity for another. For example, there is an election for a principle. The former principle loses the election and the new principle comes. There has been a change of principle. Both principles continue to live in the same city but only one person is the principle. In other words, the former principle loses status whereas the new principle gains status.

Finally, one may use the word “change” for extension. For example, there is a four-roomed home and this home was extended by adding two more rooms. The home is still the same home but extended.

For many people, conceptual change is the exchange of one entity for another, without extinction. This is called “conceptual exchange” by Hewson (1981). However, Hewson (1992) states that conceptual change would include both conceptual extension as well conceptual exchange.

Therefore, it could be said that conceptual change is a model suggesting that learning may involve changing a person’s conceptions in addition to adding new knowledge to what is already there (Posner, Strike, Hewson, & Gertzog, 1982). It involves the interaction between new and existing conceptions with the outcome being dependent on the nature of the interaction (Hewson, 1992).

Cognitive studies of conceptual change have identified two basic forms of learning that derive from the Piagetian concepts of assimilation and accommodation. Learning proceeds without difficulty if the new conception is all intelligible, plausible and fruitful. The learner understands it, accepts it, sees that it is useful.The status of the new conception will have risen in such case.This process is called assimilation by Posner et. al.(1982) and conceptual capture by Hewson (1981). If the new conception is intelligible but not plausible to the learner, the existing and new conceptions conflict, which causes the blockage of the new conception by the existing conception. In order to achieve learning the status of the existing conception has to be lowered for increasing the status of the new conception.Then, the learner accepts the new conception fully.This process is called accomodation by Posner et al.(1982) and conceptual exchange by Hewson (1981). For example, Posner et al. (1982) use the term "radical conceptual change" in the sense of a kind of "scientific revolution" in a person's mind when speaking about the type of cognitive change that Piaget calls accommodation. Correspondingly, assimilation-type change, i.e. the mere addition of new information to an existing knowledge structure without restructuring it, has been called, for example, "enrichment" (Vosniadou 1994). According to Chi et al. (1994), radical conceptual change means a cognitive shift across different ontological categories while "normal" conceptual change takes place within ontological categories.

Learning for conceptual change is not merely accumulating new facts or learning a new skill. In conceptual change, an existing conception is fundamentally changed or even replaced, and becomes the conceptual framework that students use to solve problems, explain phenomena, and function in their world (Taylor, 2001).

Four conditions are necessary for conceptual change. Posner et al., (1982) listed these four conditions for the conceptual change:

1. There must be dissatisfaction with the existing conceptions. If the learner's current understanding and ideas are satisfactory for making sense of a given phenomenon, the learner will be less likely to accept a new conception. For conceptual change to occur, they must become dissatisfied with their existing understanding. This dissatisfaction can produce the cognitive dissonance (uncomfortable thinking) that may be necessary for new learning to occur. However, though dissatisfaction with existing conceptions is the first necessary step, it is not sufficient for conceptual change. Conceptual change will not occur if the new conception is not intelligible, plausible and fruitful.
2. A new conception must be intelligible. Learners must be able to understand what the new conception means.

3. A new conception must appear initially plausible. Even if the learners understand the alternative conception, they may not be able to see how it can be applied in a given situation or used to solve a particular problem.
4. A new concept should suggest the possibility of fruitful research program. It should do more than potentially solve current problems or answer questions. It must be useful in a variety of new situations.

The extent to which the conception meets these conditions is termed as the status of a person's conception which is also represented as the degree to which learners know and accept an idea by Hewson, Beeth, and Thorley in 1998. Thus, the more conditions that a conception meets, the higher its status is. In order to achieve the conceptual change the status of the students' naive conceptions must be lowered and the status of the scientific conception must be raised (Strike & Posner, 1992). Because learners' current conceptions or ideas help them to understand and function in their world, they tend to give their current conceptions higher status than alternative conceptions.

Conceptual ecology, an individual's current concepts, is also important for the conceptual change. After meeting the conditions in order for a person to experience conceptual change, conceptual ecology provides the context in which the conceptual change occurs, that influences the change, and gives it meaning (Hewson, 1992). The conceptual ecology consists of many different kinds of knowledge, the most important of which may be epistemological commitments, metaphysical beliefs about the world, and analogies and metaphores that might serve to structure new information (Hewson, 1992).

2.2.1 Implications of Conceptual Change for Science Education

A conceptual change view of learning science sees students taking an active role in building their own knowledge by modifying their existing conceptions through the process of conceptual change (Posner et al., 1982).

For the conceptual change to occur, teachers should plan in order to create classroom interactions that produce thes four conditions stated above. When satisfying these four conditions, the conceptual change process occurs and this process helps students to understand and use the concepts.

Conceptual change model has some implications for science teaching. Posner et al. (1982) grouped the implications of conceptual change for science education as; *curricular objectives*, *content*, *teaching strategies* and *teacher role*.

Curricular Objectives

In terms of the curricular objectives, it should be aimed at developing students' awareness of their own fundamental assumptions about the world and their awareness of the epistemological and historical foundations of modern science. Making new knowledge intelligible, plausible and fruitful to students should be another curricular objective (Posner et al., 1982).

Content

The content of science courses should be such that it provides scientific theory intelligible, plausible, and fruitful, and this requirement is achieved by conditions,as,

-"retrospective anomalies" should be included,

-sufficient observational theory should be taught for students to understand the anomalies employed,

-any available metaphores, models, and analogies should be used to make a new conception more intelligible and plausible.

Teaching Strategies

To provide conceptual change, the teaching strategies mentioned below are necessary:

-developing lectures, demonstrations, problems, and labs to create cognitive conflicts in the students, Cognitive conflict strategies, derived from a Piagetian constructivist view of learning, are effective tools in teaching for conceptual change (Duit, 1999). These strategies involve creating situations where learners' existing conceptions about particular phenomena or topics are made explicit and then directly challenged in order to create a state of cognitive conflict or disequilibrium. Cognitive conflict strategies are aligned with Posner et al.'s theory of conceptual change. That is, learners must become dissatisfied with their current conceptions and this is the first step for the conceptual change model. By recognizing the inadequacy of their conceptions, students become more open to changing them. Other teaching strategies required for conceptual change are listed below:

-organizing instruction in order to diagnose errors in student thinking,

-developing the kinds of strategies for dealing with student errors

-helping students make sense of science content by representing content in multiple modes, from one mode to another (Clement,1977)

-developing evaluation techniques to help the teacher track the process of conceptual change in students (Posner& Gertzog, 1982). For example, clinical interviews or open-ended questions in class would help to obtain students' thoughts about a specific concept.

Role of the teacher

Hewson (1992) stated that the teacher's responsibility is to be aware of students' conceptions and to teach in ways that are likely to facilitate conceptual change on students. The teacher should use diagnostic techniques to elicit students' existing conceptions and reasons why they are held. And the teacher should use strategies to help students lower the status of existing problematic knowledge, and raise the status of other competing ideas. While doing this, the teacher should not be the presenter of the knowledge, however guide and coach students towards the scientifically accepted view.

2.2.2 Research Studies About Conceptual Change

There has been several research studies carried out in order to find out the effect of conceptual change approach on students' understanding of scientific concepts. These studies showed that conceptual change approach provided a better acquisition of scientific conceptions and removing alternative conceptions (Dole &

Niederhauser, 1990; Hynd & Alverman, 1986; Guzetti et al., 1993; Basili & Sanford,

1991; Ebenezer & Gaskell, 1995). For example, Hewson and Hewson (1983) employed a conceptual change approach to promote conceptual change in students regarding density, mass and volume concepts. That study showed that the use of instructional strategies taking students' misconceptions into account results in better acquisition of scientific conceptions.

Suits (2000) studied conceptual change and chemistry achievement. In this study, three qualitatively distinct achievement groups; rote learners, algorithm memorizers, and conceptualizers were formed according to the results of a chemistry achievement test. In addition, two-dimensional achievement model was formed based on the chemistry achievement test. In the first stage, *the memorize line,* students only accumulate knowledge. In the second stage, *the conceptual line* is the stage where students were able to see connections between knowledge fragments and restructure their knowledge. Results of this study indicated that the rote learners were stuck in stage one. Algorithm memorizers showed a form of weak restructuring ortuning. Conceptualizers, tended to possess a coherent set of attributes that allowed them to create new knowledge structure. This indicated the influence of conceptual change on achievement.

Eryılmaz (2002) investigated the effect of conceptual assignments and conceptual change discussions on students' achievement and misconceptions about force and motion. Test was administered to 396 high school physics students. It was administered as Force Misconceptions and Force Achievement Test to the students as a pre-test. Five conceptual assignments about force and motion were given to students. In addition, students participated in the conceptual change discussions. After the treatment period, the same test administerd to the students. The result of the study showed that conceptual change discussion was an effective means of reducing the number of misconceptions that students held.

Ayhan (2004) investigated the effect of conceptual change oriented instruction accompanied with cooperative group work on 10th grade students' understanding of acid-base concepts. Result of the study showed that conceptual change oriented instruction accompanied with cooperative group work was effective to correct the students' misconceptions of acids and bases.

Ceylan (2004) conducted a research study in order to compare the effectiveness of the conceptual change oriented instruction through demonstration and traditionally designed chemistry instruction on 10th grade students' understanding of chemical reactions and energy concepts. His findings indicated that demonstations based on conceptual change approach was effective in decreasing students' misconceptions regarding the chemical reactions and energy concepts. Sanger and Greenbowe (2000) also found that conceptual change instruction based on demonstrations was effective at dispelling student misconceptions regarding electrochemistry topic.

Beeth (1993), in his study, described research conducted in a classroom devoted to conceptual change instruction. By taking students' comments about conceptions, the teacher was able to assess his students' scientific knowledge and plan instructional activities with respect to conceptual change model. The learning environment in his classroom, created by the interaction between students' responses and planned instructional activities facilitated the development of students' conceptions.

The study of Niaz (2002) also indicated the effectiveness of conceptual change approach on freshman students' understanding of electrochemistry. Students in the experimental group were instructed by teaching experiments based on the conceptual change approach whereas students in the control group were given traditional intruction. As a result, it was found that teaching experiments based on teaching experiments enhanced freshman students' understanding of electrochemistry.

2.2.3 Conceptual Change Texts

There are various instructional strategies such as demonstration, computer assisted instruction, cooperative teaching etc. used to provide conceptual change. For

example, Wiser and Amin (2002) suggested the use of computer models coupled with verbal interactions to promote conceptual change. Similarly, Mikkila-Erdmann (2002) suggested the use of written questions and statements or text that guides students to accepted conceptions. Conceptual change texts are also the conceptual change strategies which are used to prevent students' misconceptions (Guzzetti et.al, 1993; Hynd, McWhorter, Phares & Suttles, 1994; Chambers & Andre, 1997; Kim & Van Dunsen, 1998).

Conceptual change text is the text that identifies and analyses misconceptions, and it refutes these misconceptions that students have in their mind. It is designed according to conceptual change process. It illustrates inconsistencies between the misconceptions and scientific knowledge (Kim & Van Dunsen, 1998). Conceptual change text is the text that activates students' preconceptions and warns them about possible misconceptions about the topic of interest. Misconceptions are contrasted with the scientifically accepted conceptions by providing examples and explanations. In conceptual change texts students are asked explicitly to make predictions about a given situation and then the misconceptions and explanations about the given situation are presented. They are recommended to change students' misconceptions with scientifically accepted ones (Chambers & Andre, 1997)

Many studies have been done to explore effects of conceptual change text on students' conceptions in science courses. Some of these studies are explained in the following:

Chambers and Andre (1997) investigated the relationship between gender, interest and experience in electricity, and conceptual change text manipulations on learning electric circuit concept. The result of their study showed that conceptual change text was more effective than the traditional text in conceptual understanding of electric circuit concept.

Sungur et. al. (2001) used conceptual change texts in their study. They investigated the contribution of conceptual change texts accompanied by concept mapping instruction to 10th grade students' understanding of the human circulatory system. It was found that the conceptual change texts accompanied by concept mapping instruction produced a positive effect on students' understanding of concepts and the students in the experimental group taught by conceptual change texts accompanied by concept mapping instruction performed better with respect to the human circulatory system.

Çakır et. al. (2002) investigated the effect of conceptual change text-oriented instruction over traditional instruction on 11th grade students' understanding of cellular respiration concepts and their attitudes toward biology as a school subject. The results showed that the students in the experimental group performed better with respect to cellular respiration concepts.

Alparslan et al. (2003) investigated the effect of conceptual change text instruction on grade-11 students' understanding of respiration. The result of the study indicated that the conceptual change instruction, which explicitly dealt with students' misconceptions, produced significantly greater achievement in the understanding of respiration concepts than traditional teaching methods.

Pabuçcu (2004) investigated the effect of conceptual change text oriented instruction accompanied with analogies over traditionally designed chemistry instruction for 9th grade students' understanding of chemical bonding concepts. The result of the study showed that the conceptual change text and analogy were the effective teaching strategies to dispel students' misconceptions and enhance understanding of chemical bonding concepts.

Similarly, the study of Çelebi (2004) showed the effectiveness of the conceptual change text oriented instruction on ninth grade students'understanding of phases and phase changes concepts. Çelebi (2004) found that conceptual change texts was effective in enhancing students' understanding of concepts and removal of their misconceptions.

Uzuntiryaki and Geban (2005) explored the effect of conceptual change texts accompanied with concept mapping instruction on 8th grade students' understanding of solution concepts. The results revealed that conceptual change text accompanied with concept mapping instruction caused a significantly better acquisition of scientific conceptions about the solution concept.

Günay (2005) investigated the effectiveness of conceptual change text oriented instruction accompanied with analogies over traditionally designed chemistry instruction on 10th grade students' misconceptions, their understanding of atoms and molecules concepts and attitudes towards chemistry as a school sbject. The result of the study showed that the conceptual change text oriented instruction accompanied with analogies provided better conceptual understanding of atoms and molecules and gave more opportunities to eliminate the misconceptions about the atoms and molecules concepts than the traditional instruction in chemistry.

Şeker (2006) in her study compared the effectiveness of conceptual change text oriented instruction accompanied with analogies over traditionally designed science instruction on 7th grade students' understanding of atom, molecule, ion and matter concepts and their attitudes toward science as a school subject. The result of the study showed that the conceptual change text oriented instruction accompanied with analogies provided better conceptual understanding of atom, molecule, ion and the matter concepts than the traditional instruction in science. The research also indicated that conceptual change text oriented instruction had a significant importance as a teaching strategy to identify the misconceptions in science concepts.

In sum, these research findings indicated that conceptual change texts enhanced students' acquisition of scientific conceptions. As well as conceptual change texts, analogies were also found to be effective tools to enhance students' understanding (Duit, 1991).

2.3 ANALOGIES

An analogy refers to the comparisons of structures between domains. An analogy can be seen as a process of identifiying similarities and differences between two objects (Venville & Treagust, 1996)

An analogy is defined by three parts: the target, which is the new concept being studied; the analog, which is the familiar concept to which the new concept is compared; and mapping, which is the outlining of the relationships between the target and analog (Harrison & Treagust, 1994).

Analogy plays a central role in conceptual change. Analogy supports the rapid learning of new systems since it provides a link between pre-existing conceptual structure and new problems and domains. Analogies are commonly accepted as a supportive tool used to facilitate conceptual change and overcome misconceptions to provide the conceptual understanding since they can build meaningful relations between what they already know and the new knowledge they will learn (Glynn, 1991; Thiele & Treagust, 1991; Venville & Treagust, 1997).

Analogies are believed to promote meaningful learning. Therefore, they are used frequently by authors and teachers in order to explain scientific concepts to students (Harrison & Treagust, 1993, 1994; Thiele & Treagust, 1994; Treagust, Duit, Joslin, & Lindauer, 1992). Many of the researchers emphasized the power of analogies in connecting information (Harrison & Treagust, 2000; Browns 1992; Duit, 1991). For example, Brown and Clement (1989) found that the use of analogies help students to develop their ideas and to serve as a reference point to check on plausibility of their previous explanations. Analogies also make the new concepts intelligible. Duit (1991)

supports the view that analogies are effective conceptual change agents because they enhance understanding by making connections between scientific concepts and the students' life-world experiences, and by helping students visualise abstract ideas. Analogies have been successfully used to teach difficult abstract concepts (Brown, 1994; Clement, 1993; Lin, Shiau, & Lawrenz, 1996). Duit (1991) also points out that analogies "provoke students' interest and may therefore motivate them" . Wong (1993) states that analogies help to bridge the gap between what is already understood and what is as yet unlearned.

In the study of Venville and Treagust (1996), four analogies used to teach biology topics by four different teachers were analysed from different theoretical perspectives to determine the key role they play in conceptual change process. As a result of the study, the roles that a particular analogy can play in a given context are listed as;

-*a sense maker* to transfer the basic structure of a concept from the analog domain to the target domain in order to establish intelligibility of the new science material being taught,

-*a memory aid* to help students recall a concept which is difficult to remember within newly learned content area,

-*a transformer* which facilitates the change in ontological category to which the concept belongs in the mind of the learner from “matter” to “process”, and

- *a motivator* to enhance the self-efficacy of students and give them confidence in their ability to learn the science content.

There are different presentations of analogies. Analogies may be presented to the learner as prepared elements of a lecture or they may be generated by the learners themselves. Wong (1993) finds that "constructing one's own analogy serves to (a) make new situations familiar, (b) represent the problem in the particulars of the individual's prior knowledge, and (c) stimulate abstract thinking about underlying structure or patterns" .

Some research studies have been carried out about the effectiveness of analogies. For example, Savinainen et al. (2005) found that analogy based instruction was effective in supporting conceptual change in the case of Newton’s third law.

Rigas and Valanides (2003) investigated the effectiveness of written analogies on sixth-grade students’ performance on memory and inference questions, and whether they had better performance in creating their own analogies for a scientific concept in biology. The results indicated that learning with analogies could improve eleven-year old students' performance on biology. The results support that the use of written analogies in science teaching may influence better understanding in science.

Rule and Furletti (2004) compared the use of form and function analogy object boxes to more traditional lecture and worksheet instruction during a 10th-grade unit on human body systems in their study. The study was conducted with two classes (N = 32) of mixed ability students at a high-needs rural high school in central New York State. This study showed that the use of form and function analogy object boxes significantly improved student performance in learning how human body systems work. Abstract concepts were presented in a more concrete way, facilitating student understanding. Another study carried out by Glynn and Takahashi (1998) showed that the analogies facilitated students' recall of target features both immediately after the study and 2 weeks late. Therefore, it could be said that the effect was stable.

Though analogies are effective tools for removing students' misconceptions, they can create misconceptions if used inappropriately. Therefore, they are double-edged swords; that is, they can hinder as well as help learning (Glynn, 1991). Presenting analogies with a planned teaching strategy has the potential to enhance student understanding of science concepts while reducing the incidence of misconceptions being formed. Glynn (1989) developed the teaching-with-analogies (TWA) model to prevent student misconceptions and enhance student understanding of analogies. Effective teaching using analogies appears to contain these steps (Harrison & Treagust, 1994);

1. Introduce the target concept to be learned.

2. Cue the students' memory of the analogous situation.

3. Identify the relevant features of the analog.

4. Map out the similatirities between the analog and the target.

5. Indicate where the analogy breaks down.

6. Draw conclusions about the target concept.

Therefore, explaining the differences as well as similarities between the analog and the target is necessary in order to prevent students' misconceptions. The study of Harrison and Treagust (2000) also supports this view by explaining that students who socially negotiated the shared and unshared attributes of common analogical models for atoms, molecules, and chemical bonds, used these models more consistently in their explanations.

2.4 ATTITUDES AND SCIENCE PROCESS SKILLS

As well as cognitive variables, affective variables are also important in influencing learning outcomes (Koballa, 1988). One of the affective factors influencing students' learning is the attitude. Students' attitude towards any subject has been described as a function of their beliefs about the subject and the implicit evaluative responses with those beliefs (Fishbein & Ajzen, 1975).

There are several factors affecting students' attitudes towards science. These are; gender, age, educational level of parents, parents' jobs, number of students in the classroom, relationship with the teacher, the willingness about a career in science, strategies used in the classroom etc. (Bilgin & Karaduman, 2005). Mordi (1991) in his study examined 2059 6^{th} and 10^{th} grade students and reported the factors affecting students' attitudes towards science as, home characteristics, student characteristics, teaching and learning variables, and school factors. He found that these variables affected 70% of students' attitudes towards science. These proportions are reported as, 1 % home characteristics, 16% student characteristics, 11% school factors and 41% teaching and learning factors. That study shows that teaching and learning factors are the most important factors affecting students' attitudes towards science.

Young (1998) states that attitudes are relatively durable, attitudes are learned and can therefore be taught and attitudes are related to behaviour.

It was found that students' attitude had a significant influence on their learning and teaching strategies teachers apply in the classroom has an influence in students' attitudes towards the subject positively or negatively (Brown & Story, 1979; Fraser & Fisher, 1983; Weinburgh, 1995).

Simpson and Oliver (1985) stated that favorable attitude generally account for between 20 %- 25 % of the variation in academic achievement. In their other study it was found that students' attitudes towards science are highly related to their achievement in science (Simpson & Oliver, 1990).

In the study of Bandele et al. (1998) the effectiveness of a conceptual change teaching strategy over the traditional method on 152 high school students' attitudes towards learning some biology concepts were examined. There were two groups in the study. The teacher used traditional method in the control group whereas students in the experimental group were exposed to conceptual change teaching strategy. At the end of the study, it was reported that there was a significant difference in the attitude of students in the two classes after the treatment. The study revealed a positive change in attitude in the group who received conceptual change teaching model. This indicated the effectiveness of the conceptual chance teaching strategies on enhancing students' attitudes towards biology.

Similarly, it was found that students using activity oriented techniques exhibited more favourable attitudes towards science than those taught using traditional method (Brown & Storey, 1979; May & McMillan, 1979). Mulholland and Wallace (1995) stated the need of the supportive environment and constructivist approach to teaching can help the enhancement of students' attitudes towards the subject. In addition, teachers' personality and their relationships with students were very crucial in the attitude formation of students. Haladyna, Olsen & Shaughnessy (1982) assert that teachers' enthusiasm, support for students are some the major factors in the improvement of students' attitudes.

Therefore, when teachers use more student centred approach and show more enthusiasm, the attitude of students towards the subject could be developed.

2.4.1 Science Process Skills

Arena (1996) defined science process skills as “the sequence of events that are engaged by researchers while taking part in scientific investigations” (p.34). They may be classified as basic science process skills and integrated science process skills. The basic science process skills are classified by Brotherton and Preece (1995) as observation, classification, inferring, communication, recording, using numbers, predicting, using space/ time relation, controlling variables, collecting data, measuring, and scientific thinking. They classified integrated science process skills as graphing, hypothesizing, interpreting data, formulating models, experimenting, and defining operationally.

Research studies indicated that science process skills can be taught in classroom by means of suitable teaching strategies. For example, in order to teach observation skills, teachers can allow students enough time for detailed observation. All students should be encouraged to name their observations. If a student tells his/her observation, the teacher should not regard it as a correct response since other students will stop thinking in that case. Instead, the teacher should get opinions of other students (Rapudi, 2004).

Wynne (1999) regarded science process skills as inseparable from learning of science. Various researchers found that science process skills contribute to students’ understanding of scientific concepts (Uzuntiryaki, 2003; Çelebi, 2004; Ceylan, 2004; Yavuz, 2005).

2.5 GENDER

It is seen from the literature that students’ interest and involvement in science is not homogeneous; it varies according to the different factors, among which are science subjects, or specific science topics, science related activities and gender. Gender, being a factor affecting students' interest and involvement in science can not be isolated from the other factors.

It was found from the study of Osborne and Collisions (2001) that both girls and boys found physics and chemistry interesting if they involve concrete, observable, and manipulable entities, and the activities that involve experimentation and investigation.

Dawson (2000) in his study investigated the interest of 203 South Australian Year 7 students concerning different science topics and activities taught in school. He found that boys are more likely to be interested in science than girls.

Similarly, it was found from the studies of Joyce and Farenga (1999) and Kahle and Lakes (1983) that boys tend to be more willing to participate in physical science activities.

Tamir (1991) studied a sample of 544 10th grade students in different types of schools in Israel, and Joyce and Farenga (1999) examined 111 American students aged 9-13 using questionnaires with Likert-type questions concerning science related attitudes, informal experiences, and interest. In both studies it was concluded that school physics is the least appealing subject to girls, who exhibit a marked preference to biology.

Jones et al. (2000) studied the interests , attitudes, and experiences related to science in 437 6th grade American students from different areas and socio-cultural backgrouds with a questionnaire survey. The students were asked to report on the frequency of their involvement in science-related experiences, and whether or not they are interested in different science topics. The result of the study showed that males are appealed by topics such as atomic bombs, atoms, computers, and technology, and they often report using tools and instruments, whereas females are mainly interested in topics related to biology, or in topics with an aesthetic dimension.

Christidou (2006) in his study explored Greek students' science-related interests and experiences with respect to gender differences and correlations. The result of the study showed that, girls are more interested in topics related to human biology, health, and fitness, and are more familiar with using instruments and devices , seeking information about nature, while boys are interested in science, technology, and their social dimension, and the threatening aspects of science and technology, and tend to engage more in manual work and computer use.

As a summary of the related literature; it was found that students have difficulties in understanding reaction rate concepts, and misconceptions of students about these concepts are resistant to change. Also, if these misconceptions could not be eliminated, they affect further learning negatively. Therefore, teachers, curriculum developers and textbook writers must be aware of students' misconceptions about reaction rate concepts and try to prevent them from occurring. For this reason, in the present study, we were concerned with students' misconceptions and with instructional strategies (analogies and conceptual change texts) to improve the

understanding of reaction rate concept. In addition, research studies indicated that conceptual change approach enhanced students' attitudes towards the subject. Therefore, in this study, the effect of conceptual change text oriented instruction on students' attitudes towards chemistry was also evaluated.

CHAPTER 3

PROBLEMS AND HYPOTHESES

3.1 The Main Problems and Sub-problems

3.1.1 The Main Problems

The main problems of this study:

1. Is there a significant difference between the effects of traditionally designed chemistry instruction (TDCI) and conceptual change texts oriented instruction accompanied with analogies (CCTIA) on students' understanding of rate of reaction concepts and their attitudes towards chemistry as a school subject when the effect of students' science process skills are controlled as a covariate ?
2. Is there a significant difference between the performance of males and females with respect to understanding of rate of reaction concepts and their attitudes towards chemistry as a school subject when the effect of students' science process skills are controlled as a covariate ?
3. Is there a significant effect of interaction between gender difference and treatment with respect to students' understanding of rate of reaction concepts and their attitudes towards chemistry when students' science process skills are controlled?

3.1.2 The Sub-problems

1. Is there a significant difference between the effects of traditionally designed chemistry instruction (TDCI) and conceptual change texts oriented instruction

accompanied with analogies (CCTIA) on students' understanding of rate of reaction concepts when the effect of students' science process skills are controlled as a covariate ?

2. Is there a significant difference between the performance of males and females with respect to understanding of rate of reaction concepts when the effect of students' science process skills are controlled as a covariate?

3. Is there a significant effect of interaction between gender difference and treatment with respect to students' understanding of rate of reaction concepts when students' science process skills are controlled?

4. Is there a significant difference between the effects of traditionally designed chemistry instruction (TDCI) and conceptual change texts oriented instruction accompanied with analogies (CCTIA) on students' attitudes towards chemistry when the effect of students' science process skills are controlled as a covariate ?

5. Is there a significant difference between the performance of males and females with respect to their attitudes towards chemistry when the effect of students' science process skills are controlled as a covariate?

6. Is there a significant effect of interaction between gender difference and treatment with respect to students' attitudes towards chemistry when students' science process skills are controlled?

3.2 Hypotheses

H_o1: There is no significant difference between post-test mean scores of the students taught with conceptual change texts oriented instruction accompanied with analogies (CCTIA) and those taught with traditionally designed chemistry instruction (TDCI) with respect to understanding of rate of reaction concepts and attitudes towards chemistry as a school subject when students' science process skills are controlled as a covariate.

H_o2: There is no significant difference between post-test mean scores of males and those of females with respect to their understanding of rate of reaction concepts and their attitudes towards chemistry when students' science process skills are controlled as a covariate.

H_o3: There is no significant effect of interaction between gender difference and treatment with respect to understanding of rate of reaction concepts and students' attitudes towards chemistry when students' science process skills are controlled as a covariate.

H_o4: There is no significant difference between post-test mean scores of the students taught with conceptual change texts oriented instruction accompanied with analogies (CCTIA) and those taught with traditionally designed chemistry instruction (TDCI) with respect to understanding of rate of reactions concepts when students' science process skills are controlled as a covariate.

H_o5: There is no significant difference between post-test mean scores of males and those of females with respect to their understanding of rate of reaction concepts when students' science process skills are controlled as a covariate.

H_o6: There is no significant effect of interaction between gender difference and treatment with respect to understanding of rate of reaction concepts when students' science process skills are controlled as a covariate.

H_o7: There is no significant difference between post-test mean scores of the students taught with conceptual change texts oriented instruction accompanied with analogies (CCTIA) and those taught with traditionally designed chemistry instruction

(TDCI) with respect to students' attitudes towards chemistry as a school subject when students' science process skills are controlled as a covariate.

H_o8: There is no significant difference between post-test mean scores of males and those of females with respect to their attitudes towards chemistry when students' science process skills are controlled as a covariate.

H_o9: There is no significant effect of interaction between gender difference and treatment with respect to students' attitudes towards chemistry when students' science process skills are controlled as a covariate.

CHAPTER 4

DESIGN OF THE STUDY

4.1 The Experimental Design

Non-equivalent control group design was used in this study (Gay, 1987).

Table 4.1 Research Design Of The Study

Groups	Pre-test	Treatment	Post-test
Experimental Group	RRCT ASTC SPST	CCTIA	RRCT ASTC
Control Group	RRCT ASTC SPST	TDCI	RRCT ASTC

RRCT represents Rate of Reaction Concept Test. CCTIA is Conceptual Change Oriented Instruction accompanied with Analogies whereas TDCI represents the Traditionally Designed Chemistry Instruction. SPST represents Science Process Skill Test. ASTC is Attitude Scale toward Chemistry.

As Table 4.1 indicates, experimental group received conceptual change text oriented instruction whereas the control group was taught traditionally. Both experimental and control groups received RRCT, ASTC and SPST as pre-tests in order to control students' previous knowledge in rate of reaction concepts, their attitudes towards chemistry and science process skills and examine the effect of treatment. After treatment, RRCT and ASTC were administered to both groups.

4.2 Subjects of the Study

In this study, 42 tenth grade students (22 male and 20 female) were used from two classes of a chemistry course from a public school in Çanakkale taught by the same teacher in the 2005-2006 Spring semester. This sample was chosen by a convenience sampling method. Two instruction methods used in the study were randomly assigned to groups. The experimental group who received Conceptual Change Text Oriented Instruction Accompanied with Analogies contained 21 students while the control group receiving the Traditionally Designed Chemistry Instruction had 21 students.

4.3 Variables

This study involved both independent and dependent variables.

4.3.1 Independent Variables

The independent variables of this study were; treatment (conceptual change text oriented instruction accompanied with analogies) and traditionally designed chemistry instruction, gender and science process skills.

4.3.2 Dependent Variables

The dependent variables in this study were; students' understanding of rate of reaction concepts and their attitudes toward chemistry as a school subject.

4.4 Instruments

Rate of Reaction Concept Test, Attitude Scale Toward Chemistry, Science Process Skill Test were the instruments of this study.

4.4.1 Rate of Reaction Concept Test (RRCT)

This test was developed by the researcher to measure the students' understanding of rate of reaction concepts. The Turkish version of the test was prepared because the language of instruction in chemistry course was in Turkish at the schhool. This test was composed of 20 multiple choice questions. There were five alternatives for each of the questions. Distractors which represent the misconceptions were also available among the five alternatives for each question. The content was determined by examining textbooks, instructional objectives for rate of reactions concepts and related literature (Griffiths, 1994; Chuephangam, 2000; Nakiboğlu et.al, 2002).

The concepts used in the test were:

1. Rate of reaction and its measurement
2. Collision theory
3. Activation energy
4. Factors affecting reaction rate
   i. Effect of concentration
   ii. Effect of temperature
   iii. Effect of catalyst
   iv. Effect of surface area
5. Reaction mechanism, rate law, order of reactions.

During the construction period of the test, content of rate of reaction concepts was examined and then instructional objectives were stated. Firstly, students' misconceptions were searched from chemistry education literature and then Internet sources. In addition, talks with chemistry teachers helped the researcher understand students' misconceptions in this topic. Then, questions of the test were developed according to these misconceptions and the previously determined instructional objectives.

Table4.2: A classification of students' misconceptions and related items

MISCONCEPTIONS	ITEMS
Reaction Rate:	
-Rate of a chemical reaction equals to the multiplication of reactants' concentration.	**3,12**
-Reaction rate is the time that reactants turn into products.	
-Reaction rate in a chemical reaction means the process of reactants to form products.	**7,13**
-Reaction rate is an amount of substance that turns into product in a certain temperature and concentration.	**7,13**
-All reactions occur at the same rate	**13**
Reaction Rate-Concentration:	
-In chemical reactions, reaction rate increases if one of the reactant concentration increases.	**11,12,17**
-If concentration increases then the time of reaction process increases	**15**
Reaction Rate-Temperature:	
-In exothermic reactions increasing the temperature decreases the rate of reactions.	**8,19**
-In only endothermic reactions, increasing the temperature increases the rate of reactions.	**8**
Activation Energy:	
-Activation energy does not affect the rate of a reaction.	**6,15**
-Activation energy is the highest point in energy graph.	**6**

Other factors effecting reaction rate: -Catalyst affects the reaction rate; catalyst does not take part in the reaction. - When catalyst is added to a reaction, only pathway with lower activation energy is available. -Catalyst can not decrease the rate of a reaction. -In order to activate a reaction a catalyst is needed. -Any reaction rate can be increased by increasing the surface area of reactants. -All molecular collisions can result in a chemical reaction	**1,9** **9,10** **9** **5,9** **4,18** **14**
Reaction Mechanism: -Students may have difficulties in understanding that slow step determines the rate of a reaction. -Fast step determines the rate of a reaction. -Students may confuse the reaction intermediate and catalyst in a reaction mechanism.	**13, 15,16,17,20** **13, 15,16,17,20** **1,16,20**

To examine content validity and appropriateness, the items were evaluated by two chemistry teachers in a public school in Çanakkale and a chemistry educator. Reliability of the test was found 0.72.

Rate of reaction concepts test was administered before the treatment as a pre-test to control the students' understanding of rate of reaction concepts and after the treatment as a post-test to compare the effectiveness of the treatment.

4.4.2 Attitude Scale Toward Chemistry (ASTC)

Attitude Scale Toward Chemisty, which was developed by Geban et al. (1994), measured students' attitudes toward chemistry as a school subject. This scale involved 15 items in a 5 point likert type scale (fully agree, agree, undecided, partially agree, fully disagree). The reliability of this scale was found as 0, 88. This test was given to students in both groups as a pre-test and post-test (see Appendix C). Higher score in this scale showed higher attitude students have towards chemistry; on the other hand, lower score on this scale indicated the lower attitude.

4.4.3 Science Process Skill Test

The test was originally developed by Okey, Wise and Burns (1982). It was translated and adapted into Turkish by Geban, Aşkar and Özkan (1992). The Science Process Skill Test was administered to all students to determine and control their scientific process skills before the treatment. Science Process Skill Test contained 36 four-alternative multiple choice questions with five sub-scales: identifying variables, identifying and stating hypothesis, operationally defining, designing investigations, and r graphing and interpreting data. The reliability of the test was found to be 0, 70.

4.5 Conceptual Change Texts

Conceptual change texts in the study identified the misconceptions about rate of reaction concepts and corrected them by giving analogies, examples, figures and scientific explanations. Totally ten texts were distributed to students before their lectures. The texts included the topics of; what rate of a reaction was, successful collisions, activation energy and its effect to the rate of a reaction, the position of activation energy in the energy graph, different rate of different reactions, steps of reactions, the role of a catalyst in a reaction, the effect of catalyst on a reaction, how a reaction can be faster, and how temperature affects a rate of reaction. In these texts in the beginning parts with a question students were expected to be dissatisfied with the existing conceptions, then corrected them by analogies, figures and examples. Analogies, figures and examples were selected and created in a way that they focused on the target misconception in order to change the misconception to the scientific conception. Some of the analogies in the texts were prepared by the researcher concerning the literature and internet resources and some of them were directly taken from the internet resources and adapted to the conceptual change texts.

4.6 Treatment

This study was carried out about four weeks during the 2005-2006 spring semester. 42 tenth grade students from two science classes of the same teacher were the participants in the study. In the study two different instructional methods were used. In the control group traditionally designed chemistry instruction was used and in the experimental group conceptual change texts oriented instruction accompanied by analogies was used. Each group instruction was three 45-minute sessions per week. The topics covered were rate of reaction and its measurement, collision theory, activation energy, factors affecting rate of reaction, reaction mechanism, rate law and order of reactions.

Before the treatment both groups were administered RRCT in order to determine if they have any difference in understanding the reaction rate concepts. ASTC was distributed to both classes to measure the students' attitudes towards chemistry as a school subject. Also, SPST was given to both classes to assess the students' science process skills.

The control group received traditional instruction based on mainly lecturing. The experimental group was taught by conceptual change texts oriented instruction accompanied by analogies. Both groups had the lessons in their classrooms. Experimental and control group used the same textbook.

In the control group the teacher used lecturing, questioning and discussion methods in the classroom. The teacher usually used the board in order to write the main aspects of the concepts and to state the formulas. The students listened to the teacher and took notes. Sometimes she asked questions to explore whether the concepts were understood by the students. And sometimes students asked questions. The teacher made explanations without considering the students' misconceptions.

In the experimental group, the instruction was carried out considering the conceptual change conditions. Before the instruction, the teacher was informed what the conceptual change texts oriented instruction accompanied by analogies was and how it could be used during the instruction. Each text was given to students before the instruction period. Students were asked to read the text before the class hour and bring them to the class. At the beginning of the lessons the texts were read by the teacher .By stating the questions stated at the beginning of the conceptual change texts, the teacher promoted discussion on the concept and the students' prior conceptions were activated about the concept. While answering the questions students got aware of their disagreement on the answers. Using the coming explanation of the question from the conceptual change text students noticed their misconceptions and saw the actually correct answer (dissatisfaction). Then students were directed to read the rest of the texts and reading the analogies and examples, and seeing the figures students saw scientifically correct explanations of the phenomena, focused on the target misconception in order to change the misconception to the scientific conception. After reading the texts, with a classroom discussion of the analogies students learned the concepts deeply and made connections with the real world situations and their prior knowledge. Then, with the help of the teacher they were encouraged to give real word examples of the new conception expressed in each text. The teacher was informed about the conceptual change texts and analogies before the treatment. Then, during the treatment both control and experimental groups were visited by the researcher to see the progress of the study. In addition to classroom visits, the researcher met with the teacher to solve the problems faced during the instruction with conceptual change texts.

To enhance students' understanding of the correct scientific knowledge the researcher gave big importance to the analogies. For example, while explaining whether a collision results in a reaction or not, the similarities between the colliding molecules and puzzle pieces, and wrestling bodies were introduced; the fact that in order to achieve a successful collision the colliding molecules should collide with a correct direction is similar to the completing puzzle pieces. Also, the wrestling bodies must contact each other in order to wrest, this is similar to the molecules colliding each other to result in a reaction that in order to achieve a reaction the molecules must contact each other like wrestling bodies. In this step the conditions of intelligibility and plausibility were tried to accomplish by stressing on the students' preconceptions, making relationship between the students' conceptions and scientific knowledge and giving examples. Finally, in order to achieve the fruitfulness of the knowledge, students were suggested to apply newly learned concepts to other situations. And with classroom discussions students were encouraged to use the newly learned information in explaining other situations. Before presenting each concept the instructor asked some questions to activate students' prior conceptions. Some questions were: Do all collisions result in a reaction? Does activation energy affect the rate of a reaction? How does temperature affect the rate of a reaction? How can a reaction proceed faster? Does a catalyst included in a reaction? Do reactions proceed in one step? Do all reactions proceed with the same reaction rate? Conceptual change texts were presented in Appendix C.

4.7 Analysis of Data

At the beginning of the treatment, in order to check the differences of two groups in terms of their previous knowledge about rate of reaction concepts, attitudes and science process skills, independent sample t-tests were used. In order to determine the effect of two different instructional methods and gender on understanding of rate of reaction concepts and students' attitudes by controlling the effect of students' science process skills as a covariate, the multivariate analysis of covariance (MANCOVA) model was used. Since there were two dependent variables; students' understanding of rate of reaction concepts and their attitudes toward chemistry as a school subject, in this study, MANCOVA was preferred (Fraenkel and Wallen, 1996).

4.8 Assumptions of the Study

In the study, the researcher has assumed the followings:

1. No interaction took place between the students in the control and experimental groups.

2. All the tests were administered under standard conditions.

3. All the students answered the tests sincerely.

4. The teacher followed the researcher's instructions and was not biased during the treatment.

4.9 Limitations of the Study

In this study, the following limitations were taken into consideration:

1. This study was limited to 42 tenth grade students at a public high school in Çanakkale during the Spring Semester of 2005-2006.

2. This study was limited to the unit of "Rate of Reaction".

CHAPTER 5

RESULTS AND CONCLUSION

SPSS (Statistical Package for Social Sciences) was used in the analysis of data. As mentioned in the Chapter IV, the multivariate analysis of covariance (MANCOVA) model was used in order to answer the problem and sub-problems of this study. The significance level of 0.05 was used for MANCOVA analysis.

5.1 Results

In order to check the equality of the experimental and control groups in terms of prior knowledge about rate of reaction concepts, prior attitudes towards chemistry as a school subject and science process skills, independent sample t-tests were conducted. The results of independent sample t-tests indicated that experimental and control groups were not significantly different with respect to prior understanding of rate of reaction concepts ($t=-0.596$, $p>0.05$) and attitudes towards chemistry ($t=-0.809$, $p>0.05$). These two groups were significantly different in terms of science process skills ($t=2.049$, $p<0.05$). For this reason, science process skill scores were taken as a covariate.

Descriptive Statistics

Table 5.1 gives descriptive information about achievement and attitude scores for both control and experimental groups. Similarly, descriptive statistics for achievement and attitude scores for both male and female students was explained in Table 5.2.

Table 5.1: Descriptive Statistics for Achievement and Attitude scores for both Control and Experimental Groups

Groups	Dependent variables	Skewness	Kurtosis	Mean	Std. Deviation
Control	Pre-achievement	0.217	-0.866	3.57	2.15
	Postachievement	-0.626	-0.784	11.19	1.54
	Pre-attitude	-1.646	4.175	61.23	7.8
	Post-attitude	0.872	1.756	61.66	2.36
Experimental	Pre-achievement	0.609	0.013	4.09	3.26
	Post-achievement	-1.146	0.953	12.62	2.41
	Pre-attitude	-0.559	-0.557	63.23	8.21
	Post-attitude	-1.045	0.92	64.90	7.32

As seen from Table 5.1, for the control group, mean of the pre-achievement scores for rate of reaction test is 3.57 whereas post-achievement scores for this group is 11.19. This indicates a mean score increase of 7.62. For the experimental group, mean of the pre-achievement scores is 4.09 and post-achievement scores is 12.62 indicating an increase of 8.53. This shows that mean score increase in the experimental group is higher than the one in the control group.

In terms of attitude scores, mean score of pre-attitude towards chemistry for the control group is 61.23 and mean of the post-attitude scores is 61.66, with the increase of 0.43 in the mean score. For the experimental group, mean of the pre-attitude and post-attitude scores are 63.23 and 64.90 respectively. Therefore, after treatment, attitude scores increased with 1. 67 for the experimental group.

For males and females, information about descriptive statistics was explained in Table 5.2. For males, mean of the pre-achievement score is slightly higher than females, which is 3.86 for males and 3.80 for females. However, mean of the post-achievement score for males is 12.73 and it is 11.00 for females. Mean of the pre-attitude score for females is slightly higher than the one for males; it is 61.86 for males; 62.65 for females. Mean of the post-attitude scores for males is 63.50 and for females it is, 63.05.

Table 5.2: Descriptive Statistics for Achievement and Attitude Scores for Male and Female

Gender	Dependent variables	Skewness	Kurtosis	Mean	Std. Deviation
Male	Pre-achievement	0.88	0.93	3.86	2.99
	Post-achievement	-1.10	1.364	12.73	1.93
	Pre-attitude	-0.3	-0.034	61.86	6.86
	Post-attitude	-0.083	-0.938	63.50	6.22
Female	Pre-achievement	0.182	-0.858	3.80	2.70
	Post-achievement	-0.132	-0.325	11.00	2.00
	Pre-attitude	-1.374	2.215	62.65	9.22
	Post-attitude	-1.130	1.244	63.05	8.74

Assumptions of the Multivariate Analysis of Covariance (MANCOVA)

Before conducting MANCOVA, firstly, assumptions of MANCOVA were checked. The first assumption of the MANCOVA is the multivariate normality. In order to check multivariate normality, skewness and Kurtosis values were found for dependent variables for both experimental and control groups. Table 5.1 and Table 5.2 indicate skewness and kurtosis values for post-achievement and post-attitude scores. These values vary between +2 and -2 indicating the approximate normality of the data.

For the second assumption, homogeneity of covariance matrices, Box's test was conducted. As seen from Table 5.3, Box's test revealed that this assumption was also met ($F=1.347$, $p>0.05$)

Table 5.3: Box's Test of Equality of Covariance Matrices

Box's M	13,430
F	1,347
df1	9
df2	13498,307
Sig.	,206

As well as homogeneity of covariance matrices, Levene’s Test of Equality of Error Variances was run. As Table 5.4 shows, this assumption was also validated since p values were higher than 0.05; $F=0.344$, $p>0.05$ for post attitude and $F=1.430$, $p>0.05$ for post-achievement.

Table 5.4 Levene's Test of Equality of Error Variances(a)

	F	df1	df2	Sig.
POSTATT	,344	3	38	,793
POSTACH	1,430	3	38	,249

Before conducting MANCOVA, the homogeneity of slopes assumption was checked. This assumption checks whether or not slopes relating the covariate to the dependent variable are equal. Table 5.5 indicates that there is no significant effect of interactions of fixed factors and covariate for the post-achievement scores $F(1,35)=0.045$, $p>0.05$ and likewise for the post-attitude scores $F(1,35)=0.986$, $p>0.05$. Therefore, this assumption is also validated.

Table 5.5 Evaluation of the Homogeneity of Slopes Assumption

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	POSTATT	298,458(a)	6	49,743	,884	,517
	POSTACH	87,999(b)	6	14,667	5,258	,001
Intercept	POSTATT	5467,858	1	5467,858	97,139	,000
	POSTACH	71,396	1	71,396	25,598	,000
TREATMEN	POSTATT	27,748	1	27,748	,493	,487
	POSTACH	,386	1	,386	,139	,712
GENDER	POSTATT	14,439	1	14,439	,257	,616

	POSTACH	2,842	1	2,842	1,019	,320
SPST	POSTATT	1,481	1	1,481	,026	,872
	POSTACH	28,813	1	28,813	10,331	,003
GENDER * SPST	POSTATT	15,249	1	15,249	,271	,606
	POSTACH	,912	1	,912	,327	,571
TREATMEN * SPST	POSTATT	50,335	1	50,335	,894	,351
	POSTACH	2,896	1	2,896	1,038	,315
TREATMEN * GENDER * SPST	POSTATT	55,512	1	55,512	,986	,327
	POSTACH	,125	1	,125	,045	,834
Error	POSTATT	1970,114	35	56,289		
	POSTACH	97,620	35	2,789		
Total	POSTATT	170482,000	42			
	POSTACH	6138,000	42			
Corrected Total	POSTATT	2268,571	41			
	POSTACH	185,619	41			

a R Squared = ,132 (Adjusted R Squared = -,017)
b R Squared = ,474 (Adjusted R Squared = ,384)

The last assumption, *independency of observations* was also met since all students completed the instruments themselves.

After checking the assumptions, MANCOVA was carried out in order to test the hypotheses posed in Chapter III. All hypotheses were checked at the significance level of 0.05.

Results of Testing Null Hypotheses

Hypothesis 1

The first hypothesis was “There is no significant difference between post-test mean scores of the students taught with conceptual change texts oriented instruction accompanied with analogies (CCTIA) and those taught with traditionally designed chemistry instruction (TDCI) with respect to understanding of rate of reaction concepts and attitudes towards chemistry as a school subject when students’ science process skills are controlled as a covariate.”

MANCOVA was conducted in order to analyze the effect of treatment on students’ understanding of rate of reaction concepts and their attitudes by assigning the science process skills as covariate. As seen from Table 5.6, this analysis indicated the rejection of the first null hypothesis Wilks'ג= 0.731, (F(2,36)= 6.608, $p<0.05$. Significant differences were found between the conceptual change text oriented instruction and traditional instruction on students' understanding of rate of reaction concepts and their attitudes towards chemistry. The multivariate eta-squared with the value of .269 indicates that about 27% of multivariate variance of dependent variables was associated with treatment.

Table 5.6: Results of the MANCOVA

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Intercept	Wilks' Lambda	,246	55,253	2,000	36,000	,000	,754
SPST	Wilks' Lambda	,793	4,702	2,000	36,000	,015	,207
Treatment	Wilks' Lambda	,731	6,608	2,000	36,000	,004	,269
Gender	Wilks' Lambda	,830	3,699	2,000	36,000	,035	,170
Treatment*Gender	Wilks' Lambda	,952	0,912	2,000	36,000	,411	,048

Hypothesis 2

The second hypothesis was "There is no significant difference between post-test mean scores of males and those of females with respect to their understanding of rate of reaction concepts and their attitudes towards chemistry when students' science process skills are controlled as a covariate."

As seen from Table 5.3, significant difference was found between post-test mean scores of males and those of females with respect to their understanding of rate of reaction concepts and their attitudes towards chemistry when students' science process skills are controlled as a covariate; Wilks'ג= 0.83, (F(2,36)= 3.70, $p<0.05$. The multivariate eta-squared with the value of .17 indicates that 17% of multivariate variance of dependent variables was associated with gender.

Hypothesis 3

The third hypothesis was "There is no significant effect of interaction between gender difference and treatment with respect to understanding of rate of reaction concepts and students' attitudes towards chemistry when students' science process skills are controlled as a covariate." MANCOVA analysis indicated that there was no significant effect of interaction between gender difference and treatment with respect to understanding of rate of reaction concepts and students' attitudes towards chemistry when students' science process skills are controlled as a covariate; Wilks'ג= 0.952, (F(2,36)= 0.912, p>0.05.

Table 5.7: Results of ANCOVA as follow-up MANCOVA

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	POSTATT	215,394	4	53,849	,970	,435	,095
	POSTACH	72,776	4	18,194	5,966	,001	,392
Intercept	POSTATT	4907,174	1	4907,174	88,431	,000	,705
	POSTACH	72,516	1	72,516	23,777	,000	,391
SPST	POSTATT	13,795	1	13,795	,249	,621	,007
	POSTACH	28,577	1	28,577	9,370	,004	,202
TREATMEN	POSTATT	127,763	1	127,763	2,302	,138	,059
	POSTACH	33,946	1	33,946	11,130	,002	,231
GENDER	POSTATT	4,313	1	4,313	,078	,782	,002
	POSTACH	22,880	1	22,880	7,502	,009	,169
TREATMEN * GENDER	POSTATT	95,078	1	95,078	1,713	,199	,044
	POSTACH	,540	1	,540	,177	,676	,005
Error	POSTATT	2053,177	37	55,491			
	POSTACH	112,843	37	3,050			
Total	POSTATT	170482,000	42				
	POSTACH	6138,000	42				
Corrected Total	POSTATT	2268,571	41				
	POSTACH	185,619	41				

Hypothesis 4

In order to test the 4th hypothesis, which was "There is no significant difference between post-test mean scores of the students taught with conceptual change texts oriented instruction accompanied with analogies (CCTIA) and those taught with traditionally designed chemistry instruction (TDCI) with respect to understanding of rate of reactions concepts when students' science process skills are controlled as a covariate." To test this hypothesis, analysis of covariance (ANCOVA) was conducted as a follow-up test to the MANCOVA. Table 5.7 shows the results of the ANCOVA. As seen from Table 5.7, this analysis indicated that there was a significant effect of treatment on students' understanding of rate of reaction concepts; $F(1,37)= 11.13$, $p<0.05$, $\eta^2=0.23$. Comparing mean scores of reaction rate test for both groups indicates that students taught with conceptual change text oriented instruction had significantly higher scores than the ones taught traditionally (M= 12,62 for CCTIA; M=11,19 for TDCI).

Figure 1 shows correct responses for pre-test scores of rate of reaction test for both groups. On the other hand, Figure 2 shows correct responses of post-test scores for both groups.

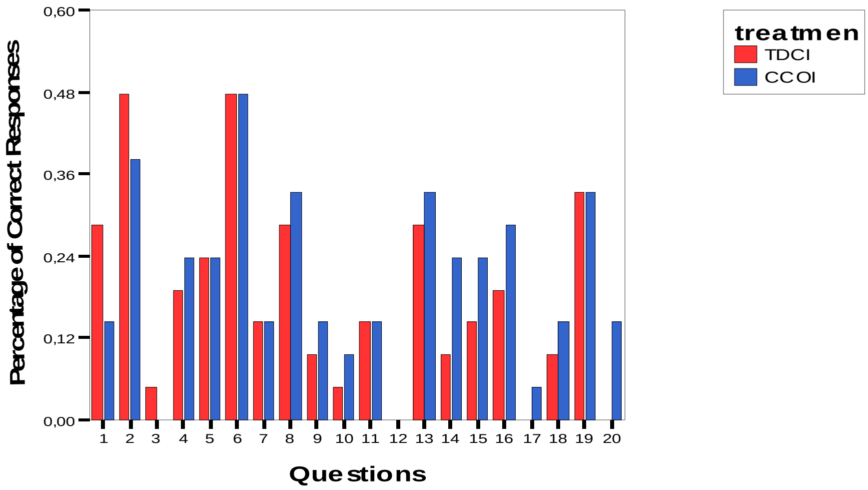

Figure 1: Comparison of the pre-test scores of CCTAI and TDCI with respect to the correct responses given to the questions

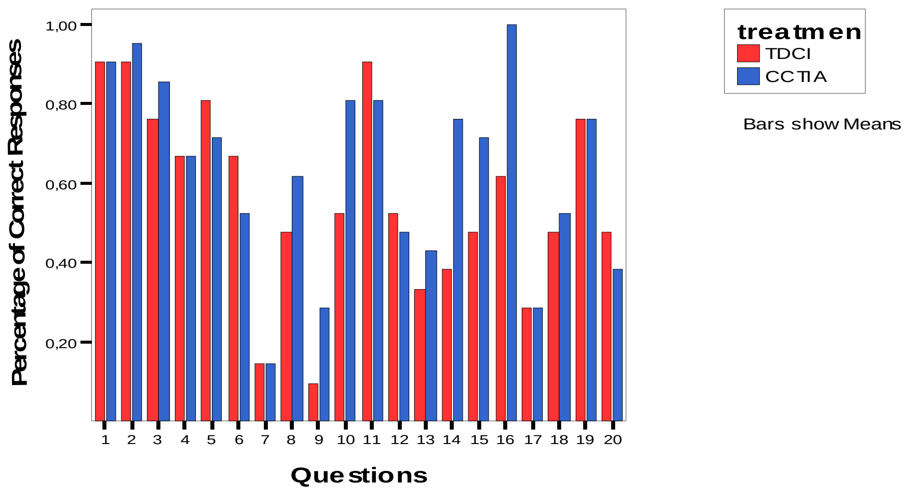

Figure 2: Comparison of the post-test scores of CCTAI and TDCI with respect to the correct responses given to the questions

Figure 2 showed that there was an observable difference between group TDCI and group CCTIA students' responses for the questions 9, 10, 14, 15 and 16. For instance; for question 9, which was about the effect of catalyst on reaction rate, 10% of the TDCI and 15% of CCTIA gave the correct response before treatment. After treatment, this percentage remained nearly the same for TDCI, however increased to 30% for CCTIA. Question 9 is one of the poorly scored item.

For the 10^{th} question, 4.8 % of the TDCI replied this question correctly whereas 9.5% of CCTIA gave the correct response to this question before treatment. However after the treatment, 80% of CCTIA group students replied correctly question 10, only half of the TDCI group students replied it correctly. This question was asked to assess students' understanding about the effect of a catalyst on rate of a reaction. That result showed that half of the students in TDCI group still had misconceptions for this question. However, most CCTIA students gave correct responses.

For question 14, before treatment, about 10% of TDCI replied this question correctly whereas this percent was about 25 % for CCTIA. In question 14, it was tried to investigate the misconception about the meaning of an activated complex.

75% of students in CCTIA group replied this question correctly, while 40% of students in TDCI group replied it correctly.

Similar result can be obtained in question 15, which is about reaction mechanism misconceptions, before the treatment about 15 % of TDCI replied this question correctly whereas 25% of CCTIA gave the correct response to the question. After the treatment 70% of students in group CCTIA replied this question correctly, while 45% of students in TDCI group replied it correctly.

Question 16 was about graph analysis according to the misconceptions of activated complex and reaction intermediate. Before treatment, about 20% of TDCI group gave the correct answer for this question; on the other hand, about 30% CCTIA group replied this question correctly. However, after treatment, all of the students in CCTIA group replied the question correctly, while 60 % of students in TDCI group replied it correctly. This indicated that CCTIA was effective in removal of misconceptions for these questions.

For questions 2, 3, 8, 13 and 18, there is a slight difference between the responses of CCTIA group students and TDCI group students in favour of CCTIA group. In question 2, 48% of TDCI and 37% of CCTIA replied correctly before treatment. After treatment, 90%of TDCI group replied the question correctly, while 95 % of CCTIA group replied correctly. This indicated larger increase for CCTIA. Question 3 was a quantitative question about rate law. Before treatment, only 10% of TDCI gave the correct response whereas none of the CCTIA students answered this question correctly. However, 75% of TDCI group replied correctly and 85% of CCTIA group replied correctly. Question 8 was about the effect of temperature on rate of a reaction. 30% of TDCI and 33% of CCTIA gave the correct responses before treatment. On the other hand, 60% of CCTOI group replied question 8 correctly, while 45 % of TDCI group replied it correctly. This indicated CCTIA was effective in removal of misconceptions. Similarly, for the question 13, about 30% of TDCI and 33% of CCTIA gave the correct response before treatment. After treatment, this increased to about 37% and 42% for TDCI and CCTIA respectively.

For questions 1, 4, 7, 17 and 19 both groups replied correctly at almost equal proportions. In question 1, students were asked to determine the catalyst in a reaction, and its commitment to the reaction. Before the treatment, 14% of CCTIA group and 29 % of TDCI group replied the question correctly. After the treatment 90% of CCTIA and the same percent of TDCI replied it correctly. Question 4 was about reaction rates of different reactions and before the treatment 18% of TDCI and about 24 % of CCTIA group replied it correctly. After the treatment, 65 % of TDCI and 65 % of CCTIA answered it correctly. Questions 7 and 17 are among the poorly scored items by both groups. For Question 7, it was aimed to assess students' understanding about the graph representation of reaction rate with respect to time. Before and after the treatment the percentage of correct responses in each group was about 14 %. Students had difficulties in graph representation in both groups. Question 17 was about the order of a reaction and factors affecting rate of reaction, before the treatment none of the students in TDCI gave correct response to it, whereas 4% of students in CCTIA gave correct responses. After the treatment about 30% in both groups gave correct response to the question. Question 19 was about the effect of temperature on reaction rate, although instructed with a conceptual change text students in both groups were equal in terms of correct responses which was about 75%.

However, in questions 5, 6, 11, 12, and 20, the correct responses of TDCI group students were a bit higher than the correct responses of CCTIA group students. Question 5 was about the effect of catalyst on a reaction, question 6 was about activation energy, question 11 was about fast and slow reactions, question 12 was about writing rate equation of a given reaction with respect to changes observed in concentrations of reactants, and question 20 was about fast and slow reactions. The results showed that the concept of reaction mechanism and quantitative question about writing reaction rate were understood better by traditionally instructed students. This may be due to the structure of the textbook questions presented during the traditional instruction.

Hypothesis 5

Similarly, analysis of covariance (ANCOVA) was run in order to test the 5th hypothesis: "There is no significant difference between post-test mean scores of males and those of females with respect to their understanding of rate of reaction concepts when students' science process skills are controlled as a covariate." This analysis revealed that there was a significant effect of gender on students' understanding of rate of reaction concepts; $F\ (1,37)= 7.50$, $p<0.05$, $\eta^2=0.17$ (See Table 5.7). Males had significantly higher achievement scores regarding the rate of reaction concepts than females; M=12.73 for male, M=11 .00 for female students.

Hypothesis 6

To test this hypothesis; "There is no significant effect of interaction between gender difference and treatment with respect to understanding of rate of reaction concepts when students' science process skills are controlled as a covariate.", ANCOVA as follow-up test to MANCOVA was used. This analysis indicated that there was not a significant effect of interaction between gender and treatment: $F\ (1,37)= 0.177$ $p>0.05$ (See Table 5.7).

Hypothesis 7

For this hypothesis, stating that there is no significant difference between post-test mean scores of the students taught with conceptual change texts oriented instruction accompanied with analogies (CCTIA) and those taught with traditionally designed chemistry instruction (TDCI) with respect to students' attitudes towards chemistry as a school subject when students' science process skills are controlled as a covariate, ANCOVA was used. As seen from Table 5.7, this analysis indicated that there was not a significant effect of treatment on students' attitudes towards chemistry: $F\ (1,37)= 2.30$, $p>0.05$.

Hypothesis 8

To answer the question posed by Hypothesis VIII stating that there is no significant difference between post-test mean scores of males and those of females with respect to their attitudes towards chemistry when students' science process skills are controlled as a covariate, analysis of covariance (ANCOVA) was used. The result showed that there was not a significant difference between the posttest mean scores of males and those of females with respect to their attitudes towards chemistry when students' science process skills are controlled as a covariate $F(1,37) = 0.078$, $p>0.05$.

Hypothesis 9

Similarly, ANCOVA analysis revealed that there was not any significant effect of interaction between gender and treatment ($F(1,37)= 1.713$, $p>0.05$, for this hypothesis, which is "There is no significant effect of interaction between gender difference and treatment with respect to students' attitudes towards chemistry when students' science process skills are controlled as a covariate." (See Table 5.7).

5.2 Conclusions

As a summary, MANCOVA analysis yielded the below conclusions:

1. The CCTIA caused a significantly better understanding and elimination of alternative conceptions related to rate of reaction concepts than TDCI.
2. There was not a significant effect of treatment (CCTIA and TDCI) on students' attitudes towards chemistry.
3. The effect of gender difference on students' understanding of rate of reaction concepts was significant. Males had significantly better scores with respect to understanding the rate of reaction concepts when compared to the females.
4. There was not any significant effect of gender on students' attitudes towards chemistry.
5. There was no significant effect of the interaction between gender and treatment on students' understanding of rate of reaction concepts
6. There was no significant effect of the interaction between gender and treatment on students' attitudes towards chemistry

CHAPTER 6

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

This chapter presents the discussion of the results examined in the previous chapter and gives implications and recommendations for further research.

6.1 Discussion

The main purpose of this study was to compare the effectiveness of Conceptual Change Texts Oriented Instruction accompanied with analogies and Traditionally Designed Chemistry Instruction on 10^{th} grade students' understanding of rate of reaction concepts and attitude toward chemistry as a school subject.

As mentioned in Chapter IV, there were two classes (groups) instructed by the same teacher. The first group (control group) received traditional teaching whereas students in the experimental group were taught by considering conceptual change texts accompanied with analogies. These texts were prepared according to the Posner et al.'s (1982) conceptual change model. At the beginning of the study, rate of reaction concepts test, attitude scale towards chemistry and science process skills tests were administered to both experimental and control groups as pre-tests. The result of this administration indicated that there was no significant difference between the scores of both groups with respect to understanding the concepts of reaction rate and attitudes towards chemistry as a subject before treatment. However, two groups were significantly different in terms of science process skills before treatment. For this reason, science process skill scores were taken as a covariate. Science process skills test measured students' ability of identifying variables, identifying and stating hypothesis, operationally defining, designing investigations, and graphing and interpreting data.

Both rate of reaction concept test and attitude scale towards chemistry as a school subject were distributed to both groups after treatment in order to assess the effect of treatment (conceptual change text oriented instruction accompanied with analogies and traditional teaching) on students' understanding of rate of reaction concepts and their attitudes towards chemistry. It was found that there was a significant effect of treatment on students' understanding of rate of reaction concepts. The comparison of post-test scores showed that students in experimental group got higher scores than the students in control group. Therefore, it can be concluded that conceptual change texts oriented instruction accompanied with analogies was more effective in learning scientific knowledge and in understanding the phenomena conceptually than traditionally designed chemistry instruction. When compared according to the elimination of misconceptions, the conceptual change texts oriented instruction accompanied with analogies also was more effective for most of the questions in this study. These results are supported by the studies of Çakır, Uzuntiryaki,and Geban (2002); Yürük and Geban (2001), and Andre and Chambers (1997) which indicated that conceptual change text instruction was more effective to get better understanding of scientific conceptions.

There may be several reasons for the effectiveness of conceptual change text oriented instruction. Firstly, conceptual change texts were designed by considering students' misconceptions about rate of reaction concepts. Ausubel (1968) stated that "the most important single factor influencing learning is what the learner already knows", which indicates importance of students' previous knowledge. Similarly, students in experimental group had the chance of actively involvement to the instruction period with the help of conceptual change texts. With conceptual change texts accompanied with analogies, students were able to compare their intuitive ideas and scientific knowledge that caused dissatisfaction in their mind. This dissatisfaction resulted in the restructuring of knowledge and misunderstanding to scientifically accepted ones. But in control group students did not actively participate in the instruction. Teacher explanations reflected the traditionally designed chemistry instruction. As stated before, conceptual change texts accompanied with analogies were the main component of the treatment in the experimental group. In these texts in order to activate the students' intuitive ideas a question was stated at the beginning of each text. After discussing this question, the correct scientific knowledge was given by analogies. So that students were able to get dissatisfied with their existing knowledge and grasp scientifically correct explanation of the phenomena. Niaz, Aguilera, Maza and Liendo (2002) have stressed the importance of giving students the opportunity to argue and discuss their ideas for conceptual change. In conceptual texts used in this study, when the question was introduced, enough time was given in the classroom. During this period students activated their prior conceptions. Then, a discussion environment was created with the help of teacher and students stated their answers to the questions. As students became aware of their own conceptions through presentation to others and by evaluation of those of their peers, students became dissatisfied with their own ideas; conceptual conflict begins to build. By recognizing the inadequacy of their conceptions, students became more open to changing them. Several researchers stated the importance of dissatisfaction of students' ideas for conceptual change (Hewson, 1992; Duit, 1999; Davis, 2001). The teacher gave feedback to some students about common misconceptions about the concepts. With these activities, students had the chance of active involvement in the learning period and had the chance of seeing some common misconceptions in their mind. Then through the remaining parts of the texts the explanation of the correct scientific knowledge was given, again the teacher explained these explanations after some time was allowed for students to read these parts. With the help of conceptual change texts accompanied with analogies students firstly got dissatisfied with the existing knowledge and then restructured it to scientifically correct phenomena, so the misconceptions about the concept were eliminated.

However, when compared with the conceptual change texts oriented instruction, the students in the control group were passive listeners during the instruction period. The teacher herself explained some important points of the concepts without considering the misconceptions students held in their mind. Traditional chemistry textbook was used as an instructional material, and there was a little interaction between the teacher and students. Some students asked questions during the instruction and the teacher answered these questions without conceptual understanding of the phenomena. After finishing the factual information about the concept the teacher allowed some time for students to answer the textbook questions which were mostly quantitative and not include conceptual understanding of the concepts.

Another purpose of this study was to find out the effect of treatment on students' attitude towards chemistry. Attitude scale towards chemistry as a school subject was used to investigate the effect of treatment on students' attitude towards chemistry. It was administered to both groups at the beginning of the treatment and the results showed that the experimental and control groups were not significantly different with respect to attitudes towards chemistry. The same test again administered at the end of the treatment and when the post attitude results were examined it was found that there was not a significant effect of treatment on students' attitude towards chemistry. Similar results were reported by Ünlü (2000), Çakır et al. (2002), Azizoğlu (2004) and Pabuçcu (2004). In these studies conceptual change approach was effective in increasing achievement in the experimental group, but the treatment was not effective in increasing students' attitude towards science significantly in the experimental group. For example, in the study of Çakır et al. (2002), conceptual change text oriented instruction had a significant effect on students' understanding of cellular respiration concepts, whereas it did not make a significant difference in students' attitude towards biology as a school subject. Both groups in the study showed statistically the similar attitudes towards biology. It was discussed that the use of text-based information did not cause a significant change for the students, and the reason reported as these conceptual change texts may have not created difference in students' attitude towards biology as a school sbject. In the present study it was also seen that conceptual change oriented instruction was more effective than the traditionally designed chemistry instruction, but conceptual change instruction did not increase significantly the students' attitude towards chemistry. Several reasons may be accounted for that result. One reason may be considered as the duration of the treatment was four weeks and this period may be seen short to change the students' attitudes towards chemistry, as mentioned by Koballa (1988) and Fishbein and Ajzen (1975), that long duration of new teaching strategies is needed to change students' attitude towards science, limited time for the application of new teaching strategy to only one unit may be short to change students' attitudes towards science. Another reason may be considered as the teacher factor. The teacher had positive attitudes towards her students in both groups before the treatment and during the treatment and most students reported their interest for her chemistry lessons before the treatment.

Another issue addressed in this study was to find out whether or not there were significant differences between the post-test mean scores of males and those of females with respect to their understanding of rate of reaction concepts. It was found that there was a significant effect of gender on students' understanding rate of reaction concepts. The results showed that boys performed better in understanding rate of reaction concepts. Males exhibited higher mean scores than females. This result is also in accordance with Gabel (1994) and Çelebi (2004)'s research which showed that males had fewer alternative conceptions. The reason might be the fact that boys are more likely to be interested in science than girls (Dawson, 2000) and males are appealed by topics related to science and technology, whereas females are mainly interested in topics related to biology (Jones et al., 2000). However, the present study indicated that there was not any significant effect of gender on students' attitudes towards chemistry.

In summary, the present study tried to show the effectiveness of conceptual change oriented instruction accompanied with analogies over traditionally designed chemistry instruction on rate of reaction concepts. It showed that the conceptual change oriented instruction accompanied with analogies provided better conceptual understanding of rate of reaction concepts than the traditionally designed chemistry instruction in chemistry.

6.2 Internal and External Validity of the Study

In this study, a convenience sampling was used to choose the high school and the classes for the treatment. Therefore, possible internal threads were considered as the subject characteristics, history, location, mortality, data collector, data collector bias, and implementation effects. These threads were desired to control during the treatment.

Data were collected in shorter time periods and at the same time in both groups to prevent the effect of history variables. The treatment lasted four weeks so that the subjects in the study were not tired and bored. With this, maturation thread was prevented. In order to prevent the effect of pre-test results to post-test results four weeks' time was enough to eliminate the contamination of students' performance on the latter test by the pre-test. The subjects in comparison groups were functionally equivalent at the beginning of the study. Also, science process skills were taken as a covariate so that the results of the study were not biased. There were no drop-outs during the treatment in both groups so that the mortality thread was prevented. The size and setting of both classes were the same and this created similar conditions for both groups. The same teacher instructed both groups and before the instruction, she was informed about the misconceptions, conceptual change approach, conceptual change texts, their application in the classroom, and data collection. Data were collected by the same teacher under the same conditions in both groups to prevent the data collection bias.

Two types of external validity were considered in this study as population validity and ecological validity. Population validity is about the generalizability of the results of the study. In this study accessible population was all tenth grade students at a public high school in Çanakkale and the sample of the study was 42 tenth grade students of the same chemistry teacher from the same public high school. The subjects were not randomly chosen to the groups, and that limited the generalizability of this study, but the students in the sample were from the middle socio-economic status families living in Çanakkale. Thus, the conclusions obtained from this study may be generalized to similar public high schools in Çanakkale and

Turkey. A study has higher ecological validity it it generalizes beyond the laboratory to more realistic field settings. In this study, both control and experimental groups were instructed in the same classroom conditions. Therefore, the findings may be generalized to similar classroom settings at similar public high schools in Turkey.

6.3 Implications

1. The teachers must be aware of the difference of rote learning and meaningful learning, and must design their instruction to promote meaningful learning.

2. Students may have some misconceptions about rate of reaction concepts and chemistry teachers should be informed about the misconceptions and their sources before the instruction.

3. Traditionally designed chemistry instruction is not enough to eliminate students' misconceptions. The teacher should consider the students' misconceptions and pre-existing knowledge when planning the instruction.

4. Conceptual change texts oriented instruction provides better conceptual understanding of the concepts. Therefore, chemistry teachers should know how to apply conceptual change texts in the classroom.

5. Chemistry teachers should be informed about the conceptual change theory and its application strategies in the instruction and should be encouraged to use these strategies during their instructions.

6. Conceptual change texts prepared with analogies can provide better understanding of the scientific concepts. Analogies may provide better grasping of knowledge during the instruction.

7. The teacher must pay attention to the materials used during the instruction. The examples, figures, textbooks should be designed according to conceptual understanding of the phenomena.

8. Teachers should provide active involvement of students through the use of conceptual change texts and some other strategies.

9. The teacher must create a positive environment during the instruction and must provide equal chance of involvement for each student during the instruction.

10. Curriculum developers should consider students' misconceptions and their effect to the gaining scientific knowledge. They should give more emphasis on conceptual change approach and should change traditional programs when planning the curriculum.

11. The textbooks should be revised and designed according to the conceptual change approach.

6.4 Recommendations

Based on the result of this study, the researcher recommends that:

1. A study can be carried out for different grade levels and different science courses.

2. This study can be conducted with a large sample size to get more accurate results and to generalize it for larger population.

3. The conceptual change texts oriented instruction accompanied with analogies can be used during the instruction of other chemistry concepts.

4. During the instruction demonstrations and group works can be combined with conceptual change texts accompanied with analogies in order to activate students.

5. For further study, student interviews may be combined with conceptual change texts to determine the students’ interest to the method.

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APPENDIX A

INSTRUCTIONAL OBJECTIVES

1. To understand the rate of reaction concepts.

2. To define reaction rate.

3. To discriminate the condition for a successful collision to ocur.

4. To understand the collision theory.

5. To define the activation energy.

6. To discriminate the position of an activation energy from the graph.

7. To find the rate law for a given reaction mechanism.

8. To find the order of a given reaction.

9. To understand the factors that affect the rate of reaction.

10. To comprehend the effect of concentration on reaction rate.

11. To comprehend the effect of temperature on reaction rate.

12. To comprehend the effect of surface area on reaction rate.

13. To know the function of a catalyst in a reaction.

14. To understand the reactions that have mechanisms.

15. To discriminate the rate determining step in a given reaction mechanism.

16. To discriminate the reaction intermediate and a catalyst in a given reaction mechanism.

APPENDIX B

RATE OF REACTION CONCEPTS TEST

Bu test sizin kimya dersindeki reaksiyon hızı konusundaki bilgilerinizi ölçmek ve değerlendirmek için geliştirilmiştir. Çoktan seçmeli 20 sorudan oluşmaktadır.

1. $\mathbf{O_2 + 2NO \longrightarrow 2NO_2}$

$\mathbf{2NO_2 + 2H_2 \quad SO_3 \longrightarrow 2H_2SO_4 + 2NO}$

tepkimesinde katalizör aşağıdakilerden hangisidir?

a) O_2 b) NO_2 c)NO d) H_2SO_3 e) H_2SO_4

2.Aşağıdakilerden hangisi tepkime hızını etkilemez?

a)Maddelerin yapısı

b)Tepkimeye girenlerin derişimleri

c)Sıcaklık

d)Çarpışma yüzeyinin büyütülmesi

e)Erime noktası

3. $\mathbf{A + 2B + C \longrightarrow AB + BC}$ tepkimesinde derişim değişmelerinin hıza etkisi şöyledir:

[A]	[B]	[C]	Hız
0,02	0,10	0,30	$2,4 .10^{-4}$
0,04	0,30	0,20	$6,4 .10^{-4}$
0,02	0,30	0,20	$1,6 .10^{-4}$
0,04	0,10	0,20	$6,4 .10^{-4}$

Tepkimenin hız bağıntısı nasıldır?

a)k. [A] [B $]^2$ [C]

b)k. [A] [B $]^2$

c)k. [A $]^3$

d)k. [A $]^2$ [B]

e)k. [A $]^2$ [C]

4.*Aynı koşullarda aşağıdaki tepkimelerin hızları göz önüne alınıyor:*

$$\mathbf{C\ (k) + H_2O \longrightarrow CO(g) + H_2\ (g) \qquad V_1}$$

$$\mathbf{H^+\ (suda) + OH^-\ (suda) \longrightarrow H_2O\ (s) \qquad V_2}$$

$$\mathbf{2Ce^{+4}\ (suda) + Hg_2^{+2}\ (suda) \longrightarrow 2Ce^{+3}(suda) + 2Hg^{+2}\ (suda) \qquad V_3}$$

Bu tepkimelerin hızları (V_1 ,V_2 ,V_3) arasındaki büyüklük ilişkisi nasıldır?

a) $V_1 = V_2 = V_3$

b)$V_3 > V_1 > V_2$

c) $V_3 > V_2 > V_1$

d) $V_2 > V_1 > V_3$

e) $V_2 > V_3 > V_1$

5. $\mathbf{A\ (g) + B(g) \xrightarrow{C} D(g) + E(g)}$ *tepkimesinde C katalizör ise C'nin tepkimeye etkisi nasıldır?*

a)Tanecikleri hızlandırır.

b)Aktifleşme enerjisi daha düşük bir yol sağlar

c)Taneciklerin tepkimeye girmesini sağlar.

d) Ürün miktarını arttırır.

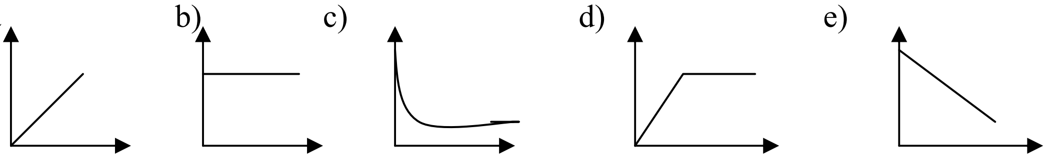
e)Taneciklerin yapısını değiştirir.

6.Aktifleşme enerjisiyle ilgili aşağıdaki ifadelerden hangisi doğrudur?

a)Tanecik sayısı-kinetik enerji grafiğindeki en üst noktadır.
b)Bir çeşit ısı enerjisidir.
c)Taneciklerin çarpışarak ürüne dönüşmeleri için gerekli kinetik enerjidir.
d)Tepkime hızını etkilemeyen bir enerjidir.
e) Bütün tepkimelerde aktifleşme enerjisi aynıdır.

7.A + B $\longrightarrow$ C tepkimesi veriliyor. Buna göre aşağıdaki grafiklerden hangisi tepkime hızının zamanla değişimini göstermektedir?

a b) c) d) e)



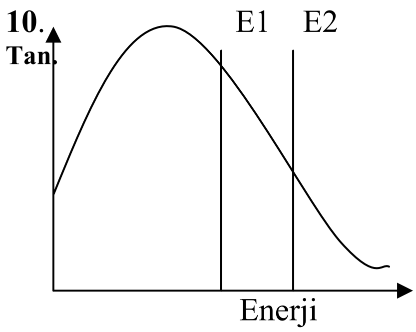
8.Endotermik ve ekzotermik tepkimeler için aşağıdaki ifadelerden hangisi doğrudur?

a) Tüm endotermik tepkimeler yavaş meydana gelir.
b) Sadece endotermik tepkimelerde sıcaklık artışıyla hız artar.
c) Endotermik tepkimelerde tanecikleri harekete geçirmek zordur.
d)Ekzotermik tepkimlerde sıcaklık arttıkça hız artar.
e)Ekzotermik tepkimelerde sıcaklık arttıkça hız azalır.

9.Katalizör için aşağıdakilerden hangisi doğrudur?

a)Her zaman kimyasal reaksiyonları hızlandırır.
b)Katalizör reaksiyonda yer almaz
c)Reaksiyonu başlatmak için katalizör gereklidir.
d) Katalizör düşük aktivasyon enerjili bir yol sağlayarak reaksiyonları hızlandırır.
e)Katalizör kullanıldığında yüksek aktivasyon enerjisine sahip olan yol kaybolur.

10.



Şekilde bir tepkimeye ait taneciklerin enerji dağılım eğrisi ve bu tepkimeye ait iki farklı eşik(aktifleşme) enerjisi gösteriliyor.E2 'den E1 ' e geçiş için aşağıdakilerden hangisi yapılmıştır?

a)Pozitif katalizör kullanılmıştır.

b)Negatif katalizör kullanılmıştır.

c)Sıcaklık düşürülmüştür.

d)Tepkimeye giren maddelerin derişimleri arttırılmıştır.

e)Tepkimeye giren tanecik sayısı azaltılmıştır.

11. $A(g) + 2B(g) \longrightarrow C(g) + 2D(g)$ **(yavaş)**

$2P(g) + C(g) \longrightarrow 2Q(g)$ **(hızlı)**

Mekanizmasına sahip tepkimede aşağıdaki işlemlerden hangisi tepkime hızını değiştirmez?

a) A derişimini arttırmak

b) Sıcaklığı arttırmak

c)Katalizör kullanmak

d)B derişimini arttırmak

e) C derişimini arttırmak

12. 2A + B + C $\longrightarrow$ 2D + E tepkimesi için başlangıç derişimleri ve tepkime hızıyla ilgili şu veriler elde ediliyor;

I.Girenlerin tümünün derişimi ikişer katına çıkarılınca hız 8 kat artıyor.
II. A'nın derişimi sabitken B ve C'nin derişimleri 3'er katına çıkarılınca hız dokuz kat artıyor.
III. B'nin derişimi sabitken A ve C'nin derişimleri 2'şer katına çıkarılınca hız yine sekiz kat artıyor.
Tepkimenin hız bağıntısı aşağıdakilerden hangisidir?

a) V=k[A][B][C]
b) $V=k[A][B]^2$
c) $V=k[A]^2[C]$
d) $V=k[A][C]^2$
e) $V=k[C]^2$

13.Tepkime hızıyla ilgili aşağıdaki ifadelerden hangisi doğrudur?

a)Tepkime hızı birim zamanda madde miktarındaki değişmedir.
b)Tepkime hızı tepkimenin başlangıcından bitimine kadar geçen zaman sürecidir.
c)Bütün tepkimeler aynı hızda gerçekleşir
d)Tepkime mekanizmasındaki en hızlı adım tepkime hızını belirleyen adımdır.
e)Tepkime hızı sadece girenlerle ifade edilir.

14. Aktifleşmiş kompleksle ilgili olarak aşağıdaki ifadelerden hangisi yanlıştır?

a) Potansiyel enerjinin en yüksek düzeye ulaştığı üründür.
b)Aktifleşmiş kompleks kararsızdır.
c)Aktifleşmiş kompleksteki taneciklerin tamamı ürünlere dönüşür.

d)Aktifleşmiş komplekste tanecikler ürünleri oluşturacak şekilde düzenlenir.

e)Aktifleşmiş kompleks potansiyel enerji grafiğinde en yüksek noktada yer alır.

15. $H_2(g) + I_2(g) \longrightarrow 2HI(g)$ **tepkimesinin mekanizması aşağıdaki gibidir.**

$I_2(g) \underset{k}{\overset{K}{\rightleftharpoons}} 2I(g)$ **(hızlı)**

$2I(g) + H_2(g) \longrightarrow 2HI(g)$ **(yavaş)**

Buna göre aşağıdakilerden hangisi doğrudur?

a) İlk adımın aktifleşme enerjisi daha yüksektir.

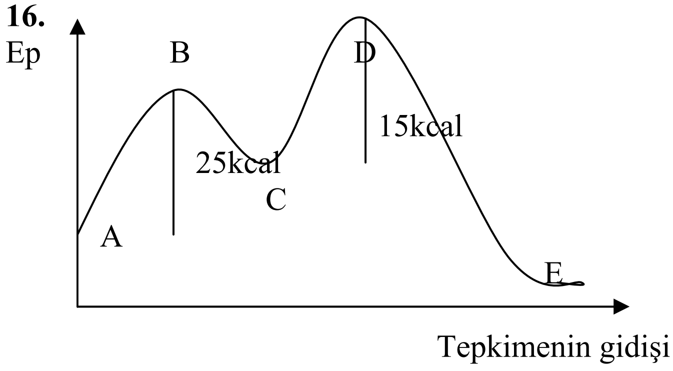
b) H_2 nin tepkimeye girme hızı I_2 nin hızının yarısıdır.

c) HI nın oluşma hızı , H_2 nin tepkimeye girme hızının iki katıdır.

d) H_2 nin derişimi iki katına çıkarılırsa tepkimenin oluşma süresi dört katına çıkar.

e)Tepkime hızını birinci adım belirler.

16.



Grafikte verilen tepkime için aşağıdaki yargılardan hangisi doğrudur?

I. $A \longrightarrow C$ tepkimesi hızı belirleyen adımdır.

II. B ve D aktifleşmiş komplekslerdir.

III. C ara üründür.

IV. $A \longrightarrow E$ tepkimesinin $\triangle H$ sı negatif işaretlidir.

a) I ve II b) III ve IV c) II ve III d)II,III ve IV e) I,II ve IV

17.2A (g) + B(g) $\longrightarrow$ 2C(g) tepkimesinin hız bağıntısı k[A]^2 dir.Buna göre

I.Tepkime birden fazla basamakta gerçekleşmektedir.
II.Tepkime ikinci derecedendir.
III. B(g) eklendiğinde tepkime hızı artar. İfadelerinden hangisi yada hangileri doğrudur?

a) Yalnız I b) YalnızII c) I, II d) I, III e) I, II ve III

18.Aşağıdaki tepkimelerden hangisi yada hangilerinde giren maddelerin yüzeyinin arttırılması hızı arttırır?

I.Zn (k) + H_2SO_4 (suda) $\longrightarrow$ Zn SO_4 (suda) + H_2(g)
II. $2H_2$(g) + 2NO (g) $\longrightarrow$ N_2(g) + $2H_2O$ (g)
III.Fe^{+2}(suda) + Cu^{+2}(suda) $\longrightarrow$ Fe^{+3}(suda) + Cu^{+1}(suda)

a)I b)II c)III d)I ve II e)I ve III

19.Aşağıdaki ifadelerden hangisi sıcaklığın tepkime hızına etkisi düşünüldüğünde doğru olur?

a)Sıcaklık arttırıldığında ekzotermik tepkimelerin hızı düşer.
b)Sıcaklık aktivasyon enerjisini düşürerek tepkime hızını arttırır.
c)Sıcaklık tepkimeye ısı vererek tepkime hızını arttırır.
d)Sıcaklığın artmasıyla taneciklerin kinetik enerjileri artar ve böylece tepkime hızı artar.

e)Sıcaklık tepkime mekanizmasını değiştirir.

20. $2Cu^{+2} + 2I^{-} \longrightarrow 2Cu^{+} + I_2$ **(hızlı)**

$Cu^{+} + S_2O_8^{-2} \longrightarrow CuSO_4^{+} + SO_4^{-2}$ **(yavaş)**

$Cu^{+} + CuSO_4^{+} \longrightarrow 2Cu^{+2} + SO_4^{-2}$ **(hızlı)**

Yukarıdaki mekanizması verilen tepkime için aşağıdaki ifadelerden hangisi yanlıştır?

a)Hızı belirleyen adım ikincisidir.

b) $S_2O_8^{-2}$ derişimi iki katına çıkarılırsa hız da iki katına çıkar.

c) Cu^{+} katalizördür.

d) $CuSO_4^{+}$ ömrü çok kısa olan bir ara üründür.

e)Net tepkime ürünleri SO_4^{-2} ve I_2 dir.

APPENDIX C

CONCEPTUAL CHANGE TEXT SAMPLE

Bütün tepkimeler aynı hızda mı gerçekleşir?

Sevgili öğrenciler, bütün tepkimelerin aynı hızda gerçekleştiğini düşünebilirsiniz, ama bu bir kavram yanılgısıdır.

Beden eğitimi derslerinde öğretmeniniz sizin önünüze bir engel koyup atlamanızı isteyebilir. Sizce sınıfınızdaki her öğrenci aynı engeli aşabilir mi? Tabi ki hayır. Kiminiz uzun, kiminiz kısa, kiminiz şişman, kiminiz zayıfsınız ve bu engeli aşabilen öğrenciler , kiloları ve boyları müsait olup yeterli enerjiye sahip öğrenciler olacaktır. Fakat öğretmeniniz bu engeli biraz daha küçültürse sınıfınızda engeli aşacak öğrenci sayısı artacaktır. Engel büyüdükçe engeli aşacak öğrenci sayısı da azalacaktır.

Tepkimeler de aynen böyle gerçekleşir, değişik hızlara ve aktifleşme enerjilerine sahiptir. Aktifleşme enerjisi küçük olan tepkimeler, engeli aşacak tanecik sayısı fazla olacağından hızlı olur. Aktifleşme enerjisi büyük olan tepkimeler engeli aşabilecek tanecik sayısı az olacağından yavaş gerçekleşir. Örneğin demirin paslanması çok yavaş gerçekleşen kimyasal bir tepkimedir. Törenlerde zevkle izlediğimiz havai fişek gösterileri ne de çabuk biter değil mi?, çünkü onlar patlama ile gerçekleşen , çok kısa süren kimyasal tepkimelerdir.

Tepkime hızı nedir?

Sevgili öğrenciler, tepkime hızı nedir sorusu size sorulunca birçoğunuzun aklına gelen şey "tepkimeye giren maddelerin ürün oluşturma sürecidir" ifadesidir. Fakat birçoğunuzun düşündüğü bu tanım bir kavram yanılgısıdır, düşünülenin askine tepkime hızı sadece girenlerin ürün oluşturma süreci değildir. Bunu şöyle ifade açıklayabiliriz;

Tepkime hızı bir fabrikadaki üretim hızına benzer. Kimyasal bir tepkimeyi otomobil fabrikasındaki üretime benzetebiliriz. Demir, plastik, ve cam gibi ham maddeler girenlerimiz ve otomobiller de fabrikanın sonunda montaj hattındaki ürünlerimizdir. Ham maddeler işlenerek otomobili oluştururlar. Biz de bu tepkimenin hızını ölçmek istediğimizde gün başına üretilen otomobillerin sayısını ya da gün başına tüketilen demir miktarını ele alabiliriz. İşte fabrikada ham maddelerin işlenerek otomobil üretim sürecinde yer almasındaki gibi, tepkime hızı ölçümü sadece girenlerle ifade edilmez.

Tepkime hızı birim zamanda girenlerin miktarındaki azalma yada ürünlerin miktarındaki artmadır.

$A(g) + B(g) \longrightarrow C(g) + D(g)$ tepkimesini ele aldığımızda A ve B'nin girenler ,C ve D' nin de ürünler olduğunu görüyoruz.

Tepkime başlangıcından itibaren tepkimedeki madde miktarında bir artma ve azalma söz konusu olacak, A ve B maddeleri başlangıçta ortamda yalnızken , ürünler oluştukça miktarları azalacak; C ve D maddeleri başlangıçta yokken A ve B maddelerinin tepkimeye girmesiyle oluşacak ve miktarları zamanla artacaktır. Görüldüğü gibi tepkimenin oluşum sürecinde girenlerin miktarında bir azalma ve ürünlerin miktarında bir artma olacaktır. Bu azalma veya artmanın zamanla değişimi tepkime hızını ifade etmemize yardımcı olur.

$$\text{Tepkime hızı} = \frac{\text{Madde derişimindeki değişme}}{\text{Zaman aralığı}} \text{ dır.}$$

Yukarıdaki tekimeyi ele aldığımızda tepkime hızını hem girenler hem de ürünler bazında yazabiliriz.

TH(A) =[A]'ndeki azalma / Δt TH(B)= [B]'ndeki azalma / Δt

TH(C) =[C]'ndeki artma / Δt TH(D) =[D]'ndeki artma / Δt

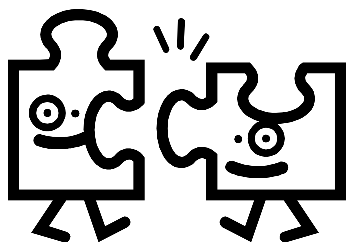
Görüldüğü gibi tepkime hızı bazılarınızın düşündüğü gibi sadece giren maddelerin derişimleri çarpımına eşit değildir, yada sadece bir ürün oluşturma süresi değildir. Sadece derişim yada bir süre ile ifade edilmez.

Tepkime hızı nedir sorusu karşısında birçoğunuzun verdiği "belli sıcaklık ve derişimde birim zamanda ürüne dönüşen madde miktarıdır" ifadesi de sahip olunan bir kavram yanılgısıdır.

Kimyasal tepkimelerin bazıları kendiliğinden oluşur, bazılarının gerçekleşmesi için enerji gerekir. Bu enerji ısı enerjisi olabilir, ışık enerjisi olabilir, mekanik enerji olabilir, elektrik enerjisi olabilir. Yani tepkime hızı her tepkime için farklıdır ve ölçüm kriterleri de yine tepkime türüne göre değişir, sıcaklık ve derişimi belli bir seviyede tutmak hızı bulmamızı sağlamaz. Örneğin, fotosentezde ışık enerjisinin yararlı bir işlevini görüyoruz, dinamit gibi bir sarsıntı olana kadar güvenli olan maddenin patlatılmasında ise mekanik enerjinin işlevine ihtiyaç duyulduğunu görüyoruz.

Her moleküler çarpışma kimyasal tepkimeyle mi sonuçlanır?

Sevgili öğrenciler, bildiğiniz gibi tepkimeler giren taneciklerin çarpışmaları neticesinde meydana gelir. Ancak birçoğunuzun düşündüğünün aksine tüm moleküler çarpışmalar kimyasal tepkimeyle sonuçlanmaz. İki taneciğin birbiriyle çarpışması onların tam olarak tepkimeye girecekleri anlamına gelmez. Başarılı bir çarpışma gerçekleşmesi için taneciklerin uygun çarpışma doğrultusunda çarpışmaları gerekir ki böylece belli atomlar bir araya gelerek ürün oluşturabilsin.



Bu olay tıpkı bir yapboz tamamlamaya benzer. Elimize aldığımız bir parçayı rasgele yerleştirerek amacımıza ulaşamayız. Her parçanın girintileri çıkıntılarıyla uyum sağlaması gerektiği bir yeri vardır ve uygun olduğu yere yerleştirilmelidir.

$\mathbf{A_2\,(g) + B_2(g) \longrightarrow 2AB(g)}$ tepkimesine göre $\mathbf{A_2\ (g)}$ ve $\mathbf{B_2(g)}$ tanecikleri çarpıştığında $\mathbf{A_2\ (g)}$ ve $\mathbf{B_2(g)}$ tanecikleri arsındaki bağlar zayıflar ve kopar. Ancak **AB(g)** maddesi oluşması için *uygun doğrultuda, yeterli hız ve enerjiyle* çarpışmaları gerekir.

Çarpışma teorisinin temeli taneciklerin tepkimeye girmeleri için mutlaka çarpışmaları gerektiğidir. Bu olayı güreş müsabakalarına benzetebiliriz.

İki güreşçinin güreşebilmeleri için birbiriyle temas etmeleri gerekmez mi?

Tepkimeler tek bir basamakta mı gerçekleşir?

Hemen hemen tepkimelerin çoğu tek bir adımda değil, birkaç adımda meydana gelir. Bir tepkimeyi oluşturan bu adımlara tepkime mekanizması denir. Bir tepkimenin mekanizması toplam tepkimeye bakarak anlaşılamaz. Her bir adım en çok iki taneciğin çarpışmasını içerir. Tepkime mekanizması deneylerle elde edilir. Tepkime mekanizmasındaki adımlar aynı hızda gerçekleşmez,kimisi yavaş kimisi hızlıdır.

Sevgili öğrenciler tepkime mekanizmasında yavaş basamağın tepkime hızını belirlediği konusunda kavram yanılgıları taşımaktasınız. Bu olayı günlük hayatımızla şöyle ilişkilendirebiliriz ,gece yatağımızda güzel bir şekilde uyuduktan sonra sabah kalkar ve okula gideriz. Gece yatağımızda uyumamızı tepkimeye başlangıç(girenler), okula varmamızı da tepkimenin sonucu(ürünler) olarak düşünelim. Bu tepkimenin başlangıcı ve sonucu arasında hangi olayları gerçekleştiririz?

-uyanırız

-banyoya girerek, yüzümüzü yıkar, duş alırız

-okul üniformamızı giyeriz

-kahvaltı ederiz

-yürüyerek, anne-babamız ya da bir arkadaşımızla veya okul servisini kullanarak okula varırız. Sizce bu adımlar herkes için aynı hızda mı gerçekleşir?

Kimimiz banyoyu kullanma esnasında yavaş, kimimiz kahvaltı esnasında yavaş, kimimizse servise binip okula varırken yavaş hareket ederiz. Yani tüm öğrenciler için mutlaka yavaş gerçekleşen bir adım vardır ve bu yavaş adım okula varma süremizi belirler. Bu yavaş basamağı hızlandırmak, tepkime hızını etkileyecek ve okula daha kısa sürede varmamızı sağlayacaktır. Yine hızlı gerçekleştirdiğimiz bir basamağı düşünelim, sizce okula varma süremizde etken olur mu? Tabi ki olmaz, hızlı gerçekleşen bir basamak tepkime hızında etkili değildir.

$H_2O_2 + 2I^- + 2H_3O^+ \longrightarrow I_2 + 4H_2O$ tepkimesi üç adımda gerçekleşmektedir.

$H_2O_2 + I^- \longrightarrow H_2O + IO^-$ (yavaş)

$IO^- + H_3O^+ \longrightarrow HIO + H_2O$ (hızlı)

$HIO + H_3O^+ + I^- \longrightarrow 2H_2O + I_2$ (hızlı)

Tepkime üç adımda gerçekleşmektedir. Tepkime hızını belirleyen adım I. Adım yani yavaş adımdır. Hızlı adımlar tepkime hızını belirlemez.

Yine aynı tepkimeyi ele alarak birçoğunuzun sahip olduğu diğer bir kavram yanılgısı reaksiyon intermediate (ara ürünü) değerlendirebiliriz. Katalizör ve reaksiyon ara ürünü karıştırılan iki kavramdır. Katalizör olabilecek bir tepkimeyi harekete geçiren, kimyasal tepkime oluşumunu sağlayan, fakat kendisi tepkime sonunda değişime uğramayan maddedir. Reaksiyon ara ürünü ise tepkimenin bir basamağında üretilip diğer bir basamağında tüketilen, toplam tepkimede yer almayan madde, ya da maddelerdir. Yukarıdaki tepkimede IO^- I. Basamakta üretilip II. Basamakta kullanılmaktadır. HIO II. Basamakta oluşup III. Basamakta kullanılmaktadır. Her ikisi de toplam tepkimede gözükmemektedir.

Katalizör tepkimeye girer mi?

Sevgili öğrenciler birçoğunuz katalizörün tepkimeye girmediğini düşünür. Ancak bu bir kavram yanılgısıdır.

Katalizör olabilen bir tepkimeyi harekete geçiren, kimyasal tepkime oluşumunu sağlayan, fakat kendisi tepkime sonunda değişime uğramayan maddedir.

Katalizör günlük hayatımızda tıpkı düğün törenlerindeki nikah memuru gibidir. Nikahın gerçekleşmesini sağlayan, törenin hızını belirleyen, kendi yaşamında bir değişiklik olmamasına rağmen evlenen çiftlerin hayatlarını tamamen değiştiren kişi değil midir nikah memuru?

Bazı katalizörler tepkimenin bir basamağında tüketilirler ve daha sonraki bir basamağında yeniden oluşurlar.

O_2 + **2NO** $\longrightarrow$ $2NO_2$

$2NO_2$ + 2 H_2SO_3 $\longrightarrow$ $2H_2SO_4$ + **2NO**

Tepkimesini incelediğimizde **NO**'nun birinci basamakta tepkimeye girerek kaybolduğunu ve ikinci basamakta tekrar oluştuğunu görüyoruz.

Sahip olduğunuz diğer bir kavram yanılgısı da tepkimenin başlaması için katalizör gerektiğidir. Ancak katalizör olmayacak bir tepkimeyi gerçekleştiremez. Katalizör olabilen bir tepkimenin hızına etki eder.

Sanılanın aksine tüm katalizörler tepkime hızını artırmaz, tepkime hızını artıran katalizörlerin yanısıra yepkime hızını azaltan katalizörler de vardır. Bunlara negatif katalizör veya inhibitör denir. İnhibitörler aktiflenme enerjisini artırarak tepkime hızını azaltır.

Caddelerdeki alt ve üst geçitler inhibitör, köprüler ve tüneller ise aktivatörler gibidir.

Katalizör tepkimeyi nasıl etkiler?

Sevgili öğrenciler, bir çoğunuz, katalizör kullanıldığında yüksek aktivasyon enerjisine sahip olan yolun kaybolduğunu düşünür. Bu bir kavram yanılgısıdır. Katalizörün reaksiyona etkisini şu örnekle açıklayabiliriz. İki vadi ve bu iki vadiyi birbirine bağlayan yüksek bir dağ olduğunu düşünelim, ve bu vadiler arası geçişin tek yolu bu dağ olsun. Bir vadiden diğerine ancak en aktif kişiler geçebilir. Oysa bu dağın altından açılan bir tünel çok daha fazla kişinin bir vadiden diğerine geçişini sağlayacaktır. Tünel, dağın yüksekliğine bir etki yapmazken, kişilere geçiş işin alternatif bir yol sağlayacaktır. Yani, tünel açılmakla, dağ kaybolmaz.

İki vadi arasındaki geçişte yüksek dağı aşarak geçmeye çalışanların sayısı çok az olacaktır. Bu da yüksek bir aktivasyon enerjisi engelinden dolayı , çok az sayıdaki etkin çarpışma sonucu çok yavaş ilerlemesine benzer.

Tünel kullanarak çok daha fazla kişinin bir vadiden diğerine geçmesi ise katalizör kullanıldığında reaksiyonun daha düşük enerjili aktif kompleks içeren değişik bir gidiş yoluyla gerçekleştiğini göstermektedir.

Öyleyse katalizör, reaksiyonun daha düşük bir aktivasyon enerjisiyle alternatif bir gidiş yoluyla gerçekleşmesini sağlamaktadır.

Katalizör etkilenmesi tepkimenin aktivasyon enerjisini aşacak tanecik sayısını ancak daha düşük bir aktivasyon enerjisiyle alternatif bir gidiş yoluyla gerçekleşmesini sağlayarak artırmakta ve böylece tepkimeyi hızlandırmaktadır.

Aktifleşme enerjisi tepkime hızını etkiler mi?

Sevgili öğrenciler birçoğunuz aktifleşme (eşik) enerjisinin tepkime hızını etkilemediğini düşünüyor. Bu yanlış bir düşüncedir ki bu olayı şöyle açıklayabiliriz;

Şekildeki koyu renkli yol dağın solundaki vadiden (girenlerden) sağındaki vadiye (ürünlere) doğrudur.Başlangıç noktasının üstündeki tepe ise girenler ve ürünler arasındaki geçiş halidir. Ve birçok kişi için tepenin bir tarafından diğer tarafına geçme isteği tepenin diğer kısmının yokuş aşağı almasına bakmaksızın bu yolun uzunluğuna bağlıdır.

Bir kimyasal tepkimenin gerçekleşmesi de ayın şekildedir. Belirli bir kinetik enerjiye sahip taneciklerin uygun doğrultuda etkin çarpışma yaparak ürünlere dönüşebilmeleri için gerekli bir minimum enerji vardır. *Eşik enerjisi yada aktifleşme enerjisi denilen bu enerji ne kadar küçük olursa, bu enerjiyi aşıp etkin çarpışma yapabilen tanecik sayısı da o kadar fazla olur.*

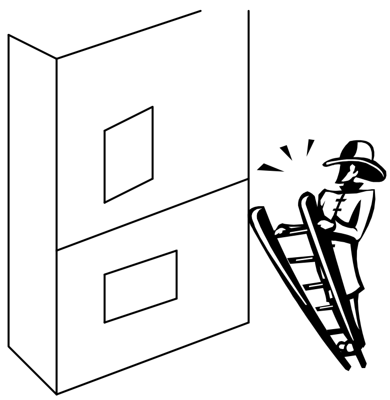
Şekilde de görüldüğü gibi yol ne kadar kısa olursa bir vadiden diğer vadiye gitmeye istekli insan sayısı da o kadar fazla olur.

Öyleyse, *aktijleşme (eşik) enerjisi tepkime hızını etkiler.*

Aktifleşme enerjisi enerji grafiğinin en yüksek yerinde midir?

Sevgili öğrenciler **aktifleşme(eşik)** enerjisi hakkında birçoğunuzun sahip olduğu diğer bir kavram yanılgısı aktivasyon enerjisinin enerji grafiğinde en yüksek yer olduğu düşüncesidir.

Yeterli **aktifleşme(eşik)** enerjisi eklendiğinde, tepkimeye giren tanecikler aktifleşmiş kompleksi oluşturmak için birbirine daha yakın hareket ederler. Aktifleşmiş kompleks hali taneciklerin toplanma halidir ve potansiyel enerjisi hem girenlerden hem de ürünlerden fazladır. ***Aktifleşmiş kompleks hali tepkimenin ürünler oluşacak şekilde ilerlemesinden önceki kararsız , geçiş halidir***.



İtfaiyecinin 2. kattaki yangına müdahale etmesi için merdiveniyle 2.kat hizasına gelmesi yeterli midir? Birazcık daha tırmanarak daha yüksek bir potansiyel enerjiye sahip pencere eşiğini aşması ve içeriye girmesi gerekmez mi? Görevini

tamamladıktan sonra da 2. kattan direkt zemine inemeyeceğinden yine pencerenin eşiğine kadar çıkıp ondan sonra merdiveniyle inmesi gerekmez mi? İşte her iki durumda da pencere eşiği, aynen aktifleşmiş kompleks gibi, olayın başlangıcından sonuna ulaşmak için aşılması gereken belli yüksek bir enerji durumunu anlatmaktadır. ***Öyleyse enerji grafiğindeki en yüksek yer aktifleşme enerjisi değil, kararsız aktifleşmiş kompleksin enerjisidir.***

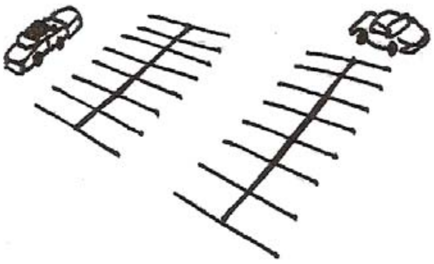
Tepkimeyi nasıl hızlandırabiliriz?

Bazı kimyasal tepkimeler, örneğin havai fişek, dinamit gibi patlayıcıların tepkimeleri, neredeyse anlık olaylardır. Demirin paslanması gibi tepkimeler ise çok yavaş ilerler, öyle ki sonuçlarını görmek yıllar alabilir. Tepkimeler, ancak girenlerin moleküllerinin birbiriyle temasta bulunmasıyla gerçekleşebilir, bu nedenle birbiriyle çarpışan molekül sayısı artırıldığında tepkimenin hızı da artar.Çarpışan moleküllerin sayısını artırmanın yani tepkimeyi hızlandırmanın bir yolu yüzey alanını genişletmektir, böylelikle daha fazla miktarda tepken tepkimeye girebilir, ancak yüzey alanı dendiğinde birçoğunuzun sahip olduğu bir kavram yanılgısı da yüzey alanı artırmanın tüm tepkimelerde hızı artıracağının düşünülmesidir.

Mermer mutfak tezgahının üzerine limon damlattığımızda tezgahta bir değişim fark ederiz,kalsiyum karbonatın doğada bulunan bir biçimi olan mermer, asit ile tepkimeye girer. Fakat bu hızlı bir süreç değildir.Mermer ince toz haline getirilirse yüzey alanı büyük ölçüde artar ve tepkime öylesine hızlanır ki karbon dioksit kabarcıkları hızla meydana gelir.

Örnekte de görüldüğü gibi tepkimeye giren maddelerin temas yüzeyinin artırılması heterojen yani reaktiflerin farklı fazlarda bulunduğu tepkimelerde moleküllerin çarpışma sayısını ve böylece tepkime hızını artırır.

Tepkime ortamı bir çözelti ise, çözeltinin derişimi, yani çözücüdeki bileşiğin molekül sayısı artırılarak aynı etki elde edilir, yani tepkime hızlanır. Şekildeki park yerinde sadece iki araba vardır ve birbirleriyle çarpışmaları çok düşük bir ihtimaldir.



Oysa, aşağıdaki şekilde arabaların park esnasında birbirleriyle çarpışma ihtimali çok yüksektir.

Tepkimeler de aynen bu örnekteki gibi gerçekleşir, tepkime hızı tepkimeye giren maddelerin derişimleri ile orantılıdır. Reaktantların yapılarından başka, derişimleri de o kimyasal reaksiyonun hızını önemli ölçüde etkiler. Reaksiyona girebilmeleri için taneciklerin çarpışmaları gerekir. O halde reaksiyon ortamında daha çok sayıda reaktant taneciği bulunması, daha fazla sayıda çarpışmanın gerçekleşmesine neden olur. Böylece reaktantların derişimlerindeki artma çarpışma sayısını ve dolayısıyla reaksiyon hızını artırır.

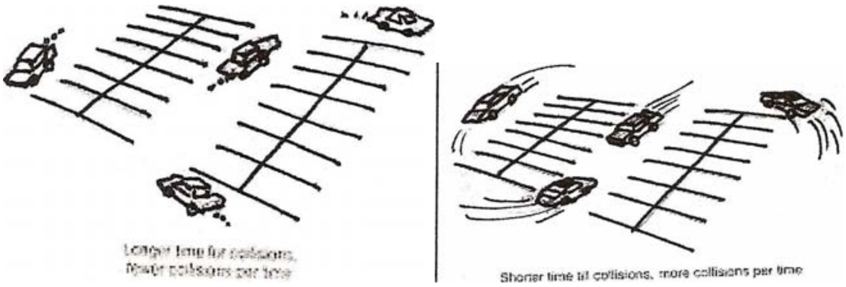
Öyleyse, reaktantlardan birinin derişiminin artması reaksiyon hızını artırır demek yerine, bu olayı çarpışma teorisiyle açıklamamız gerekir. Reaksiyon ortamında daha çok sayıda reaktant taneciği bulunması, daha fazla sayıda çarpışmanın gerçekleşmesine neden olur ve böylece reaktantların derişimlerindeki artma çarpışma sayısını ve dolayısıyla reaksiyon hızını artırır demek daha açıklayıcı olur.

Diğer bir yanılgı da derişimin artırılmasının tepkime için geçen süreyi artırması şeklinde algılanmasıdır. Oysa artan süre değil, tepkimenin hızıdır.

Sıcaklık tepkime hızını nasıl etkiler?

Sevgili öğrenciler annenizi yoğurt yaparken izlemişsinizdir, mayayı süt ılıkken koyup, kabın üzerine de sıcak tutması için bir şeylerle örter. İşte ortamın sıcaklığını artırarak tepkimenin yani mayalanmanın daha kısa sürede gerçekleşmesini sağlamış olur. Tepkime ortamının ısıtılması pek çok tepkimeyi hızlandırabilir.Bu, moleküllerin daha hızlı hareket ederek daha sık çarpışmasını sağlar.

Tepkime ortamının ısıtılması pek çok tepkimeyi hızlandırabilir.Bu, moleküllerin daha hızlı hareket ederek daha sık çarpışmasını sağlar.



Sıcaklığın artırılması taneciklerin kinetik enerjilerinin artmasına sebep olur . Tepkimeye giren taneciklerin kinetik enerjilerinin artması, hızlarının artmasına ,daha sık ve etkin çarpışmalar yapmalarına neden olur Böylece, aktifleşmiş kompleks oluşturan tanecik sayısı ve tepkime hızı artar.

Eğer reaksiyon kabı ısıtılarak ortamın sıcaklığı yükseltilirse çarpışmakta olan moleküllerin çok daha büyük bir kısmı tanecikler arası bağların kırılmasına yetecek enerjiye ulaşır. Reaktantların sıcaklığını yükseltmek, taneciklerin kinetik enerjilerini ve dolayısıyla hızlarını artırır. Bu ise hem reaksiyona neden olabilecek etkin çarpışma sayısını artırır, hem de çarpışan taneciklere aktivasyon enerjisi engelini aşmaya yetecek kadar enerji kazandırır.

Örneğin yiyeceklerin bozulması ve ekşimesi kimyasal bir olaydır. Yiyecekler sıcakta bırakıldığında kısa sürede bozulur.

Sıcaklığın tepkime hızına etkisi düşünüldüğünde sahip olduğunuz diğer bir kavram yanılgısı da ekzotermik ve endotermik tepkimelere etkisinin farklı olduğu düşüncesidir. Sıcaklığın artırılması endotermik ve ekzotermik tepkimeleri hızlandırır. Sıcaklık artışı tepkimeye giren taneciklerin aktivasyon enerjisini aşması için gerekli kinetik enerjiyi sağlar.

APPENDIX D

BİLİMSEL İŞLEM BECERİ TESTİ

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

1. Bir basketbol antrenörü, oyuncuların güçsüz olmasından dolayı maçları kaybettiklerini düşünmektedir. Güçlerini etkileyen faktörleri araştırmaya karar verir. Antrenör, oyuncuların gücünü etkileyip etkilemediğini ölçmek için aşağıdaki değişkenlerden hangisini incelemelidir?
a. Her oyuncunun almış olduğu günlük vitamin miktarını.
b. Günlük ağırlık kaldırma çalışmalarının miktarını.
c. Günlük antrenman süresini.
d. Yukarıdakilerin hepsini.

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

c. Kullanılan benzin miktarı ile.

d. Kullanılan katkı maddesinin miktarı ile.

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

a. Arabanın ağırlığı.

b. Motorun hacmi.

c. Arabanın rengi

d. a ve b.

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

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

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

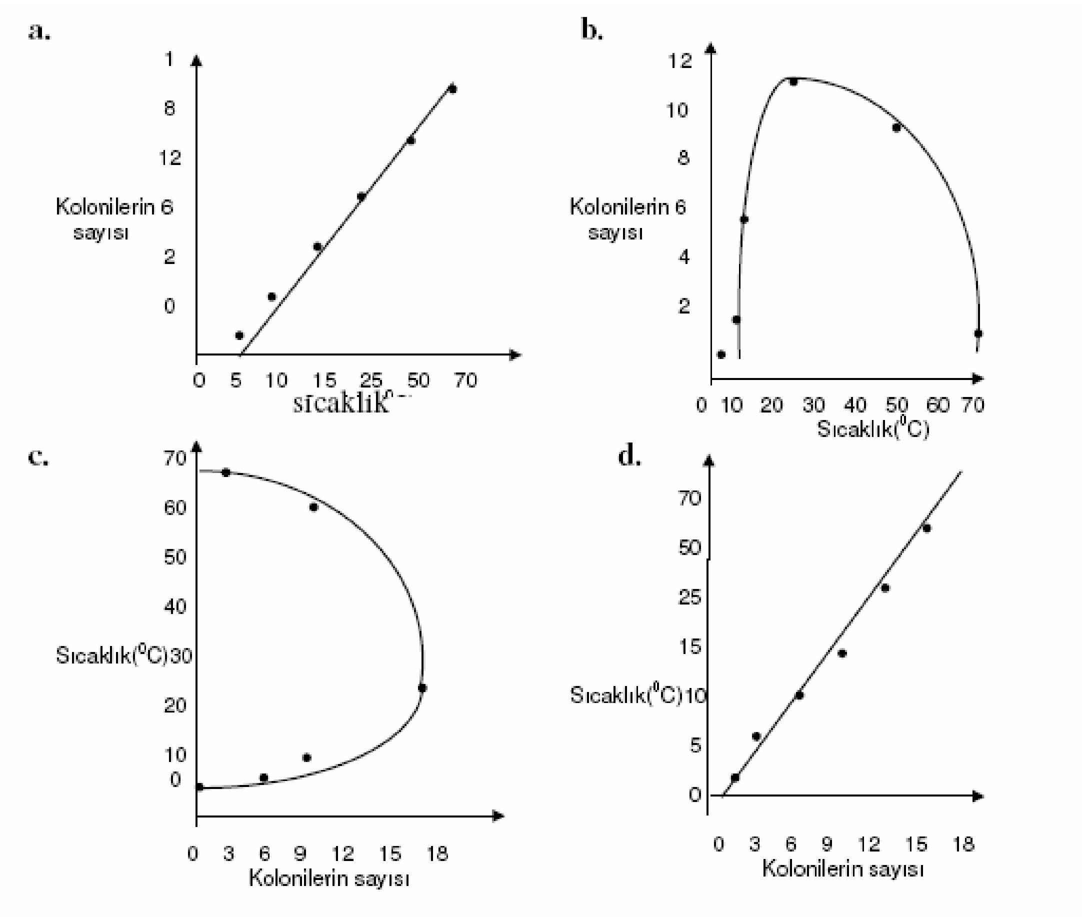
c. Büyük evlerin ısınma giderleri fazladır.

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

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

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

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?



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

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

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

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

d. Arabalar eskidikçe kaza yapma olasılıkları artar.

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

a. Her deneyde arabanın gittiği toplam mesafe ölçülür.

b. Rampanın (eğik düzlem) eğim açısı ölçülür.

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

d. Her iki deneyin sonunda arabanın ağırlıkları ölçülür.

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

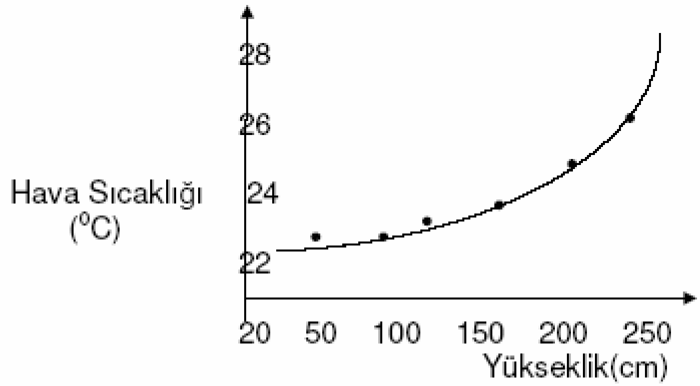
a. Tarlaya ne kadar çok gübre atılırsa, o kadar çok mısır elde edilir.

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

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

d. Mısır üretimi arttıkça, üretim maliyeti de artar.

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



a. Yükseklik arttıkça sıcaklık azalır.

b. Yükseklik arttıkça sıcaklık artar.

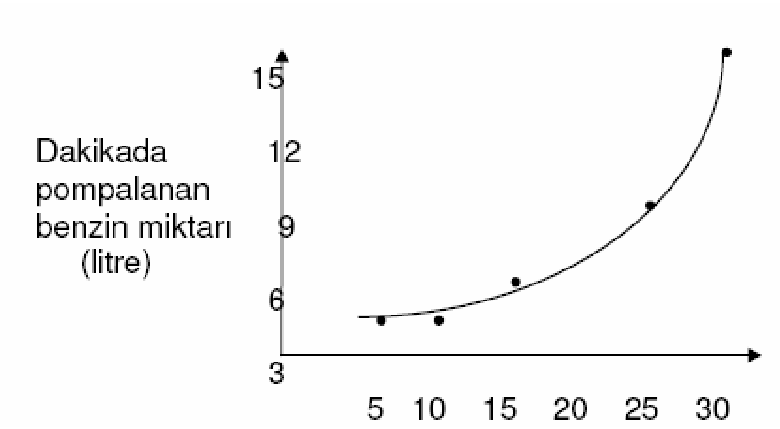
c. Sıcaklık arttıkça yükseklik azalır.

d. Yükseklik ile sıcaklık artışı arasında bir ilişki yoktur.

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

a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.
b. İçlerinde farlı miktarlarda hava olan topları, aynı yükseklikten yere bırakır.
c. İçlerinde aynı miktarlarda hava olan topları, zeminle farklı açılardan yere vurur.
d. İçlerinde aynı miktarlarda hava olan topları, farklı yüksekliklerden yere bırakır.

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi açıklamaktadır?
a. Hortumun çapı genişledikçe dakikada pompalanan benzin miktarı da artar.
b. Dakikada pompalanan benzin miktarı arttıkça, daha fazla zaman gerekir.
c. Hortumun çapı küçüldükçe dakikada pompalanan benzin miktarı da artar.
d. Pompalanan benzin miktarı azaldıkça, hortumun çapı genişler.

Önce aşağıdaki açıklamayı okuyunuz ve daha sonra 12, 13, 14 ve 15 inci soruları açıklama kısmından sonra verilen paragrafı okuyarak cevaplayınız.
Açıklama: Bir araştırmada, bağımlı değişken birtakım faktörlere bağımlı olarak gelişim gösteren değişkendir. Bağımsız değişkenler ise bağımlı değişkene etki eden faktörlerdir. Örneğin, araştırmanın amacına göre kimya başarısı bağımlı bir değişken olarak alınabilir ve ona etki edebilecek faktör veya faktörler de bağımsız değişkenler olurlar.
Ayşe, güneşin karaları ve denizleri aynı derecede ısıtıp ısıtmadığını merak

etmektedir. Bir araştırma yapmaya karar verir ve aynı büyüklükte iki kova alır. Bunlardan birini toprakla, diğerini de su ile doldurur ve aynı miktarda güneş ısısı alacak şekilde bir yere koyar. 8.00 - 18.00 saatleri arasında, her saat başı sıcaklıklarını ölçer.

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

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

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

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

16. Can, yedi ayrı bahçedeki çimenleri biçmektedir. Çim biçme makinesiyle her hafta bir bahçedeki çimenleri biçer. Çimenlerin boyu bahçelere göre farklı olup bazılarında uzun bazılarında kısadır. Çimenlerin boyları ile ilgili hipotezler kurmaya

başlar. Aşağıdakilerden hangisi sınanmaya uygun bir hipotezdir?

a. Hava sıcakken çim biçmek zordur.

b. Bahçeye atılan gürenin miktarı önemlidir.

c. Daha çok sulanan bahçedeki çimenler daha uzun olur.

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

17, 18, 19 ve 20 inci soruları aşağıda verilen paragrafı okuyarak cevaplayınız.
Murat, suyun sıcaklığının, su içinde çözünebilecek şeker miktarını etkileyip etkilemediğini araştırmak ister. Birbirinin aynı dört bardağın her birine 50 şer mililitre su koyar. Bardaklardan birisine 0 0C de, diğerine de sırayla 50 0C, 75 0C ve 95 0C sıcaklıkta su koyar. Daha sonra her bir bardağa çözünebileceği kadar şeker koyar ve karıştırır.

17. Bu araştırmada sınanan hipotez hangisidir?

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

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

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

d. Kullanılan suyun miktarı arttıkça sıcaklığı da artar.

18. Bu araştırmada kontrol edilebilen değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

19. Araştırmanın bağımlı değişkeni hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

20. Araştırmadaki bağımsız değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.
b. Her bardağa konulan su miktarı.
c. Bardakların sayısı.
d. Suyun sıcaklığı.

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

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

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

24. Ahmet, buz parçacıklarının erime süresini etkileyen faktörleri merak etmektedir. Buz parçalarının büyüklüğü, odanın sıcaklığı ve buz parçalarının şekli gibi faktörlerin erime süresini etkileyebileceğini düşünür. Daha sonra şu hipotezi sınamaya karar verir: Buz parçalarının şekli erime süresini etkiler.

Ahmet bu hipotezi sınamak için aşağıdaki deney tasarımlarının hangisini uygulamalıdır?

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

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

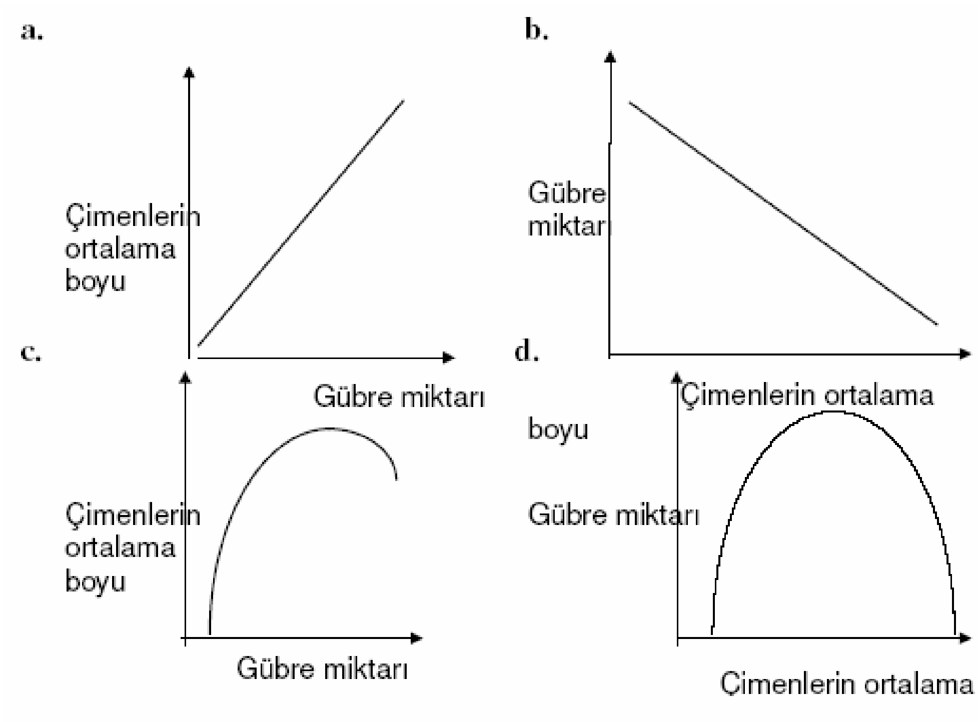
c. Her biri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar aynı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

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

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

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

Tablodaki verilerin grafiği aşağıdakilerden hangisidir?



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

a. Farelerin hızını ölçer.

b. Farelerin, günlük uyumadan durabildikleri süreyi ölçer.

c. Her gün fareleri tartar.

d. Her gün farelerin yiyeceği vitaminleri tartar.

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

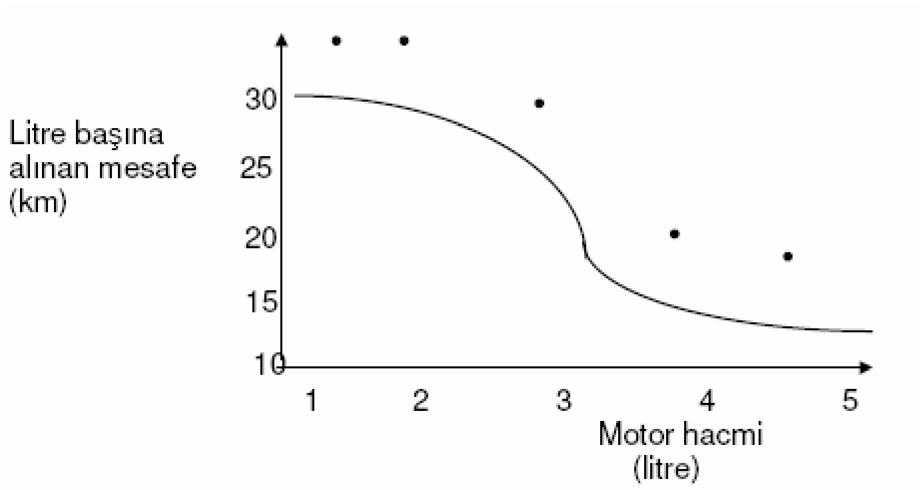
a. Daha fazla şekeri çözmek için daha fazla su gereklidir.

b. Su soğudukça, şekeri çözebilmek için daha fazla karıştırmak gerekir.

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

d. Su ısındıkça şeker daha uzun sürede çözünür.

28. Bir araştırma grubu, değişik hacimli motorları olan arabaların randımanlarını ölçer. Elde edilen sonuçların grafiği aşağıdaki gibidir:



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi gösterir?

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

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

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

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

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

Toprağa karıştırılan yaprakların domates üretimine etkisi araştırılmaktadır. Araştırmada dört büyük saksıya aynı miktarda ve tipte toprak konulmuştur. Fakat birinci saksıdaki torağa 15 kg., ikinciye 10 kg., üçüncüye ise 5 kg. çürümüş yaprak karıştırılmıştır. Dördüncü saksıdaki toprağa ise hiç çürümüş yaprak karıştırılmamıştır.Daha sonra bu saksılara domates ekilmiştir. Bütün saksılar güneşe konmuş ve aynı miktarda sulanmıştır. Her saksıdan elde edilen domates tartılmış ve kaydedilmiştir.

29. Bu araştırmada sınanan hipotez hangisidir?

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

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

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

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

30. Bu araştırmada kontrol edilen değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

31. Araştırmadaki bağımlı değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

32. Araştırmadaki bağımsız değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

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

a. Kullanılan mıknatısın büyüklüğü ile.

b. Demir tozlarını çeken mıknatısın ağırlığı ile.

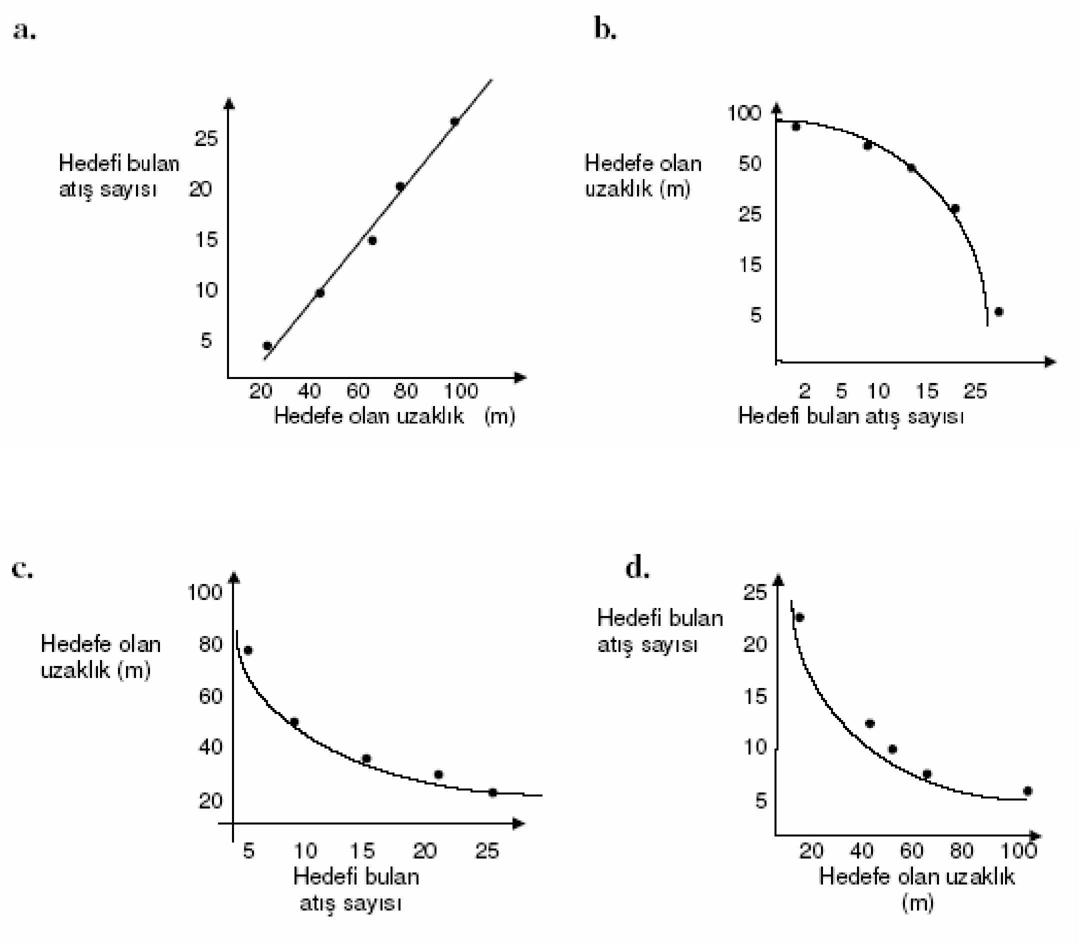
c. Kullanılan mıknatısın şekli ile.

d. Çekilen demir tozlarının ağırlığı ile.

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

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

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?



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

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

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

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

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

36. Murat Bey'in evinde birçok elektrikli alet vardır. Fazla gelen elektrik faturaları dikkatini çeker. Kullanılan elektrik miktarını etkileyen faktörleri araştırmaya karar verir.

Aşağıdaki değişkenlerden hangisi kullanılan elektrik enerjisi miktarını etkileyebilir?

a. TV nin açık kaldığı süre.

b. Elektrik sayacının yeri.

c. Çamaşır makinesinin kullanma sıklığı.

d. a ve c.

APPENDIX E

KİMYA DERSİ TUTUM ÖLÇEĞİ

AÇIKLAMA: bu ölçekte, kimya dersine ilişkin tutum cümleleri ile her cümlenin karşısında "Tamamen Katılıyorum", "Katılıyorum", "Karasızım", "Katılmıyorum" , "hiç Katılmıyorum" 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 yaşantıda çok önemli yeri yoktur.					
4. Kimya ile ilgili ders problemlerini çözmekten hoşlanırım.					
5. Kimya konularıyla ilgili daha çok şey öğrenmek isterim.					
6.Kimya dersine girerken sıkıntı duyarım.					
7. Kimya derslerine zevkle girerim.					
8. Kimya derslerine ayrılan ders saatinin daha fazla olmasını isterim.					
9. Kimya dersini 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 içinde Kimya dersi sevimsiz gelir.					
14. Kimya konularıyla ilgili tartışmaya katılmak bana cazip gelmez.					
15. Çalışma zamanımın önemli bir kısmını kimya dersine ayırmak isterim.					