CONCEPTUAL CHANGE ORIENTED INSTRUCTION AND STUDENTS' MISCONCEPTIONS IN GASES

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ABSTRACT

CONCEPTUAL CHANGE ORIENTED INSTRUCTION AND STUDENTS' MISCONCEPTIONS IN GASES

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The purpose of this study was to investigate the effects of conceptual change oriented instruction accompanied by demonstrations and gender on tenth grade students' understanding of gases concepts, and attitudes toward chemistry. Hundred tenth grade students from two classes taught by the same teacher in a public high school were enrolled in the study in the Fall semester of 2003-2004. Control group students were taught by traditionally designed chemistry instruction (TI), while experimental group students were instructed by conceptual change oriented instruction accompanied by demonstrations (CCID). Gases Concept Test and Attitude Scale toward Chemistry were administered to both groups as a pre-test and post-test to assess the students understanding of gases concepts and students' attitudes toward chemistry, respectively. Science Process Skills Test was given at the beginning of the study to determine students' science process skills. Learning Style Inventory was also given to all students to determine their learning styles. After treatment, interviews were conducted with the teacher and several students from the two groups. The hypotheses were tested by using analysis of covariance (ANCOVA) and two-way analysis of variance (ANOVA). The results showed that CCID caused significantly better acquisition of the scientific conceptions related to gases than TI. There was no significant effect of the treatment on the students' attitudes toward chemistry. No significant effect of gender difference on students' understanding the concepts about gases and students' attitudes toward chemistry was found. Science process skill was determined as a strong predictor in understanding the concepts related to gases.

Keywords: Conceptual Change Approach, Gases, Demonstration, Misconception, Attitude toward Chemistry, Science Process Skills

ÖZ

KAVRAMSAL DEĐÝÞÝM YAKLAªIMINA DAYALI ÖĐRETÝM VE ÖĐRENCÝLERÝN GAZLAR KONUSUNDAKÝ KAVRAM YANILGILARI

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Temmuz 2004, 167 sayfa

Bu çalýþmanýn amacý demonstrasyon destekli kavramsal deðiºim yaklaþýmýna dayalý öðretimin onuncu sýnýf öðrencilerinin gazlarla ilgili kavramlarý anlamalarýna ve kimya dersine yönelik tutumlarýna etkilerini incelemektir. Çalýþmaya 2003-2004 Güz döneminde bir devlet okulundaki ayný kimya öðretmeninin iki ayrý onuncu sýnýfýndaki yüz öðrenci katýlmýþtýr. Kontrol grubunda geleneksel yöntem kullanýlýrken deney grubunda demonstrasyon destekli kavramsal deðiºim yaklaþýmýna dayalý öðretim yöntemi kullanýlmýþtýr.

Öðrencilerin gazlarla ilgili kavramlarý anlama düzeylerini belirlemek için Gazlar Kavram Testi her iki gruba ön-test ve son-test olarak uygulanmýþtýr. Her iki gruptaki öðrencilere kimya dersine yönelik tutumlarýný belirlemek için Kimya Dersi Tutum Ölçeði ön-test ve son-test olarak verilmiºtir. Bilimsel iºlem becerilerini belirlemek için çalýþmanýn baþýnda Bilimsel Ýþlem Beceri Testi her iki grubun öðrencilerine uygulanmýþtýr. Ayrýca, Öðrenme Stilleri Envanteri her iki gruptaki öðrencilere öðrenme stillerini belirlemek amacýyla uygulanmýþtýr. Çalýþmanýn sonunda öðretmen ile ve her iki gruptan bazý öðrencilerle ayrý ayrý görüºmeler yapýlmýþtýr. Araºtýrmanýn hipotezleri ortak deðiºkenli varyans analizi (ANCOVA) ve iki yönlü varyans analizi (ANOVA) kullanýlarak sýnanmýþtýr. Sonuçlar demonstrasyon destekli kavramsal deðiºim yaklaþýmýna dayalý öðretimin gazlarla ilgili kavramlarýn anlaþýlmasýnda daha etkili olduðunu göstermiºtir. Demonstrasyon destekli kavramsal deðiºim yaklaþýmýna dayalý öðretimin kimya dersine yönelik tutuma anlamlý bir etkisinin olmadýðý saptanmýþtýr. Cinsiyet farkýnýn gazlar konusunu anlamada etkili olmadýðý ve kimya dersine yönelik tutuma da anlamlý bir etkisinin olmadýðý belirlenmiºtir. Bilimsel iºlem becerisinin öðrencilerin gazlarla ilgili kavramlarý anlamalarýna istatistiksel olarak anlamlý katkýsý olduðu belirlenmiºtir.

Anahtar Kelimeler: Kavramsal Deðiºim Yaklaþýmý, Gazlar, Demonstrasyon, Kavram Yanýlgýsý, Kimyaya Yönelik Tutum, Bilimsel Ýþlem Becerisi

To My Husband AKIN and My Daughter ECE

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LIST OF ABREVIATIONS

CCID	: Conceptual Change Oriented Instruction
TI	: Traditionally Designed Chemistry Instruction
EG	: Experimental Group
CG	: Control Group
GCT	:Gases Concept Test
ASTC	: Attitude Scale Toward Chemistry
SPST	: Science Process Skills Test
LSI	: Learning Style Inventory
$\overline{X}$	: Mean
F	: F statistic
t	: t statistic
df	: Degrees of Freedom
p	: Significance Level
MS	: Mean Square
MSE	: Mean Square Error
SS	: Sum of Squares
N/n	: Sample Size

CHAPTER I

INTRODUCTION

Learning is widely accepted as a dynamic process in which the new information interacts with existing knowledge of the learner. The cognitive structure of the preexisting knowledge of learners affects the way of interpretation of new knowledge. For this reason, Ausubel (1968) states that "If I had to reduce all of educational psychology to one principle, I would say this: the most important single factor influencing learning is what the learner already knows. Ascertain this and teach him accordingly". Moreover, Ausubel emphasizes that it is necessary to distinguish between meaningful learning and rote learning. Meaningful learning occurs when the learner's appropriate existing knowledge interacts with the new learning in a nonarbitrary and substantive way. Rote learning or memorization occurs when no such interaction takes place. The criteria for learning material to be meaningful are described as its logical structure; and the extent to which it is appropriate for assimilation in the cognitive structure of the learner's preexisting knowledge. If the material to be learned lacks logical meaning, the learner has no the relevant ideas in his own cognitive structure, and lacks a meaningful learning set (a disposition to link new concepts, propositions, and examples, to prior knowledge and experience) rote learning occurs (Ausubel and Robinson, 1969).

Some studies point out that the students are successful in solving algorithmic problems (Nakleh and Mitchell, 1993; Nurrenbern and Pickering, 1987), memorizing the formula (Lin, Cheng and Lawrenz, 2000), but are unable to integrate facts and formula (Yager, 1991) and fail to solve conceptual problems. From this aspect, one of the main aims of science education and perhaps the most important is to develop in learners a rich and full understanding of the key concepts and principles of life sciences, physical science, and earth and space sciences.

Students do not enter classrooms as empty vessels waiting to be filled with knowledge. Students' minds are full of notions about everyday and scientific phenomena before they are introduced to them through formal instruction. Rather, students enter classrooms with well-established notions, beliefs and interpretations about scientific phenomena. The research literature which identifies the students' informal ideas about everyday and scientific phenomena is extensive and has been reviewed by a number of researchers (Driver and Easley, 1978; Osborne, Bell and Gilbert, 1983; Driver, Guesne and Tiberghien, 1985; Eylon and Lynn, 1988; Wandersee, Mintzes, and Novak, 1994). This body of research proposes that students develop some informal ideas which make sense of the world around them. In different studies these informal ideas have been described and named in different ways as preconceptions, misconceptions, alternative frameworks (Driver and Easley, 1978), spontaneous reasoning

(Viennot, 1979), children's science (Gilbert, Osborne, and Fensham, 1982), intuitive beliefs (McCloskey, 1983), naive beliefs (Caramazza, McCloskey, and Green, 1981), and alternative conceptions (Hewson and Hewson, 1989). Students' alternative conceptions are considered as quite different from scientific conceptions. These alternative conceptions affect how the scientific knowledge is learned and have been found to hinder learning and meaningful understanding of scientific concepts taught in school (Hewson and Hewson, 1983; Shuell, 1987).

The research literature on sources of students incorrect conceptions show that the variety of students' interactions with the physical and social world (Strauss, 1981), textbooks (Cho, Kahle, and Nordland, 1985; Sanger and Greenbowe, 1999), everyday knowledge (Prieto, Blanco, and Rodriguez, 1989) and interactions with teachers (Gilbert and Zylberstajn, 1985) can lead to nonscientific conceptions. Hesse and Anderson (1992) pointed to students' preference for commonsense thinking in place of scientific concepts. They observed that the students use analogies to everyday events for their explanations and even the acquired scientific vocabulary students use nonscientific words ("fancy words"). Schmidt (1997) emphasized how some definitions as well as some labels of chemical concepts, for example redox reaction and neutralization, led the students to develop concepts deviating from those accepted as scientific.

Chemistry is a science that involves many abstract concepts that can be incorrectly interpreted and learned by the students. The fact that students can not view what happen at molecular level makes the interpretation of the chemical phenomena difficult. In chemistry, many studies focused on identifying students misconceptions related to the particulate nature of the matter (Novick and Nussbaum, 1981, Osborne and Cosgrove, 1983; Griffiths and Preston, 1992), chemical equilibrium (Wheeler and Kass, 1978; Quilez-Pardo and Solaz-Portoles, 1995, Gussarsky and Gorodetsky, 1990), chemical and physical changes (Stavridou and Solomonidou, 1989; Hesse and Anderson, 1992) and chemical bonding (Peterson, Treagust and Garnett, 1989; Nicoll, 2001; Taber, 2003). Gases is another abstract topic where students have difficulties. Understanding gases requires understanding the matter at molecular level. To understand gases and their properties it is important to understand that the quantity and mass are conserved in all transformations that gas undergoes. Understanding behavior of gases at molecular level is essential in order to comprehend and interpret the gas laws, how air moves and produces pressure, and chemical reactions involving gases.

Misconceptions held by students have many common features. One and most important is that the misconceptions are strongly resistant to traditional teaching (Driver and Easley, 1978). Consequently, in many studies it has been investigated how students change their alternative conceptions to scientific conceptions (Clement, 1982; Lee, Eichinger, Anderson, Berkheimer, and Blakeslee, 1993; Nussbaum and Novick, 1982). If the aim of science education is to develop in learners full understanding of the scientific concepts then, there should be effective instructional approaches eliciting meaningful acquisition of the scientific knowledge. This kind of instruction should facilitate the transformation of the preexisting incorrect knowledge to scientific one. From this aspect, learning can be viewed as conceptual change and constructivist teaching approaches seem to be effective in providing learning environments in which students use actively the knowledge, construct their views about science, and develop critical thinking.

In 1978-1979 Posner et al.(1982) developed a model of conceptual change. This model is based on constructivist theory in which the new knowledge is constructed through activities aimed at creating conceptual conflict within each learner. According to Posner et al. (1982) conceptual change can be accomplished only if the students are aware of the difficulties that their old conceptions hold, and that new and plausible conceptions which resolve these difficulties are available. The integration of the new knowledge with alternative conceptions is a complex process which undergoes if the four conditions of the conceptual change are met:

1. Dissatisfaction with the existing conceptions
2. Intelligibility of the new conception
3. Plausibility
4. Fruitfulness of the new conception

The conceptual change can be promoted by conceptual change discussions that allow students to exchange their ideas with their classmates and the teacher. Research studies showed that oral discussions develop students' critical thinking and understanding of the concepts (Hogan, Nastasi, and Pressley, 2000). Nussbaum and Novick (1982) in their teaching strategy based on the Piagetian notion of accommodation, used discussion and debating as means of initiating students alternative conceptions and make students aware of their thinking.

Conceptual change discussion was also found as effective means of reducing the students’ misconceptions (Eryýlmaz, 2002).

An effective way to promote the students understanding of abstract concepts is also to perform demonstrations. The use of demonstrations in class help students understand the theories (Walton, 2002) and keep their interest during the lecture. The conceptual change oriented instruction accompanied by demonstrations used in this study was to enhance the students’ understanding and reduce the misconceptions related to gases concepts.

Many research studies showed that the type of instruction affected students’ attitudes toward science as a school subject and that the students attitudes had potential to affect students’ motivation, interest, and achievement in science (Rennie and Punch, 1991; Parker, 2000; Chambers and Andre, 1997; Greenfield, 1996). In this study, the effect of treatment on students’ attitudes toward chemistry was also investigated.

This study also investigated the contribution of science process skills to students’ understanding of gases concepts. Science process skills were described as terminal skills for solving problems or doing experiments (Beaumont-Walters and Soyibo, 2001). Science process skills involve identifying variables, identifying and stating hypotheses, operationally defining, designing investigations, graphing and interpreting data, explaining results and deducing conclusions. Low performance in using science process skills can be considered as important indicator of serious instructional problems (Mestre and Lochhead, 1990).

Literature focusing on improving strategies in conceptual change provides guidelines for designing curricula and teaching strategies taking account of students' alternative conceptions and changing alternative conceptions to scientific conceptions. In this study, the conceptual change oriented instruction accompanied by demonstrations was used to correct misconceptions related to gases. Also, the effects of gender differences and science process skills were investigated with respect to students understanding of gases concepts. The effect of instruction on students' attitudes was also determined.

CHAPTER II

RELATED LITERATURE

Research on students' conceptions in science is based on the idea that the cognitive structure of the learner considerably influences the learning process and the idea that students construct their knowledge actively. Many research studies investigated students' conceptions before instruction, as well as the change of these conceptions during instruction. Conceptions prior to instruction were called as preconceptions, while misconceptions were identified as conceptions formed by instruction itself. Studies on students' conceptions are important from two aspects. Firstly, the researchers to develop their general theories investigate students' conceptions. Secondly, the science educators interested in guiding students to science investigate students' conceptions with the aim of improving science learning (Duit, 1991). Successful instruction would be that which creates learning environments providing students with opportunities to change their incorrect conceptions to scientific conceptions. Learning scientific concepts meaningfully is the main goal of science education. Particularly in chemistry the major obstacle in learning the concepts is their abstract nature. Discussions help teachers to recognize students' ideas about the concepts and also help students to become aware of their thinking. Demonstrations embedded within the instructional sequence are useful tools for introducing the abstract concepts in a concrete form. Constructivist view of learning emphasizes the importance of the affective domain. Instruction based on conceptual change approach, which is rooted in constructivist frameworks, may help teachers to affect the students' attitudes toward or interests in science. On this ground, the literature were examined with respect to students' conceptions, misconceptions in gases, conceptual change approach, discussion, demonstrations, and student's attitude and its relation with achievement.

2.1 Students' Conceptions in Science

The research literature which identifies the students' informal ideas about everyday and scientific phenomena is extensive and has been reviewed by a number of researchers (Driver and Easley, 1978; Osborne, Bell and Gilbert, 1983; Driver, Guesne and Tiberghien, 1985; Eylon and Lynn, 1988; Wandersee, Mintzes, and Novak, 1994). This body of research proposes that students develop some informal ideas which make sense of the world around them. In different studies these informal ideas have been described and named in different ways as preconceptions, misconceptions, alternative frameworks (Driver and Easley, 1978), spontaneous reasoning (Viennot, 1979), children's science (Gilbert, Osborne, and Fensham, 1982), intuitive beliefs (McCloskey, 1983), naive beliefs (Caramaza, McCloskey, and Green, 1981), and alternative conceptions (Hewson and Hewson, 1989). Do all these terms indicate different things or imply same things?

It is well established that, during everyday life, children develop their own ideas that they use to make sense of the natural phenomena they experience in the world around them (Anderson, 1986). Conception is an individual interpretation of the outside world and of the behavior within it. Preconceptions indicate the conceptions formed before formal instruction.

Children's science term also indicate children's idea formed prior to formal science teaching. Children have beliefs about how things happen or have clear meanings for words which are used in everyday language and science (Gilbert, Osborne, and Fensham, 1982). The views which children bring with them to science classes are, to them logical and coherent. But these views influence how and what children learn from their classroom experiences. Gilbert et al. (1982) delineated three ways of interactions of student ideas with classroom instruction. Their first assumption is that students enter classroom with little or no knowledge relevant to the content of instruction. The second assumption supposes that the ideas held by students can be easily displaced by effective instruction. The third assumption recognizes that the students' ideas are resistant to change. The interaction between these stable conceptions and instruction may yield several different outcomes: the students retain their idea intact; the students retrieve both their conceptions and school science knowledge or students may hold a form of synthesis between the two. Of course, the desired situation is students to gain a perspective which resembles that of school science.

Driver and Easley (1978) proposed the term alternative framework to indicate the interpretations that arise from pupils' personal experience of natural events and their attempt to make sense of them for themselves, prior to instruction. Later Driver (1981) used alternate frameworks to indicate the pupils' beliefs which differ from the currently accepted view and from the intended outcome of learning experiences. Schmidt (1997) described the term alternative framework as opposed to the alternative conception as a set of students' ideas that can be seen as a meaningful and logical coherent alternative to a science concept.

Driver and Erickson (1983) defined conceptual framework as the mental organization imposed by an individual on sensory inputs as indicated by regularities in an individual's responses to particular problem settings. They suggested that it would be realistic to plan learning programs over months and years, not hours and days. Also, they concluded that longitudinal studies of students' scientific conceptualizations both during and after formal instruction would make contribution to our understanding of conceptual change.

The term alternative conception (Hewson and Hewson, 1989) is used to describe a conception that in some aspects is contradictory to or inconsistent with the concept. Such inconsistencies usually appear in one or more relations of the conception with other conceptions. Alternative conception often involves more than one concept.

The word misconception has distinguished from the alternative framework on the basis of the source of misunderstanding. The misconception refers to ideas formed as a result of incorrectly assimilation of formal models or theories (Driver and Easley, 1978). In other words, misconceptions are students' ideas which differ from those accepted by experts (Gabel and Bunce, 1994; Nakleh, 1992). Ausubel's theory puts forward an explanatory device to interpret the incorrect assimilation of knowledge. During learning process, it is suggested that pupils are relating new knowledge to existing knowledge. If the cognitive structure holds incorrect conceptions, these incorrect conceptions interfere with subsequent learning. Because of the wrong connections new knowledge can not be connected to pupil's existing structure and misunderstanding of the concept occurs (Nakleh, 1992).

Champagne, Gunstone, and Klopfer (1983), West and Pines (1985), and Osborne and Wittrock (1983, 1985) have summarized findings from the research on children's ideas as following:

1. Children have ideas and views concerning many science topics, even at a young age and before any formal education on the subject.
2. These naive descriptive and explanatory preconceptions are often different in significant ways from scientists' views, but are sensible and useful to the children who hold them.
3. Children's preconceptions often show remarkable consistency across diverse populations. They influence children's understanding of the scientific conceptions presented by their teachers, who are frequently unaware of the existence of such views.
4. Preconceptions are remarkably resistant to change by traditional instructional methods. These student views may remain uninfluenced, or be influenced in unexpected ways, by science teaching.

Students' ideas, no matter how they are named, appear to be students' difficulties in understanding science concepts. The studies on students' conceptions have some consequences for further research on science teaching and learning. Duit (1991) summarizes these as following:

1. To change the aims of science teaching – Science instruction has to convince students that both their everyday conceptions and the science conceptions are conceptions in their own right which are valid in specific contexts only. But Duit's radical proposal is to let students stay with their everyday conceptions which are undoubtedly of value in most everyday situations.
2. To change the content structure of instruction – To change the setup of content to avoid misunderstandings or to challenge conceptions.
3. New teaching aids, for example computer, may help to overcome difficulties
4. To change teaching strategies – There is need of teaching strategies to guide students from their preconceptions to science conceptions. These strategies should aim conceptual change and also consider students needs.
5. To employ strategies of meta-learning – Meta-learning strategies may help to overcome difficulties in learning science. These are strategies for promoting students' insight into their learning processes and enhancing them.
6. To teach teachers constructivistic ideas – "Constructivistic ideas can only work in school practice if teachers are familiar with them and are convinced of their value."

If the goal of science education is to provide a learner with a coherent scientific perspective which he understands, appreciates, and can relate to the environment in which he lives and works then, students should be encouraged to express their views and teachers need to listen to, be interested in, understand and value the views that pupils bring with them to science lessons (Gilbert, Osborne, and Fensham, 1982). Students should be given opportunities to explore new phenomena and ideas; to listen to and appreciate alternative points of view without loosing their self-confidence to comprehend and to act; and to construct their own knowledge (Driver and Erickson, 1983). Only in this way the educators can decide what to do and how to do it.

2.2 Students' Misconceptions in Gases

Gases cause difficulties for children since they are invisible. Children's naive belief of matter is derived from the "seeing is believing" principle. If particles can not be "seen" they do not need to exist. Stavy (1988) puts forward that this invisibility prevents children from forming a concept of gas spontaneously.

In their study, Novick and Nussbaum (1978) interviewed 13-14 years old students to identify their ideas about gases after teaching. The findings showed that 60 % of the students consistently used particle ideas. Another idea that was difficult to be realized was the random motion of particles. Students aged 16 and above seem to understand that gas particles are uniformly distributed in a vessel

(Novick and Nussbaum, 1981), but when asked, “Why do not the particles fall to the bottom?” only around half thought that the particles were in constant motion.

Novick and Nussbaum (1978) asked 13-14 years old students to draw a picture to represent air in a partially evacuated flask. A significant proportion drew air around the sides of the flask, or in a mass at the bottom. Students showing the air composed of tiny particles drew the particles in clumps or occupying only part of the flask. The students explained their reasoning by saying that there are attractive forces that hold particles in place. Their 1981 study revealed that about 20 % of students aged above 16 think “repulsive forces between the particles” prevent particles falling to the bottom of the flask. The ideas of attractive and repulsive forces imply static particles, confirming that particle movement in a gas is difficult to grasp.

Novick and Nussbaum (1978, 1981) investigated students’ answers to the question “What is there between the particles?”. Sample consisted of 13-14 years old Israeli and 10-20 years old American students. Results showed that students have considerable difficulties on the notion that empty space exists between particles. Students arguing that there is something between the particles answered that there is dust and other particles, other gases such as oxygen and nitrogen, air, dirt, germs, may be a liquid, unknown vapors,… Students arguing that there is no space explained that the particles are closely packed or no place is completely empty.

Novick and Nussbaum (1981) report that about 40 % of 16 years old students think increased particle motion is the result of heating a gas. Some part of students aged 16 explain that “particles are forced apart” while another used the idea of repulsive forces. Decreasing in particle motion on cooling seems to be harder than the notion of increased particle motion on heating. Less that 30 % of students aged between 16-18 years yielded correct responses and only 20 % of university students. Approximately 50 % of students at any age responded by saying that particles are able to “shrink”, “condense”, “sink” or “settle”. The idea that cooling of a gas leads to liquefaction was drawn by students pictorially as air accumulating around the sides or at the bottom of the vessel. Approximately 70 % of the students from age 13 to university level used such drawings, pointing that misconceptions about liquefaction are widespread. The possible reason of those misconceptions was explained as students’ efforts to explain the decrease in volume of a gas on cooling not by decreasing particle motion but by increased attractive forces.

Sometimes those students who successfully describe that matter consists of particles assign bulk properties to particles themselves. These kinds of conceptions were revealed in a study carried out with 30 grade-12 Canadian students drawn from 10 high schools (Griffiths and Preston, 1992). Data were collected using interviews. The interview guide consisted of two parts, one related to molecules and the other to atoms. Questions in the first part were about the structure, composition, size, shape, weight, bonding, and energy of water molecules. The second part questions were about the structure, shape, size, weight, and perceived animism of atoms. Subjects were grouped as Academic-

Science, Academic-Nonscience, and Nonacademic-Nonscience according to their academic average and science courses (chemistry, biology, or physics) completed or on completing. Each group consisted of 10 students. At the end of the research, 52 misconceptions were identified. Misconceptions related to gaseous state of water were as following:

- Water molecules from the gaseous phase (steam) are the smallest/largest.
- Water molecules from the gaseous state are the lightest.
- Matter exists between atoms.
- Collisions may result in a change of atomic size.

Nurrenbern and Pickering (1987) examined students' abilities to solve the conceptual problems related to gases. They conducted the study in the general chemistry program at two universities, on different classes ranging in size from 14 to 99 students. As part of routine class examinations students were asked to do both a traditional problem on gases (either Boyle's law, Charles's law, or the combined gas law) and also to do a multiple-choice question that had no mathematical content but asked for a purely conceptual understanding of gases. The results of the study revealed that students were more successful in solving the traditional type questions. The researchers claimed that teaching students to solve problems about chemistry is not equivalent to teaching them about the nature of matter. Students can be able to solve problems about gases without knowing anything about the nature of a gas.

De Berg (1995) also studied students' performances on solving qualitative and quantitative tasks. Paper and pencil test was administered to 101 students (17- and 18-year-olds). Students were supposed to solve tasks related to Boyle's law which did not require the use of a mathematical equation for its solution. Questions showed different states of compression of air in a sealed syringe. The results showed that 34 % and 38 % of students did not understand the concepts of volume and mass, respectively, of a gas under such conditions. Students' performance on an inverse ratio (2:1) task was found to be gender dependent. Students answering correctly to the qualitative tasks also answered correctly the quantitative tasks. The researcher suggests that the use of tasks requiting qualitative solutions have potential to reduce the dependence on algorithms.

Sanger, Phelps, and Fienhold (2000) developed an instructional approach to improve students' conceptual understanding of the molecular processes occurring when a can containing water is heated, sealed, and cooled. Two groups, control and experimental were taught by different kinds of instruction. The control group consisted of 70 students received instruction using static chalkboard drawings and overhead transparencies. The experimental group, 86 students, received the similar instruction including the use of a computer animation of this process at the molecular level. The can-crushing demonstration in which a soda can containing small amount of water was heated on a hot plate to boil the water, removed from the heat and sealed by inverting over a container of cold water was shown to all students. The students in the experimental group in addition, viewed the computer animation. The students were asked to predict what happen to the can and to explain what happen at molecular level. The students in the experimental group were more likely to predict that can would collapse and were less likely to quote memorized mathematical relationships. The students in the control group quoted gas laws in their predictions. Some of the misconceptions identified among control group students are as follows:

- The gas molecules when heated are expanded and when they cool they shrink back not taking up as much space as before.
- The gas molecules take the shape and volume of the container they are in.
- The water vapor inside it would continue to press out against the can due to Charles law, and the can would possibly explode if the pressure was large enough.

Lee et al. (1993) conducted study to examine students' conceptual frameworks that students use to explain the nature of matter and molecules, and to assess the effectiveness of two alternative curriculum units in promoting students' scientific understanding. The study involved 15 sixth-grade science classes taught by 12 teachers. Data were collected through paper-and-pencil tests and clinical interviews for two consecutive years. The clinical interview included eight major tasks, each with several subtasks, concerning the nature of matter, three states of matter, expansion and compression of gases, thermal expansion, dissolving, melting and freezing, boiling and evaporation, and condensation. The interviews were administered to 24 target students before and after instruction each year. The results revealed that students tended to attribute observable properties to molecules themselves. For example, students argue that the ice molecules would be colder than the ones in the water. Also, students believe that air flows like water from one place to another, and thus, is unevenly distributed. On question why gases are compressible and liquids are not students focused on observable differences between air and water. Some students said that they were unable to compress water in a syringe because water is “harder” or “heavier” than air. On a task that required to predict what would happen to a balloon on top of a cold bottle when the bottle warmed up most of the students predicted that the balloon blow up or get larger because of hot air or heat, rather than thermal expansion. Thus, students believed that air in the bottle moved from the bottom to the top, and therefore, there was hot air at the top and cold air at the bottom. Another misconception was that when a substance evaporates it no longer exists. About the second part of the study the results showed that the students taught by the revised unit in Year2 performed significantly better than the students taught by the original commercial curriculum unit in Year1.

Case and Fraser (1999) investigated students’ understanding of the mole concept. The subjects were selected among first year chemical engineering students formally taught about mole concept. Interviews were conducted with 15 students to reveal their misconceptions related to mole concept. Although the study explored misconceptions related to mole concept misconceptions realted to gases were also identified. According to the studens explanations the volume of a gas was not proportional to its amount. This difficulty increased when students were presented with a system containing mixture of gases. The students tended to think that the mixture contained more molecules since it was made of different kinds of gases.

Hesse and Anderson (1992) investigated students' conceptions of chemical change. Subjects of the study consisted of 100 high school juniors and seniors in beginning chemistry class. All 100 students were administered a written test at the end of the six-week unit on chemical change. The unit included both laboratory activities and class discussions. From the 100 students, 11 were chosen for clinical interviews. The interview questions were on the students' answers given to the questions in the previously administered written test. The results showed that students consistently ignored both the existence and the substantive nature of gaseous products or reactants. Researchers discussed that the naive conceptions form the basis of explanations which focus upon analogies to everyday events and that the textbook authors should also help teachers become aware of the common naive conceptions students bring to chemistry classrooms. The results of the study also showed that traditional teaching methods are ineffective in helping students learn this topic. In addition, it was emphasized that there is a need of teaching methods and materials that can address specific naive conceptions and permit students to investigate their effectiveness. Furthermore, Hesse and Anderson put forward that schools of education need to include conceptual change teaching techniques as part of their method courses for prospective science teachers.

Stavy (1988) conducted study to find out how the concept gas develops in Israeli students. The sample consisted of students from the fourth grade to the ninth grade. Seventh grade students were tested after they had studied the topic The Structure of Matter. Each age group included 20 students. Each student was interviewed independently while being shown materials and processes. Two identical tasks were shown to students. First task was gas escaping from a CO_2

cartridge and gas escaping from soda water. After each task the students were asked about the weight of the cartridge or soda water before and after the gas escaped. The second task was a question about what the term gas means. The students in the fourth to sixth grade answered incorrectly except seventh graders, most probably as a consequence of learning the topic. The incorrect answers to the question were:

- The weight does not change after the release of gas (because of the students' idea that gas is weightless).
- The weight of the water rises after the gas is releasing from it (because of the students' idea that gas is light or gas adds lightness).

In another study Stavy (1990) examined Israeli children's (ages 9-15) conceptions of changes in the state of matter from liquid or solid to gas, as well as their understanding of the reversibility of this process. Each student was interviewed while being shown the materials and the processes. First task was related to the evaporation of acetone. The subjects were presented with two identical closed test tubes, each containing one drop of acetone. The acetone in one tube was heated until it completely evaporated. The students were asked about the conservation of matter and conservation of properties of matter such as smell. Also the conservation of weight and reversibility of the process were asked. The second task was related to the sublimation of iodine. The subjects were presented with two identical closed test tubes, each containing an iodine crystal of identical size. The iodine in one tube was heated, upon which it turned completely to a purple gas filling the entire volume of the test tube. The students were asked about the conservation of matter and conservation of properties of matter such as smell.

Also the conservation of weight and reversibility of the process were asked. It was found that the students who recognize the conservation of mass in one of the tasks did not necessarily recognize the conservation of mass in the second task. Students' beliefs were:

- Gas is lighter than the same material in its liquid or solid state.
- Gas has no weight.

Students who perceived the conservation of matter, properties, and weight in their explanations focused on the facts that "the tube was closed" and "the material only changed its state or form". Common incorrect explanations about reversibility were that the matter was no longer present and therefore it was not possible to retrieve it or simply that gas cannot be changed back into liquid.

The conservation of mass seems to be a difficult for understanding when it also should be applied to reaction involving reactants or products in gaseous state. Based on the "genetic epistemology" hypothesis that students' scientific conceptions resemble the historical development of the science Furio Mas, Perez, and Harris (1987) conducted a study at 12 schools with 1198 students in age from 12 years to 17-18 years. They prepared a simple test consisting of two questionnaires of four questions. Questionnaire 1 included four items about an experiment involving the complete vaporization of a liquid in a hermetically sealed container. They asked about conservation of substance, of weight, and of mass. Questionnaire 2 also included four items which asked students to predict what would happen to the weight of various substances in a number of chemical processes, which included the apparent disappearance of material due to the involvement of gases. The test was administered to all students. The results showed that students apply conservation of mass to substances while they ignore this law for weight and mass conservation. Also, the results showed that, in every age group, there is a significant difference in the proportion of students holding conception that gases are substances without weight, and the proportion of correct answers increases with age. The researchers, in addition, suggested the use of conceptual change strategies to enhance the students' understanding of phenomena involving gases.

Benson, Wittrock, and Baur (1993) investigated students' preconceptions in gases. The study included 1098 students from second grade to university. Demonstration was performed for the elementary, junior high and senior high students, while high school and university students were given a piece of paper that outlines two flasks in the demonstration. Demonstration began by showing two identical airtight flasks. Both flasks were opened to the air in the room and then closed. The first flask was left in this condition. The air in the second flask was removed by using a large syringe connected to the rubber tubing. The participants were told to look at the two flasks with "magic magnifying spectacles" and to draw what they see. The students' drawings revealed the following misconceptions:

- Air is a continuous (nonparticulate) substance.
- Gas behavior is similar to liquid behavior.
- There is relatively little space between gas particles.

Séré (1986) investigated the ideas 11 years olds have about gases prior to teaching. She found that children associate gases with the use and function of objects, like footballs, tires and suction pads. Children’s ideas like “hot air rises” and “air is everywhere” were often expressed. Also, air was frequently described as being alive, for example, “air always wants to expand everywhere”. These ideas may arise through experience of draughts and wind as well as using air around the home.

Paik et al. (2004) investigated students’ conceptions of state change and conditions of state chages. Subjects were selected among kindergarteners, second grade, fourth grade, sixth grade, and eighth grade studenrs. Five students from each level, total of 25 students, were interviewed on tasks related to boiling, condensation, melting and solidification. Second grade students tended to explain that vapor changes to gas, air, steam, or wind. The upper grade students had some conceptions of the invisible gas state but few of them could explaine the conditions of state changes.

Lonning (1993) conducted a study in which he examined the effectiveness of cooperative learning strategies on students’ verbal interactions and achievement in tenth grade general science. Subjects consisted of 36 tenth grade students. Test of conceptual understanding was used to measure the students’ achievement in understanding the concepts presented during instruction. The test was consisted of five open-ended questions about the particulate nature of matter. Also Verbal Interaction Scheme was used to categorize verbalizations that took place while students worked in groups. Some naive conceptions related to air were identified as follows:

- In compressed air the particles are compacted like a solid and do not move.
- Particles of air are surrounded by air.
- Air particles are very far apart.
- Cookie smell is made of particles but air is not. The smell is carried out through the air.
- When the air is compressed, the particles stick together.
- Warm air is thicker cool air is thinner.

Lin and Cheng (2000) investigated students' and chemistry teachers' understanding of gas laws. The subjects were 119 11^{th} grade students and 36 high school chemistry teachers. The researchers used a 4-item open-ended pencil-and-paper test asking to predict the results of a demonstration or to explain or draw a diagram. Two items were related to Boyle's law, one about Charles's law and one requiring drawing the molecular behavior after heating a gas mixture. All of the questions were qualitative, that is, did not required arithmetic calculations. The analysis of the students' and teachers' answers revealed that students misuse PV=nRT formula; they can not apply the Boyle's law to explain qualitative question; subjects failed to distinguish between "system" and "surrounding". Also the study revealed three major misconceptions of kinetic theory:

- Molecules were pushed down by the atmospheric pressure.
- Molecules stay away from heat.
- Molecules expand when they are heated.

She (2002) examined the process of conceptual change in respect of air pressure and buoyancy as result of instructing with the Dual Situated Learning Model. Twenty 9th grade Taiwanese middle schol students partiipated in the study. Some of the students' perceptions related to air pressure in a syringe before treatment were as followings:

- Syringe cannot be pressed because air pressure exists inside the syringe.
- The syringe cannot be pressed because air occupies space.

Reseracher used interview-about-events technique to elicit students' understanding about concepts before demonstrations. After exposing students to demonstrations the students were asked to "think aloud" in order to understand the process of conceptual change. Results demonstrated that the notion of buoyancy required more dual situated learning events for conceptual change to occur than that for air pressure.

2.3 Conceptual Change Teaching Strategies

Constructivist approaches emphasize the idea that knowledge can be constructed and the learner is the active builder of his/her knowledge. According to constructivist view of learning the connection of the new knowledge to the existing knowledge is important in order to promote meaningful learning. Teachers should take into consideration the students' prior knowledge because it is the most important factor effecting the meaningful acquisition of the concepts. The answer of the question, "How the prior knowledge can be connected with the new knowledge?" is related to conceptual change.

Conceptual change can be accomplished through three kinds of instructional strategies: (1) the induction of cognitive conflict through anomalous data; (2) the use of analogies to guide students' change; and (3) cooperative and shared learning to promote collective discussion of ideas.

Nussbaum and Novick (1981) presented a design for learning activities which embodies a cognitive conflict strategy: students are expected to restructure their conceptions in order to accommodate results that present discrepancies when compared to predictions and explanations derived from their own ideas. This sequence occurs in the following order:

1. The teacher creates a situation which requires students to invoke their frameworks in order to interpret it.
2. The teacher encourages the students to describe verbally and pictorially their ideas.
3. The teacher assists them, non-evaluatively, to state their ideas clearly and concisely.
4. Students debate the pros and cons of the different explanations that have been put forward. This will create cognitive conflict within many of those participating.
5. The teacher supports the search for the most highly generalisable solution and encourages signs of forthcoming accommodation in students.

Rowel and Dawson (1979) introduced three form of resolution that may occur between pairwise conflicts. First form, the logical force of one of the alternatives may be obvious to an individual student. Second form, the student may consider an analogous situation to the one under consideration and see one alternative as more effective there. Third form, neither of the alternatives seems entirely appropriate, so unifying ideas is constructed.

In a study on students' concepts of temperature, Stavy and Berkovitz (1980) designed exercises which would try to bring the children's qualitative-verbal, representation system into conflict with their quantitative-numerical, representation system. The researchers expected that the instructional materials would yield resolution of this conflict and result in both representation systems predicting similar final temperatures in water-mixing experiments.

Posner et al. (1982) established a theory that attempted to explain how "people's central, organizing concepts change from one set of concepts to another set, incompatible with the first" (p. 211). They explained two types of conceptual change, assimilation and accommodation. The first type, that is assimilation, occurs when "students use existing concepts to deal with new phenomena". The second form of conceptual change, that is, accomodation occurs when "the student must replace or reorganize his central concepts". In their study they have focused on the second type of conceptual change and described four conditions that must be fulfilled before this type of change to occur:

1. There must be dissatisfaction with existing conceptions. The individual must realize that the existing conceptions create difficulties or do not

work before considering a new one. The major source of dissatisfaction is the anomaly. An anomaly exists when one is unable to assimilate something.

2. A new conception must be intelligible. The individual must be able to grasp how experience can be structured by a new concept sufficiently to explore the possibilities inherent in it. Finding theories intelligible requires more than just knowing what the words and symbols mean. Ýntelligibility also requires constructing or identifying a coherent representation of what a passage or theory is saying. Analogies and metaphors can make the new ides intelligible.
3. A new conception must be plausible. That is, the learner should believe that the conception is true and consistent with other knowledge.
4. A new concept must be fruitful. The learner should be able to solve new problems by using the new conception.

These conditions do not define directly what teachers or students should do in the classrooms. Teachers must help students to meet each of the conditions to achieve conceptual change.

Hewson and Hewson (1983) suggested teachers to ensure that students find new content intelligible, plausible, and fruitful by taking account of prior knowledge. Because a conception presented by the teacher can be plausible to one student but not to another. Based on this ideas they proposed a new approach to conceptual change including new teaching strategies as integration, differentiation, exchange and conceptual bringing. These teaching strategies were applied to 90 9^{th} grade students to teach density, mass and volume concepts. The results of the study indicated that the instructional strategy used in the experimental group was responsible for the acquisition of a significantly greater number of scientific conceptions of density, mass, and volume.

One of the common techniques to help students to change their old and inappropriate idea to scientific ones was to use of refutational texts (Guzzetti et al., 1993). But some of the educators argue that telling students how the world work in a text cannot be as effective as having students experience scientific notions of the world through experimentation (Lloyd, 1990; Newport, 1990; Osborne, Jones, and Stein, 1985).

Demonstration when combined with other techniques was also found to be effective (Swafford, 1989; Hynd, Alvermann, and Qian, 1997). Hynd et al. (1997) investigated changes in preservice elementary school teachers' conceptions about projectile motion. The teachers (n=73) were randomly assigned to groups where the concepts were the lessons were carried out using combinations of text and demonstration techniques. Demo-text condition was found effective in short-term assessment while only text condition was found to be effective in producing long-term change.

Cosgrove and Osborne (1985) reviewed several instructional models and proposed a generative learning model of teaching which suggests:

1. The teacher needs to understand the scientist views, the children views and his or her own views in relation to the topic begin taught.

2. Children must have opportunity to explore the context of the concept within a real situation and needed to engage to clarify their own views as clearly as in the learning process.
3. Students debate their ideas with each other and teacher introduces the science view where it is necessary. This requires the teacher to make the concept intelligible and plausible by experimentation, demonstration or reference to analogy.
4. Teacher should provide opportunities for application of new ideas based on commonplace.

Discussion was also found to be an effective means of eliciting conceptual change (Guzzetti et al., 1993; Eryýlmaz, 2002; Nussbaum and Novick; 1982).

Driver and Oldham (1986) proposed a teaching sequence for promoting conceptual change from a constructivist point of view:

1. Orientation: a context for the instruction is presented and relevance of the topic to the students established.
2. Elicitation: students are given opportunities to make their personal conceptions explicit to other students, the teacher, and most importantly, to themselves.
3. Restructuring, modification, and extension: involves activities designed to allow students to exchange ideas with peers and construct and evaluate new ideas.
4. Application: provides opportunities for students to try out their newly constructed concepts in familiar and new contexts.

Conceptual change for students and teachers is viewed not just as a process of replacement of old ideas but also as a process of learning to relate ideas to appropriate contexts.

2.4 Discussions: Tools for Conceptual Change

The role of discussion in learning is widely acknowledged and its function is interpreted within a number of theoretical perspectives. While Piagetian perspective points out the personal construction of the knowledge, Vygotsky' emphasizes the construction of knowledge as a social process. The talk with peers and the teacher is at the center of students' conceptual understanding. The exchange of ideas in science classes can occur by different means as lectures, recitations, guided-discussions, student-generated inquiry discussions, and small group interactions. In science classes teachers frequently direct questions that ask "what students believe and why" (van Zee et al., 2001; van Zee and Minstrell, 1997b; Roth, 1996).

During a lecture the teacher is the active person and makes efforts to transmit knowledge to students. The content of such knowledge generally consists of facts. Students' responsibilities during lectures are to listen and remember. Recitations are similar to lectures. As with lectures the knowledge typically consists of facts and procedures. The teacher is responsible for judging the students' answers, while students are responsible for giving answers that agree with those intended by the teacher.

Student-generated inquiry discussion differs from previous two kinds of discussion in terms of knowledge constructed by the students. The knowledge involves more than memorizing. Students ask questions one another and explain their understandings. Students question frequently and spontaneously. The students are responsible for creative woks and inventing their own ways of thinking.

Small group-interactions with the teacher present are similar to guided discussions, while in small interactions, without the teacher present, the students construct their knowledge by asking one another questions. Additionally students explain their understanding and do tasks that provide a necessary link for their asking and explaining. Small group discussions were found to be effective in providing students the opportunity to develop learning skills and increasing their reasoning (Alexopoulo and Driver, 1996; Gayford, 1993). Also, Weaver (1998) emphasized that the students favored laboratory or hands-on activities and this kind of activities could promote conceptual change when combined with discussion and reflection.

Guided discussions often evolve from small group interactions. During a guided discussion, a teacher helps students to construct knowledge by interpreting and asking questions to develop their understanding of a concept. In such discussions, the teacher is responsible for eliciting the students thinking and facilitating the students expressing their own ideas, especially when these are different from the teacher's expectations. One of the most important properties of the guided discussions is that teacher basically asks conceptual questions to elicit student thinking. In guided discussions the teacher primarily direct questions such as “Do you think so? Tell me why?” (van Zee et al., 2001; Settlage, 1995).

Van Zee et al. (2001) emphasized that the key aspect of asking questions that develop conceptual understanding is eliciting students’ experiences. The second important is diagnosing and refining student ideas. In their study, guided discussions were assisted by demonstrations to initiate reasoning and reveal what students find confusing. During discussion of the activities the teacher frequently asked questions, such as “what is your evidence for that idea? What might you infer from that observation?”. They suggested that the teachers who guide discussions firstly “must decide how to respond to the students’ thinking”.

As a part of the process of exploring and comprehending information presented, discussions were used as tools of improving scientific or other kind of understanding (Solomon, 1992).

Considering that discussion makes students aware of their understanding discussions were integrated in teaching strategies dealing with remedying students misconceptions (Nussbaum and Novick, 1982, Erýlmaz, 2002). Nussbaum and Novick (1982) developed a teaching strategy based on the Piagetian notion of accommodation in which used discussion and debating as means of initiating students alternative conceptions about the particulate nature of matter and make students aware of their thinking. Erýlmaz (2002) also showed that conceptual change discussion is an effective method of reducing students’ misconceptions about force and motion.

Solomon (1992) also put forward that discussion can be an appropriate way to enhance students understanding of “controversial issues”.

In this study, teacher guided discussions were used as a part of the conceptual change instruction to initiate students’ alternative conceptions, clarify where the students are wrong and develop their understanding of gases concepts.

2.5 Demonstrations

The traditional approach to teaching chemistry includes the use of the symbolic representation of matter. This approach points out the use of chemical and mathematical symbols and equations (Johnstone, 1991). Many research studies showed that students are successful in solving algorithmic problems using formula without understanding the underlying chemistry concepts (Bunce, Gabel, and Samuel, 1991; Nurrenbern and Pickering, 1987). Teaching chemistry using demonstrations or real world examples helps to introduce chemistry topics at macroscopic level. The word macroscopic refers to something that is large enough to be seen with naked eyes (Johnstone, 1991). Demonstrations are one of the macroscopic approaches serving to teach chemistry.

Chemistry to be understood fully needs to be experienced either visually or cognitively. Teaching chemistry concepts through demonstrations can benefit students at the time of the demonstrations or later on. Demonstrations help teacher to attract students’ attention to the subject, makes students more interested and focused on what may happen. Thus, students become more enthusiastic about spending time studying the topic comprehensively. Teaching accompanied by demonstrations helps strengthen students' understanding of scientific phenomena. Demonstrations have become important cognitive aids that reflect real-life scientific concepts and laws.

Glasson (1989) investigated the effectiveness of teaching with hands-on and teacher demonstration laboratory methods on declarative (factual and conceptual) and procedural knowledge (problem-soling) achievement. Students enrolled in hands-on laboratory method class worked on the apparatus, collected data and made calculations, while in demonstration class the teacher worked on the apparatus and collected data, and students did some calculations on the data. He found that although there was no difference between with respect to declarative knowledge, there was a significant difference with respect to procedural knowledge. The students taught with hands-on laboratory method were able to link related ideas that they experienced, and construct integrated knowledge.

Hugo (1993) expressed that students will be more interested and open-minded if the demonstration addresses an issue that students perceive as being important in their lives. Additionally, if teacher is able to use the demonstration continuously as a pathway to future learning then the value of such a demonstration will be further enhanced.

A demonstration by a professionally trained chemistry teacher can show exciting effects and properties, also such a demonstration help to promote and maintain interest in chemistry (Iddon, 1986). Gunstone and Champagne (1990) argued that laboratory work could successfully be used to promote conceptual change if small qualitative laboratory tasks are used and accompanied with discussion and reflection.

To teach chemistry topics at university level Miller (1993) used demonstration-exploration-discussion method (D-E-D). Miller states that although the process is linear-lesson begin with demonstration then go to exploration and finally, to discussion-in practice it is much dynamic. Miller compared achievement chemistry courses of students taught by D-E-D and students taught by traditional lectures. The results showed that the D-E-D method had no effect and students showed about the same achievement. But Miller argued that teaching with D-E-D method fosters active student participation and creativity, and facilitates learning chemistry. D-E-D method was defended as method replacing the teacher as the source of knowledge and the center of activity. Learning to respect diversity, to work cooperatively, to ask questions, to explore, and to invent were explained as positive outcomes of the D-E-D method.

Demonstrations are useful tools in order to foster conceptual understanding but they must be carefully selected. If a series of demonstrations is to be used, then the demonstrations should deal with a single concept. In contrary, conceptual confusion may occur. Extraneous variables, which can distract children from constructing the intended meaning, should not be observable to children. Demonstrations should be performed in place which is visible for all children. Demonstrations should be supported by additional activities in order to enable students to test their conceptual understanding they construct as a result of observing demonstration (Shepardson, Moje, and Kennard-McCelland, 1994).

Benson et al. (1993) suggested that simple, visible, and believable demonstrations that stimulate cognitive conflict might prove to be an effective technique for promoting the desired conceptual changes. Baker (1999) also put forward that a good lecture-demonstration should include reliable and reproducible demonstrations.

2.6 Attitude and Achievement: Is There a Relationship?

Attitude toward science is another possible factor affecting the students' science achievement as well as students' alternative conceptions or misconceptions. Many research studies focused on the relationship among instruction, achievement and attitude and results provided evidence that there is a relationship among instruction, achievement and attitude (Duit, 1991; Francis and Greer, 1999; Greenfield, 1996; George, 2000; Koballa and Crawley, 1985; Rennie and Punch, 1991).

Francis and Greer (1999) investigated secondary school pupils' attitudes toward science. Sample consisted of 2129 students in the third, fifth and lower sixth years of Protestant and Catholic grammar schools in Northern Ireland. Results demonstrated males have more positive attitude toward science than females and that younger pupils have more positive attitude toward science than older students.

George (2000) examined the change in the students' attitudes toward science over the middle and high school years using data from the Longitudinal Study of American Youth. The results of the study showed that students' attitudes toward science generally decreased over the middle and high school years. Teacher encouragement of science and peer attitudes were also found as significant predictors of students' attitudes, while the effects of parents were found to be quite small and statistically non-significant, with the exception of the seventh grade in the study.

Uzuntiryaki (2003) investigated the effect of constructivist teaching approach on students understanding of chemical bonding concepts and attitudes toward chemistry as a school subject. The results of the study indicated that the instruction based on constructivist approach had a positive effect on students' understanding of chemical bonding concepts and produced significantly higher positive attitudes toward chemistry as a school subject than the traditionally designed chemistry instruction.

Çetin (2003) examined the effect of conceptual change based instruction on ninth grade students' achievement and understanding levels of ecology, attitudes towards biology, and attitudes towards environment. She found that the conceptual change texts oriented instruction accompanied by demonstrations in small groups had a significant effect on students' understandings of ecological concepts. Her study results also showed that the treatment had no significant effect on the attitudes towards biology and attitudes towards environment.

However, there are some studies that did not support the positive relationship among instruction, achievement, and attitude. Kesamang and Taiwo (2002) studied the relationship between Botswana junior secondary school students' attitudes toward science and their science achievement. They found that there was significant negative relationship between students' attitudes towards science and their science achievement.

The extensive research on students' conceptions shows that students have misconceptions that influence their understanding of the science concepts during and even after instruction. Chemistry is one of the difficult science subjects. Especially, students have difficulties in understanding concepts which can not be visualized. Gases concepts because of their abstract nature are difficult to be learned. Incorrect interpretations of daily experiences about gases also add some incorrect conceptions to the students' minds. Conceptual change based teaching methods seem to be effective in remedying students' misconceptions. For this reason, in this study, we examined the effectiveness of the conceptual change oriented instruction accompanied by demonstrations on students' understanding of gases concepts and their attitudes toward chemistry as a schools subject when students' science process skills were controlled.

CHAPTER III

PROBLEMS AND HYPOTHESES

3.1 The Main Problem and Sub-problems

3.1.1 The Main Problem

The main problem of this study is:

What are the effects of conceptual change oriented instruction accompanied by demonstrations and gender on tenth grade students' understanding of concepts related to gases, and attitudes toward chemistry as a school subject?

3.1.2 The Sub-problems

In this study the following sub-problems have been stated:

1. Is there a significant mean difference between the effects of conceptual change oriented instruction and traditionally designed chemistry instruction on students' understanding of concepts related to gases when the effect of science process skills test is controlled as a covariate?

2. Is there a significant difference between females and males in their understanding of concepts related to gases concepts when the effect of science process skills test is controlled as a covariate?
3. Is there a significant effect of interaction between treatment and gender with respect to students' understanding of concepts related to gases concepts when the effect of science process skills test is controlled as a covariate?
4. What is the contribution of students' science process skills to their understanding of concepts related to gases?
5. Is there a significant mean difference between students taught trough conceptual change oriented instruction and traditionally designed chemistry instruction with respect to their attitudes toward chemistry as school subject?
6. Is there a significant mean difference between males and females with respect to their attitudes toward chemistry as a school subject?

3.2 Null Hypotheses

$H_0 1$: There is no significant difference between the post-test mean scores of the students taught with conceptual change oriented instruction and students taught with traditionally designed chemistry instruction in terms of concepts related to gases when the effect of science process skills is controlled as a covariate.

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

$H_0 3$: There is no significant effect of interaction between treatment and gender on students' understanding of concepts related to gases when the effect of science process skills is controlled as a covariate.

$H_0 4$: There is no significant contribution of students' science process skills to understanding of concepts related to gases.

$H_0 5$: There is no significant mean difference between students taught with conceptual change oriented instruction and traditionally designed chemistry instruction with respect to their attitudes toward chemistry as a school subject.

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

CHAPTER IV

DESIGN OF THE STUDY

4.1 The Experimental Design

In this study the Non Equivalent Control group design as a type of Quasi-Experimental design was used (Gay, 1987). The research design of the study is presented in Table 4.1.

Table 4.1 Research Design of the Study

Group	Before Treatment	Treatment	After Treatment
EG	GCT ASTC, LSI SPST	CCID	GCT ASTC
CG	GCT ASTC, LSI SPST	TI	GCT ASTC

In table 4.1, EG represents the experimental group instructed by the conceptual change oriented instruction accompanied by demonstrations (CCID). CG represents the control group instructed by the traditional instruction (TI). While the control group was instructed by TI that involved lecturing, the experimental group was instructed by conceptual change oriented instruction accompanied by demonstrations.

GCT is the Gases Concept Test, ASTC is the Attitude Scale toward Chemistry, SPST is the Science Process Skills Test, and LSI is the Learning Style Inventory. To investigate the effect of the treatment on students' achievement and understanding levels of gases, attitudes towards chemistry, the GCT and ASTC were administered to all subjects as pre- and post-tests. Additionally, the SPST and LSI were given to all subjects only before the treatment.

Two teaching methods were randomly assigned to the classes. The equivalence of the groups with regard to initial level of understanding of gases concepts and their attitude toward chemistry was ascertained from the pre-tests (ASTC, GCT). Experimental and control groups were trained by the same teacher. She has 19 years previous teaching experience of high school chemistry. Each group instruction was three 45-minute sessions per week and the topic was addressed over a 6-week period. Before the treatment, the teacher was informed what the conceptual change oriented instruction accompanied by demonstrations was and how it could be used. The control group received traditional instruction based on lecturing and discussion in class. Although the experimental group was taught by conceptual change oriented instruction accompanied by demonstrations, both of the groups got the lessons in their classrooms. Experimental and control groups were assigned the same homework questions and used the same textbook. The teacher allowed the researcher to observe the groups during the treatment.

Prior to the treatment, pilot test of Gases Concept Test was conducted. The sample of GCT was chosen according to stratified sampling. The pilot GCT was administered to 175 tenth grade students from two high schools in the Fall Semester of 2003-2004.

4.2 Population and Sample

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

The subjects of this study included 100 tenth grade students from two randomly selected science classes taught by the same teacher. The study was carried out during the Fall Semester of 2003-2004.

The classes were chosen among four science classes at a public high school by a random sampling. Two teaching methods were randomly assigned to the classes. The experimental group consisted of 49 students while the group instructed by the traditional instruction consisted of 51 students. There were 27 female and 22 male students in the experimental group. Students' ages ranged from 15 to 17 years. In the experimental group dominant learning style was assimilating learning style. Twenty-one students showed preference in assimilating learning style. Ten of the experimental group students were divergers. Students prefering converging and accommodating learning styles were in equal proportions. Nine students showed converging learning style and nine students showed accommodating learning style. In the control group there were 25 female and 26 male students whose ages ranged from 14 to 17 years. In the control group as in the experimental group, assimilating learning style was dominant with 28 students. The second one was converging learning style with 11 students. Divergerging learning style was prefered by 7 students, while accommodating learning style was prefered by 5 students.

4.3 Variables

4.3.1 Independent variables

The independent variables of this study were two different types of instruction (conceptual change oriented instruction accompanied by demonstrations and traditional instruction), gender, science process skills test scores (SPST), and learning style inventory scores. SPST was considered as continuous variable and was measured on interval scale. Instruction type or treatment, gender, and learning styles were considered as categorical variables and were measured on nominal scale. Treatment was coded as 1 for the experimental group and 2 for the control group. Students' gender was coded as 1 for female and 2 for male students. Scores obtained from learning style inventory (LSI) were used in categorizing students according to the four learning styles as diverger, assimilator, converger, and accommodator.

4.3.2 Dependent variables

The dependent variables in this study were students' conceptual understanding of gases concepts measured by post-GCT and students' chemistry attitude scores measured by post-ASTC. Post-GCT and post-ASTC were measured by the Gases Concept Test (GCT) and the Attitude Scale toward Chemistry (ASTC), respectively.

4.4 Instruments

There were five tools used to collect data used in addressing the research questions of the present study. These were the Gases Concept Test (GCT), Attitude Scale toward Chemistry (ASTC), Science Process Skills Test (SPST), and Learning Style Inventory (LSI). Additionally, interviews were conducted with the students from experimental and control groups. Structured interview was conducted with the teacher to take her opinion about the effectiveness of the conceptual change oriented instruction accompanied by demonstrations. Non-systematic classroom observations were carried out in the experimental and control groups by the researcher.

The conceptual change oriented instruction, which was introduced to the students in the experimental group, was accompanied by demonstrations that were prepared as result of a careful examination of the literature, and variety of chemistry textbooks.

4.4.1 The Gases Concept Test

The test was developed by the researcher. Prior to the selection and development of the test items, the instructional objectives of the Gases unit were stated (See Appendix A). Tenth grade chemistry textbooks, chemistry questions asked in the University Entrance Exam, and questions used previously in the studies related to students' misconceptions regarding gases were used in constructing the Gases Concept Test (GCT). The test was examined by three experts in chemistry education and by the chemistry teacher for the appropriateness of the questions to the instructional objectives.

Prior to the treatment, pilot test of Gases Concept Test was conducted. The sample of GCT was chosen according to stratified sampling. The pilot GCT was administered to 175 tenth grade students from two high schools in the Fall Semester of 2003-2004. Students' GCT scores ranged from 0 to 40. The alpha reliability of the test was found to be 0.78.

The test consisted of 40 five-alternative multiple-choice items: while 29 of them were qualitative questions, 11 of 40 were quantitative questions (See Appendix B). Each item has one correct answer and four distracters. The qualitative questions tested the students conceptions with respect to the given gas concept. Because the students' conceptions might be misconceptions the distracters of the qualitative questions involved these misconceptions. The quantitative questions required arithmetical calculations based on gas laws formula. The classification of the students' misconceptions was constructed as a result of the examination of the literature related to the gas concepts (see Table 4.2).

Table 4.2 Classification of Students' Misconceptions Probed by GCT

Misconceptions	**Item**
Conservation of matter applies to solids and liquids, but may be ignored for gaseous reactants and products.	13
Molecules increase in size with change of state from solid to liquid to gas.	1
Gases have no mass.	13, 18
The decrease in volume as a gas cools is due to increased attractive forces between particles, rather than decreased molecular motion.	8
The energy gradually dies, so the gas motion stops and balloon deflates.	6
Matter exists between atoms.	9
Collisions may result in a change of atomic size.	6
The particles in a gas are unevenly scattered in any enclosed space.	15
Heated air weighs more than cold air.	19
Hot air weighs less than cold air.	19
Air neither has mass nor can it occupy space.	19
An evacuated can or deflated bike tire has less pressure inside than out.	17
Pressure acts downward only.	22
In compressed air the particles are compacted like a solid and do not move.	4
When heated the molecules expand, when cooled they shrink.	8
When the air is compressed, the particles stick together.	4
The air particles are all pushed to the end of the syringe.	4
Misuse of Boyle's law	14
Misuse of Charles's law	16
Gas behavior is similar to liquid behavior.	20

4.4.2 Attitude Scale toward Chemistry (ASTC)

The previously developed scale (Geban et al., 1994) was used to measure students' attitudes toward chemistry as a school subject. This scale consisted of 15 items in 5-point likert type scale: fully agree, agree, undecided, disagree, and fully disagree. The reliability was found to be 0.83. This test was given to students in both groups before and after the treatment (See Appendix C). It covered both positive and negative statements. Total possible ASTC scores range is from 15 to 75. While lower scores show negative attitudes toward chemistry, higher scores show positive attitudes toward chemistry.

4.4.3 Science Process Skills Test

The test was originally developed by Okey, Wise and Burns (1982). It was translated and adopted into Turkish by Geban, Aºkar, and Özkan (1992). This test contained 36 four-alternative multiple-choice questions. The reliability of the test was found to be 0.85. This test measured intellectual abilities of students related to identifying variables, identifying and stating hypotheses, operationally defining, designing investigations, and graphing and interpreting data (See Appendix D). Total possible score of the SPST was 36. The test was given to all students in the study.

4.4.4 Learning Style Inventory

All students were administered the revised Learning Style Inventory originally developed by Kolb (1985). The test was translated and adopted into Turkish by Aºkar and Akkoyunlu (1993) (See Appendix E).

The Learning style inventory is a 12-item self-reporting instrument in which individuals try to describe their learning styles. The 12 items consist of short statements concerning learning situations and each of the items asks respondents to rank four sentence endings that correspond to the four learning modes – Concrete Experience (CE), Reflective Observation (RO), Abstract Conceptualization (AC), and Active Experimentation (AE). The scores for each of the four learning modes range from 12 to 48. To find the dominant learning style of an individual the scores from four learning modes are combined and subtracted. The combination scores of AC-CE and AE-RO are plotted on the learning style grid (see Figure 4.1) and the dominant learning style of the individual is determined as diverging, assimilating, converging or accommodating.

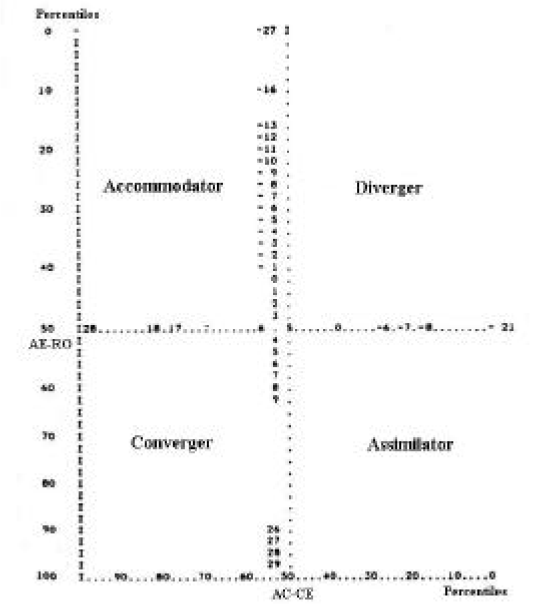

Figure 4.1 Learning-style type grid.

4.4.5 The Interview Scales

When the treatment ended and the post-tests were administered to all of the students the teacher and some of the students from the experimental and control groups were interviewed.

The interview with the teacher was conducted in a semi-structured format. The main aim was to bring more information about the effectiveness of the conceptual change oriented instruction accompanied by demonstrations. The interview questions focused on the teacher's opinions about the applicability of the conceptual change oriented instruction accompanied by demonstrations. Also, the teacher responded about her preference in using the new instruction. Additionally, the students' interests in the two types of the instruction were asked. The interview session took nearly one hour. A tape recorder was used to record the conversation.

The interviews with the students were conducted in a structured form. Interview questions were prepared on the basis of the common misconceptions found in the literature related to the gas concepts. The questions focused on 1) defining gas 2) explaining differences between a real and an ideal gas, 3) the behavior and characteristics of atoms or molecules of a compressed gas, 4) properties of hot and cold air, 5) conservation of mass in chemical reactions involving at least one compound in gaseous state, 6) diffusion of gases, and 7) last question was asked to take students' opinions about the conceptual change oriented instruction accompanied by demonstrations. Six students from the experimental and six students from the control groups were interviewed. Each interview with a student took approximately 40 minutes and interviews were recorded on a tape recorder.

4.4.6 The Classroom Observations

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

4.5 Treatment

Treatment duration was six weeks during the Fall Semester of 2003-2004. Two teaching methods were randomly assigned to the classes. Experimental and control groups were instructed by the same teacher. She has 19 years previous teaching experience of high school chemistry. During the treatment, the gases topic was covered as part of the regular classroom curriculum in the chemistry course. Each group instruction was three 45-minute sessions per week. The topics covered were kinetic molecular theory, pressure (the barometer, manometer), properties of gases (indefinite shape and volume, low density, compressibility, condensation, diffusion), the gas laws (Boyle's law, Charles' law, Gay-Lussac's law, kinetic theory and Avogadro's principle, combined gas law, ideal gas law), Dalton's law of partial pressures, diffusion of gases (Graham's law), chemical equations and gas law calculations.

At the beginning of the instruction, both groups were administered GCT to determine whether there was any difference between two groups with regard to understanding of gases concepts prior to instruction. LSI was given to identify students' learning styles. Also, ASTC was given to measure students' attitudes toward chemistry as a school subject. Additionally, SPST was distributed to all students in the groups to assess their science process skills.

The control group received traditional instruction based on lecturing and discussion in class. Although the experimental group was taught by conceptual change oriented instruction accompanied by demonstrations, both of the groups took the lessons in their classrooms. Experimental and control groups were assigned the same homework questions and used the same textbook.

In the traditionally designed chemistry instruction, the teacher used lecturing, questioning and discussion in class. Teaching strategy was based on teacher exploration. The teacher frequently used chalkboard and wrote the main ideas, formula or solutions of the problems. The students listened to the teacher and took notes. Sometimes some of the students asked questions. The teacher answered the questions and directed new questions to explore whether the concept was understood. The teacher made explanations without considering the students' misconceptions. The teacher frequently assigned quantitative questions. While the students were solving the questions the teacher roomed the room and gave some clues when needed. When students were ready to listen to, the teacher wrote the correct solution on the board. Then, students compared their solutions with the correct one. At the end of the lesson the teacher assigned homework questions.

The experimental group was taught under the conceptual change conditions. Before the treatment, the teacher was informed what the conceptual change oriented instruction accompanied by demonstrations is and how it can be used. The instruction was based on conditions under which the students' misconceptions were activated and could be replaced with scientific conceptions and new conceptions could be incorporated with existing conceptions.

The lessons in the experimental class began with questions asked by the teacher (see Appendix F for an example lesson). In this way the teacher promoted discussion on a concept related to gases. For example, the teacher began the lesson by asking whether all gases have the same diffusion rate. The aim was to activate the students' prior conceptions (misconceptions) about the concept. Discussion continued by showing to the students an experimental setting designed to demonstrate that different gases have different diffusion rates. While the students looked at the setting the teacher asked new question, where on the glass tube do you expect NH_3 and HCl join? A new discussion guided by the teacher began. When the students' got aware of their disagreement on the answer the teacher performed the demonstration. In this way, the teacher provided environment in which the students notice their misconceptions and see the actually correct answer (dissatisfaction). So, the students had opportunity to contrast their misconceptions with the scientifically correct conceptions. To advance the acquisition of the scientifically correct response the teacher asked new questions. For example, why the expansion of the volume causes the lower pressure or in another lesson, she asked why different gases have different diffusion rates. The teacher waited for some answers and she started to explain the phenomena on the basis of the gas laws and theory. Also, she distributed worksheets on which students studied individually or in pairs. The worksheets included questions on the related concept. The students read the questions and tried to find the correct answer. Then, the teacher explained each question. While explaining the concepts, the teacher emphasized on students' preconceptions and misconceptions and why they were wrong. The lesson continued by presenting students with new situations and examples to enhance understanding of the concepts (plausibility). The teacher tried to give examples from daily life situations as much as possible to improve understanding. For example, she explained why in different seasons, summer and winter, the pressure of the tires need adjustment. At the end of the lesson teacher assigned homework (fruitfulness). Some of them were: Explain how hot-air balloon rises? Why the pressure in the automobile tires measured after a long drive is higher than the pressure measured before?

At the end of the treatment, all students were administered GCT as post-test. They were also given ASTC.

4.6 Demonstrations

Demonstrations used within conceptual change oriented instruction aimed to cause conceptual conflict and dissatisfaction with the existing but incorrect conceptions in the students' minds. The demonstrations were presented in such way that students could see that they are wrong in their reasoning. Additionally, each of the demonstrations was designed to overcome particular misconceptions.

Demonstrations were presented in the accordance with the sequence of the topics. Following demonstrations were performed in the experimental group:

1. Compressibility of gases (see Appendix G)
2. A gas expands to fill the container (see Appendix H)
3. Gas volume changes with temperature (see Appendix I)
4. What happen to the balloons filled with H_2 and N_2: A matter of density (see Appendix J)
5. The relationship between temperature and pressure (see Appendix K)
6. The relationship between pressure and amount (see Appendix L)
7. Diffusion of gases (NH_3 and HCl) (see Appendix M)

For the first demonstration, the aim was to demonstrate students that the gases can be compressed while the solids and liquids resist significant changes in volume. Also, the teacher's purpose was to overcome the common misconception that "intermolecular distance in gases is not much greater than in liquids and solids". Additionally, during the demonstration teacher discussed the questions: What happened at molecular level that led to change in the volume of the gas? Are there changes in the molecular properties such as molecule shape and molecule size? Why we could not compress the solid (sugar) and the liquid (water)?

The purpose of the second demonstration was to show that gases fill the space available in the container and after the evacuation of some amount of the gas using a syringe the distribution of the gas does not change. This demonstration was performed to show that after evacuation of some gas the holes do not occur and that the entire mass of gas is not pulled towards the opening as argued by students enrolled in the study conducted by Novick and Nussbaum (1978). Also, the teacher discussed some questions related to the students' ideas about the constant and random motion of the gas molecules: How the gas molecules fill the container? Why we can not see any hole in the gas after evacuation some amount of it? Why the gas molecules do not collide at the bottom of the container after a while?

The third demonstration was performed to show the relationship between volume and temperature. Also, the teacher discussed the incorrectness of the students' idea that when gases expand or contract the result is uneven distribution of gas. Some of the questions discussed were: What happen to the gas molecules after heating? Is there any change in the molecule size and shape? What can you say about the distances between gas molecules before and after heating? What is the reason of the volume expansion? How kinetic molecular theory explains the volume-temperature relationship?

The fourth demonstration was performed to show that there are different forces acting on a gas such as gravity and the atmospheric pressure or the buoyant force of the air. The teacher discussed why the balloon filled with nitrogen (N_2) fell down on the ground while the balloon filled with hydrogen (H_2) rose. She focused on the fact that gases have density and the density differ from gas to gas. Additionally, she attempted to correct the students' idea that the atmosphere exerts pressure from up to down.

The aim of the fifth demonstration was to show the relationship between pressure and temperature. For this purpose the teacher heated the manometer and showed the difference between the mercury levels. Then she asked questions to discuss the factors that led to an increase in the pressure: What happened to the molecules after heating? Which properties of the molecules changed after heating? Compare the frequency of the molecule collisions on the mercury surface before and after heating?

The sixth demonstration was designed to show the relationship between pressure and amount. This was accomplished by changing the amount of the air in the manometer and observing the difference in the mercury levels. The air was added in and removed from the manometer by using a syringe. At each step teacher asked questions: What happened at molecular level that led to an increase/decrease in the pressure? What changed on the mercury surface that led to the pressure changes? The questions revealed students' incorrect conceptions about the phenomenon. Then, she tried to correct the misconceptions by explaining and discussing the correct situation.

The aim of the last demonstration was to show that different gases have different diffusion rates. Before performing the demonstration the teacher asked students where on the glass tube do you expect the gases (NH_3 and HCl) meet? After activating the students' misconceptions the teacher carried out the demonstration. Then, she asked whether the students' expectations satisfied. Additional questions that helped to discuss the diffusion concept were: Why the meeting point is close to HCl? Why different gases have different diffusion rates? How the kinetic molecular theory explains the different diffusion rates?

All of the demonstrations were easy to do. Few and common chemicals were used in the demonstrations: H_2, I_2, NH_3, and HCl. There was no dangerous demonstration.

4.7 Data Analysis

4.7.1 Descriptive and Inferential Statistics Analyses

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

ANCOVA was used to determine effectiveness of two different instructional methods related to gases concepts by controlling the effect of students' science process skills as a covariate. Additionally, this analysis revealed the contribution of science process skills to the variation in students' understanding. To test the effect of treatment and gender difference on students' attitudes toward chemistry as a school subject two-way ANOVA was used.

4.7.2 Missing Data Analysis

Before the analysis of the data, missing data analysis was performed. Although the total of the students included in the treatment was 109 the final sample included in the data analysis consisted of 100 students. Five students from the experimental and four students from the control group were excluded from the study because they were not present on the date of the post-GCT. There were five missing data related to students' gases concept post-test scores and students' attitudes toward chemistry pre-ASTC scores. There were four missing data related to the science process skills test scores (SPST). The percentage of missing data of the pre-tests was 4.6 %. Science it was less than 5 % of the whole data, the series mean of the entire subjects (SMEAN) was used to replace the missing data (Cohen and Cohen, 1983).

4.8 Assumptions of the Study

1. There was no interaction between groups.
2. The teacher followed the researcher's instructions and was not biased during the treatment.
3. The GCT, ASTC, LSI, and the SPST were administered under standard conditions.
4. The classroom observations were performed under standard conditions.
5. Interviews with the teacher and the students were conducted under standard conditions.
6. The subjects answered the questions of the tests and the questions of the interview sincerely.
7. The teacher answered the interview questions sincerely.

4.9 Limitations of the Study

1. This study was limited to the unit of gases.
2. This study was limited to 100 tenth grade students at a public high school in Ankara during the Fall Semester of 2003-2004.

CHAPTER V

RESULTS AND CONCLUSIONS

This chapter presents the results of the study under five headings: the classroom observations, the results of the descriptive statistics related to the Gases Concept Test, Attitude Scale toward Chemistry, Learning Style Inventory and students' learning styles, the results related to the inferential statistics of testing 6 null hypotheses, the results of interviews with teacher and students, and conclusions.

5.1 The Classroom Observations

In this study, the observations were performed to ensure the non-biased implementation of the treatment in the control and experimental groups. Additionally, the researcher observed the students' responses to the treatment in the experimental group.

The treatment was conducted over six weeks in two classes at a public high school in Ankara. The researcher observed twelve 45-min sessions for the experimental group and eight 45-min sessions for the control group during the treatment. The researcher only took some notes; she was inactive and silent during the observations.

The conceptual change oriented instruction was implemented in the experimental group, while the traditional approach was conducted in the control group. The teacher used lecturing in the control group, while she used conceptual change approach and performed demonstrations related to the gas properties and gas laws in the experimental group. At the beginning of the application of the conceptual change oriented instruction the teacher had some difficulties with classroom control. The difficulties originated because the class was crowded (54 students) and there was noise when the students were discussing the questions asked by the teacher. In the following lessons, the students were familiar with the instructional approach and did not make noise when they were discussing and watching the demonstrations. All of the students were willing to discuss on the demonstrations but the limited time and the crowdedness of the class did not allowed the participation of all of the students. The teacher guided discussions successfully in the experimental group while the discussions in the control group were ineffective.

Students in the control group were unwilling to discuss and there were few students participating in the discussions. Lecturing and solving questions bored students so that they started talk each other and made noise. The control group was also crowded (55 students) and the teacher made more effort to control the students. The students were less active and they easily lost their motivation even though the teacher made attempts to gain their attention on the topic by giving interesting examples from everyday life.

As a result, the observations in the two groups revealed that the conceptual change oriented instruction accompanied by demonstrations was more effective in keeping the students' interest in the topic, motivating them to discuss and making them active learners than the traditional instruction in the control class.

5.2 Descriptive statistics

Descriptive statistics related to the students' gases concept pre- and post-test scores, chemistry attitudes pre- and post-test scores, and science process skills test scores in the control and experimental groups were conducted. The results were shown in Table 5.1.

Students' gases concept test scores range from 0 to 40. The higher scores mean the greater success and more understanding in gases. In table 5.1, the mean of the pre-GCT is 10.65 and the post-GCT is 20.39 in the experimental group, while the mean of the pre-GCT is 9.24 and the post-GCT is 12.43 in the control group. The mean score increase of 9.73 in the experimental group is higher than the mean score increase of 3.19 in the control group. The students in the experimental group were more successful and acquired more understanding in gases than students in the control group.

Students' attitudes scale toward chemistry scores range from 15 to 75 with higher scores mean more positive attitudes toward chemistry. In Table 5.1, the mean of the pre-ASTC is 52.04 and the post-ASTC is 57.32 in the experimental group with mean score increase of 5.28. In the control group, the mean of the pre-ASTC is 55.73 and the post-ASTC is 54.80 with mean score decrease of .93.

Students' science process skills test scores range from 0 to 36 and greater scores indicate higher abilities in solving science problems. As shown in Table 5.1, the mean of SPST is 19.09 in the experimental group and 14.45 in the control group.

The Table 5.1 also shows some other descriptive statistics as range, minimum, maximum, standard deviation, skewness, and kurtosis values. The skewness of the pre-GCT was .167 and the post-GCT was -.160 in the experimental group, while the skewness of the pre-GCT was 1.324 and the post-GCT was 2.030 in the control group. The skewness values of the pre-and post-ASTC were -.505 and -.032 in the experimental group, and -.693 and -.512 in the control group, respectively. The kurtosis values are also shown in Table 5.1. The skewness and kurtosis values near to 0 indicate the normal distribution of the variables. In this study, the distribution of the variables can be accepted as normal.

Table 5.1 Descriptive Statistics Related to The Gases Concept Test (GCT), The Attitude Scale toward Chemistry (ASTC), and The Science Process Skills Test (SPST)

GROUP		DESCRIPTIVE STATISTICS							
		N	Range	Min	Max	Mean	Std. Dev.	Skewness	Kurtosis
	Pre-GCT	49	17	2	19	10.65	3.71	.167	-.141
	Post-GCT	49	21	10	31	20.39	4.83	-.160	-.283
EG	Pre-ASTC	49	56	17	73	52.04	10.27	-.505	1.832
	Post-ASTC	49	74	33	41	57.32	8.00	-.032	-.354
	SPST	49	21	7	28	19.09	4.80	-.123	-.247
	Pre-GCT	51	22	2	24	9.24	3.67	1.324	4.535
	Post-GCT	51	20	7	27	12.43	4.04	2.030	5.366
CG	Pre-ASTC	51	50	25	75	55.73	10.06	-.693	.892
	Post-ASTC	51	51	23	74	54.80	10.78	-.512	.350
	SPST	51	21	6	27	14.45	4.89	.295	-.286

Students' learning styles were determined by Learning Style Inventory. In the experimental and control group the distribution of the learning styles among students was similar. Figure 5.1 shows the students' learning style preferences in the experimental group. The students' learning style preferences in the control group were given in Figure 5.2. It can be seen that the dominant learning style in both groups is assimilating learning style and that the minority of the students possesses accommodating learning style.

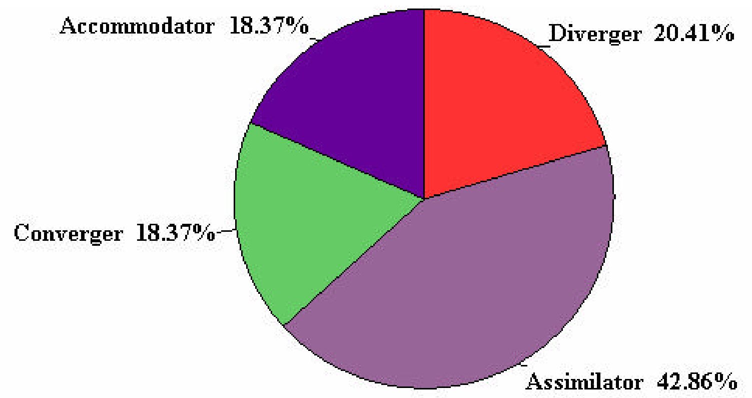

Figure 5.1 Learning style preferences in the experimental group.

In the experimental group 42.9 % of the students showed preference in assimilating learning style. The proportion of assimilating learning style was 54.9 % in the control group. Divergers were 20.4 % of the students in the experimental group, while in the control group the proportion was 13.7 %.

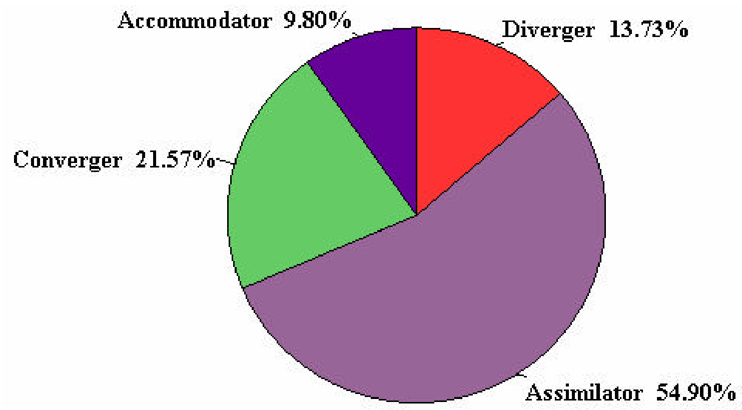

Figure 5.2 Learning style preferences in the control group.

Converging learning style showed approximately similar distribution in the experimental group (18.4 %) and the control group (21.6 %). Accommodators were 18.4 % of the students in the experimental group. In the control group 9.8 % of the students had accommodating learning style.

5.3 Inferential Statistics

This section presents the results of analyses of 6 null hypotheses stated in chapter III. The hypotheses were tested at a significance level of .05. Analysis of covariance (ANCOVA) and analysis of variance (ANOVA) were used to test the hypotheses. Statistical analyses were carried out by using the SPSS/PC (Statistical Package for Social Sciences for Personal Computers).

The results of independent samples t-test analyses showed that there was no significant difference at the beginning of the treatment between the CCID group and TI group in terms of students' understanding of gases concepts measured by pre-GCT ($t(98) = 1.907$, $p = .059$), and students' attitudes toward chemistry measured by pre-ASTC ($t(98) = -1.814$, $p = .073$). Significant difference was found between the two groups with respect to science process skills (t (98) = 4.782, $p < 0.001$).

5.3.1 Null Hypothesis 1

The first hypothesis stated that there is no significant difference between the post-test mean scores of the students taught with conceptual change oriented instruction and students taught with traditionally designed chemistry instruction with respect to understanding gases concepts when science process skills is controlled as a covariate. To test hypothesis 1 analysis of covariance (ANCOVA) was conducted. The results are summarized in Table 5.2.

Table 5.2 ANCOVA Summary (Understanding)

Source	df	SS	MS	F	p
Covariate (Science Process Skills)	1	129.895	129.895	7.078	.009
Treatment	1	919.716	919.716	50.115	.000
Gender	1	7.565	7.565	.412	.522
Treatment*Gender	1	46.883	46.883	2.555	.113
Error	95	1743.458	18.352		

The result showed that there was a significant difference between post-test mean scores of the students taught by CCID and those taught by TI with respect to the understanding of gases concepts, $F(1, 95) = 50.115$, MSE = 18.352, $p < .001$.

The CCID group scored significantly higher than TI group ($\overline{X}$(CCID) = 20.39, $\overline{X}$(TI) = 12.43).

Figure 5.3 shows the proportions of correct responses to the questions in the post-GCT for two groups. As seen in the Figure 5.3 there was a difference in the proportion of correct responses between the two groups to the questions in the GCT. Remarkable differences were observed in the students' answers to the questions 1, 4, 6, 8, 9, 14, 20, 22, and 40.

In question 1, students were asked to select the property of a molecule which changes with state change from solid to liquid to gas. After treatment, in the experimental group 87.8 % of the students answered question correctly by choosing the alternative indicating that distance between the molecules and kinetic energy change. In the control group, 52.9 % of the students answered the question correctly. As expected, the misconception held by the students in both groups was that molecules increase in size with state change.

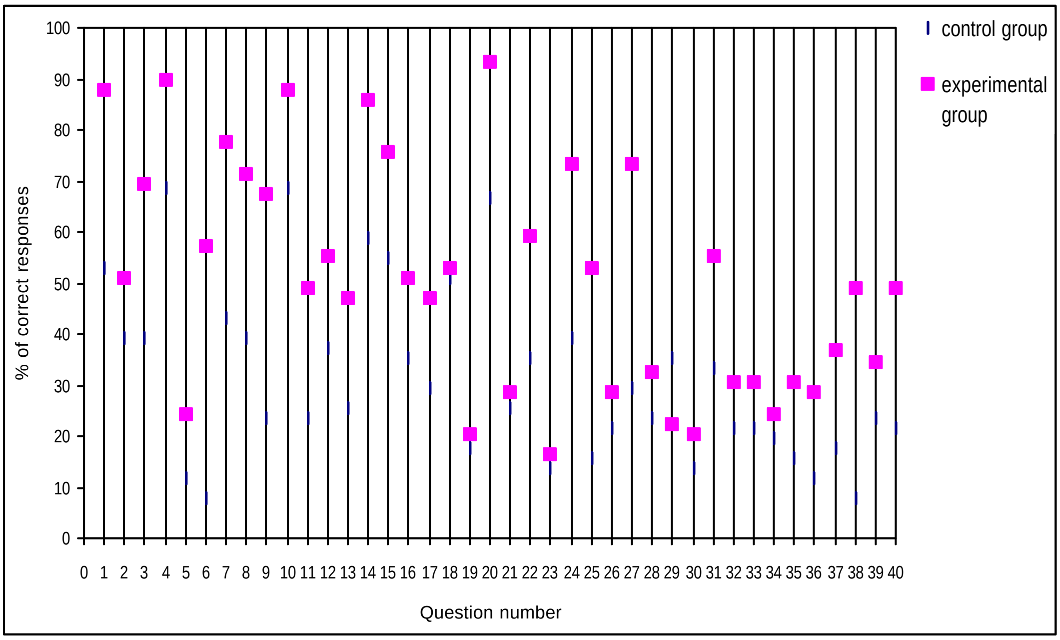

Figure 5.3 Comparison between post-GCT scores of the CCID group and the TI group.

Question 4 tested the students' idea about what happen to the molecules of air compressed in a syringe. The majority of the students in both groups gave correct answer to the question. In the control group, 68.6 % of the students answered correctly, while in the experimental group 89.8 % of the students showed higher achievement for this question. In the control group, the common misconception was that after compressing the molecules stop moving (15.7 %). Among experimental group students the common misconception was that molecules get smaller after compressing (6.1%).

Remarkable difference was observed in the proportion of students' correct answers to the question 6 in two groups after treatment. Question 6 was related to effusion of gases. In the question it was explained that an inflated balloon after some days deflated and asked what happened to the balloon. Before treatment, the first common misconception was that the weather became colder and molecules clustered. This misconception was observed either in the experimental group (32.7 %) or the control group (66.7 %). Similarly, the second common misconception that the atmospheric pressure rose and made balloon small was observed in the experimental and the control groups as 36.7 % and 11.8 %, respectively. After treatment, the proportion of the correct answer that balloon had a pore increased from 2.0 % to 7.8 % in the control group. In the experimental group, the proportion of the correct response increased from 2.0 % to 57.1 %. Although the students in the experimental group showed higher achievement, the results showed that students in the experimental and control groups still possess the two predetermined misconceptions with equal percentages of 14.3.The misconceptions that this item measured and percentages of experimental and control group students' answers are given below:

Table 5.3 Percentages of Selected Alternatives for Question 6

Question 6: A rubber balloon is filled with hydrogen gas and the opening is tightly tied. Few days later the balloon deflates. Which of the following explain why the balloon deflated? 	Percentage of students' responses (%)	
	Experimental Group	Control Group
Alternative A The energy of molecules gradually died and the molecules stopped moving.	6.1	0.0
Alternative B * Balloon had a pore. * Correct alternative	57.1	7.8
Alternative C Weather became colder and molecules clustered.	14.3	54.9
Alternative D Molecules got smaller as a result of collisions.	4.1	11.8
Alternative E The atmospheric pressure rose and made balloon small.	14.3	25.5

Question 9 asked what there is between the gas molecules. Before treatment, the dominant idea was that there is air between the gas molecules. This alternative conception was observed not only in the control group (45.1 %) but also in the experimental group (32.7 %). After treatment, the proportion of correct answer that there is space between the gas molecules increased from 19.6 % to 23.5 % in the control group, while the increase was from 32.7 % to 67.3 % in the experimental group. Considerable part of the students in the experimental group (28.6 %) possessed the given misconception even after the treatment.

A similar difference between CCID group and TI group was also observed for question 14. This question asked application of the Boyle's law to an experimental setting. There was an Erlenmeyer flask tightly closed by a rubber stopper containing a funnel. The question was why the addition of water becomes difficult after the water level reaches the foot of the funnel. When the water reached the food of the funnel a closed system was created. So, the continuing addition of the water decreases the volume of the air inside the flask. Considering the Boyle's law, the decrease in the volume will increase the pressure and this make harder the water to enter. Before treatment, the proportion of correct students' answers was 54.9 % in the control group, while in the experimental group was 59.2 %. After treatment, there was no remarkable change in the proportion of correct answers in the control group (58.8 %), while the proportion of correct answers in the experimental was 85.7 %. After treatment, the results showed that both experimental group and control group students had misconception that states that there is an upward pushing force exerted by the water in the flask, which prevents the water in the funnel from entering. The percentage of having the given misconception was 8.2 % in the experimental group and 25.5 % in the control group.

Question 20 dealt with the students' ideas about the properties of gases. Almost all of the students (93.9 %) in the experimental group were successful in answering the question by selecting the idea that gases behave similarly to liquids when they are poured into a container as non-property of gases. Achievement in the control group was 66.7 %. Before treatment, the proportion of students answering correctly was 71.4 % for the experimental group. In the control group there was an interesting situation: before treatment the proportion of students answering correctly (76.5 %) was higher than that after the treatment.

In question 22, students were asked to explain the direction of the atmospheric pressure. Confusing results, similarly to question 20, were obtained. Before treatment, the 39.2 % of the students in the control group answered correctly by selecting the choice that atmospheric pressure acts from all directions. This proportion showed slight decrease (35.3 %) after the treatment. The dominant misconception in the control group was that the atmospheric pressure acts downward with slight increase from 15.7 % to 23.5 %, after the treatment. In the CCID group, 59.2 % of the students answered correctly after the treatment, while before treatment this proportion was 44.9 %. In the experimental group, there was also an increase from 6.1 % to 16.3 % for the same misconception as in the control group.

For question 40, 49.0 % of the students in the experimental group defined correctly the conditions (high temperature and low pressure) under which a real gas approaches the ideal behavior. Before treatment, in CCID group only 8.2 % of the students were able to state the conditions. In the control group, the percentage of correct answer increased from 13.7 % to 21.6 % after the treatment. The common misconception in the TI group was that there are no such conditions (29.4 %). The common misconception in the CCID group was that a real gas approaches ideal behavior under high pressure and low temperature (14.3 %).

As a result, after instruction the students in the experimental group was more successful that students in the control group. Additionally, the CCID group students completed the treatment with fewer misconceptions than students in the control group.

5.3.2 Null Hypothesis 2

To answer the question posed by hypothesis 2 which states that there is no significant difference between post-test mean scores of females and males with respect to understanding of gases concepts when the effect of students' science process skills is controlled, analysis of covariance was used. Table 5.2 also gives the effect of gender difference on students' understanding of gases concepts. The results revealed that there was no significant mean difference between female and male students with respect to understanding gases concepts, $F(1, 95) = .412$, $MSE = 18.352$, $p = .522$. The mean post-test scores were 21.29 for females and 19.27 for males.

5.3.3 Null Hypothesis 3

To test hypothesis 3 stating that there is no significant effect of interaction between treatment and gender on students' understanding of gases concepts when the effect of science process skills is controlled as a covariate, analysis of covariance (ANCOVA) was run. Table 5.2 also gives the interaction effect on understanding of gases concepts. The findings showed that there was no significant interaction effect between gender and treatment on students' understanding of gases concepts, $F(1, 95) = 2.555$, $MSE = 18.352$, $p = .113$.

5.3.4 Null Hypothesis 4

To test hypothesis 4 which states that there is no significant contribution of students' science process skills to understanding of gases concepts, analyses of covariance (ANCOVA) was used. The results indicated that there was a significant contribution of science process skills on students' understanding of gases concepts, $F(1, 95) = 7.078$, $MSE = 18.352$, $p = .009$.

5.3.5 Null Hypothesis 5

The null hypothesis 5 stated that there is no significant mean difference between students taught with conceptual change oriented instruction and traditionally designed chemistry instruction with respect to their attitudes toward chemistry as a school subject. In order to test the hypothesis two-way analysis of variance (ANOVA) was performed. Table 5.4 summarizes the results of this analysis.

Table 5.4 ANOVA Summary (Attitude)

Source	df	SS	MS	F	p
Treatment	1	162.526	162.526	1.788	.184
Gender	1	80.600	80.600	.887	.349
Treatment*Gender	1	81.962	81.962	.901	.345
Error	96	8728.079	90.917		

The results showed that there was no significant mean difference between students taught through conceptual change oriented instruction and traditionally designed chemistry instruction with respect to attitudes toward chemistry as a school subject, F (1, 96) =1.788, p = .184.

5.3.6 Null Hypothesis 6

In order to test the hypothesis 6 stating that there is no significant difference between post-attitude mean scores of females and males, two-way analyisis of variance (ANOVA) was carried out. Table 5.4 shows the effect of gender difference on students' attitudes. The results indicated that there was no significant mean difference between female and male students with respect to their attitudes toward chemistry as a school subject, F (1, 96) = .887, p = .349.

5.4 The Interviews

Interview sessions were conducted with two teachers and several students from the experimental and the control groups.

5.4.1 Interview with the Teacher

In this study, the teacher was interviewed to take her opinion about the effectiveness of the conceptual change oriented instruction accompanied by demonstrations. The examples of the excerpts from the interview conducted with the teacher are presented below:

Q1. What is the opinion of the teacher about the applicability and effectiveness of the conceptual change oriented instruction?

Interviewer: What do you think about teaching gases with conceptual change oriented instruction accompanied by demonstrations?

Teacher: It was an interesting experience for me. I need to confess that the method was difficult for me… directing discussions in the experimental group needed more efforts than in the control group. Also, demonstrations needed more attention. This method was new not only for me but also for the students. Until they grasped the aim of the discussions they made noise. When they understood that each discussion had a purpose they became more silent and were in accordance with me. During the demonstrations they were attentive and watched carefully to see the results. Especially in gases, it is difficult to show the behavior of the gases on a chalkboard. The demonstrations in the experimental group helped students to visualize all explained in their textbooks via pictures and lot of words. I think it was amazing for the students too learning by demonstrations and discussion. Demonstrations and discussions are the neglected parts of our teaching methods. Learning occurs when student discusses the concepts. We are saying students to imagine the gases, to imagine the behavior of gas molecules, etc. Instead of this, we must do demonstrations or made students do experiments. Of course, making demonstrations requires preparation but students will start to discuss what they see. So, they will improve their ability to interpret the events.

Interviewer: What do you think about the effectiveness of the new instruction?

Teacher: I wish I taught the concepts by using demonstrations, discussions or whatever that makes teaching process student-centered. We spent 1.5 months or six weeks for teaching gases. Unfortunately, in the control group we taught some formula and how the students may solve gas problems by using these formulas. In the experimental group, the students began to discuss, to interpret *what they see and the most important they realized that all they learn is related to their everyday life. I think that they never forget the performed demonstrations. Discussions motivated the students. They learned how to interpret the qualitative questions as well as the quantitative questions.*

Interviewer: Do you think there are difficulties in applying the new method?

Teacher: First of all, the 10th grade chemistry curriculum is very loaded. Important topics such as gases, equilibrium, and kinetics follow each other. Secondly, we want to take students to laboratories but the physical opportunities of the labs are limited. Thirdly, the students want to get higher grades and to achieve in the university entrance exam. So, it is impossible to use laboratories for each lesson because demonstrations are time consuming. Also, there is a curriculum that should be followed. Especially in our school the classes are very crowded. There are high schools with size of 20 students per class while our school has classes with size of 55 students. Guiding discussion in a crowded class is very difficult and time consuming. Additionally, because of the crowded class students may not benefit fairly from the demonstrations.

Q2: Which kind of the instruction the teacher would prefer in future: using the traditional instruction or conceptual change oriented instruction?

Interviewer: Which teaching method, traditional or conceptual change oriented would you prefer in future?

Teacher: I liked very much the new method but it is time consuming. Additionally, I spent time to learn how this new method can be applied, while *teaching traditionally does not requires extra preparation.. The curriculum is loaded and I have to complete the determined program on time. Our classes are very crowded. I am confused…the new method is more effective, student is engaged actively in learning process, but time consuming; the traditional instruction is less effective, teacher centered and does not contribute to students' in improving their understanding. Moreover, all of the chemistry topics are not appropriate to teach with demonstrations but the discussion and conceptual change approach can be applied.*

Q3: Is there a difference with respect to students' interest in the instruction between the experimental and control group?

Interviewer: Could you compare the students' interest in the topic during the instruction with the new and the traditional method?

Teacher: Although teaching by demonstrations and discussion was a new method for the students it attracted their attention. Demonstrations helped them to visualize from many aspects the properties of gases and gas laws. The experimental settings also attracted their attention and led them to be more attentive while waiting for the results of the demo. Unfortunately, the students in the control group could not see the demonstrations. The students in the control group lost their attention after a short period of time. They were bored and unwilling to listen to. Control group students made noise by talking each other, while experimental group students competed with each other to begin to speak after a posed question. I can say that the students in the experimental group were more interested in the topic than the students in the control group.

The teacher liked teaching with conceptual change oriented instruction accompanied by demonstrations. She explained that there were difficulties in implementing the method but its effectiveness on students understanding and interest in the topic was considerable.

5.4.2 The Students Interviews

In this study, the students were interviewed on questions related to 1) defining gas 2) explaining differences between a real and an ideal gas, 3) the behavior and characteristics of atoms or molecules of a compressed gas, 4) properties of hot and cold air, 5) conservation of mass in chemical reactions involving at least one compound in gaseous state 6) diffusion of gases, and last question was asked to take students' opinions about the conceptual change oriented instruction accompanied by demonstrations. During transcription, students were given numbers to prevent any confusion. Students with odd numbers were experimental group students, while the students with even number were control group students. The examples of the excerpts from the interviews conducted with the students are presented below:

Q1: Could you explain "gas" to a person who does not know what a gas is in such a way to imagine it?

Student1: State of matter in which the space between particles is the greatest with respect to other states of the matter. A gas can fill the container in which is present and takes shape of the container. hmmm… a gas can smell or not… there are colorful and colorless gases.

Student3: A gas has no definite shape and volume…the molecules of a gas move faster and the kinetic energy of a gas is greater than that of other states of the matter. There are collisions between gas molecules.

Student5: A gas has mass…the interaction between gas molecules is least…a gas can be compressed, because there is space between the molecules.

Students in the experimental group explained different properties of a gas. They were successful in defining a gas based on the macroscopic and microscopic properties of a matter.

Student2: The particles in a gas are disordered. The particles are not uniformly distributed. The particles of a solid are more stable and ordered. We can see solids and liquids but we can not see gases.

Student 4: A matter that fills all space around us is gas… we do not have to see the gas, we can feel it. They may have color or not.

Student6: A gas has properties such pressure and temperature. The molecules of a gas can go from one place to other. The particles can stay at their places at the same time they can move…

Students in the control group have partial understanding of a gas as a matter. They mentioned little about the properties at molecular level. They did not mention about the space between the molecules of a gas. Also, they did not say anything about whether there are some interactions between the gas molecules or not.

Q2: what is the difference between an ideal and a real gas?

Student1: the molecules of an ideal gas have less volume than that of a real gas.

Student5: Ideal gas is an assumption. There is no such gas on the world. But compared with real gases it is assumed to have negligible molecule volume, elastic collisions and no interactions between the molecules.

Student2: There are some conditions under which a real gas can behave as an ideal gas. If the molecular mass is small, the temperature is high and the pressure is low then a gas is ideal.

Both students in the experimental and control group showed understanding of the ideal and real gas.

Q3: You see the syringe. There is air in the syringe. How would the air molecules be affected when the plunger is pushed?

Student6: Molecules get smaller.

Student2: Molecules get smaller in size, hence the volume of the air decreases.

Student1: The distance between the molecules decreases. The collisions between the molecules increase. So, the pressure increases.

Student3: The kinetic energy of the molecules decreases… because the distance between the molecules decreases the molecules move less. So the kinetic energy decreases.

Some of the students in the experimental group still possess misconceptions. Although the students in the experimental group do not possess ideas that molecules can change in size when they are compressed as students in the control group they have misconceptions related to different properties. For example, they believed that the kinetic energy is related to the space that molecules move. The students thought that compression lead to decrease in the molecular speeds. They used the expression that relates the average kinetic energy and root-mean square speed ($\overline{E_k} = \frac{1}{2} m\overline{u^2}$) and deduced that if molecular speed decreases the kinetic energy decreases too. When those students were remembered the formulae of the root-mean square speed ($u_{rms} = \sqrt{\frac{3RT}{M}}$) then they realized that speed depends on the temperature.

Interviewer: Could you explain why the plunger backs out?

Student1: The pressure in the syringe increased because of the compression. The plunger will move until the pressure inside the syringe becomes equal to the outside pressure, that is atmospheric pressure.

Student7: Plunger moves because the molecules try to come to their state before compressing. The molecules try to reach the distance that is normal for a gas.

Student8: Gases have a kinetic energy. By compressing the molecules become closer. When we stop compressing due to this energy the molecules will push each other. To reach their movement prior to the compressing, the molecules react to pushing.

While the responses of the experimental group students reflect the sound understanding of the concept, the explanations of the students in the control group indicated their incorrect reasoning. They explained the behavior of the molecules as the behavior of something alive that can react to pushing and have an idea about the "normal distance" between the molecules of a gas.

Q4: Suppose that you have two identical balloons filled with air. The balloons have the same volume, only one of them is filled with hot air and other balloon is filled with cold air. The balloons are at the same height from the ground.

Problem 1. What will happen when you release the balloons at the same time?

Student10: The hot balloon rises, while the cold balloon falls on the ground. The molecules in the hot air are lighter. The temperature changes the weight of the molecules.

Student12: Temperature is inversely proportional to the altitude. Increase in the elevation results in decrease in the temperature. The high altitudes are cold…So, the balloon with cold air rises. The molecules in the hot balloon are more active, they will push the balloon to the ground.

Student3: Hot balloon will fall more slowly than the cold balloon. For example, the hot air balloons because of the difference in the density of the air they rise up.

Student7: Hmmm… the balloon with high density of air will fall faster than the balloon with low density of air.

Student5: They will fall at the same time…why? I have no idea…

The students' incorrect answers were due to the common misconception that "hot air weights less than cold air". The students had partial understanding about the buoyant force exerted on the balloon by the surrounding air. The students also could not relate the density and the buoyant force.

Problem 2. Is there a difference between the pressures of the balloons?

Student5: The movement of molecules increases with temperature. So, the number of collisions per unit of area at unit of time increases… the pressure of the hot balloon is greater than the pressure of the cold balloon.

Student8: The pressures are different…the pressure in the hot balloon is higher than the pressure in the cold air. Pressure and temperature are directly proportional.

The students both in experimental and the control group grasped the relationship between temperature and pressure. While students in the control group were able to explain the relationship based on the formulae, the students in the experimental group were able to explain the phenomenon at molecular level.

Q5: You have a cup of soda water and you see the releasing gas bubbles. Explain is there a difference in the weight of the soda water before and after the gas escaped?

Student1: The weight of the soda water decreases after gas escaped. The gas has mass. The decrease in the mass will be as the mass of the escaping gas.

Student8: The weight does not change. The gas has no effect on the weight of the soda water.

Student12: I think that the weight increases after the gas is released from soda water. The gas makes soda water lighter.

The students' incorrect reasoning that the weight does not change was due to the common misconception that gases have no mass or weight. The students argued that the weight rises after releasing the gas based on the common misconception that gas makes things lighter.

Q6: When your mother is baking cookies in the kitchen you can smell the smell of fresh baked cookies although you are in the family room. How does the smell get from the kitchen to the family room?

Student8: …because of the gases' diffusion property.

Student10: The smell is a gas. Gases spread. The smell also spreads.

Student9: The smell is carried through the air. Smell attaches to the gas molecules.

Student7: Smell is the property of a gas. When a gas spreads, the smell also spread because the smell is its property.

Although students in the experimental group were able to explain the diffusion of gases they confused when the diffusion of the smell was asked. Experimental group students answered correctly to the question1 asking the properties of a gas and even they explained that gases may had smell or not some of the students thought the smell as something behind the gas molecule or attached to the gas molecule.

Q7: What do you think about learning the gases with the new method?

Student1: I hate memorizing formula. I like interpreting and I learn better when I apply theory to practice. I think that all events have a reason to occur. Discussing is important for me because this is an opportunity to share ideas with others. When discuss I feel free to say all that I think. The worst was the noise during discussions. I wish all topics to be instructed in this way. Demonstrations helped me to understand the relationships between variables such as P, T, V, and n without memorizing the gas laws' formula.

Student9: I liked demonstrations…I think that we can forget all that we discussed but not what we saw. All demonstrations that were performed are in my mind. The demonstrations were interesting but I can not see properly the setting because I was at the end of the classroom and some of the students were not sitting down. Sometimes we make experiments in the laboratory. Watching demonstrations is more enjoyable than making experiments.

Student3: I do not like chemistry so much. By this new method the topic became attractive. I can not imagine things written on the chalkboard or in the textbooks. Demonstrations were very useful and helped me to understand better the texts in the chemistry textbook.

Most students liked the method but they complained about the crowdedness of the class and noise during the demonstrations. The most liked part of the instruction was performing the demonstrations. Additionally, students expressed that they liked discussing because they felt comfortable to share all ideas that they thing.

5.5 Conclusions

In the light of the findings obtained by the statistical analyses, the followings can be deduced:

1. The conceptual change oriented instruction accompanied by demonstrations caused a significantly better acquisition of scientific conceptions related to gases and elimination of misconceptions than traditionally designed chemistry instruction.
2. Science process skills had a contribution to the students' understanding of gases concepts.
3. There was no significant effect of gender on the students' understanding of gases concepts and their attitudes toward chemistry as a school subject.
4. The conceptual change oriented instruction accompanied by demonstrations and traditionally designed chemistry instruction produced statistically the same attitudes toward chemistry as a school subject.

CHAPTER VI

DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

6.1 Discussion

The purpose of this study was to investigate the effectiveness of conceptual change oriented instruction accompanied by demonstrations on tenth grade students' understanding of gases concepts and attitude toward chemistry as a school subject.

Based on the statistical analyses results given in Chapter V, it can be concluded that the conceptual change oriented instruction accompanied by demonstrations caused a significantly better acquisition of scientific conceptions related to gases and remediation of misconceptions than traditionally designed chemistry instruction. However, both gender and treatment did not cause any statistically significant increase in students' attitudes toward chemistry.

In this study, gases topic is studied, which includes concepts difficult to be grasped because of their invisible nature (Stavy, 1988; Stavy, 1990; Benson et al., 1993). This topic also requires well-grounded knowledge related to the particulate nature of matter topic which includes atoms, physical and chemical properties of matter, and states of matter. Most students think that there is air between molecules of a gas. Also, they hold the misconception that in chemical reactions in which gases are involved mass is not conserved. The science teachers should consider the fact that students have some ideas about scientific phenomena prior to instruction and arrange the instructional sequence in such a way to make students be aware of their thinking. Also, students should be given opportunity to express their ideas, discuss them either with the teacher or a peer, and realize that his/her ideas are incorrect. Then, the teacher has to provide more evidences to show that the students' ideas are incorrect. At the same time the teacher should introduce the correct conception by making the concept concrete and understandable for the students.

Constructivist teaching strategies and strategies based on the conceptual change approach are powerful tools to achieve this goal (Novick and Nussbaum, 1982; Posner et al., 1982; Hewson and Hewson, 1983; Yager, 1991). This study produced similar findings with other research studies arguing that the conceptual change approach is an effective tool improving students' understanding of scientific concepts. Novick and Nussbaum (1982) used conceptual change discussion method to remedy students misconceptions related to the particulate nature of the matter. The results showed that the method was effective in improving students' understandings. Furthermore, Eryýlmaz (2002) showed that the conceptual change discussion was effective in remedying the students' misconception in force and motion. Sönmez (2002) also found that the students taught with refutational texts supported with discussion web had better understanding of concepts related to electric current and fewer misconceptions than did the students taught by traditional methods. Similarly, Bayýr (2000) demonstrated that conceptual change text instruction in chemical change and conservation of mass concepts was effective on students' understanding of the concepts. Bayýr (2000) also showed that there was no statistically significant difference between male and female students with respect to achievement related to chemical change and conservation of mass concepts after the treatment. Niaz (2002) used a teaching startegy that could facilitate conceptual change in freshman students' understanding of electrochemistry. Teaching experiments were used as situations creating conceptual conflicts. The results of the study showed that teaching experiments enhanced students' understanding of electrochemistry.

The students in the experimental group were taught by the conceptual change oriented instruction accompanied by demonstrations. Firstly, the teacher initiated the students' alternative conceptions by asking questions. Then, the teacher gave some students opportunity to express their ideas. Discussion guided by the teacher went on until students became aware of the fact that they possess different ideas. Instruction continued with performing a demonstration to give students opportunity to contrast the alternative conceptions with scientifically correct conception. This step (dissatisfaction) was important because the students noticed that their existing ideas (alternative conceptions) were not useful in explaining the demonstrated scientific phenomenon. Both discussions and demonstrations helped students to criticize their thinking. To advance the acquisition of the scientifically correct response the teacher asked new questions and gave examples from daily life situations as much as possible to improve understanding. The teacher focused on students’ incorrect ideas and misconceptions and discussed why they were wrong. The students were satisfied when realized that new conceptions were more effective in explaining the situations (plausibility). The lesson finished with a question requiring further investigation on the newly learned concept (fruitfulness). In the experimental group both teacher and students were actively involved in teaching-learning process.

In the control group where traditionally designed chemistry instruction was used, the teacher made efforts to transmit the knowledge to the students. The teacher used lecturing method and the knowledge generally consisted of facts. The students were passive; they listened to their teacher and took notes. The teacher directed questions, later explained the correct answers but did not consider the students’ prior knowledge and did not make efforts to correct the misconceptions. However, the students in the control group were not aware of their conceptions, neither scientific nor misconceptions. A reason for the better concept acquisition in the experimental group can be the continuous process of exchange and differentiation of the existing concepts and the integration of new conceptions with existing conceptions. Whereas, the control group students added the scientific conceptions to their conceptual framework which was full of alternative conceptions.

Another purpose of the present study was to investigate whether there was a significant mean difference between male and female students with respect to understanding gases concepts. The results indicated that there was no significant mean difference between male and female students. Also, the interaction between gender and treatment had no significant effect on students understanding of gases concepts. Gender arises as an important factor effecting achievement especially in physics. Male students' interest in and their previous experiences with mechanical devices such as electrical circuits facilitates the acquisition of the physics concepts (Chambers and Andre, 1997). Chemistry is a fair science with respect to females and males' daily experiences related to the concepts about gases and gas laws. This situation might be the reason of no significant difference between female and male students with respect to their understanding of concepts related to gases. Çakýr et al. (2002) also pointed that gender difference was not effective in students' achievement in chemistry concepts. However, Bunce and Gabel (2002) showed that females and males' achievement in the same chemistry topic could be different when they were taught by different methods. Bunce and Gabel (2002) found that females taught the particulate representations were successful as well as males, whereas females who were not taught the particulate representations achieved significantly lower than males.

This study supported the findings of the previous literature and showed that the conceptual change oriented instruction was effective than the traditionally designed instruction. However, the conceptual change instruction did not increase significantly students' attitudes toward chemistry. Attitude was defined as a mental state that pre-disposes a learner to choose to behave in a certain way (Gagné, 1985). Situations in which the learner is actively involved can influence deeply held beliefs and attitudes. The conceptual change oriented instruction accompanied by demonstrations provided students learning environment in which they had opportunity to exchange ideas and to discuss the conceptions. Additionally, the interviews revealed that students liked this method, especially the part of carrying out demonstrations. The students expressed the difficulties of imagine the things written on the chalkboard and the contributions of the demonstrations to visualize gas phenomena. Since the treatment was effective in enhancing the students’ understanding of gases concepts and increased students’ interest there should be another reason of no change in attitude. Duration of the treatment was six weeks. Although it is noticeably long time for teaching a topic it can be concluded that more time is needed for changing students’ attitudes.

Also, gender difference was not effective in students’ attitudes toward chemistry. Similar results were reported by Ünlü (2000). She investigated the effectiveness of conceptual change approach on students’ achievement of atom, molecule, and matter concepts. While the treatment was effective alone in increasing students’ achievement, both treatment and gender were found no effective in changing students’ attitudes toward science significantly. Çakýr (2002) found that the case-based instruction did not improve students’ attitudes toward biology and gender did not differentiate students with respect to performance skills, attitudes toward biology, higher order thinking skills, and academic knowledge. Also, Yavuz (1998) reported that the conceptual change oriented instruction accompanied with laboratory activities was effective on students’ understanding of acid-base concepts but no effective in increasing attitudes toward science. On the contrary, Jones, Howe, and Rua (2000) found a significant gender difference with respect to science experiences, attitudes, perceptions of science courses, and careers.

However, there are some studies demonstrating the effectiveness of the conceptual change oriented instruction on the students' attitudes toward science (Sungur and Tekkaya, 2003; Gedik, 2001). Gedik (2001) examined the effectiveness of demonstration method based on conceptual change approach on students understanding of electrochemistry concepts. Demonstration method based on conceptual change approach was found to produce higher positive attitudes toward chemistry than the traditionally designed chemistry instruction.

In this study Kolb's Learning Style Inventory was used to determine students' learning style preferences as diverging, assimilating, converging, and accommodating. The results showed that the majority of both experimental group and control group students preferred assimilating learning style. Kolb (1985) described the learning ways of individuals with diverging, assimilating, converging and accommodating learning style. Divergers were described as people best at viewing concrete situations from many different points of view. Individuals with diverging learning style are interested in people, tend to be imaginative and emotional, and tend to specialize in the arts. In formal learning situations, divergers prefer to work in groups, listening with open mind and receiving personalized feedback. Assimilators are less focused on people and more interested in ideas and abstract thinking. In formal learning situations, individuals with assimilating learning style prefer readings, lectures, exploring analytical methods, and having time to think things through. Convergers have the ability to solve problems and make decisions based on finding solutions to questons or problems. People with converging learning style prefer to deal with technical tasks and problems. In formal learning situations, individuals with this style prefer to experiment with new ideas, simulations, laboratory assignments, and practical applications. Accommodaors are described as individuals who have the ability to learn from hands-on experience and perform well in situations where they must addopt to new circumstances. In formal learning situations, accommodators prefer to work with others to get assignments done, to set goals, to do field work, and to test out different approaches to completing a project (Kolb, 1985). Past research showed that teaching according to students' learning style increases students' achievement (Shaughnessy, 1998; Dunn and Stevenson, 1997). Also Cano-Garcia and Hewitt Hughes (2000) investigated whether the students' academic achievement can be predicted by their learning styles. The results indicated that those students showing a style of learning directly related to concrete experience obtained higher academic achievement. Dawn Farkas (2003) investigated the effects of teaching through traditional versus learning-style instructional methods on 7th grade students'achievement, attitudes, empathic tendencies, and transfer skills. The results of the study showed that teaching through learning-style instructional method had significant effects on students' achievement and attitudes, and produced statistically significant high scores on empathy scale and high performance on task transfer with large effect sizes. Also, Burke and Dunn (2003) reported similar results. In the present study, students were taught by the conceptual change oriented instruction accompanied by demonstrations. But the majority of the students in the experimental group were students with assimilating learning style who prefer to learn through lectures or readings. Based on these findings we may explain the nonsignificant effect of the treatment on students' attitudes toward chemistry as a school subject. The majority of the experimental group students were assimilators and they are interested in abstract thinking, whereas the convergers who are interested in experimentations and practical applications were in minority with 9 students. Teaching through demonstrations is appropriate way to instruct students with converging learning style not students with assimilating learning style. Because of this, even the treatment was successful in enhancing acquisiton of concepts related to gases it seemed to be ineffective in producing significant differences between experimental and control group students' attitudes toward chemistry.

Furthermore, in this study, the science process skills test was given to all students who participated in the study in order to determine whether there was a significant difference between the two groups with respect to students' science process skills. The results showed that the groups are significantly different in terms of science process skills. Therefore, this variable was controlled as a covariate.

As a result, the current study showed that students had difficulties in understanding gases concepts and held misconceptions. The conceptual change approach promotes students' understanding of scientific concept. Well-intended questions activate existing knowledge, help to integrate existing and new conceptions and enhance meaningful learning.

6.2 Implications

In the light of the findings of the present study the following implications could be offered:

1. If a goal of instruction is to enhance meaningful acquisition of scientific concepts, one of the powerful strategies would be the conceptual change approach. This approach facilitates the integration of the previous and new knowledge. The integration would result in meaningful learning if the cognitive structure of the learner's preexisting knowledge has relevant ideas. If there is no relevant ideas the students would try to make the new conception meaningful by interpreting it from their own point of view. This would lead to formation of the alternative conceptions and misconceptions. Changing the old and useless conceptions to new and plausible conceptions would be the matter of a well-designed conceptual change based instruction.
2. The results of the post-GCT showed that the students possess the same misconceptions with those previously found in different research studies. No matter where on the world students live or they are taught, they have misconceptions. Students should be aware of their preexisting knowledge whether it functions or not. Conceptual change based instruction makes students aware of their preexisting knowledge. Especially, discussions provide environment in which students freely express their ideas. This is important from the teacher aspect because in this way s/he could identify the problematic concepts and design the instruction to deal with those concepts. During teacher guided discussions the teacher has opportunity to reveal students' thoughts and also direct them toward scientifically correct ideas by asking

questions. Some teachers may argue that discussions are time consuming. However, the benefits of the discussions become superior.

3. In the conceptual change oriented instruction accompanied with demonstrations, the demonstrations serve as main tools of creating cognitive conflict. The cognitive conflict is important because makes students realize the difficulties which old conceptions hold and that the new conceptions are plausible and resolve these difficulties. Demonstrations also make visual the gas behavior and the relationships between variables such as pressure, volume, temperature, and amount. Additionally, demonstrations help the teacher to attract students' attention to the topic.
4. Chemistry textbooks, as a main source of the knowledge, could be revised and designed to introduce the topics based on the conceptual change conditions.
5. Sometimes the teachers have troubles with designing effective demonstrations both to attract students' attention and teach particular concept. Because of this, a guide book including efficient demonstrations related to different chemistry topics might be designed.
6. The teachers can identify students' misconceptions by different tools such as open-ended questions, misconception tests, and interviews before and after instruction. Identifying misconceptions before instruction helps teacher to decide on the concepts to be emphasized, the sequence of the instruction, and skills to be improved. Identifying the misconceptions after instruction reveal the concepts that need extra

emphasis. Also, the teacher can rearrange the instructional sequence to increase the students' understanding of the problematic concepts.

7. Chemistry curriculum should be designed on conceptual change conditions.
8. Because the teachers are faced with the challenge of changing students' alternative conceptions or misconceptions to scientific conceptions, teacher education should place an emphasis on teaching strategies based on conceptual change approach.
9. Teachers should be sensitive to the students' attitudes. They must realize that attitudes affect the students' achievement and try to make students possess positive attitudes toward chemistry as a school subject.

6.3 Recommendations

Based on the results of the study the followings can be offered:

1. Similar research studies can be conducted with a larger sample size and in different high schools to provide generalization to a bigger population.
2. The conceptual change oriented instruction accompanied with demonstrations can be carried out for different grade levels.
3. The conceptual change oriented instruction accompanied with demonstrations can be used to teach different chemistry topics.
4. Further research can be conducted to evaluate students' motivation, interest in demonstrations, reasoning abilities, and learning styles effect on students' performance in chemistry topics.

5. Conceptual change oriented instruction can be accompanied with videotaped demonstrations instead of actual demonstrations in class. This may save the time of making preparations related to the experiments.
6. Different instruments such as worksheets including pictorial presentations and conceptual problems, and conceptual assignments to enrich the instruction of gases topic.
7. Further research studies can be conducted to investigate the effectiveness of the conceptual change oriented instruction accompanied by demonstrations on retention of the concepts related to gases.
8. In this study teacher guided whole class discussion was used. Future studies can be conducted to assess the effectiveness of the conceptual change oriented instruction supported by demonstrations and discussion in small-groups.
9. Further studies can be conducted using the conceptual change approach with different teaching strategies such as hand-on activities and problem-based learning in remediation of students' misconceptions and increasing students' understanding in gases.

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APPENDIX A

INSTRUCTIONAL OBJECTIVES

1. To distinguish characteristics of a solid, liquid and gas at molecular level.
2. To select the non-characteristics of gases among the characteristics.
3. To explain on the basis of kinetic molecular theory what happen to the gas molecules when the gas is compressed in a syringe.
4. To explain pressure on the basis of kinetic theory.
5. To infer the relation between kinetic molecular theory and gas laws.
6. To describe diffusion.
7. To predict for a gas the unchangeable physical properties when temperature changes at constant volume.
8. To explain cooling of a gas at molecular level.
9. To describe the space between gas molecules.
10. To describe the conservation of mass for reactions involving compounds in gaseous state.
11. To predict the results of change in variables of a gas for a given experimental setting.
12. To draw the best representation of scattering of gases in an enclosed space.
13. To explain differences between hot air and cold air on the basis of kinetic molecular theory.

14. To put in order the pressure in deflated and inflated balloons, and atmospheric pressure.
15. To describe the conditions under which the solubility of a gas increases.
16. To describe direction of the atmospheric pressure.
17. To use Avogadro's law to predict the volume of a gas under given conditions.
18. To use Ideal gas law to solve a problem.
19. To arrange Ideal gas law equation to calculate the molecular formula of a gas.
20. To use Charles' law to solve a problem.
21. To use Graham's law to predict the composition of a mixture.
22. To arrange Ideal gas law to calculate the mass of a gas molecule.
23. To explain the factors affecting the pressure measured by a manometer.
24. To identify factors affecting distance between the gas molecules.
25. To draw the best representation of partial pressure of a gas in a mixture.
26. To use Dalton's law to calculate the partial pressure of any gas in a mixture.
27. To arrange Ideal gas law equation to compute the density of a gas under specified conditions.
28. To use Graham's law to calculate the molecular formula of a gas.
29. To arrange Ideal gas law equation to compute the pressure of a gas in a manometer.
30. To convert information given in a graphical form to statement.
31. To identify the conditions of P and T under which a real gas most closely approximate ideal gas behavior.

APENDIX B

GAZLAR KAVRAM TESTÝ

Yönerge: Bu test sizin Gazlar konusundaki kavramlarý ne derecede öðrendiðinizi deðerlendirmek için hazýrlanmýþtýr. Testte toplam kýrk (40) tane çoktan seçmeli soru vardýr. Her bir sorunun beº tane seçeneði ancak sadece bir tane doðru cevabý vardýr. Sorularý cevaplarken dikkatli olmanýz ve cevaplarý cevap anahtarýna iºaretlemeniz gerekmektedir!

1) Bir maddenin katýdan sývýya, sývýdan gaz haline geçtikçe moleküllerinin aºaðýda verilen özelliklerinden hangisi ya da hangileri deðiºir?

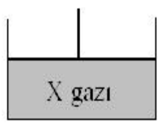
I. Kinetik enerjileri
II. Büyüklüðü
III. Moleküller arasýndaki mesafe

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

2) Gazlarla ilgili verilen ifadelerden hangisi <u>yanlýþtýr</u>?

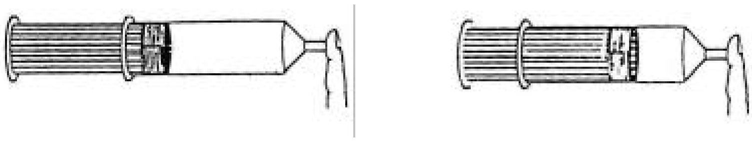
a) Ayný sýcaklýkta bütün gazlarýn ortalama kinetik enerjileri ve yayýlma hýzlarý aynýdýr.
b) Gaz basýncý, gazýn moleküllerinin içerdiði atom sayýsýna ve cinsine baðlýdýr.
c) Tanecikli yapýya sahiptir.
d) Gaz basýncý, birim hacimdeki tanecik sayýsýna baðlýdýr.
e) Gazlar, bulunduklarý kabýn her tarafýna yayýlýrlar.

3) ªekilde verilen sistemin pistonu aºaðýya doðru itilirse X gazýnýn niceliklerinden hangisi deðiºir?



a) Sýcaklýðý
b) (PxV) deðeri
c) Ortalama molekül hýzý
d) Birim zamanda birim yüzeye çarpan molekül sayýsý
e) Moleküllerin ortalama kinetik enerjisi

4) Hava ile dolu bir þýrýnganýn ucu kapatýlmakta ve þýrýnganýn pistonu havayý sýkýþtýracak ºekilde itilmektedir. Bu sýkýþtýrma sonucunda havayý oluºturan moleküllere ne olur?



a) Moleküllerin hepsi þýrýnganýn ucuna toplanýr.
b) Moleküller birbirine yapýþýr.
c) Moleküller küçülürler.
d) Sýkýþtýrýlan moleküllerin hareketi durur.
e) Moleküller arasýndaki mesafe azalýr.

5) Kinetik teorinin aºaðýda verilen varsayýmlarýndan hangisi ideal gaz kanununun gerçek gazlara uygulanabilmesini mümkün kýlar?
a) Sürekli ve rasgele parçacýk (atom veya molekül) hareketi.
b) Sýcaklýkla orantýlý olarak deðiºen ortalama kinetik enerji.
c) Parçacýklar arasýnda ihmal edilebilir çekim kuvvetleri.
d) Parçacýklar arasýnda esnek çarpýþmalar.
e) Ýhmal edilebilir parçacýk hacmi.

6) Kauçuk bir balon Hidrojen gazý ile doldurulduktan sonra aðzý sýkýca baðlanýr. Ancak birkaç gün sonra balonun söndüðü görülmektedir. Aºaðýdakilerden hangisi bu durumu en iyi açýklamaktadýr.

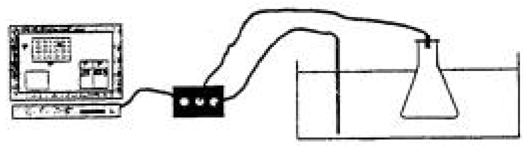
a) Zamanla moleküllerin enerjisi tükenir ve hareketleri durur.
b) Balon deliktir.
c) Hava soðumuºtur ve moleküller bir araya kümelenmiºtir.
d) Moleküller çarpýþa çarpýþa küçülmüºlerdir.
e) Dýþ basýnç artmýþ ve balonu küçültmüºtür.

7) Bir miktar Ne gazý hacmi sabit tutularak ýsýtýldýðýnda aºaðýdaki niceliklerden hangisi <u>deðiºmez</u>?
a) Basýnç
b) Kinetik enerji
c) Yoðunluk
d) Moleküllerin ortalama hýzý
e) Moleküllerin çarpýþma sýklýðý

8) Bir gaz örneðinin hacmi sabit tutularak sýcaklýðýný düºürmek gazý oluºturan atomlarýn/moleküllerin üzerinde nasýl bir etki oluºturur?
a) Atomlarýn/moleküllerin enerjisi ve hýzý azalýr.
b) Atomlar/moleküller yoðunlaþýr.
c) Atomlar/moleküller çökelirler.
d) Atomlar/moleküller büzülür ve küçülürler.
e) Atomlar/moleküller arasýndaki çekim kuvveti artar.

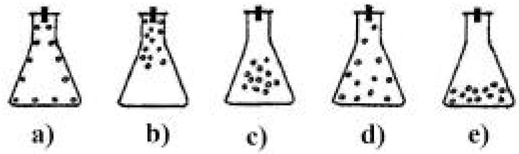
9) Bir gazý oluºturan atomlarýn/moleküllerin arasýnda ne vardýr?
a) hava
b) su buharý
c) baºka gazlar
d) hiç bir ºey yoktur
e) yabancý maddeler (toz, kir gibi)

Takip eden 10, 11, ve 12. sorularý aºaðýda verilen açýklamaya göre cevaplandýrýnýz.

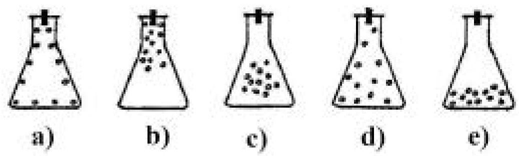


Hava içeren kapalý bir kap ºekilde gösterildiði gibi su banyosunun içine yerleºtirilmiºtir ve bilgisayara baðlanmýþtýr. Sýcaklýk deðiºimleri kaba yerleºtirilen termometre ile takip edilmektedir. Ayrýca kap basýncý ölçen bir alete de baðlanmýþtýr ve basýnç bilgisayarda okunabilmektedir. Su banyosunun sýcaklýðý 25 ^{o}C ve basýnç 1 atm'dir.

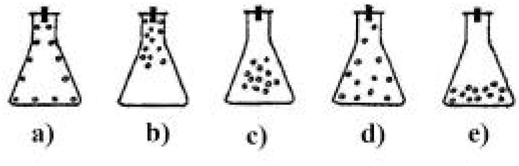
10) 25 ^{o}C'de havayý oluºturan parçacýklarýn kap içindeki daðýlýmýný en iyi gösteren ºekil hangisidir?



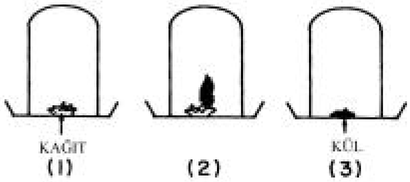
11) Su banyosuna buz ilave edilerek kaptaki sýcaklýk 0 ^{o}C'ye kadar düºürülmektedir. Sýcaklýk deðiºiminin havayý oluºturan parçacýklarý etkileyecek kadar bekledikten sonra parçacýklarýn kap içindeki daðýlýmýný en iyi gösteren ºekil hangisidir?



12) Isýtýcý yardýmýyla su banyosundaki su ýsýtýlarak gazý içeren kabýn sýcaklýðý 60 ^{o}C'ye yükseltilmektedir. Bu durumda parçacýklarýn kap içindeki daðýlýmýný en iyi gösteren ºekil hangisidir?

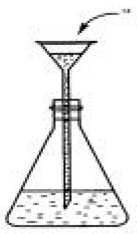


13) Aºaðýda verilen ºekilde Durum 1’de bir parça kaðýt cam fanusun içine konmaktadýr. Durum 2’de kaðýt yakýlmakta ve Durum 3’te küller oluºmaktadýr. 1, 2 ve 3 durumlarýnda herºey tartýldýðýna göre, sonuç aºaðýdakilerden hangisinde doðru verilmiºtir.



a) Durum 1 daha büyük aðýrlýða sahip.
b) Durum 2 daha büyük aðýrlýða sahip.
c) Durum 3 daha büyük aðýrlýða sahip.
d) 1 ve 2 ayný aðýrlýða sahip ve 3’ten daha aðýrdýr.
e) Hepsi de ayný aðýrlýða sahip.

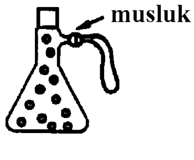
14)

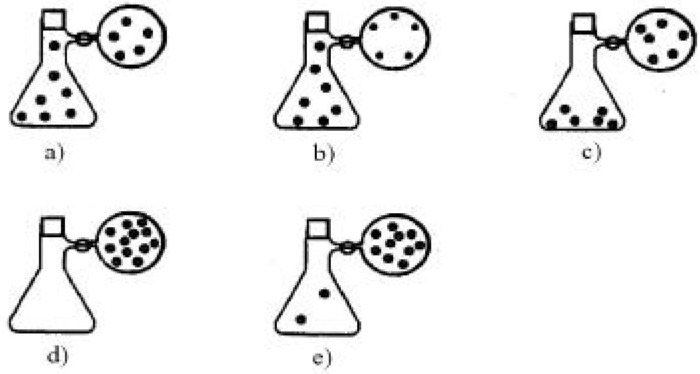


ªekilde gösterildiði gibi cam bir kap huni ile birleºtrilmiº bir kapakla sýkýca kapatýlmaktadýr. Huni yardýmýyla kaba su ilave edilmektedir. Ancak su seviyesi huninin ayaðýný geçtikten sonra su ilavesi zorlaºmaktadýr. Bu zorluðun nedeni aºaðýdaki durumlardan hangisinde doðru verilmiºtir.

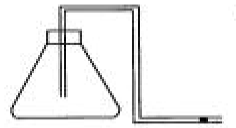
a) Su ilavesi ile kabýn içindeki hava sýkýþýr ve iç basýnç artar. Oluºan basýnç su giriºini engeller.
b) Kaptaki su giriºi kapatmaktadýr ve su giremez.
c) Kaptaki su yukarýya doðru itme kuvveti uygulamaktadýr ve su giremez.
d) Kaptaki suyun kaldýrma kuvveti daha fazla su ilavesini kaldýramaz duruma gelmiºtir.
e) Kap daha büyük olsaydý daha fazla su alýrdý.

15) Hava ile dolu bir kaba ºekilde gösterildiði gibi bir balon baðlanmaktadýr. Daha sonra aradaki musluk açýlarak kap ýsýtýlmakta ve balon ºiºmektedir. Balon ºiºtikten sonra kaptaki ve balondaki havanýn daðýlýmýný en iyi açýklayan ºekil hangisidir?





16) ª ekilde verilen sistemde cam borunun içinde bir damla civa bulunmaktadýr. Kabýn içindeki sýcaklýk ve basýnç deðiºimine baðlý olarak civa damlasý saða ya da sola hareket etmektedir. Eðer düzenek, sýcaklýðý 26 ^oC olan bir odadan sýcaklýðý 5^oC olan baºka bir odaya götürülürse civa damlacýðýnýn hareket yönünü ve bu hareketin nedenini tahmin ediniz.



a) Sabit kalýr, çünkü basýnç sabittir.
b) Sabit kalýr, civanýn saðý da solu (kabýn içi) da ayný sýcaklýkta.
c) Sola, sýcaklýk düºünce kabýn içindeki basýnç da düºer.
d) Saða, sýcaklýk düºünce kabýn içindeki basýnç azalýr ve hacim artar.
e) Saða, sýcaklýk düºünce hacim azalýr ve basýnç artar.

17) Atmosfer basýncýnýn P_{atm} olduðu bir ortamda hava ile dolu bir balonun basýncý P_{dolu} olarak ölçülmektedir. Balonun aðzý açýlýp sönmesi beklenmektedir ve sönmüº balonun basýncý $P_{\text{sönmüº}}$ olarak ölçülmektedir. Aºaðýdakilerden hangisinde P_{atm}, P_{dolu} ve $P_{\text{sönmüº}}$ basýnçlarýnýn iliºkisi doðru olarak verilmiºtir.
a) $P_{\text{sönmüº}} < P_{atm} < P_{dolu}$
b) $P_{atm} = P_{\text{sönmüº}}$, $P_{atm} < P_{dolu}$
c) $P_{atm} = P_{dolu} = P_{\text{sönmüº}}$
d) $P_{atm} > P_{dolu}$, $P_{\text{sönmüº}} = 0$
e) $P_{atm} < P_{dolu}$, $P_{\text{sönmüº}} = 0$

18) Maden suyu elde etmenin yolu suda CO_2 (karbon dioksit) gazý çözmektir. Sudan ve karbon dioksitten oluºan çözelti için hangisi doðrudur?
a) Çözeltinin kütlesi, suyun ve CO_2'in kütleleri toplamýndan fazladýr.
b) Çözeltinin kütlesi, suyun ve CO_2'in kütleleri toplamýna eºittir.
c) Çözeltinin kütlesi suyun kütlesine eºittir, gazýn bir etkisi yoktur.
d) Çözeltinin kütlesi, suyun ve CO_2'in kütleleri toplamýndan azdýr.
e) Hiçbiri.

19) Soðuk ve sýcak havanýn özellikleri ile ilgili verilen yargýlardan hangisi doðrudur?
a) Sýcak hava ile soðuk hava farklý hacimlere fakat ayný kütleye sahiptirler.
b) Isýtýlan hava soðuk havadan daha aðýrdýr.
c) Sýcak hava soðuk havadan hafiftir.
d) Havanýn kütlesi de hacmi de yoktur, sýcak ya da soðuk farketmez.
e) Sýcak havanýn molekülleri genleºirler, soðuk havanýnkiler ise büzülür.

20) Gazlarýn özellikleri ile ilgili aºaðýdaki yargýlardan hangisi yanlýþtýr?
a) Gaz atomlarý/molekülleri sürekli hareket halindedir.
b) Gaz atomlarý/molekülleri arasýndaki baðlar yok denecek kadar zayýftýr.
c) Bir kaba konulduklarýnda sývýlar gibi kabýn dibinde bulunurlar.
d) Gaz atomlarý/molekülleri rasgele hareket ederler, belli bir hareket düzeni yoktur.
e) Gazlar sývýlaºtýrýlabilirler.

21) Aºaðýdaki etkilerden hangisi ya da hangileri uygulanýrsa bir gazýn sudaki çözünürlüðü artar?

I. Suyun sýcaklýðýný artýrmak
II. Gazýn basýncýný artýrmak
III. Suyun miktarýný artýrmak
IV. Ortamýn sýcaklýðýný artýrmak

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

22) Havada asýlý duran bir cisme atmosfer basýncýnýn etki edip etmediðini görebilseydiniz basýncýn yönü hakkýnda ne derdiniz?

a) Aºaðý doðru
b) Yukarý doðru
c) Her yönden: aºaðý, yukarý,sað ve sol
d) Ýki yönde: aºaðý ve yukarý
e) Etkisi yoktur

23) Üç balon üç farklý gazla O_2, Cl_2 ve H_2 ile doldurulmaktadýr. Oda ºartlarýndaki gazlardan 0.1'er mol kullanýlmaktadýr. Gazlarla ºiºirilen balonlarýn hacimlerini kýyaslayýnýz. (O:16, Cl: 35.5, H:1)

a) En büyük klor gazý içerenin olur, kütlesi daha büyük.
b) En büyük hidrojen gazý içerenin olur, çünkü en hafif gaz.
c) Hacmi hesaplamak için sýcaklýk ve basýncý bilmek gerekir.
d) Üç balon da ayný büyüklükte olur.
e) Oda ºartlarýndaki basýncý bilmek gerekir.

24) 27 ^{o}C sýcaklýkta ve 4.1 atm basýnçta 0.100 mol hidrojen gazý 600 mL hacim kaplamaktadýr. Hacmin sabit kaldýðýna göre, –3 ^{o}C'ta kadar soðutulan gazýn basýncý nedir?

a) 3.1 atm b) 3.7 atm c) 4.0 atm d) 4.6 atm e) 5.1 atm

25) 16 gram X gazýnýn 273 K'de basýnç-hacim çarpýmý (PV) 5.60 L.atm dir. Bu X gazý aºaðýdakilerden hangisi olabilir? (H: 1, O: 16, S: 32)

a) SO_3 b) O_2 c)H_2S d) O_3 e) SO_2

26) Hacimleri eºit iki balonda eºit sýcaklýkta X ve Y gazlarý bulunmaktadýr.

I. X gazýnýn aðýrlýðý Y ninkinin 4 katýdýr.
II. X in molekül aðýrlýðý Yninkinin yarýsýdýr.

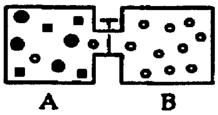
Buna göre X balonundaki basýnç, Y balonundakinin kaç katýdýr?

a) 1/4 b)1/2 c) 2 d) 4 e) 8

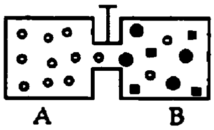
27) Bir miktar metan (CH_4) gazý 1 atm basýnçta ve 7 ^{o}C'ta 5.6 L hacim kaplamaktadýr. 27 ^{o}C'ta ve 1 atm basýnçta gazýn kapladýðý hacim nedir?

a) 5.2 L b) 6.0 L c) 6.8 L d) 7.6 L e) 22.4 L

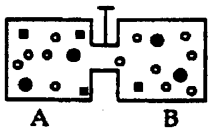
28) ªekildeki A ve B kaplarý bir muslukla birleºtirilmiºlerdir. Her iki kabýn da basýncý 1 atm dir. A kabý kükürt dioksit (•), carbon dioksit (■) ve azot (○) karþýmý ile doludur. B kabý ise sadece azot içermektedir.



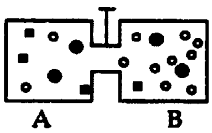
Musluk açýldýktan 1 saat sonra karýþým homojen hale gelmektedir. Aºaðýdaki ºekillerden hangisi moleküllerin musluk açýldýktan 30 dak sonraki olasý bir daðýlýmýný göstermektedir?



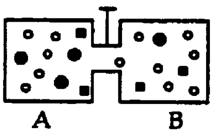
a)



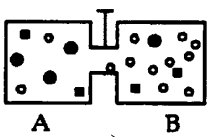
b)



c)

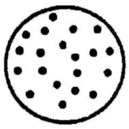


d)

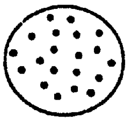


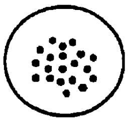
e)

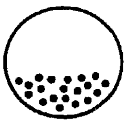
29) Aºaðýdaki ºekil 20 ^oC ve 3 atm basýnçta hidrojen gazý ile dolu silindir ºeklindeki çelik bir tankýn enine kesitidir. Noktalar, tanktaki bütün hidrojen moleküllerinin daðýlýmýný temsil etmektedirler.

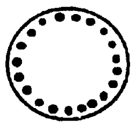


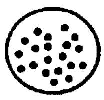
Sýcaklýk –5 ^oC'ta düºürüldüðünde aºaðýdaki ºekillerden hangisi kapalý çelik tanktaki hidrojen moleküllerinin muhtemel daðýlýmýný göstermektedir?


a)


b)


c)

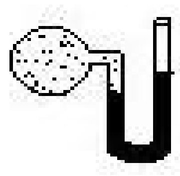

d)


e)

30) Bir gazýn 0 ^oC'de ve 1 atm basýnç altýnda 11.2 L'si 14 gramdýr. Bu gazýn bir molekülünün kütlesi kaç gramdýr?

a) $14/6.02x10^{23}$
b) $28x6.02x10^{23}$
c) $7x6.02x10^{23}$
d) $7/6.02x10^{23}$
e) $28/6.02x10^{23}$

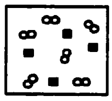
31) ªekildeki manometre ile kapalý kaptaki gazýn basýncý ölçülmek isteniyor. Aºaðýdakilerden hangisi bulunacak deðeri etkilemez?



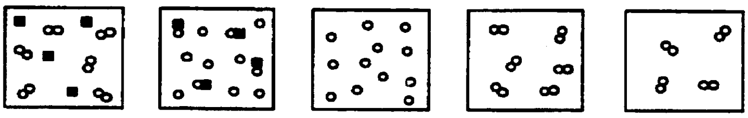
a) Bulunulan enlem
b) Ortamýn sýcaklýðý
c) U-borusunun çapý
d) Deniz yüzeyinden yükseklik
e) Kullanýlan sývýnýn özkütlesi

32) Gaz halinde belli bir miktar maddeye,
I. sabit hacimde sýcaklýðýn artýrýlmasý
II. sabit sýcaklýkta basýncýn artýrýlmasý
III. tamamýnýn sývýlaºtýrýlmasý
iºlemlerinden hangileri uygulandýðýnda, o maddenin moleküller arasý uzaklýðýnýn azalmasý beklenir?
a) Yalnýz I b) Yalnýz II c) Yalnýz III d) I ve II e) II ve III

33) Hacmi 200 mL olan kapalý bir kap 15 ^{o}C'ta ºekilde gösterildiði gibi oksijen (∞) ve helyumdan (■)oluºan bir karýþým içermektedir.



Aºaðýdakilerden hangisi oksijen gazýnýn kýsmi basýncýný göstermektedir?



a) b) c) d) e)

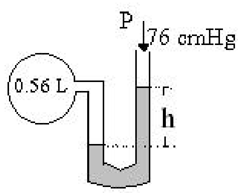
34) Sabit hacimli bir kapta bulunan m gram O_2'in basýncý P'dir. Bu kaba ayný sýcaklýkta m gram SO_2 gazý ilave edilmektedir. Gaz ilavesinden sonra oksijenin kýsmi basýncý ne olur? (O_2: 32; SO_2: 64)

a) 2P b) P c) 3/2 P d) 2/3P e) 1/2P

35) C_4H_8 gazýnýn 0 ^{o}C ve 0.25 atmosfer basýnç altýndaki özkütlesi kaç g/L'dir?

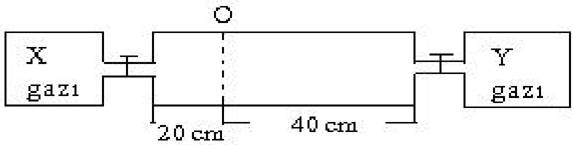
a) 0.625 b) 0.75 c) 1.00 d) 1.25 e) 1.40

36) ªekildeki kapta 0 ^{o}C'ta 1.5 gram C_2H_6 gazý vardýr. Kabýn hacmi 0.56 L ve dýþ basýnç 76 cmHg olduðuna göre h yüksekliði kaç cm'dir? (C:12, H:1)



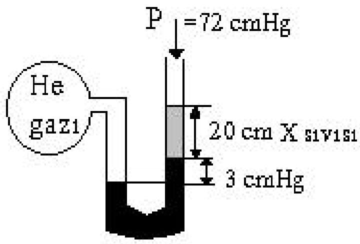
a) 19 b) 28 c) 38 d) 57 e) 76

37) ªekildeki sistemde sýcaklýklarý ayný olan X ve Y gazlarý ayný anda musluklar açýlarak býrakýldýðýnda O noktasýnda karþýlaþýyorlar. X ve Y gazlarý aºaðýdakilerin hangisinde doðru olarak verilmiºtir? (H:1, He: 4, O:16, C:12, S: 32)



	X	Y
a)	CH_4	SO_2
b)	CH_4	He
c)	H_2	He
d)	O_2	SO_3
e)	O_2	CH_4

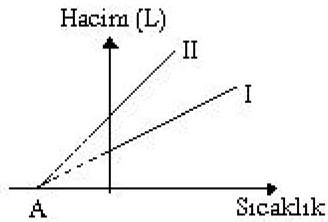
38) ªekildeki sistem dýþ basýncýn 72 cmHg olduðu ortamdadýr. Manometrede civa ve X sývýsý bulunmaktadýr. (d_{civa} =13.6 g/cm^3; d_x= 3.4 g/cm^3)



Buna göre He gazýnýn basýncý kaç cmHg'dýr?

a) 75 b) 78 c)80 d) 95 e) 100

39) Yandaki grafik bir mol ideal gazýn hacim sýcaklýk deðiºimini göstermektedir.
Bu grafikle ilgili aºaðýdaki açýklamalardan hangisi <u>yanlýþtýr</u>?



a) II. deneydeki hacim, I. deneydekinden büyüktür.
b) A noktasý mutlak sýfýr noktasýdýr.
c) Sýcaklýk birimi ^oC'dir.
d) A noktasý –273 ^oC'dir.
e) II. deneydeki V/T oraný, I. deneydeki V/T oranýna eºittir.

40) Bir gerçek gazýn ideal gaz davranýþýý gösterebileceði P ve T ºartlarý nelerdir?
a) Yüksek P ve düºük T
b) Düºük P ve düºük T
c) Düºük P ve yüksek T
d) Yüksek P ve yüksek T
e) Hiçbiri

Table B.1 Gazlar Kavram Testinin Cevap Anahtarý

1 – d	9 – d	17 – b	25 – e	33 – d
2 – b	10 – d	18 – b	26 – e	34 – b
3 – d	11 – d	19 – a	27 – b	35 – a
4 – e	12 – d	20 – c	28 – d	36 – e
5 – c	13 – e	21 – b	29 – a	37 – b
6 – b	14 – a	22 – c	30 – e	38 – c
7 – c	15 – a	23 – d	31 – c	39 – e
8 – a	16 – c	24 – b	32 – e	40 – c

APPENDIX C

KÝMYA DERSÝ TUTUM ÖLÇEÐÝ

AÇIKLAMA: Bu ölçek, Kimya dersine iliºkin tutum cümleleri ile her cümlenin karþýsýnda Tamamen Katýlýyorum, Katýlýyorum, Kararsýzým, Katýlmýyorum ve Hiç Katýlmýyorum olmak üzere beº seçenek verilmiºtir. Her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneði iºaretleyiniz.

	Tamamen Katýlýyorum	Katýlýyorum	Kararsýzým	Katýlmýyorum	Hiç Katýlmýyorum
1. Kimya çok sevdiðim bir alandýr…………………………..	○	○	○	○	○
2. Kimya ile ilgili kitaplarý okumaktan hoºlanýrým………….	○	○	○	○	○
3. Kimyanýn günlük yaºantýda çok önemli yeri yoktur……..	○	○	○	○	○
4. Kimya ile ilgili ders problemlerini çözmekten hoºlanýrým………………………………………………..	○	○	○	○	○
5. Kimya konularýyla ile ilgili daha çok ºey öðrenmek isterim………………………………………………………	○	○	○	○	○
6. Kimya dersine girerken sýkýntý duyarým………………….	○	○	○	○	○
7. Kimya derslerine zevkle girerim…………………………	○	○	○	○	○
8. Kimya derslerine ayrýlan ders saatinin daha fazla olmasýný isterim………………………………………………………	○	○	○	○	○
9. Kimya dersini çalýþýrken caným sýkýlýr……………………	○	○	○	○	○
10. Kimya konularýný ilgilendiren günlük olaylar hakkýnda daha fazla bilgi edinmek isterim……………………………	○	○	○	○	○
11. Düºünce sistemimizi geliºtirmede Kimya öðrenimi önemlidir……………………..…………………………..	○	○	○	○	○
12. Kimya çevremizdeki doðal olaylarýn daha iyi anlaþýlmasýnda önemlidir……………………………………	○	○	○	○	○
13. Dersler içinde Kimya dersi sevimsiz gelir………………	○	○	○	○	○
14. Kimya konularýyla ilgili tartýþmaya katýlmak bana cazip gelmez………………………………………………………	○	○	○	○	○
15. Çalýþma zamanýmýn önemli bir kýsmýný Kimya dersine ayýrmak isterim……………………………….…………….	○	○	○	○	○

APPENDIX D

BÝLÝMSEL ÝÞLEM BECERÝ TESTÝ

AÇIKLAMA: Bu test, özellikle Fen ve Matematik derslerinizde ve ilerde üniversite sýnavlarýnda karþýnýza çýkabilecek karmaþýk gibi görünen problemleri analiz edebilme kabiliyetinizi ortaya çýkarabilmesi açýsýndan çok faydalýdýr. Bu test içinde, problemdeki deðiºkenleri tanýmlayabilme, hipotez kurma ve tanýmlama, iºlemsel açýklamalar getirebilme, problemin çözümü için gerekli incelemelerin tasarlanmasý, grafik çizme ve verileri yorumlayabilme kabiliyelerini ölçebilen sorular bulunmaktadýr. Her soruyu okuduktan sonra kendinizce uygun seçeneði yalnýzca cevap kaðýdýna iºaretleyiniz.

Bu testin orijinali James R. Okey, Kevin C. Wise ve Joseph C. Burns tarafýndan geliºtirilmiºtir. Türkçeye çevrisi ve uyarlamasý ise Prof. Dr. Ýlker Özkan, Prof. Dr. Petek Aºkar ve Prof. Dr. Ömer Geban tarafýndan yapýlmýþtýr.

1. Bir basketbol antrenörü, oyuncularýn güçsüz olmasýndan dolayý maçlarý kaybettiklerini düºünmektedir. Güçlerini etkileyen faktörleri araºtýrmaya karar verir. Antrenör, oyuncularýn gücünü etkileyip etkilemediðini ölçmek için aºaðýdaki deðiºkenlerden hangisini incelemelidir?

a. Her oyuncunun almýþ olduðu günlük vitamin miktarýný.

b. Günlük aðýrlýk kaldýrma çalýþmalarýnýn miktarýný.

c. Günlük antreman süresini.

d. Yukarýdakilerin hepsini.

2. Arabalarýn verimliliðini inceleyen bir araºtýrma yapýlmaktadýr. Sýnanan hipotez, benzine katýlan bir katký maddesinin arabalarýn verimliliðini artýrdýðý yolundadýr. Ayný tip beº arabaya ayný miktarda benzin fakat farklý miktarlarda katký maddesi konur. Arabalar benzinleri bitinceye kadar ayný yol üzerinde giderler. Daha sonra her arabanýn aldýðý mesafe kaydedilir. Bu çalýþmada arabalarýn verimliliði nasýl ölçülür?

a. Arabalarýn benzinleri bitinceye kadar geçen süre ile.

b. Her arabanýn gittiði mesafe ile.

c. Kullanýlan benzin miktarý ile.

d. Kullanýlan katký maddesinin miktarý ile.

3. Bir araba üreticisi daha ekonomik arabalar yapmak istemektedir. Araºtýrmacýlar arabanýn litre baþýna alabileceði mesafeyi etkileyebilecek deðiºkenleri araºtýmaktadýrlar. Aºaðýdaki deðiºkenlerden hangisi arabanýn litre baþýna alabileceði mesafeyi etkileyebilir?

a. Arabanýn aðýrlýðý.

b. Motorun hacmi.

c. Arabanýn rengi

d. a ve b.

4. Ali Bey, evini ýsýtmak için komºularýndan daha çok para ödenmesinin sebeblerini merak etmektedir. Isýnma giderlerini etkileyen faktörleri araºtýrmak için bir hipotez kurar. Aºaðýdakilerden hangisi bu araºtýrmada sýnanmaya uygun bir hipotez <u>deðildir</u>?

a. Evin çevresindeki aðaç sayýsý ne kadar az ise ýsýnma gideri o kadar fazladýr.

b. Evde ne kadar çok pencere ve kapý varsa, ýsýnma gideri de o kadar fazla olur.

c. Büyük evlerin ýsýnma giderleri fazladýr.

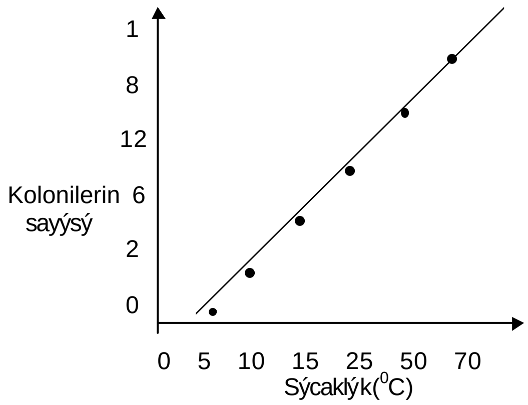
d. Isýnma giderleri arttýkça ailenin daha ucuza ýsýnma yollarý aramasý gerekir.

5. Fen sýnýfýndan bir öðrenci sýcaklýðýn bakterilerin geliºmesi üzerindeki etkilerini araºtýrmaktadýr. Yaptýðý deney sonucunda, öðrenci aºaðýdaki verileri elde etmiºtir:

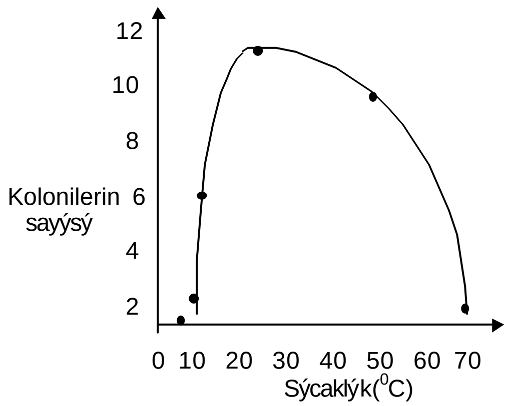
Deney odasýnýn sýcaklýðý (^{0}C)	Bakteri kolonilerinin sayýsý
5	0
10	2
15	6
25	12
50	8
70	1

Aºaðýdaki grafiklerden hangisi bu verileri doðru olarak göstermektedir?

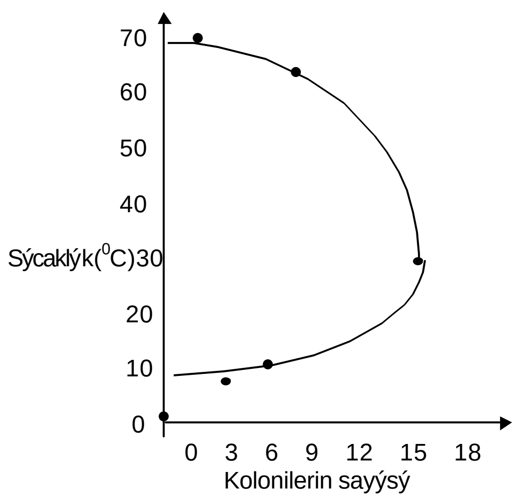
a.



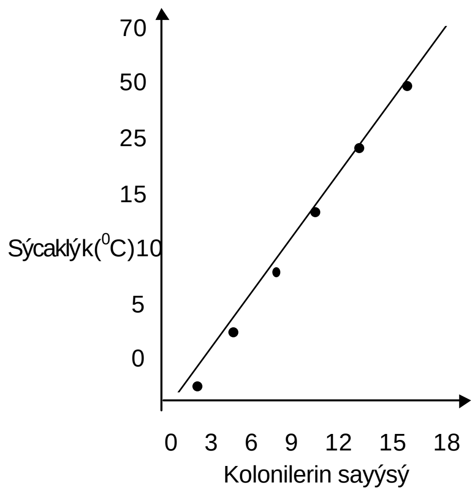
b.



c.



d.



6. Bir polis ºefi, arabalarýn hýzýnýn azaltýlmasý ile uðraºmaktadýr. Arabalarýn hýzýný etkileyebilecek bazý faktörler olduðunu düºünmektedir. Sürücülerin ne kadar hýzlý araba kullandýklarýný aºaðýdaki hipotezlerin hangisiyle sýnayabilir?

a. Daha genç sürücülerin daha hýzlý araba kullanma olasýlýðý yüksektir.

b. Kaza yapan arabalar ne kadar büyükse, içindeki insanlarýn yaralanma olasýlýðý o kadar azdýr.

c. Yollarde ne kadar çok polis ekibi olursa, kaza sayýsý o kadar az olur.

d. Arabalar eskidikçe kaza yapma olasýlýklarý artar.

7. Bir fen sýnýfýnda, tekerlek yüzeyi geniºliðinin tekerleðin daha kolay yuvarlanmasý üzerine etkisi araºtýrýlmaktadýr. Bir oyuncak arabaya geniº yüzeyli tekerlekler takýlýr, önce bir rampadan (eðik düzlem) aºaðý býrakýlýr ve daha sonra düz bir zemin üzerinde gitmesi saðlanýr. Deney, ayný arabaya daha dar yüzeyli tekerlekler takýlarak tekrarlanýr. Hangi tip tekerleðin daha kolay yuvarlandýðý nasýl ölçülür?

a. Her deneyde arabanýn gittiði toplam mesafe ölçülür.

b. Rampanýn (eðik düzlem) eðim açýsý ölçülür.

c. Her iki deneyde kullanýlan tekerlek tiplerinin yüzey geniºlikleri ölçülür.

d. Her iki deneyin sonunda arabanýn aðýrlýklarý ölçülür.

8. Bir çiftçi daha çok mýsýr üretebilmenin yollarýný aramaktadýr. Mýsýrlarýn miktarýný etkileyen faktörleri araºtýrmayý tasarlar. Bu amaçla aºaðýdaki hipotezlerden hangisini sýnayabilir?

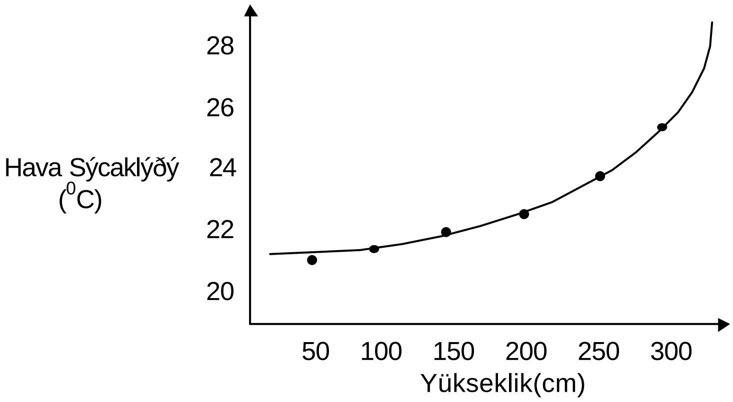
a. Tarlaya ne kadar çok gübre atýlýrsa, o kadar çok mýsýr elde edilir.

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

c. Yaðmur ne kadar çok yaðarsa , gübrenin etkisi o kadar çok olur.

d. Mýsýr üretimi arttýkça, üretim maliyeti de artar.

9. Bir odanýn tabandan itibaren deðiºik yüzeylerdeki sýcaklýklarla ilgili bir çalýþma yapýlmýþ ve elde edilen veriler aºaðýdaki grafikte gösterilmiºtir. Deðiºkenler arasýndaki iliºki nedir?



a. Yükseklik arttýkça sýcaklýk azalýr.

b. Yükseklik arttýkça sýcaklýk artar.

c. Sýcaklýk arttýkça yükseklik azalýr.

d. Yükseklik ile sýcaklýk artýþý arasýnda bir iliºki yoktur.

10. Ahmet, basketbol topunun içindeki hava arttýkça, topun daha yükseðe sýçrayacaðýný düºünmektedir. Bu hipotezi araºtýrmak için, birkaç basketbol topu alýr ve içlerine farklý miktarda hava pompalar. Ahmet hipotezini nasýl sýnamalýdýr?

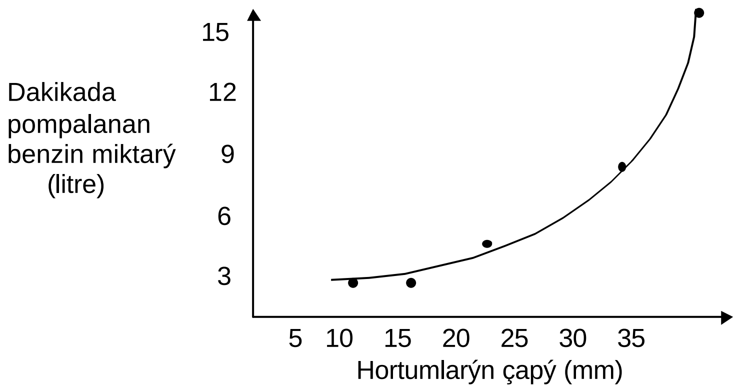
a. Toplarý ayný yükseklikten fakat deðiºik hýzlarla yere vurur.

b. Ýçlerinde farklý miktarlarda hava olan toplarý, ayný yükseklikten yere býrakýr.

c. Ýçlerinde ayný miktarlarda hava olan toplarý, zeminle farklý açýlardan yere vurur.

d. Ýçlerinde ayný miktarlarda hava olan toplarý, farklý yüksekliklerden yere býrakýr.

11. Bir tankerden benzin almak için farklý geniºlikte 5 hortum kullanýlmaktadýr. Her hortum için ayný pompa kullanýlýr. Yapýlan çalýþma sonunda elde edilen bulgular aºaðýdaki grafikte gösterilmiºtir.



Aºaðýdakilerden hangisi deðiºkenler arasýndaki iliºkiyi açýklamaktadýr?

a. Hortumun çapý geniºledikçe dakikada pompalanan benzin miktarý da artar.

b. Dakikada pompalanan benzin miktarý arttýkça, daha fazla zaman gerekir.

c. Hortumun çapý küçüldükçe dakikada pompalanan benzin miktarý da artar.

d. Pompalanan benzin miktarý azaldýkça, hortumun çapý geniºler.

Önce aºaðýdaki açýklamayý okuyunuz ve daha sonra 12, 13, 14 ve 15 inci sorularý açýklama kýsmýndan sonra verilen paragrafý okuyarak cevaplayýnýz.

Açýklama: Bir araºtýrmada, baðýmlý deðiºken birtakým faktörlere baðýmlý olarak geliºim gösteren deðiºkendir. Baðýmsýz deðiºkenler ise baðýmlý deðiºkene etki eden faktörlerdir. Örneðin, araºtýrmanýn amacýna göre kimya baºarýsý baðýmlý bir deðiºken olarak alýnabilir ve ona etki edebilecek faktör veya faktörler de baðýmsýz deðiºkenler olurlar.

Ayºe, güneºin karalarý ve denizleri ayný derecede ýsýtýp ýsýtmadýðýný merak etmektedir. Bir araºtýrma yapmaya karar verir ve ayný büyüklükte iki kova alýr. Bunlardan birini toprakla, diðerini de su ile doldurur ve ayný miktarda güneº ýsýsý alacak ºekilde bir yere koyar. 8.00 - 18.00 saatleri arasýnda, her saat baþý sýcaklýklarýný ölçer.

12. Araºtýrmada aºaðýdaki hipotezlerden hangisi sýnanmýþtýr?

a. Toprak ve su ne kadar çok güneº ýþýðý alýrlarsa, o kadar ýsýnýrlar.

b. Toprak ve su güneº altýnda ne kadar fazla kalýrlarsa, o kadar çok ýsýnýrlar.

c. Güneº farklý maddeleri farklý derecelerde ýsýtýr.

d. Günün farklý saatlerinde güneºin ýsýsý da farklý olur.

13. Araºtýrmada aºaðýdaki deðiºkenlerden hangisi kontrol edilmiºtir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sýcaklýðý.

c. Kovalara koyulan maddenin türü.

d. Herbir kovanýn güneº altýnda kalma süresi.

14. Araºtýrmada baðýmlý deðiºken hangisidir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sýcaklýðý.

c. Kovalara koyulan maddenin türü.

d. Herbir kovanýn güneº altýnda kalma süresi.

15. Araºtýrmada baðýmsýz deðiºken hangisidir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sýcaklýðý.

c. Kovalara koyulan maddenin türü.

d. Herbir kovanýn güneº altýnda kalma süresi.

16. Can, yedi ayrý bahçedeki çimenleri biçmektedir. Çim biçme makinasýyla her hafta bir bahçedeki çimenleri biçer. Çimenlerin boyu bahçelere göre farklý olup bazýlarýnda uzun bazýlarýnda kýsadýr. Çimenlerin boylarý ile ilgili hipotezler kurmaya baºlar. Aºaðýdakilerden hangisi sýnanmaya uygun bir hipotezdir?

a. Hava sýcakken çim biçmek zordur.

b. Bahçeye atýlan gübrenin miktarý önemlidir.

c. Daha çok sulanan bahçedeki çimenler daha uzun olur.

d. Bahçe ne kadar engebeliyse çimenleri kesmek de o kadar zor olur.

17, 18, 19 ve 20 nci sorularý aºaðýda verilen paragrafý okuyarak cevaplayýnýz.

Murat, suyun sýcaklýðýnýn, su içinde çözünebilecek ºeker miktarýný etkileyip etkilemediðini araºtýrmak ister. Birbirinin ayný dört bardaðýn herbirine 50 ºer mililitre su koyar. Bardaklardan birisine 0 ^{0}C de, diðerine de sýrayla 50 ^{0}C, 75 ^{0}C ve 95 ^{0}C sýcaklýkta su koyar. Daha sonra herbir bardaða çözünebileceði kadar ºeker koyar ve karýþtýrýr.

17. Bu araºtýrmada sýnanan hipotez hangisidir?

a. ª eker ne kadar çok suda karýþtýrýlýrsa o kadar çok çözünür.

b. Ne kadar çok ºeker çözünürse, su o kadar tatlý olur.

c. Sýcaklýk ne kadar yüksek olursa, çözünen ºekerin miktarý o kadar fazla olur.

d. Kullanýlan suyun miktarý arttýkça sýcaklýðý da artar.

18. Bu araºtýrmada kontrol edilebilen deðiºken hangisidir?

a. Her bardakta çözünen ºeker miktarý.

b. Her bardaða konulan su miktarý.

c. Bardaklarýn sayýsý.

d. Suyun sýcaklýðý.

19. Araºtýmanýn baðýmlý deðiºkeni hangisidir?

a. Her bardakta çözünen ºeker miktarý.

b. Her bardaða konulan su miktarý.

c. Bardaklarýn sayýsý.

d. Suyun sýcaklýðý.

20. Araºtýrmadaki baðýmsýz deðiºken hangisidir?

a. Her bardakta çözünen ºeker miktarý.

b. Her bardaða konulan su miktarý.

c. Bardaklarýn sayýsý.

d. Suyun sýcaklýðý.

21. Bir bahçývan domates üretimini artýrmak istemektedir. Deðiºik birkaç alana domates tohumu eker. Hipotezi, tohumlar ne kadar çok sulanýrsa, o kadar çabuk filizleneceðidir. Bu hipotezi nasýl sýnar?

a. Farklý miktarlarda sulanan tohumlarýn kaç günde filizleneceðine bakar.

b. Her sulamadan bir gün sonra domates bitkisinin boyunu ölçer.

c. Farklý alanlardaki bitkilere verilen su miktarýný ölçer.

d. Her alana ektiði tohum sayýsýna bakar.

22. Bir bahçývan tarlasýndaki kabaklarda yaprak bitleri görür. Bu bitleri yok etmek gereklidir. Kardeºi "Kling" adlý tozun en iyi böcek ilacý olduðunu söyler. Tarým uzmanlarý ise "Acar" adlý spreyin daha etkili olduðunu söylemektedir. Bahçývan altý tane kabak bitkisi seçer. Üç tanesini tozla, üç tanesini de spreyle ilaçlar. Bir hafta sonra her bitkinin üzerinde kalan canlý bitleri sayar. Bu çalýþmada böcek ilaçlarýnýn etkinliði nasýl ölçülür?

a. Kullanýlan toz ya da spreyin miktarý ölçülür.

b. Toz ya da spreyle ilaçlandýktan sonra bitkilerin durumlarý tespit edilir.

c. Her fidede oluºan kabaðýn aðýrlýðý ölçülür.

d. Bitkilerin üzerinde kalan bitler sayýlýr.

23. Ebru, bir alevin belli bir zaman süresi içinde meydana getireceði ýsý enerjisi miktarýný ölçmek ister. Bir kabýn içine bir litre soðuk su koyar ve 10 dakika süreyle ýsýtýr. Ebru, alevin meydana getirdiði ýsý enerjisini nasýl öiçer?

a. 10 dakika sonra suyun sýcaklýðýnda meydana gelen deðiºmeyi kaydeder.

b. 10 dakika sonra suyun hacminde meydana gelen deðiºmeyi ölçer.

c. 10 dakika sonra alevin sýcaklýðýný ölçer.

d. Bir litre suyun kaynamasý için geçen zamaný ölçer.

24. Ahmet, buz parçacýklarýnýn erime süresini etkileyen faktörleri merak etmektedir. Buz parçalarýnýn büyüklüðü, odanýn sýcaklýðý ve buz parçalarýnýn ºekli gibi faktörlerin erime süresini etkileyebileceðini düºünür. Daha sonra ºu hipotezi sýnamaya karar verir: Buz parçalarýnýn ºekli erime süresini etkiler. Ahmet bu hipotezi sýnamak için aºaðýdaki deney tasarýmlarýnýn hangisini uygulamalýdýr?

a. Herbiri farklý ºekil ve aðýrlýkta beº buz parçasý alýnýr. Bunlar ayný sýcaklýkta benzer beº kabýn içine ayrý ayrý konur ve erime süreleri izlenir.

b. Herbiri ayný ºekilde fakat farklý aðýrlýkta beº buz parçasý alýnýr. Bunlar ayný sýcaklýkta benzer beº kabýn içine ayrý ayrý konur ve erime süreleri izlenir.

c. Herbiri ayný aðýrlýkta fakat farklý ºekillerde beº buz parçasý alýnýr. Bunlar ayný sýcaklýkta benzer beº kabýn içine ayrý ayrý konur ve erime süreleri izlenir.

d. Herbiri ayný aðýrlýkta fakat farklý ºekillerde beº buz parçasý alýnýr. Bunlar farklý sýcaklýkta benzer beº kabýn içine ayrý ayrý konur ve erime süreleri izlenir.

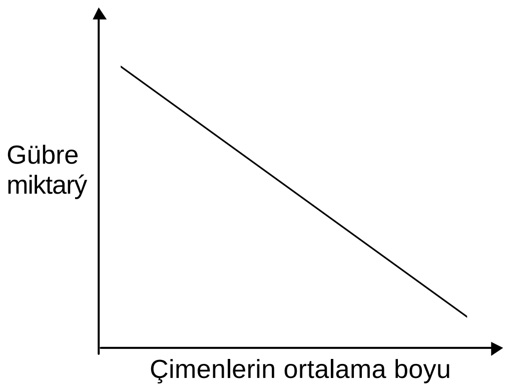
25. Bir araºtýrmacý yeni bir gübreyi denemektedir. Çalýþmalarýný ayný büyüklükte beº tarlada yapar. Her tarlaya yeni gübresinden deðiºik miktarlarda karýþtýrýr. Bir ay sonra, her tarlada yetiºen çimenin ortalama boyunu ölçer. Ölçüm sonuçlarý aºaðýdaki tabloda verilmiºtir.

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

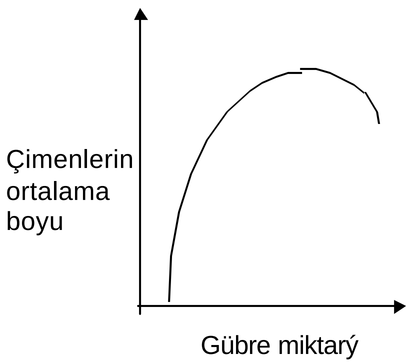
Tablodaki verilerin grafiði aºaðýdakilerden hangisidir?

a.

b.



c.



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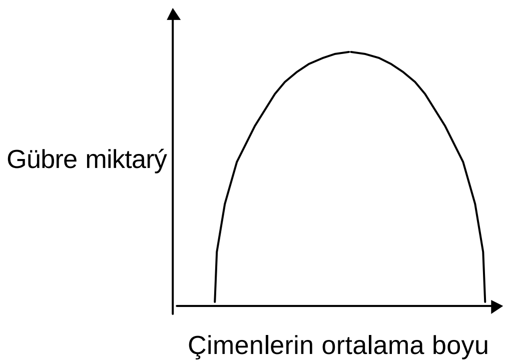


26. Bir biyolog ºu hipotezi test etmek ister: Farelere ne kadar çok vitamin verilirse o kadar hýzlý büyürler. Biyolog farelerin büyüme hýzýný nasýl ölçebilir?

a. Farelerin hýzýný ölçer.

b. Farelerin, günlük uyumadan durabildikleri süreyi ölçer.

c. Hergün fareleri tartar.

d. Hergün farelerin yiyeceði vitaminleri tartar.

27. Öðrenciler, ºekerin suda çözünme süresini etkileyebilecek deðiºkenleri düºünmektedirler. Suyun sýcaklýðýný, ºekerin ve suyun miktarlarýný deðiºken olarak saptarlar. Öðrenciler, ºekerin suda çözünme süresini aºaðýdaki hipotezlerden hangisiyle sýnayabilir?

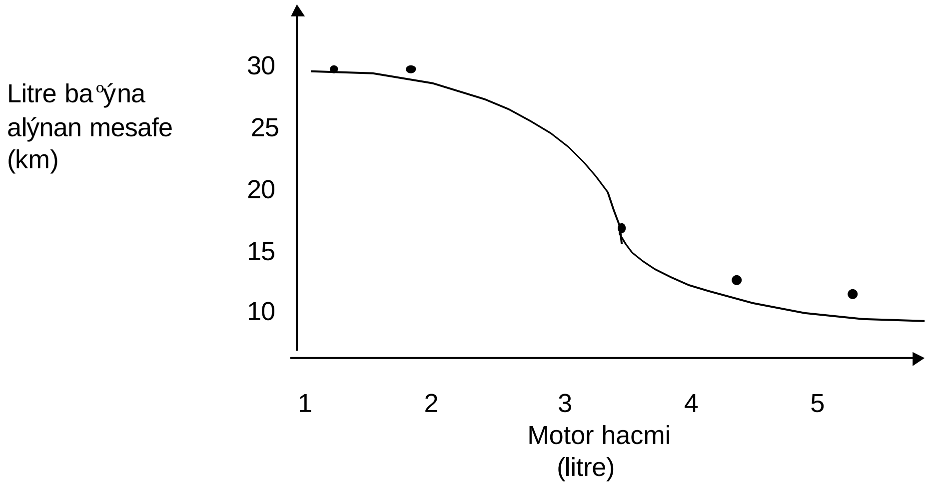
a. Daha fazla ºekeri çözmek için daha fazla su gereklidir.

b. Su soðudukça, ºekeri çözebilmek için daha fazla karýþtýrmak gerekir.

c. Su ne kadar sýcaksa, o kadar çok ºeker çözünecektir.

d. Su ýsýndýkça ºeker daha uzun sürede çözünür.

28. Bir araºtýma grubu, deðiºik hacimli motorlarý olan arabalaýrýn randýmanlarýný ölçer. Elde edilen sonuçlarýn garfiði aºaðýdaki gibidir:



Aºaðýdakilerden hangisi deðiºkenler arasýndaki iliºkiyi 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, arabanýn motoru o kadar küçük demektir.

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

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

29, 30, 31 ve 32 nci sorularý aºaðýda verilen paragrafý okuyarak cevaplayýnýz.

Topraða karýþtýrýlan yapraklarýn domates üretimine etkisi araºtýrýlmaktadýr. Araºtýrmada dört büyük saksýya ayný miktarda ve tipte toprak konulmuºtur. Fakat birinci saksýdaki toraða 15 kg., ikinciye 10 kg., üçüncüye ise 5 kg. çürümüº yaprak karýþtýrýlmýþtýr. Dördüncü saksýdaki topraða ise hiç çürümüº yaprak karýþtýrýlmamýþtýr.

Daha sonra bu saksýlara domates ekilmiºtir. Bütün saksýlar güneºe konmuº ve ayný miktarda sulanmýþtýr. Her saksýdan eled edilen domates tartýlmýþ ve kaydedilmiºtir.

29. Bu araºtýrmada sýnanan hipotez hangisidir?

a. Bitkiler güneºten ne kadar çok ýþýk alýrlarsa, o kadar fazla domates verirler.

b. Saksýlar ne kadar büyük olursa, karýþtýrýlan yaprak miktarý o kadar fazla olur.

c. Saksýlar ne kadar çok sulanýrsa, içlerindeki yapraklar o kadar çabuk çürür.

d. Topraða ne kadar çok çürük yaprak karýþtýrýlýrrsa, o kadar fazla domates elde edilir.

30. Bu araºtýrmada kontrol edilen deðiºken hangisidir?

a. Her saksýdan elde edilen domates miktarý.

b. Saksýlara karýþtýrýlan yaprak miktarý.

c. Saksýlardaki toprak miktarý.

d. Çürümüº yaprak karýþtýrýlan saksý sayýsý.

31. Araºtýrmadaki baðýmlý deðiºken hangisidir?

a. Her saksýdan elde edilen domates miktarý

b. Saksýlara karýþtýrýlan yaprak miktarý.

c. Saksýlardaki toprak miktarý.

d. Çürümüº yaprak karýþtýrýlan saksý sayýsý.

32. Araºtýrmadaki baðýmsýz deðiºken hangisidir?

a. Her saksýdan elde edilen domates miktarý.

b. Saksýlara karýþtýrýlan yaprak miktarý.

c. Saksýlardaki toprak miktarý.

d. Çürümüº yapak karýþtýrýlan saksý sayýsý.

33. Bir öðrenci mýknatýslarýn kaldýrma yeteneklerini araºtýrmaktadýr. Çeºitli boylarda ve ºekillerde birkaç mýknatýs alýr ve her mýknatýsýn çektiði demir tozlarýný tartar. Bu çalýþmada mýknatýsýn kaldýrma yeteneði nasýl tanýmlanýr?

a. Kullanýlan mýknatýsýn büyüklüðü ile.

b. Demir tozalarýný çeken mýknatýsýn aðýrlýðý ile.

c. Kullanýlan mýknatýsýn ºekli ile.

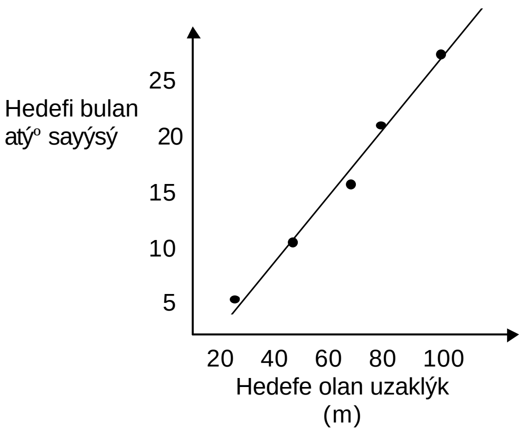
d. Çekilen demir tozlarýnýn aðýrlýðý ile.

34. Bir hedefe çeºitli mesafelerden 25 er atýþ yapýlýr. Her mesafeden yapýlan 25 atýþtan hedefe isabet edenler aºaðýdaki tabloda gösterilmiºtir.

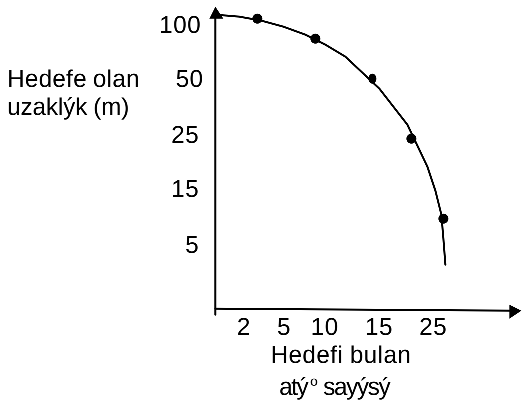
Mesafe(m)	Hedefe vuran atýº sayýsý
5	25
15	10
25	10
50	5
100	2

Aºaðýdaki grafiklerden hangisi verilen bu verileri en iyi ºekilde yansýtýr?

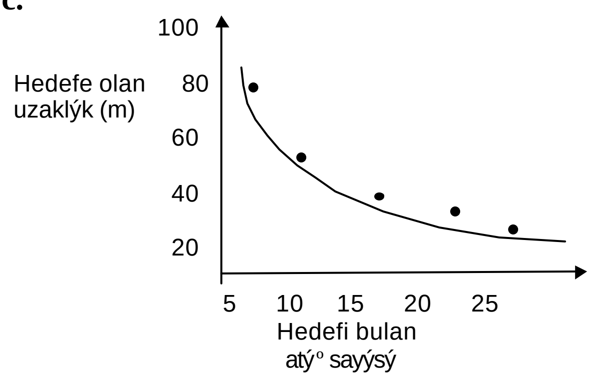
a.



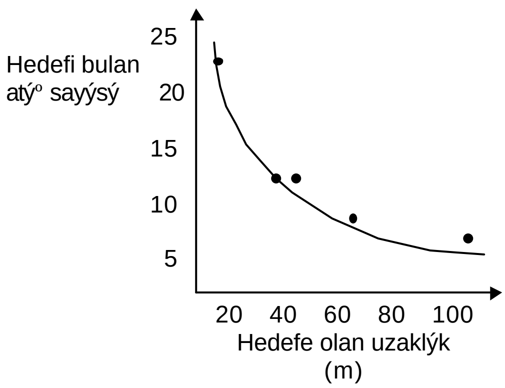
b.



c.



d.



35. Sibel, akvaryumdaki balýklarýn bazen çok hareketli bazen ise durgun olduklarýný gözler. Balýklarýn hareketliliðini etkileyen faktörleri merak eder.Balýklarýn hareketliliðini etkileyen faktörleri hangi hipotezle sýnayabilir?

a. Balýklara ne kadar çok yem verilirse, o kadar çok yeme ihtiyaçlarý vardýr.

b. Balýklar ne kadar hareketli olursa o kadar çok yeme ihtiyaçlarý vardýr.

c. Suda ne kadar çok oksijen varsa, balýklar o kadar iri olur.

d. Akvaryum ne kadar çok ýþýk alýrsa, balýklar o kadar hareketli olur.

36. Murat Bey'in evinde birçok elektrikli alet vardýr. Fazla gelen elektrik faturalarý dikkatini çeker. Kullanýlan elektrik miktarýný etkileyen faktörleri araºtýrmaya karar verir. Aºaðýdaki deðiºkenlerden hangisi kullanýlan elektrik enerjisi miktarýný etkileyebilir?

a. TV nin açýk kaldýðý süre.

b. Elektrik sayacýnýn yeri.

c. Çamaþýr makinesinin kullanma sýklýðý.

d. a ve c.

APPENDIX E

ÖÐRENME STÝLLERÝ ENVANTERÝ

Yönerge: Bu envanterin amacý öðrenme stilinizi belirlemektir. Aºaðýda her birinde dörder cümle bulunan on iki tane durum verilmektedir. Her durum için size en uygun cümleyi 4, ikinci uygun olaný 3, üçüncü uygun olaný 2, en az uygun olaný ise 1 olarak ilgili cümlenin baþýnda býrakýlan boºluða yazýnýz. Teºekkür ederim.

Örnek:		Hatýrlamanýz için:
Öðrenirken	__4__ mutluyum.	4 – en uygun olan
	__1__ hýzlýyým.	3 – ikinci uygun olan
	__2__ mantýklýyým.	2 – üçüncü uygun olan
	__3__ dikkatliyim.	1 – en az uygun olan

1. Öðrenirken --- duygularýmý göz önüne almaktan hoºlanýrým. --- izlemekten ve dinlemekten hoºlanýrým. --- fikirler üzerine düºünmekten hoºlanýrým. --- birºeyler yapmaktan hoºlanýrým.	7. En iyi --- kiºisel iliºkilerden öðrenirim. --- gözlemlerden öðrenirim. --- akýlcý kuramlardan öðrenirim. --- uygulama ve denemelerden öðrenirim.
2. En iyi --- duygularýma ve önsezilerime güvendiðimde öðrenirim. --- dikkatlice dinlediðim ve izlediðimde öðrenirim. --- mantýksal düºünmeyi temel aldýðýmda öðrenirim. --- birºeyler elde etmek için çok çalýþtýðýmda öðrenirim.	8. Öðrenirken --- kiºisel olarak o iºin bir parçasý olurum. --- iºleri yapmak için acele etmem. --- kuram ve fikirlerden hoºlanýrým. --- çalýþmamdaki sonuçlarý görmekten hoºlanýrým.
3. Öðrenirken --- güçlü duygu ve tepkilerle dolu olurum. --- sessiz ve çekingen olurum. --- sonuçlarý bulmaya yönelirim. --- yapýlanlardan sorumlu olurum.	9. En iyi --- duygularýma dayandýðým zaman öðrenirim. --- gözlemlerime dayandýðým zaman öðrenirim. --- fikirlerime dayandýðým zaman öðrenirim. --- öðrendiklerimi uyguladýðým zaman öðrenirim.
4. Öðrenirken --- duygularýmla öðrenirim. --- izleyerek öðrenirim. --- düºünerek öðrenirim. --- yaparak öðrenirim.	10. Öðrenirken --- kabul eden biriyim. --- çekingen biriyim. --- akýlcý biriyim. --- sorumlu biriyim.
5. Öðrenirken --- yeni deneyimlere açýk olurum. --- konunun her yönüne bakarým. --- analiz etmekten ve onlarý parçalara ayýrmaktan hoºlanýrým. --- denemekten hoºlanýrým.	11. Öðrenirken --- katýlýrým. --- gözlemekten hoºlanýrým. --- deðerlendiririm. --- aktif olmaktan hoºlanýrým.
6. Öðrenirken --- sezgisel biriyim. --- gözleyen biriyim. --- mantýklý biriyim. --- hareketli biriyim	12. En iyi --- akýlcý ve açýk fikirli olduðum zaman öðrenirim. --- dikkatli olduðum zaman öðrenirim. --- fikirleri analiz ettiðim zaman öðrenirim. --- pratik olduðum zaman öðrenirim.

APPENDIX F

AN EXAMPLE OF A LESSON ON RELATIONSHIP OF VOLUME AND TEMPERATURE

Introduction

Teacher: Last lesson you learned the properties of gases such as no definite volume and shape, also their property to fill completely the space in the container in which they are present because of their intrinsic and continuous motion. You also learned that gas particles, when compared with those of liquids and solids, are relatively far apart from one another. You learned P-V relationship and you had an assignment to investigate: Is there a relationship between breathing and Boyle’s law?

(Students explained what they learned regarding the assignment question. At the end of the discussion teacher explained the answer of the question and continued to the lesson.)

In this lesson you will learn about the realtionship between volume and temperature.

Dissatisfaction

Teacher: You know that the matter can exist in three states: solid, liquid and gas state. For example ice, water and vapor. You know that you can obtain water by heating ice. If you continue heating, the water evaporates and passes to vapor form. Now, consider what would happen to gas if you continued heating?

(Some students explained that gas molecules expand, other students explained that molecules stay away from the heat and go far to the heat source.)

Teacher: Okay, you have different answers and you do not aggree on an idea. Let you see the flask connected with a balloon. Observe carrefully what happens to the balloon when the flask is heated?

(The teacher performed demonstration. Students saw that the balloon expanded.)

Teacher again asked: What happened to the gas molecules after heating? Is there any change in the molecule size or shape?

Some students again claimed that the molecules got bigger and because of this the balloon expanded.

Teacher: You know, the human body is also made of atoms and molecules. If your argument is correct than we should shrink or get smaller when the weather gets colder, and we should expand or get bigger when the weather gets hotter. Atoms and molecules do not change their size or shape with temperature, volume, and pressure changes. Okay, now say me what is the reason of volume expansion?

(The teacher guided discussion until students realized that there may be change in the distance between gas molecules.)

Teacher: You know the fact that gases distribute evenly even after evacuation of some gas from the flask. The reason of the balloon expansion is the even distribution of gas molecules. In the present experiment the balloon had space to be filled by gas molecules. After heating gas molecules filled the balloon and balloon inflated. Could you compare the distance between gas molecules before and after heating?

(Students stated that molecules after heating went far from one another.)

Teacher: Okay, the distance between molecules increased. However, it is not clear why after heating the intermolecular distance increased. Could you explain why molecules went away from each other?

(The discussion continued until students stated that heating the gas increased the energy of the molecules. Then the teacher started to explain the relationship between volume and temperature on the basis of kinetic molecular theory postulates.)

Intelligibility

Teacher: Charles' law describes the direct relationship of temperature and volume of a gas. Increasing temperature causes increase in the volume. To explain why this happens, let's explore temperature and volume in terms of kinetic molecular theory. The molecules move in different directions at different speeds and they have an average amount of energy. This average amount of energy is the temperature of the gas. Increasing temperature increases the energy of the gas molecules, the molecules start to move faster and the frequency of collisions among molecules and between molecules and container increases. The gas molecules will move until they impact another molecule or the container. Increase in molecular motion causes the molecules to hit the sides of the container more often and with more force making the balloon expand. The volume of the balloon will expand until pressure inside the container become equal to the outside pressure. Cooling the gas would have the inverse effect, making the balloon smaller.

(The teacher also solved quantitative questions requiring the application of Charles' law equation of $\frac{V_1}{T_1} = \frac{V_2}{T_2}$)

Plausibility

The teacher continued by giving examples from daily life situations, which indicated the volume and temperature relationship. In this way the teacher advanced the acquisition of the V-T relationship.

Teacher: You can see the volume and temperature relationship in the reactions in which gases are produced suddenly with accompanying release of energy. In such reactions explosions occur. This explains how gunpowder propels bullets, and it explains the force produced by rocked fuel. For example, a typical rocked reaction is as:

$$2N_2H_{4(l)} + N_2O_{4(g)} \rightarrow 4H_2O_{(g)} + 3N_{2(g)}$$

In such reactions large amounts of gas are produced. Notice the relatively large number of moles of gas produced. Considering volume and temperature relationship you also can explain why deodorant container should not be left in the sun. Is there anyone who wants to explain the danger of leaving the deodorant container in the sun?

The teacher gave students opportunity to express their ideas related to the answer of the question. In this way the teacher provided opportunity students to test the usefulness of the new conception.

Fruitfulness

At the end of the lesson teacher assigned homework which requires the application of the new conceptions to the new situations.

Teacher: Okay, I think that you are ready to investigate a new problem: explain how a hot-air balloon rises? This is your homework. We will discuss your answers on this assignment next lesson.

APPENDIX G

COMPRESSIBILITY OF GASES

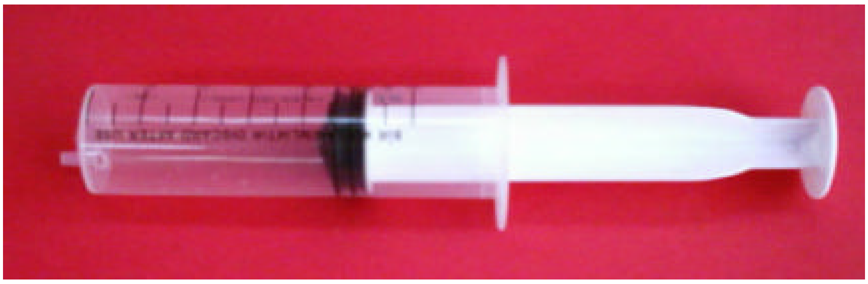


Figure G.1 Syringe filled with air before compression.

Figure G.2 Syringe filled with air after compression.

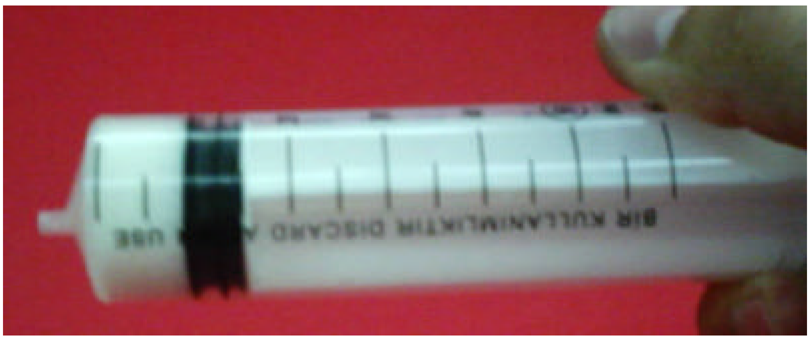


Figure G.3 Incompressibility of a solid.

APPENDIX H

A GAS EXPANDS TO FILL THE CONTAINER

Figure H.1 Flask with solid iodine before heating.

Figure H.2 When iodine was heated it passed to gaseous form and filled flask.

APPENDIX I

GAS VOLUME CHANGES WITH TEMPERATURE

Figure I.1 Flask filled with air before heating.

Figure I.2 Flask filled with air after heating: the balloon inflated.

APPENDIX J

WHAT HAPPENS TO THE BALLOONS FILLED WITH H_2 AND N_2? A MATTER OF DENSITY

Figure J.1 Balloon filled with hydrogen rose when balloon filled with nitrogen fell to the floor.

APPENDIX K

RELATION BETWEEN TEMPERATURE AND PRESSURE

Figure K.1 Mercury levels of the manometer are equal before heating.

Figure K.2 Mercury levels of the manometer are not equal after heating.

APPENDIX L

RELATION BETWEEN PRESSURE AND AMOUNT

Figure L.1 Mercury levels of the manometer are equal before adding air.

Figure L.2 Mercury levels of the manometer are not equal after evacuating some amount of air.

Figure L.3 Mercury levels of the manometer are not equal after adding some amount of air.

APPENDIX M

DIFFUSION OF GASES

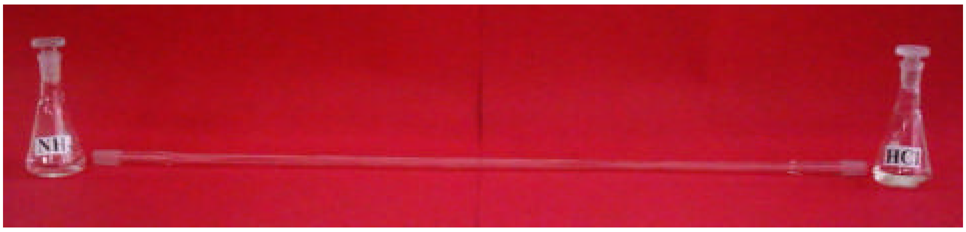


Figure M.1 Before connecting flasks filled with NH_3 and HCl.

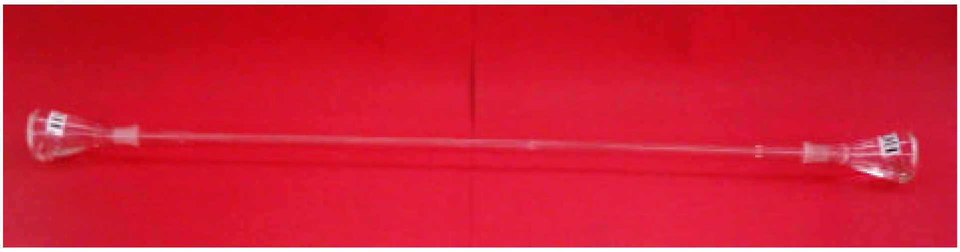


Figure M.2 At the beginning of the connection of the flasks filled with NH_3 and HCl.

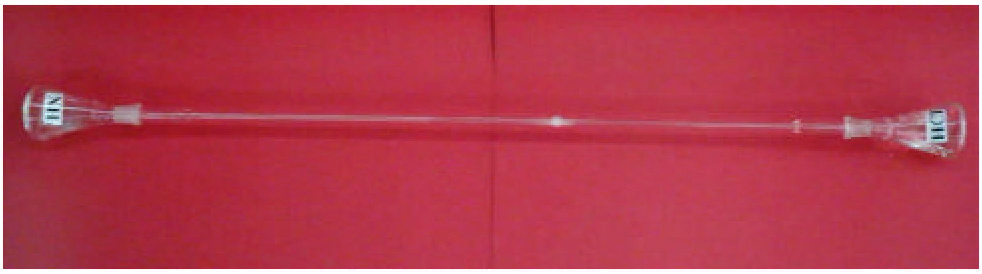


Figure M.3 NH_3 and HCl gases diffused with different rates and reaction occured close to the gas with higher molecular weight.

VITA

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