IMPLEMENTATION OF CONCEPTUAL CHANGE ORIENTED INSTRUCTION USING HANDS ON ACTIVITIES ON TENTH GRADE STUDENTS' UNDERSTANDING OF GASES CONCEPTS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

İNCİSER İPEK

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
SECONDARY SCIENCE AND MATH EDUCATION

FEBRUARY 2007

Approval of the Graduate School of Natural and Applied Sciences.

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ABSTRACT

IMPLEMENTATION OF CONCEPTUAL CHANGE ORIENTED INSTRUCTION USING HANDS ON ACTIVITIES ON TENTH GRADE STUDENTS' UNDERSTANDING OF GASES CONCEPTS

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February 2007, 111 pages

The purpose of this study was to compare the effectiveness of the conceptual change oriented instruction using hands-on activities and traditionally designed chemistry instruction on 10^{th} grade students' understanding of gases concept. Also, the effect of instruction on students' attitude toward chemistry as a school subject was investigated. The sample of the study consisted of 59 tenth grade students from two chemistry classes in a public high school. This study was conducted during the 2006-2007 fall semester. The classes were randomly assigned as control and experimental groups. Students in the control group were instructed by traditionally designed chemistry instruction whereas students in the experimental group were instructed by the conceptual change oriented instruction accompanied with hands-on activities. 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 to determine their attitudes toward chemistry, respectively. Science Process Skills Test was given only at the beginning of the instruction to determine students' science process skills.

The hypotheses were tested by using multivariate analysis of variance (MANOVA). The post-test results showed that conceptual change oriented instruction using hands-on activities caused a significantly better acquisition of scientific conceptions related to gases concept. But it was found that treatment has no significant effect on students' attitudes toward chemistry as a school subject.

Keywords: Conceptual Change Approach, Gases, Hands-on, Misconceptions, Attitude toward Chemistry

ÖZ

BASİT ARAÇLARLA ÖĞRENMEYE DAYALI KAVRAMSAL DEĞİŞİM METODUNUN 10. SINIFTA GAZLAR KONUSUNDA UYGULANMASI

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Şubat 2007, 111 sayfa

Bu çalışmanın amacı basit araçlarla yaparak öğrenmeye dayalı kavramsal değişim metodunun onuncu sınıf öğrencilerinin gazlarla ilgili kavramları anlamalarına etkisini geleneksel yöntem ile karşılaştırmaktır. Ayrıca bu yöntemin öğrencilerin kimya dersine yönelik tutumlarına etkisi de araştırılmıştır.

Çalışma, 2006-2007 güz döneminde bir devlet lisesinde gerçekleştirilmiştir. Çalışmaya aynı öğretmenin iki ayrı onuncu sınıfındaki 59 öğrenci katılmıştır. Sınıflar rasgele deney grubu ve kontrol grubu olarak seçilmiş; deney grubunda basit araçlarla öğrenmeye dayalı kavramsal değişim metodu, kontrol grubunda ise geleneksel yöntem ile ders işlenmiştir. Öğrencilerin gazlarla ilgili kavramları anlama düzeylerini belirlemek için Gazlar Kavram Testi her iki gruba ön-test ve son-test olarak uygulanmıştır. Ayrıca öğrencilerin kimya dersine yönelik tutumlarını ve bilimsel işlem becerilerini belirlemek amacıyla sırasıyla Kimya Dersi Tutum Ölçeği ve Bilimsel işlem Beceri testi çalışmanın başında her iki gruba da uygulanmıştır. Daha sonra kavramsal değişim metodunun öğrencilerin kimya dersine karşı tutumlarına etkisini ölçmek amacıyla Kimya dersi tutum ölçeği her iki gruba da son-test olarak verilmiştir.

Araştırmanın hipotezleri çok değişkenli varyans analizi (MANOVA) kullanılarak test edilmiştir. Sonuçlar basit araçlarla öğrenmeye dayalı kavramsal değişim metodunun gazlarla ilgili kavramların anlaşılmasında daha etkili olduğunu göstermiştir. Ancak kavramsal değişim metodunun öğrencilerin kimya dersine yönelik tutumlarına karşı anlamlı bir etkisi bulunmamıştır.

Anahtar Kelimeler: Kavramsal Değişim metodu, Gazlar, basit araçlarla yaparak öğrenme, Kavram Yanılgısı, Kimyaya Yönelik Tutum

To My Husband ERHAN

ACKNOWLEDGMENTS

I would like to express my deepest gratitude to my supervisor Assist. Prof. Dr. Esen Uzuntiryaki for her guidance, advice, criticism, encouragements and insight throughout the research.

I would also like to thank to Selda Yıldırım who applied my teaching methods in her classroom.

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LIST OF ABBREVIATIONS

CCIH	: Conceptual Change Oriented Instruction Using Hands-on Activities
TDCI	: Traditionally Designed Chemistry Instruction
EG	: Experimental Group
CG	: Control Group
GCT	: Gases Concept Test
ASTC	: Attitude Scale Toward Chemistry
SPST	: Science Process Skills Test
C	: Mean
F	: F statistic
t	: t statistic
df	: Degrees of Freedom
p	: Significance Level
MS	: Mean Square
$\overline{X}$	: Mean of the sample
MSE	: Mean Square Error
SS	: Sum of Squares
η^2	: Effect size
N/n	: Sample Size

CHAPTER I

INTRODUCTION

In current educational system, students are coming to classes to be taught and teachers to teach. However, learning occurs through the individual's own construction, it cannot be realized by a teacher (Nieswandt, 2001; Driscoll, 1994). Within this constructivist perspective, learning is an active process in which knowledge is constructed by a learner through the combination of new information with existing ideas (Hewson & Hewson, 1984). Existing ideas are known as prior knowledge of a learner (Teichert & Stacy, 2002). Ausubel in 1968 emphasized the importance of prior knowledge by the words "*The most important single factor influencing learning is what the learner already knows. Ascertain this and teach accordingly"*.

When relating new knowledge with existing ideas, some students can shape the knowledge differently in their minds from the scientific conceptions, although the same teacher teaches all the students. Such conceptions that are inconsistent with the accepted scientific conceptions are defined as misconceptions (Schmidt, 1997).

Students have several misconceptions in chemistry due to its highly abstract and complex concepts (Nurrenbern & Pickering, 1987). Many researchers have suggested that students have problems with understanding abstract, invisible and higher hierarchical levels of science concepts (Brown, 1993; Murray, Schultz, Brown & Clement, 1990; Gabel, Samuel & Hunn, 1987). Nakhleh (1992) concluded that some students could not construct their own chemistry concepts at the beginning of learning, for that reason they become unsuccessful. Moreover, even after the formal instruction of chemistry concepts, they still hold some misconceptions (Abraham, Grzybowsky, Renner & Marek, 1992).

The gases concept in chemistry is another abstract topic where students hold misconceptions. Understanding gases concept scientifically will provide them to understand the reasons of why everyday things behave as they do. For example how we breathe, why automobile tire deflates in cold weathers, how hot air balloons flies, how air bags save our lives etc. can be all explained by the behaviour of the gases. Unfortunately most of the studies in science education show that students are unable to understand behaviour of gases due to its invisibility and because it requires to understand the concept in molecular level (Novick & Nussbaum, 1981; Benson, Wittrock & Baur, 1993; Hwang, 1995 Brook, Briggs & Driver, 2003).

If the students build the knowledge in a wrong way then further learning will be influenced negatively and meaningful understanding of scientific conceptions be hindered (Nakhleh, 1992). This concern and the importance of gases in our lives have encouraged the researcher to investigate students' conceptual science knowledge in behavior of gases. However, these misconceptions cannot be changed into scientific phenomena by only presenting a new concept or telling the learners that their views are inaccurate. Adding new knowledge will not change the students existing wrong ideas. If a student does not resolve the contradiction between what he believes and what the scientific concept says, then learning does not come true. Then what should be done to change the existing wrong ideas?

According to Gabel, Sherwood and Enochs (1984) one way of helping students to overcome their misconceptions in chemistry is that make them first understand the chemical concepts qualitatively before they are presented quantitatively. At this situation conceptual change instruction will remediate the ill (having misconceptions) students. Conceptual change model, developed by Posner, Strike, Hewson and Gertzog (1982) says that in order to change misconceptions to scientific conceptions first student be *dissatisfied* about his wrong conceptions. Then new phenomena should be present in a way that students give it a meaning by connecting it with existing ideas, which Posner et al. (1982) called this stage as *intelligibility*. Students will refuse to learn the knowledge if it does not make any sense to his life. Teachers often hear "Why do I have to know this information and how will I ever use it in the future" kind of questions from students at lessons. Therefore, to settle down the new phenomena, student must satisfy by seeing the *plausibility* of the knowledge and the new concept must be *fruitful* to be able to use it for the further situations.

Hands-on activities are one of the effective conceptual change tools in science education (Weaver, 1998). Students sometimes smothered in science content that science lessons are highly theoretical and abstract. Therefore hands-on activities may provide students' bridge from the abstract to the concrete applicable science. In this sense hands-on activities may help to student's satisfaction (p. 16-18).

By this context, the main aim of the present study was to investigate the effectiveness of conceptual change oriented instruction fostered by hands-on activities over traditional instruction on gases concepts.

CHAPTER II

REVIEW OF THE RELATED LITERATURE

Current chemistry instruction focuses on the subjects that are discrete knowledge pieces without consistent integration across concepts. As a result in instruction the emphasis is on the fragmented acquisition of knowledge and algorithms rather than development of integrated knowledge (Claesgens, Scalise, Draney, Wilson & Stacey, 2002). Also Harding and Donaldson (1986) criticised that chemistry education was so idealized and abstract that it was divorced from reality. As a result, if the goal of chemistry instruction is to have students both solve conceptual and algorithmic problems then the approach for the chemistry instruction must change (Phelps, 1996). According to Hesse and Anderson (1992), Driver et al. (1994) and Bodner (1991) traditional chemistry instruction does not promote that kind of conceptual understanding in most students.

On this base, this chapter consists of previous and current research studies related to theoretical and empirical background of this study. Related current and past studies that take place in this part are about misconceptions, misconceptions in gases subject, constructivism and conceptual change approach, hands-on teaching and students' attitude and its relation with achievement.

2.1 Misconception

Knowledge is the result of a constructive activity and cannot simply be transferred to a passive receiver. Knowledge has to be built up by each individual and all knowledge must be socially constructed based on the learner's existing knowledge and experiences (von Glasersfeld, 1993). These existing knowledge or prior conceptions may differ substantionally from the ideas to be taught and these conceptions influence further learning which are resistant to change. Therefore, many research studies have done to identify the students' informal ideas about scientific phenomena. Students' conceptions that are inconsistent with the accepted scientific concepts have been defined by various terms:

- alternative conceptions (Hewson & Hewson,1989)
- alternative frameworks (Driver & Easley, 1978)
- children' science (Gilbert, Osborne & Fensham, 1982)
- intuitive beliefs (McCloskey, 1983)
- spontaneous reasoning (Viennot ,1979),
- naive beliefs (Caramazza, Mc Closkey & Green ,1981)
- preconceptions (Anderson & Smith ,1983)
- misconceptions (Nakhleh, 1992; Schmidt, 1997)

These terms all contain the common meaning that ideas that are inconsistent with the scientific knowledge however they differ in some way. For example children's science indicates children's informal beliefs about everyday world prior to formal science instruction. Preconceptions also refer to ideas formed before formal instruction but it need not be always non-scientific (Teichert & Stacy, 2002). As similar, alternative frameworks express the informal ideas before instruction. However it refers to the interpretations arising from students' personal experience of everyday world. Prior ideas before instruction have important role in learning because students don't enter science classes as empty vessels waiting to be filled with knowledge. Rather, they enter school and science classes with well-established ideas with how and why everyday things behave as they do (Posner et al., 1982; Resnik, 1983; Palmer, 1999). On the other hand, misconceptions can be formed during instruction. Misconceptions are defined as the ideas formed as a result of incorrectly assimilation of formal models or theories (Driver & Easley, 1978). Later Smith, diSessa and Roschelle (1993) describe misconceptions as " students' efforts to extend existing useful conceptions to instructional contexts".

The characteristics of misconceptions were identified by Champagne, Gunstone and Klopfer (1983); West and Pines (1985) and Osborne and Wittrock (1985) as following:

- Children have ideas and views concerning many science topics before formal education.
- These naive and explanatory preconceptions are often different in significant ways from scientists' views, but are sensible and useful to the children.
- Children's preconceptions often show remarkable consistency across diverse population. They influence children's understanding of the scientific conceptions presented by their teachers and who are frequently unaware of the existence of such views.
- Preconceptions are remarkably resistant to change by traditional instructional methods. These students' views may remain uninfluenced, or be influenced in unexpected ways, by science teaching.

Children interact with their environment and they make sense of the world around them by using their experiences. However, all experiences do not always lead to scientific explanation about how things work which cause misconceptions. For example, Herron (1996) argued that meanings of the same words are different in chemistry and everyday life. In other words, chemistry languages have meaning only in chemistry contexts; students cannot link the chemistry terms with real world.

Traditional instruction and teachers' own misconceptions also result in students' misconceptions (Westbrook & Marek, 1992). In addition, some problematic representations shown in textbooks are the other source of misconceptions. For instance, when concrete scientific models are used for explaining abstract concepts, students only learn the presented models but not the concepts (Renner & Marek, 1988; Stepans, 1991). Research studies, which have been done over the past 20 years, indicated that students' ideas have been influenced by

- daily experiences and observations

- everyday language
- textbooks
- traditional teaching methods
- using symbolic representations
- making analogies
- teachers’ explanations etc. which are the main sources of misconceptions (Wandersee, Mintzes, & Novak, 1994; Prieto, Watson & Dillon, 1992; Haidar & Abraham, 1991; Taber, 1995).

According to Chi and Roscoe (2002) preconceptions can be easily and readily revised through instruction but misconceptions are highly resistant to change. Research on misconceptions covers all grade level of students and even teachers. Also, it was found that the age of the samples having misconceptions have ranged from lower-level elementary students to university students (Nussbaum & Novak, 1976; Benson et al., 1993). Furthermore in their research Lin and Cheng (2000) found that teachers and students hold similar misconceptions. These findings were supported by Champagne et al. (1983) stating that misconceptions in science instruction do not depend on the ages, ability, gender and cultural status. They claim that the naive description and explanatory systems show remarkable consistency across diverse populations, irrespective of age, ability, or nationality.

Students' misconceptions have been studied for many chemistry topics. In chemistry instruction subjects must be instructed considering both the macroscopic level (observable view of concept), and the microscopic level (the molecular view) (Claesgens et al., 2002) since confusion of macroscopic and microscopic properties are the main sources of the misconceptions in chemistry (Hesse & Anderson, 1992; Griffiths & Preston 1992). Some of the chemistry topics that students have misconceptions included heat and temperature (Erickson, 1979; Anderson, 1986; Stavy & Avrams, 1990); structure of atom (Ben-Zvi, Eylon & Siberstein, 1986); matter and its phases, the particle theory of matter (Haidar & Abraham, 1991; Griffiths & Preston, 1992; Lee, Eichinger, Anderson, Berkheimer & Blakeslee, 1993; Fellows, 1994; Ginns & Walter, 1995). Gases subject in chemistry is another abstract topic that students hold misconceptions.

2.2 Misconceptions about gases

At schools students learn the gases concept at primary, middle and high school levels. For that reason this topic is an important issue throughout the school curriculum. Furthermore gases are in all part of our lives. To inflate a bicycle or automobile tire, to measure the barometric pressure, to fly the hot-air balloon even breathing we need to understand the behaviour of the gases. However, in all levels students encounter serious problems with the scientific understanding of the behaviour of gases due to its invisibility compared to other concepts in chemistry (Stavy, 1988). Similarly, many researches have suggested that students have difficulty in developing abstract, invisible, process and higher hierarchical levels of science concepts (Brown, 1993; She, 2002).

In order to understand how students develop gas concepts, Stavy (1988) studied with students from 4^{th} grade (aged 9-10 years) to 9^{th} grade (aged 14-15 years). Each group involved 20 students and all of them were interviewed independently while being shown materials and processes such as gas escaping from CO_2 cartridge and a cup of soda water. The concept of gas was introduced in the fifth grade only at the level of evaporation of the liquid water and in the seventh grade; three states of matter and the properties of gases such as volume, weight and the particulate nature were taught. All students were asked whether the weight of the system changed after gas escaping from a CO_2 cartridge and from a soda water. They were also asked to define the term *gas***.** The results showed that students hold multiple views. Their ideas were not consistent and might change when the case changed, until grade level seven. For example, they thought that gas has no weight when CO_2 gas escaping from soda water but, they also thought the same gas has weight but lighter when it was in a cartridge. He explained this inconsistency, as young students tend to use irrelevant bits of knowledge. Students also could not develop a general idea of gas prior to learning. After instruction about the states of matter and the particulate theory of matter in seventh grade, they could only apply this knowledge in the ninth grade.

Benson et al. (1993) also investigated common misconceptions related to the nature of gases on 1098 students from elementary to university chemistry students by using clinical interview technique and case study developed by Novick and Nussbaum in 1978 and 1982. For the elementary, junior high, senior high students, demonstration was performed to detect students' pre-existing ideas. In the demonstration two identical airtight flasks were used. One of them was filled with room air (1 atm of pressure) and from the second flask half of the air had been removed (0.5 atm of pressure) with a syringe. Then all the students were asked to draw the sketches of the air in these flasks. The drawings with straight or wavy lines were classified as continuous (a representation of visible liquid behaviour) and the drawings that contained discrete dots, circles were included in the particulate drawings. At the end of the research, misconceptions found related to nature of gas were as follows:

- air is a continuous (non particulate) substance
- gas behaviour is similar to liquid behaviour (unlike the idea that gases expand to fill their containers)
- there is relatively little space between gas particles

After the chi-square analysis the researcher claimed that there is a negative relationship between misconceptions and grade level.

It was found that even after instruction, the students might hold misconceptions. Hwang (1995) investigated students' understanding the concept of gas volume of in junior high, senior high and university students. Students were applied two tests related to volume of gas and particulate nature of gas respectively after they had studied the topic of gas concept. Students thought that;

- volume of a gas is the size of a particle
- the volumes of different gases are proportional to their particle numbers in a container
- two –liter gas can not be placed in one-liter container.

The researcher found that although the students had studied the gas volume concept, they still have some misconceptions. Also, like Benson's et al. study, as the students' grade levels increased their misconceptions decreased.

Brook et al. (2003) studied students' initial knowledge on gases concept at the upper secondary school level (15 years old, 10^{th} grade) by using both quantitative and qualitative approach. As a quantitative approach 90 students were administered a questionnaire before and after the instruction on gases. It was found that students had such misconceptions:

- gas has a mass is not obvious for the students
- "gases occupies all the space " is not a part of the initial knowledge
- students use macroscopic level for representing gas, they draw gas like a continuous whole. (e.g football)

The qualitative approach involves making a case study. To investigate the changes of students' knowledge, questionnaires and interviews were made on six students. Before the instruction students thought that quantity and volume are the same thing. They also thought that air did not exert the same pressure in different directions. At the end of the instruction, they changed their ideas that quantity does not vary like volume and air exerts the same pressure in all directions.

Another study related to students' understanding of the gases concept was done by de Berg in 1995. He examined the students understanding of the relation between pressure and volume of compressed air in a syringe. The sample was 101, 17-18 year old college students. He asked about a diagram, which include a syringe before and after compression. Most of the students answered correctly that after compression the volume decreased. On the other hand, some of the students (% 25) answered that volume did not change, because any air escaped. Séré (1985) explained this situation, based on his study with 11-12 year old students that they relate volume with the amount of gas.

Students also have problems with uniformity of gas mixtures. Cho, Park and Choi, (2000) did their research on 11^{th} grade high school students' conceptions on kinetic theory of gases. The data were collected through semi-structured and participant observations on 3 male students by a case study and in depth interviews with 12 students who are high, intermediate and low in achievement score in order to determine the relationship between academic achievement of students and conceptual change learning. The students were instructed by cooperative learning method. Before the instruction students thought that

- the massive component will sink and lighter air will raise up in a sealed flask
- oxygen and nitrogen occupy different spaces in a flask because it has fixed volume, but in a balloon gases mixed together because it is translatable freely
- gases occupy different spaces according to their molecular weights
- smaller molecular weight gases diffuse more slowly
- molecular motion of gases stop at an ending point in the diffusion
- pure substance approximates ideal gases more than compound does
- ratio of volume and molar number was proportional to each other for gases mixture in vessel

After the instruction they still had misconceptions on the uniformity of gases mixture, but they could explain the motion of gases with a kinetic energy and they also realized that mixture of gases had a constant average kinetic energy. As a result, the students confused experimental knowledge with scientific knowledge.

Another difficulty of students' is related to conservation of mass. Mas, Perez and Harris (1987) did their research at 12 schools to 1198 students whose ages ranged from 12 years to 18 years. The students were applied two questionnaires consisting of 4 questions each. Questionnaire 1 involves the experiment of total vaporization of a liquid in a closed container. Students were asked about the conservation of substances, of weight, of mass and the risen of gases. In questionnaire 2 students were expected to predict the weights of various substances in a chemical process in which disappearance of material due to the involvement of gases exists. After the chi-square analysis the results indicate that although students could perceive the idea of conservation of substances, they have problems with the weight and mass conservation. Also students believed that liquids have lost mass when they vaporized and this is the reason why gases rise. The results found in questionnaire 2 showed that the percentage of wrong answers become higher when the amount of material transformed to gases increases. As a summary, three of four adolescents do not accept the principle of conservation of mass when gases are reagents or products.

As well as students, teachers may have misconceptions about gases concept. For example, Lin et al. (2000) studied with both students and teachers. They focused on the application of gas laws in practical situations instead of mathematical calculations. He used 119, 11^{th} grade students and 36 high school chemistry teachers in his research. A qualitative 4 item open-ended, pencil and paper test was applied to both students and teachers. It was asked to predict the result of demonstrations and to draw a diagram. Item 1 and 2 were related to Boyle's law and item 3 was associated with Charle's law. For the last item, only students were asked to draw the molecular behaviour of gas mixture after heated. The results showed that both students and teachers had common misuse of PV=nRT formula and also students had failure in distinguishing between "system" and "surrounding". Furthermore, the study revealed three major misconceptions of kinetic theory of gases:

- atmospheric pressure pushes gas molecules down
- gas molecules rise and stay away from heat
- molecules expands when they are heated.

Finally, analysis of the teachers' responses revealed that teachers and students hold similar conceptions of gases.

According to research studies, students perform better in algorithmic problems compared to conceptual problems in gases concept. Sawyer (1990) investigated if the ability to solve problems was equivalent to understanding the molecular concepts. In addition, she studied student success on conceptual versus numerical problems. She applied a test to freshman chemistry students taken general chemistry course. The test questions consisted of stoichiometry problems (used as a first examination) and gas law problems (used as a second examination). The questions were appeared as a traditional and concept questions for both of the subjects. As a result, she found that even the best numerical problem solvers performed poorly on the concept questions. According to her, teachers should give attention to both qualitative and quantitative nature of chemistry. Similarly, Nakhleh and Mitchell (1993) also focused on students' achievement in conceptual and algorithmic problems on gas laws and found higher achievement in algorithmic problems than conceptual problems.

The findings in the related literature indicate that because of more emphasis has been placed on the quantitative knowledge compared to qualitative knowledge at chemistry classes, misconceptions still exist after instruction even after becoming a teacher. In addition, these misconceptions and students' understanding have been shown to be robust to typical science instruction (Driver, Guesne & Tiberghien, 1985).

As a result, many researches try to find a way to understand how students change their misconceptions into scientific conceptions. Research studies have shown that using traditional textbook and lecture method make students passive receivers, also students are unable to integrate facts and formulas when they are taught traditionally. For that reason, this kind of instruction does not promote conceptual understanding in most students, so it is not the effective way to teach (Dykstra, Boyle & Monarch, 1992; Yager, 1991). Therefore researches develop different teaching strategies that provide scientific conceptual understanding in students. These strategies are based on constructivist learning approach (Osborne & Wittrock, 1983, 1985) and Ausubelian assimilation theory of learning (Ausubel, Novak, & Hanesian, 1978; Novak, 1977; Novak & Gowin, 1984). In this study, conceptual change model proposed by Posner et al. (1982), which is based on constructivist approach, was used.

2.3 Constructivism

How human beings learn about the events occuring around has fascinated philosophers and educators and the term “constructivism” rises. Constructivist approach proposes an explanation for the nature of knowledge and how human beings learn (Richardson, 1997; Wu & Tsai, 2005).

Von Glasersfeld (1993) indicates that the source of knowledge is the real world and we give viable and useful meanings to objects and events to explain the real world. The cognition can be adaptable and enables learner to construct viable explanations of experiences by making sense of the world outside in a subjective way. So, the knowledge to be useful and viable, it need not be reflect the world as it really is because the mind construct the knowledge rather than facsimile the reality (Von Glasersfeld, 1995).

In learning, “students construct personal meaning of the subject matter through their interactions with the physical and social world. It is the student who must make sense out of the experinces” (Chiappetta & Koballa, 2002). Therefore knowledge cannot be received passively but can be built up actively by the cognizing subject (Von Glasersfeld, 1990). Piaget’s learning theory suggests that human beings started from childhood as “active meaning-makers’ rather than passive “recipients” of knowledge. In other words, knowledge cannot be transferred from teachers to the head of the students, rather students construct their own meanings by making links with existing ideas through senses such as seeing, hearing, touching, smelling, and tasting (Pines & West, 1986; Tobin, 1990).

Therefore, learning is a process of knowledge construction and occurs by changing and organizing cognitive structure. Learning may take place by changing person's conceptions rather than simply adding new knowledge to what is already there. In this sense, learning takes place when the learners’ existing ideas change either by addition of new knowledge or reorganization of what is already known (Von Glasersfeld, 1984). What is already there in learner’s mind is the key point in constructivist learning. Meaningful learning occurs when students make connection between new ideas and relevant elements with their existing cognitive structures (Chiappetta & Koballa, 2002).

In a contructivist view learners are active organisms seeking meaning. Learner does not memorize teachers' sentences or from textbooks. In other words, learning is a seeking meaning by actively connecting the knowledge of real world contexts with the experiences and existing ideas. "Hence, there is no knowledge without a knower" (Osborne, 1996 p.57). Constructivist learning suggests that learning occurs with both individual construction and social interaction by personal experience (Ernest, 1995). In this sense knowledge can be constructed by an individual through interactions with the physical world and social environment (Von Glasersfeld, 1993). Interaction with objects and events situmulates the construction of knowledge (Chiappetta & Koballa, 2002). Social construction of a knowledge emphasis on discussions, collaboration, negotiation and sharing meanings (Ernest, 1995).

Although the individual construct the knowledge himself or herself according to constructivist approach, teachers' role in constructing knowledge is very important. Constructivist teachers must consider students' needs and interests individually and lessons must be structured to develop students' higher order thinking skills such as problem solving, reasoning, critical thinking and active use of knowledge which are the goals of constructivism (Brooks & Brooks, 1999). Then they must guide students by organizing a theme, giving advice, hints or various forms of helps. In this sense the teacher is a facilitator, coach or co-explorer according to constructivism.

The other important role of the teachers' is engaging students in instruction by creating student-centred environment. In a student centred environment students are active enough to ask questions freely, come to their own conclusion, perform their own experiments, analyze, interpret or predict information.

Teaching and learning process also requires interaction. These interactions include social negotiations and making discussions. Negotiations take place between the teacher and the student in a constructivist classroom. The learner takes independent role negotiating with others. Discussions and negotiations enable individuals to understand other students' ideas and gain perspectives to individuals when building new ideas (Driver, Asoko, Leach, Mortimer & Scott, 1994). Therefore, teaching and learning roles are characterized by negotiation rather than imposition (Cobb, 1988).

Jonassen (1991) summarized application of constructivism to the learning environment as follows:

- ♣ Create real-world environments that employ the context in which learning is relevant.
- ♣ Focus on realistic approaches to solving real world problems.
- ♣ The instructor is a coach and analyser of the strategies used to solve these problems.
- ♣ Stress conceptual interrelatedness, providing multiple representations or perspectives on the content.
- ♣ Instructional goals and objects should be negotiated and not imposed.
- ♣ Provide tools and environments that help learners interpret the multiple perspectives of the world.
- ♣ Learning should be internally controlled and mediated by the learner.

Studies showed that constructivist-teaching strategies were effective in enhancing students' understanding and achievement in science (Roth, 1990; Cheung & Taylor, 1991; Vosniadou, 1991; Lorsbach & Tobin 1992; Vosniadou et al., 2001; Liang & Gabel, 2005)

Uzuntiryaki and Geban (2004) investigated the effectiveness of constructivist approach on ninth grade students' understanding of chemical bonding concepts. During the instruction first, students' prior knowledge determined by questions and students were allowed to discuss the concept. These discussions provided students to criticise their thinking and be aware of the concepts. Then, the new concept was explained by the teacher using analogies. The results of the study indicated that constructivist approach provide better understanding of the concepts.

In another study, Caprio (1994) examined the effectiveness of the constructivist approach compared with the traditional lecture-lab method. He concluded that students taught by constructivist approach had significantly better exam grades and they felt more confident of their learning. Tynjala (1998) found similar results with Caprio, on educational psychology students. Students, taught by constructivist approach were given assignments related to transforming and activating prior knowledge, comparing and criticizing theories. Results showed that students taught by constructivist approach acquired an ability to apply knowledge and developed their thinking and communication skills.

In the present study, the effectiveness of conceptual change model proposed by Posner et al. (1982), which is based on constructivist approach, was examined.

2.4 Conceptual Change Method

Research studies show that traditional chemistry instruction does not promote conceptual understanding in most students (Hesse, Anderson, 1992; Driver et al., 1994; Bodner, 1991). In traditional chemistry teaching, presentation of a sequence of equations and facts takes place (Bodner, 1991). Also students are taught only to get the correct answers using algorithmic solutions (Nakhleh & Mitchell, 1993). Fellows (1994) stated that students could pass their exams by memorizing facts and formulas or using algorithms. However, they cannot describe, explain, and make interpretations about real world phenomena because memorized facts and algorithms do not make any use. In that kind of lecture oriented instruction, students' perspective of chemistry will be only receiving knowledge. As a result students do not try to understand ideas or concepts; they rather collect facts without making judgments in traditional classrooms.

On the other hand, meaningful learning requires links between new knowledge and the existing ideas of students. Students' misconceptions are resistant to change as they rely on their existing notions when understanding their world. They may not easily get rid of their ideas and adopt a new way of thinking. Simply presenting a new concept or telling the learners that their views are inaccurate will not result in a change in their conceptions. Therefore, students' conceptions should be starting point for instruction. Then, science teachers should try to change students' ideas, which are different from scientific explanations (Chiappetta & Koballa, 2002).

As a result, learning science in a meaningful way requires the learner to realign, reorganize, or replace existing misconceptions in order to accommodate new ideas. This process of changing is called *conceptual change* (Smith, Blakeslee & Anderson, 1993). Conceptual change model appeared in the science education scene in 1982 with the article of "Accomodation of a Scientific Conception: Toward a Theory of Conceptual Change" (Posner et al., 1982). This model is based on Piaget's (1977) notions of assimilation and accommodation as well as Thomas Kuhn's description of scientific revolution (Kuhn, 1970).

Piaget explained *assimilation* as the incorporation of experiences with own mental structures. He thought that during concrete experience if the learner conflicts between assimilated information and mental structures, assimilation cannot be possible and *disequilibrium* occurs. Disequilibrium makes the learner seek for equilibrium. Regaining *equilibrium* by changing cognitive structures in order to accept new structures results in *accommodation*.

Posner et al. (1982) developed Piaget's notions and applied Kuhn's ideas to individual learning for bringing about conceptual change. On this base when constructivism focuses on a general process of learning, conceptual change gives importance to the specific conditions in which existing structures are replaced by new information (Weaver, 1998). According to Posner et al. conceptual change has two phases:

- assimilation (students use existing concepts to deal with new phenomena)
- accommodation (students replace or reorganize their concepts)

They claimed that if existing conceptions are compatible enough to deal with new phenomena, this expected change is called “assimilation” and if existing conceptions are inadequate or incompatible to explain new phenomena then more fundamental change is necessary which is called “accommodation”. They also argued that for a learner to accommodate a new conception four conditions had to be met:

1. Posner et al. (1982) developed the Piaget’s disequilibrium stage in the form of dissatisfaction. It says that learner must be *dissatisfied* with existing conceptions resulting in a failure to explain conflicting experiences. If the learner satisfied with his ideas to give meaning to the phenomena, then the learner may not accept the new conception.
2. Then suggested replacement conception must be *intelligible*. Learners must be able to comprehend the meaning of alternative conception. That means the learner must know what the concept means and able to construct the coherent representation of it. Because students do not going to adopt a new conception unless they can first represent it to themselves.
3. The new conception must be *plausible*. Even if the learner understands the alternative conception, he may not be able to apply the new concept to a given situation or solve a particular problem. Also the conception must be consistent with other knowledge.
4. The alternative conception must be *fruitful*. The new conception should do more than solving current problems and appliance of current situations. It must be useful for different problems and variety of situations that means the concept must open new areas of inquiry.

Posner et al, (1982) analysed the conceptual changes in elementary, high school and university students as well as in science teachers.

After Posner et al. (1982), several different definitions were suggested about conceptual change. For example Chi and Roscoe (2002) conceive conceptual change as a repair of misconceptions. He stated that misconceptions are miscategorizations of concepts and conceptual change is the reassignment of concepts to correct those categories. On the other hand according to diSessa (2002) conceptual change requires organizing fragmented knowledge in mind which means diverse kinds of naive knowledge reorganized into complex system in students' minds. Other researchers thought that conceptual change occurs when there are introduction of the new knowledge, reinterpretation of existing misconceptions and exposure the new models that do not require extinction of the old conception (Caravita & Hallden 1994). Although researches define conceptual change using different terms, they all agree that creating links with prior knowledge is important to promote conceptual change.

Conceptual change can occur if only a person realizes that his/her previous observations and scientific ideas are inaccurate. According to the cognitive theory, when students confront with conflicting data, they can prefer to refuse the data, ignore it, or memorize it rather than posses conceptual change (McCloskey, 1983). Hewson (1992) noted that because the existing ideas already has an advantage over the new conception then the status of existing ideas should be lowered and the status of new conception should be raised. That means the student must accept and understand new conception and believe its usefulness. In addition Niaz, Aguilera, Maza and Liendo (2002) have claimed that if students are given opportunity to argue and express their ideas, their understanding can go beyond the explanation of experimental detail as conceptual change strategy supports.

In conceptual change model teachers' role changes from managing to facilitator or guidance. The role of teacher when instructing conceptual change model is not how a teacher do conceptual change instruction, it is rather what a teacher should think when students are engaged in instruction for the intended conceptual understanding (Beeth, 1995).

In order to see the effectiveness of conceptual change oriented instruction in science classes several studies have done. For example, She (2002) developed a dual situated learning model for conceptual change related to air pressure and buoyancy. He randomly selected 20 students (age 14-15) at ninth grade level from a Taiwanese middle school. He first probed the students' ontological view concerning the concepts of air pressure and buoyancy using the interview -about-events technique. The whole process was video-recorded for each student. He detected the students' knowledge and misconceptions about compressibility of gases and direction of an air pressure concerning students' predictions. He reported most of the students thought that the air couldn't be compressed or exerts pressure. Also they believed that air pressure has a direction. After demonstrations and the presentations of the actual events students were asked to explain why the events were different from their preconceptions to construct a conceptual change. Approximately most of the students changed their ideas that air molecules could be compressed or there was a space between the air molecules after applying the conceptual change teaching based on the dual situated learning events. And they also began to think that air exerted pressure on all sides which means air pressure has no direction after the conceptual change instruction.

Another study related to conceptual change teaching was done by Rollnick and Rutherford (1993). They examined the effectiveness of conceptual change model when remediating misconceptions on air pressure and particles relating to gases. They carried out the study on 145 students and teachers for about two weeks. Conceptual change instruction was based on practical activities with materials, group discussions and questions with blank spaces for the students to fill. At the beginning concept map was used to show the students how the topics would be developed. Then the problem "how we breathe" presented and a lung model, consisting rubber diaphragm, of human breathing was given to students allowed to manipulate them. On the lung model, they were asked how it works and changes in pressure were explained in terms of space taken up by air. The effectiveness of the method was assessed by students' post-test scores of the concept test and found that conceptual change model is significantly superior on remediating alternative conceptions on air pressure.

Azizoğlu in 2004 investigated the effects of conceptual change oriented instruction accompanied by demonstrations to overcome the misconceptions of tenth grade chemistry students in gases concept. Forty-nine students were treated as experimental group and fifty-one students formed the control group in a public school in Turkey. Demonstrations were aimed to cause conceptual conflict and dissatisfaction with the existing but incorrect conceptions in the students' minds. Also each of the demonstrations was designed to overcome particular misconceptions and they were performed by the teacher. During demonstrations concepts were discussed. Before the instruction students thought that molecules' size change when the state change. They also thought that when compressing the air in a syringe, the motion of the molecules would stop. After the instruction she concluded that conceptual change instruction is effective tool for improving students' understanding in scientific concepts considering the students' post-test scores of the gases concept test.

Although taught by the same teacher, students may have different level of conceptual change. According to Caillot and Chartrain (2001), the ways in which students change their conceptions does not depend only the quality of teaching. He found that students' relation to knowledge is one possible factor that could explain the different conceptual changes observed in class taught by the same teacher.

Another cognitive variable that affect students' understanding of science is their science process skills. Science process skills are defined as proficiency to find, interpret and judge evidences under different conditions they encounter. Through these skills, individuals can observe, predict, make inferences, analyze data, formulate hypothesis and perform experiments (Harlen, 1999; Lazarowitz 2002). In this sense there are positive relationships between students' science process skills and their achievements in science (Padilla, 2004; Walters & Soyibo, 2001)

On the other hand, conceptual change is not only influenced by cognitive factors. Affective and social factors also contribute to conceptual change. Since it was found that students' attitudes affect conceptual change process (Duit, 1999), it is important to define the term "attitude" and explain some studies on it.

2.5 Attitude

In social science, attitude term is defined as the "posture of the mind". In a detailed way, it is a readiness to respond in a favourable or unfavourable manner to a particular objects such as real-life situations, ideas, events or people. It includes feelings (prefer, like-dislike, interest, confidense, value, and competence) towards objects (Oskamp, 1977; Koballa, 1990). According to Fishbein and Ajzen (as cited in Oskamp, 1977) attitude have three components that are cognitive, affective (emotional) and behavioral. Cognitive component consist of the ideas and beliefs, which the individual holds towards the attitute object. While affective component refers to the feelings and emotions, behavioral component includes action tendencies towards the attitude object. However, later these three components of attitudes are distinguished and they suggest that the term "attitude" be reserved only for affective dimension which states favorability toward an object. Cognitive dimension label as "beliefs" and behavioral dimension label as "behavioral intensions".

As a result, the attitude of an individual is his/her feelings towards the object. In this study the attitude object is the science as a school subject. Attitude towards science and scientific attitude has different meanings (Koballa, Crawley & Shrigley, 1990). While scientific attitude is cognitive and more related with student behavior commonly associated with curiosity, scepticism and willingness, attitude toward science is defined as a "learned response evaluating our feelings within the environment related to science learning" (p. 369).

Attitudes form and change throughout people's lives and many factors affect the acquisition process. For that reason, it is very important to facilitate this process for the humankind's benefits (Koballa, 1992). Attitude is also effective in knowledge construction, which determine the students' academic achievement. Oliver and Simpson (as cited in Koballa, 1990) in the longitudinal study tested the relationship between students' attitude toward science and science achievement on 3902 students.

The concluded that positive changes in students' attitudes results in improved science achievement.

Krynowsky (as cited in Koballa, 1990) investigated the relationship between learning environment and tenth grade students' attitude toward science. Learning environment changed toward the satisfaction with the work, interest in the class, organization of teacher explanations and perceived usefulness of science knowledge. Results showed that when the theoretical instruction changed students' attitudes changed positively toward science.

In science education, many research studies showed that the type of instruction affected students' attitudes toward science as a school subject (Chang, 2002; Parker, 2000). When students are active participants at lessons their attitudes towards science affected positively and positive attitude influences students' science achievement in a positive direction. (Bristow, 2000; Freedman, 1997).

Uzuntiryaki and Geban (2004) investigated the effect of constructivist-based instruction on students' attitude toward chemistry. The study was applied on 42, 9^{th} grade chemistry students for the chemical bonding concepts. In the constructivist group, students' prior knowledge activated and student-student interaction promoted during instruction. The results showed that constructivist based instruction produced more positive attitudes toward chemistry than traditional instruction. They explained this situation as active involvement of students in science activities and to have a chance to use their prior knowledge produced favourable feelings toward science. They concluded that attitude is an important variable for better understanding and had a positive affect in students' achievement.

Francis and Greer (1999) investigated secondary school students' attitudes toward science. They did their research on 2129 students in the third, fifth and sixth grade levels in Northern Ireland. Results showed that males have more positive attitude toward science than females and younger students have more positive attitude toward science than older students. The same results were obtained by

George (2000) from the longitudinal study in America. He examined how students' attitudes change towards middle and high school years and found that as the grade level increases students' attitudes towards science decreases.

Papanastasiou and Papanastasiou (2004) investigated which factors affect students' attitudes towards science based on their TIMSS data. They did their research on 8^{th} grade students in Australia, Canada, Cyprus, and Korea. They found that teaching has direct influence on students' attitudes toward science in all countries, which indicates that teachers have strong effect on their students. The other factors effecting students attitudes are level of aspiration exerted by the students, their families, and their peers. The study also implies that science activities influence students' attitudes, for that reason participation in science activities is very important for gaining positive attitudes towards science.

To sum up, teaching with conceptual change strategy involves using various techniques to help students change their conceptual framework. Scientists foster conceptual change in students by several instructional methods such as conceptual change texts, refutational texts, analogies, demonstrations, discussions, concept maps (Novak & Gowin, 1984; Novak & Wandersee, 1990; Hynd et. al., 1997) and hands-on activities (Glasson, 1989) etc. In the present study, hands-on activities were used.

2.6 Hands-on Teaching

Taking into consideration the process of learning, science instruction requires that the students become active participants in the development of their own theoretical frameworks. Only observing a demonstration or event, like in the traditional classroom, is not enough to promote a conceptual change. For the learner dissatisfy with the event he/she should examine his/her thinking about the event such as "What I am thinking does not match with my experiences." (Beeth, 1995). Hands-on activities may help students to compare their thoughts with the experiences that they gain with hands-on learning.

"Hands-on" term is derived from the words "lab" and "experiment". But hands-on involves more than those terms. Hands-on learning means learning by doing. It requires engaging with objects, materials or phenomena and inferring meaning from those experiences (Haury & Rillero, 1994). Also hands-on activities allow the student to handle, manipulate or observe a scientific process. On this context, hands-on activities are material centered and manipulative activities (Doran, 1990). Manipulation of materials or engaging with materials provides them to perceive concrete concepts and also experiencing and touching things will develop their perceptual and psychomotor skills (Ross and Kurtz, 1993). According to Smith (1990), when students engage in a process, they became convinced of the plausibility of the knowledge and meaningful understanding occurred.

Tobin (1990) stated that learning by hands-on derived from constructivist approach. Constructivism requires that students need to experience what they learn in a direct way and they need time to think and to give meaning of what they are learning. In this sense, hands-on activities allow students to learn in a meaningful way and engage in a process of constructing knowledge as an individual (p. 405).

Many research studies have been done to indicate the effectiveness of hands-on instruction. It has been shown that students who are instructed by hands-on materials, achieve higher than those taught by traditional textbooks (Bredderman, 1982; Stohr-Hunt, 1996; Freedman, 1997; Hardal, 2003; Türk, 2005).

Handerhan and Janet (1994) implemented hands-on science curriculum for chemistry topics to physical science students graduated from high school. The curriculum units included introduction to chemistry (properties of matter, physical and chemical changes, behaviour of gases), introduction to atomic structure (atom, molecule, elements and compounds), chemical formulas and equations, common chemical (acid and bases) supported with many hands-on activities. The activities required only common materials readily available in kitchen and grocery stores. Activities were presented to students with activity sheets including list of materials, procedure, questions pertaining to activity, explanations and discussions of the events occurring during activities and they were performed by the students. The activities were tested on 14 students during 72 hours and they showed considerable improvement in post-test scores. Researchers concluded that hands-on science helped students to increase their level of confidence in the area of chemistry.

In his study Stohr-Hunt (1996) analysed the relation between frequency of hands-on experiences and standardized science achievement scores of eighth grade students. He found that whom experience hands-on activities either everyday or once a week score significantly higher than the students who experience hands-on activities once a month or less than that or never.

In addition hands-on learning can improve students' attitudes toward science as a school subject (Kyle et al., 1988; Rowland, 1990; Jones et al., 2003) and develop their science process skills (Hofstein & Lunetta, 2004; Walters & Soyibo, 2001). Bilgin (2006) investigate the effects of hands-on activities on eight grade students' science process skills and attitudes toward science. The study conducted over 15 week period on 55 students in two different classes. Hands-on activities were included different science contents such as mass and volume, temperature, combustion, etc. Students in the experimental group discussed the open-ended questions, reading content knowledge and doing hands-on activities cooperatively. He found that hands-on activities help students developing their science process skills and students' attitudes toward science in a positive direction.

In the light of related literature, it can be said that students hold misconceptions due to variety of reasons. Although many different teaching strategies have been tried, students still hold misconceptions. For this reason this study aimed to measure the effectiveness of conceptual change strategy fostered by hands-on activities on students' understanding of gases concept and their attitudes towards chemistry subjects.

CHAPTER III

PROBLEMS AND HYPOTHESES

3.1 The Main Problem and Sub problems

3.1.1 The Main Problem

The purpose of this study is to investigate the effects of conceptual change oriented instruction using hands-on activities compared to the traditionally designed chemistry instruction on 10^{th} grade students' understanding of gases concepts and their attitudes toward chemistry as a school subject.

3.1.2 The Sub-problems

1. Is there a significant effect of treatment (conceptual change oriented instruction using hands-on activities versus traditional instruction) on collective dependent variables of students'understanding gases concepts and their attitudes towards chemistry?

2. Is there a significant mean difference between the effects of conceptual change oriented instruction using hands-on activities and traditionally designed chemistry instruction on students' understanding gases concepts?

3. Is there a significant mean difference between students taught by conceptual change oriented instruction using hands-on activities and traditional instruction with respect to their attitudes toward chemistry as a school subject?

3.2 Null Hypotheses

Ho1: There is no significant effect of treatment (conceptual change oriented instruction using hands-on activities versus traditional instruction) on the collective dependent variables of students'understanding gases concepts and their attitudes towards chemistry.

Ho2: There is no significant effect of treatment (conceptual change oriented instruction using hands-on activities versus traditional instruction) on students'understanding of gases concepts.

Ho3: There is no significant effect of treatment (conceptual change oriented instruction using hands-on activities versus traditional instruction) on students' attitudes toward chemistry.

CHAPTER IV

DESIGN OF THE STUDY

4.1 The Experimental Design

This study was a kind of quasi-experimental study. The design used in this study was non-equivalent control group design (Gay, 1987). The Table 4.1 presents the research design of the study.

Table 4.1 Research Design of the Study

Groups	**Pre-test**	**Treatment**	**Post-test**
Experimental Group	GCT SPST ASTC	CCIH	GCT ASTC
Control group	GCT SPST ASTC	TDCI	GCT ASTC

In this table,

- GCT represents Gases Concept Test.
- CCIH is Conceptual Change Oriented Instruction using Hands-on Activities.
- TDCI refers to Traditionally Designed Chemistry Instruction.

- SPST is Science Process Skill Test.
- ASTC represents Attitude Scale Toward Chemistry.

4.2 Participants

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 chemistry students at a public school in Mamak in Ankara, Turkey. The results of the study would be generalized to the accessible population and the target population.

The sample of this study was 10^{th} grade chemistry students at Anatolian high school in Mamak in Ankara. The sample contained 55 tenth grade students from two randomly selected chemistry classes taught by the same teacher. The teacher has 14 years teaching experience in high school chemistry. She has a degree of master and also she is student at a philosophy of doctorate programme for chemistry education. Two teaching methods were randomly assigned to the classes. The experimental group consisted of 27 students (9 male, 18 female) and instructed by the CCIH, while the control group included 28 students (13 male, 15 female) and instructed traditionally. The study was carried out during the fall semester of 2006-2007 academic year.

4.3 Variables

4.3.1 Independent Variables

The independent variables of this study were the treatment (conceptual change oriented instruction using hands-on activities and traditional instruction) and science process skills. Treatment was considered as categorical variable and measured on a nominal scale. Science process skills test was considered as continuous variables and measured on an interval scale.

4.3.2 Dependent variables

Dependent variables in this study were students' understanding of the gases concepts and their attitudes towards chemistry. These dependent variables were measured by post-gases concept test, and post-attitude scale toward chemistry, respectively.

4.4 Instruments

The Gases Concept Test, Science Process Skills Test and Attitude Scale Toward Chemistry were used as instruments in the study.

4.4.1 Gases Concept Test (GCT)

This test included 20 multiple-choice questions. It was a kind of five item alternative test. Each question had only one correct answer and four distracters. The related concepts in the test were properties of gases, kinetic theory of gases, diffusion of gases and gas laws. The questions were investigating students' conceptual understanding.

The test was developed by the researcher. During the process of preparation, first the content of the gases unit and instructional objectives were determined. Then students' misconceptions were identified from the related literature (Stavy, 1988; Hwang 1995; de Berg 1995; Brook et al. 2003; Benson 1993; Mas, Perez & Harris 1987; Cho, Park & Choi, 2000; Lin, Cheng & Lawrenz 2000). See Table 4.2

Table 4.2 Classification of Students' Misconceptions Probed by GCT

Misconceptions	Item
1. The total pressure of gases is different than the pressure at a point in a closed system.	1
2. When the altitude increases air pressure also increases.	2
3. Gas particles expand when heated, shrink when cooled.	3, 16
4. Gas particles rise and stay away from heat.	4
5. Gas particles are unevenly scattered in any enclosed space.	4
6. Gases exert force in only one direction	5
7. Matter, especially air, exists between particles.	6
8. Diffusion rate of gases increases with increasing molecular weight.	7
9. Smaller molecular weight gases diffuse more slowly	7
10. The pressure of air inside the balloon is different from the pressure outside.	8
11. Deflated bike tire or balloon has less pressure inside than outside	8
12. Gases weight can be ignorable.	9
13. Conservation of matter applicable to solids and liquids but may be ignored for gaseous reactants or products	9
14. Conceptual calculations are not obvious for students.	10, 20
15. In a closed container the volume of a gas decreseas when the temperature decreases.	11
16. The existance of the gas can be ignorable in a closed container when there is some amount of liquid in it.	12
17. Gases don't mix homogeneously in a closed system; oxygen and nitrogen gases occupy different spaces in a flask.	13, 15
18. When the air compressed air particles heaped up or shrivelled.	14
19. When the air compressed particles stick together.	14
20. When the air compressed air particles gather to the end of the syringe.	14
21. Gases occupy different spaces according to their molecular weights.	15
22. Heated air weighs less than cold air or vice versa.	16, 18
23. When the gases compressed, the gas motion gradually decreases.	17
24. Gas pressure depends on the kinds of gas.	18
25. Molecules increase in size with change of state from solid to liquid to gas.	19

The test was prepared benefited from university entrance exam questions, questions from the chemistry textbooks and from the literature (Hwang, 1995; Novick & Nussbaum, 1978, 1981; Mas, Perez & Harris, 1987; Zoller, Lubezky, Nakhleh, Tessier & Dori, 1995; Lin et al., 2000; Lonning, 1993; Séré, 1986; Benson et al., 1993; Sawrey, 1990; Azizoğlu, 2004). The questions were aimed to test students' conceptions, whether they were misconceptions or scientific conceptions. For content validity the text was examined by a group of experts in chemistry and science education, and by the course instructors for the appropriateness of the questions to the instructional objectives. The pilot study of the test was conducted to 62 tenth grade students at a college in Ankara in June 2006. Considering the data obtained from the pilot study, the final test obtained.

The reliability of the test was found to be .711 using item analysis programme. The test was applied to both groups first before instruction to determine whether there is a significant mean difference between the two groups in terms of understanding gases concept. It was also applied to both groups after the instruction to compare the effectiveness of the treatment.

4.4.2 Attitude Scale toward Chemistry (ASTC)

The attitude scale, developed by Geban et al. (1994), was used to measure the students' attitudes toward chemistry as a school subject. It was likert type scale containing 5 point (fully agree, agree, undecided, partially agree, fully disagree) and consisted of 15 items. The reliability of the scale was 0.83. This test was given to both groups before and after the treatment to see whether the treatment lead any significant difference in their attitudes towards chemistry.

4.4.3 Science Process Skills Test

This test was developed by Okey, Wise and Burns (1982) and translated and adopted into Turkish by Geban, Aşkar, and Özkan (1992). It contained 36 four alternative item multiple-choice questions. The reliability of the test was found to be

0.85. The test was applied to both groups only prior the instruction to determine whether there is a significant mean difference between the two groups in terms of their intellectual abilities. Intellectual abilities refer to identifying variables, identifying and stating hypotheses, operationally defining, designing investigations, and graphing and interpreting data in the test.

4.5 Treatment

This study was conducted over a six-week period in the fall semester of 2006. Two classes participated in the study; one of them was assigned as an experimental group to be instructed by conceptual change oriented instruction using hands-on activities and the other as a control group to be instructed through traditional instruction. The two teaching methods randomly assigned to the classes. Both groups were instructed by the same teacher throughout the application, covered the same subject matter and used the same textbook. Instructional objectives were the same for each class and all measuring materials were identical. Both classes took the same reading assignments as homework. Before the treatment the teacher was informed about the conceptual change oriented instruction using hands-on activities. During the treatment, the gases concept topics were covered as a part of the regular curriculum. The researcher observed both groups randomly. The classroom instructions were two 40-minute sessions per week. The concepts instructed for both groups were as follows:

- Properties of gases
- Volume of gases
- Kinetic Theory of gases
- Diffusion of gases
- Pressure of gases
- Gas laws (Charles law, Boyle Marriott, Dalton, Avogadro, Gay Lussac)
- Ideal gas law
- Partial pressure of gases

In the control group, traditionally designed instruction that was mainly teacher- centered was applied. Instruction was guided mainly by lecturing method supported by questions and discussions. During classroom instruction, the teacher wrote the topic on the board and without revealing students' prior conceptions she explained the topic. Explanation was carried out by writing the main ideas, formulas or solutions of the problems on the board. Students were passive as they only listened and took some notes. To check the students' understanding, the teacher asked questions which students answered by using their memorized knowledge. When the topics did not include algorithmic questions, topics were discussed in the classroom and the teacher behaved as a facilitator to make them reached the correct end. When the topics included quantitative questions students tried to solve the algorithmic problems and teacher gave some clues when needed. At the end of the lesson, the teacher assigned them homework questions.

The experimental group was instructed by conceptual change oriented instruction using hands-on activities. This strategy was based on the Posner's et al. (1982) conceptual change theory, which is a constructivist approach. Before the treatment the teacher was informed about the conceptual change strategy, hands-on activities and how they could be applied. In addition, misconceptions that students might have about gases concept were explained to the teacher. The instruction was based on revealing students' preconceptions and misconceptions, replacing these misconceptions with scientific conceptions and relating their prior conceptions with the new concepts.

The instruction started with conceptual questions. The students discussed the questions by the control of the teacher (without forming groups) and disagreement occurred between the students. The teacher only guided them without giving the correct answer. By this way, students' prior conceptions activated and their misconceptions were determined. For example, the teacher began the instruction of Boyle's Law by asking what would happen to a gas if squeezed? Students' explanations were varied such as gas particles get smaller, nothing changes, the speed of particles increases etc. After obtaining students' alternative conceptions, the students engaged with the hands-on activities concerning how pressure of the gas affects volume, with small groups (5 or 6 students). The groups were formed heterogeneously based on their previous semester chemistry grades. During the activities, the students drew graphs showing the relation of pressure and volume with regard to their data. The teacher continued asking conceptual questions and they realized the actual reason of the situation. By this way dissatisfaction occurred at the students. The lesson continued by scientific explanation of the concept (intelligibility). For example teacher stated that the distance between gas particles comprised the 99% of the volume. Increasing the pressure of a gas means decreasing the distance between gas particles, as a result the volume decreases, but because temperature is constant, the speed of the particles would not change. In addition, during explanation teacher emphasized students' misconceptions and why they were wrong. To make the new concept plausible for the students, the topic was supported with examples from daily life. For example, the teacher explained why it becomes difficult after a while to fill bottles with colognes or oil by the help of funnel, or why helium filled balloons inflate or burst when the altitude increases. At the end of the lesson, the teacher assigned homework (fruitful) such as how we breathe. (See Appendix F for sample lesson based on conceptual oriented instruction using hands-on activities). The researcher observed the classes in both groups randomly (See observation checklist in Appendix B).

At the end of the treatment, both groups were administered GCT as post-test to compare the effectiveness of the conceptual change method. They were also given ASTC to see if the new method made any change about their attitudes.

4.6 Hands-on Activities

Hands-on activities were performed by the students in the experimental group during class hours. These activities were prepared by the researcher in the light of related literature and using Internet resources (Orna, 1993; Herr & Cunningham, 1999; Paradis & Spotz, 2006). Activities were presented in accordance with the sequence of the topics. The activities performed in the experimental group were as follows:

1. Diffusion of gases (Appendix G)
2. Diffusion rate of gases (Appendix G)
3. Direction of air pressure (Appendix H)
4. Magnitude of air pressure (Appendix H)
5. Relationship between volume and temperature (Appendix I)
6. Is hot air lighter than cold air (Appendix I)
7. Pressure changes with volume (Appendix J)
8. Relationship between pressure and amount (Appendix K)
9. Relationship between volume and amount (Appendix L)
10. Relationship between pressure and temperature (Appendix M)

The materials used in the activities were readily available at home or markets. Activities were presented to students with activity sheets including list of materials, procedure, and questions pertaining to activity. Additionally explanations and discussions of the events occurred during activities to make students reach the scientific reasoning.

Activities were designed to overcome particular misconceptions. They were also aimed to dissatisfy students with their non-scientific ideas. While explanations and discussions during the activities aimed to meet intelligibility condition of conceptual change, pertaining questions in the activities aimed to fulfil plausibility condition of conceptual change.

4.7 Analysis of Data

The data obtained from GCT and SPST and ASTC of the two groups were analysed as descriptive and inferential statistics using the statistical program for social science (SPSS) in the study.

As a descriptive statistics mean, standard deviation, skewness, kurtosis, range, maximum, minimum values and histograms were analysed for two groups.

The inferential statistic analyses were computed to test the hypotheses of the study using one-way multivariate analyses of variance (MANOVA).

4.8 Assumptions of the Study

1. The participants of the study responded accurately and honestly to all measurements used in this study.
2. The teacher was not biased during the treatment.
3. Reliability and validity issues of all measurements used in this study were accurate enough to enable the researcher to make accurate assumptions.
4. The difference of implementer (researcher instead of the teacher) had no effect on the results of the study.
5. The groups did not interact with each other.

4.9 Limitations of the study

1. The results of the study were limited to the 60 tenth grade students in a high achievement public school.
2. The study was limited to the gases concept.

CHAPTER V

RESULTS AND CONCLUSIONS

In this chapter results of the study are presented in three sections. In the first section, descriptive statistics of the data obtained from tests stated in the instrumentation part. Section two includes hypotheses testing as an inferential statistics. The findings of the study take place in the third section as a conclusion part.

5.1 Descriptive Statistics

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

Table 5.1 Descriptive Statistics Related to GCT, ASTC and SPST.

DESCRIPTIVE STATISTICS										
		N	Range	Min	Max	Mean	Std.Dev.	Std Err.	Skew.	Kurtos.
EXPERIMENTAL GROUP	Pre-GCT	27	6	3	9	5.67	1.69	.325	.675	-.297
	Post-GCT	27	8	8	16	11.81	2.29	.440	.391	-.853
	Pre-ASTC	27	50	20	70	52.63	13.08	2.518	-.947	.675
	Post-ASTC	27	41	32	73	56.26	11.20	2.156	-.774	.273
	SPST	27	8	18	26	22.30	2.47	.476	.132	-1.111

Table 5.1 Continued

		N	Range	Min	Max	Mean	Std.Dev.	Std Err.	Skew.	Kurtos.
CONTROL GROUP	Pre-GCT	28	11	0	11	5.82	25.52	.477	-.036	.595
	Post-GCT	28	11	3	14	9.21	2.81	.530	-.388	-.553
	Pre-ASTC	28	44	27	71	52.70	11.54	2.180	-.486	-.110
	Post-ASTC	28	52	18	70	52	12.34	2.332	-1.300	2.281
	SPST	28	16	14	30	22.86	3.95	.747	-.503	.224

Gases concept test scores range from 0 to 20. The higher scores mean the greater understanding in gases concept and consequently more achievement in gases concept. According to Table 5.1, pre-test and post-test results of the gases concept test indicates that the mean score increase is 6.18 in the experimental group while the mean score increase is 3.45 in the control group. The students in the experimental group were more successful and acquired more understanding in gases concept than students in the control group.

Attitudes scale toward chemistry scores range from 15 to 75 and higher scores means more positive attitudes toward chemistry. The mean scores of the ASTC in experimental group increases 3.29 points and the mean scores of the ASTC decreases of .64 point in control group when comparing the pretest and post test scores of the students.

Science process skills test scores range from 0 to 36 and higher scores indicate higher abilities in solving science problems. As shown in Table 5.1, the mean of SPST is 22.43 in the experimental group and 22.86 in the control group which means science process skills of the students are equal across groups.

The Table 5.1 also shows some other descriptive statistics such as range, minimum, maximum, standard deviation, skewness, and kurtosis values. According to the kurtosis and skewness values shown in Table 5.1. it can be concluded that the normality of the distribution of variables can be acceptable in the study.

5.2 Inferential Statistics

In this part, statistical analyses of the preliminary test scores, testing of the MANOVA assumptions, statistical model of MANOVA and the analyses of the hypotheses stated in chapter III are given. MANOVA was used to test the hypotheses at a significance level of 0.05.

5.2.1 Statistical Analyses of Preliminary Test Scores

Before performing MANOVA analyses, independent samples t-test analyses was performed to investigate whether there was a significant mean difference between the two groups with respect to students' understanding of gases concept (GCT), their attitude towards chemistry as a school subjcet (ASTC) and science process skills (SPST) before the treatment.

The results showed that there was no significant difference at the beginning of the treatment between CCIH and TDCI in terms of students' understanding gases concepts ($t=0.266$, $p>0.05$). In addition, there was not significant mean difference with respect to students' science process skills ($t= 0.622$, $p>0.05$) between the two groups. No significant difference was found with respect to students' attitudes toward chemistry, either ($t= 0.021$, $p>0.05$)

In addition, the correlations between SPST and dependent variables (understanding and attitude) were investigated. Table 5.2 shows the correlation results between dependent variables and science process skills.

Table 5.2 Correlation Results of the Post- GCT and Post-ASTC with SPST

	Post-GCT		Post-ASTC	
	Pearson Corr.	Sig.	Pearson Corr.	Sig.
SPST	.103	.453	.164	.232

According to Table 5.2, SPST does not significantly correlate with the dependent variables of post- GCT and Post- ASCT. As a result of these analyses, MANOVA was run in order to test the hypotheses of this study.

5.2.2 Assumptions of one-way Multivariate Analysis of Variance

Before starting data analyses in the MANOVA, dependent variables were tested for assumptions of MANOVA, which are multivariate normality distribution, equality of covariances and variances, independency of observations.

Since there is no statistical analysis available for multivariate normality, univariate normalities were checked for each of the dependent variables by skewness and kurtosis values given in table 5.1. Skewness of the scores obtained from post-GCT and post ASTC is between the range minus to plus twice of the standard error value, which shows the skewness, and kurtosis values were approximetely in an acceptable range for a normal distribution.

For the equality of covariance assumption, Box's test of equality of covariance matrices was conducted for dependent variables which are post-test scores of the GCT and ASTC both for experimental and control group. As seen from the Table 5.3, in this study the assumption of covariance equality has met because $F (3, 529248)= 0.797$, $p>.05$ which means groups have equal covariance according to GCT and ASTC scores accross groups.

Table 5.3 Box's Test of Equality of Covariance Matrices

Box's M	2.493
F	0.797
df1	3
df2	529248
Sig.	.495

For the equality of variances assumption, Levene's Test of Equality was used. As indicated in Table 5.4, $F(1, 53) = 1.546$ and $p > .05$ for GCT and $F(1,53) = .037$, $p > .05$ for ASTC which means the assumption of equality of variance is provided for each dependent variables.

Table 5.4 Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Post-GCT	1.546	1	53	.219
Post-ASTC	.037	1	53	.848

The last assumption requires that independency of observation was examined. To meet this assumption classroom observations were made by the researcher both in experimental group and control group. It is assumed that participants did not influence eachother.

As a result, all the assumptions of MANOVA were met.

5.2.3 Multivariate Analysis of Variance Model

One-way MANOVA was used to test the hypotheses of this study. The dependent variables are posttest scores of the GCT and ASTC; the independent variable is the treatment. Table 5.5 shows the results of the MANOVA.

Table 5.5 MANOVA Test Results

	Wilks' Lambda	F	Hypothesis df	Error df	Sig. (p)	Eta-Squared	Observed Power
Intercept	.035	710.917	2.000	52.000	.000	.965	1.000
Treatment	.788	6.995	2.000	52.000	.002	.212	.912

5.2.4 Null Hpotheses Testing

Hypothesis 1:

The first hypothesis stated that there is no significant effect of treatment (conceptual change oriented instruction using hands-on activities versus traditional instruction) on the collective dependent variables of students'understanding gases concepts and their attitudes towards chemistry.

Multivariate Analysis of Variance (MANOVA) was used to test the Hypothesis 1.The results were summarized in Table 5.5.

As seen in the Table 5.5; Wilks' Lambda = .788, $p < .05$, therefore the first null hypotheses is rejected. The results showed that there was a significant difference between conceptual change oriented instruction using hands-on activities and traditional instruction on the collective dependent variables. The CCIH group scored significantly higher than TDCI group ($\overline{X}$ (CCIH) = 11.81, $\overline{X}$ (TDCI)= 9.21 Table 5.1). The multivariate η^2= .212 indicates that 21 % of multivariate variance of the dependent variables is associated with the treatment factor.

Hypothesis 2:

The second hypothesis states that there is no significant effect of treatment (conceptual change oriented instruction using hands-on activities versus traditional instruction) on students'understanding of gases concepts.

To test the effect of independent variable (treatment) on certain dependent variable (understanding gases concept) among groups' follow-up ANOVA results were checked. See Table 5.6.

Table 5.6 Follow-up ANOVA Summaries for Post-GCT

Source	SS	df	MS	F	sig. (p)	Eta Squared	Observed Power
Corrected Model	92.957	1	92.957	14.125	.000	.210	.958
Intercept	6078.557	1	6078.557	923.665	.000	.946	1.000
Treatment	92.957	1	92.957	14.125	.000	.210	.958
Error	348.788	53	6.581				
Total	6495.000	55					
Corrected Total	441.745	54					

As seen in the Table 5.6; F (1, 53)= 14.125, $p< .05$. Therefore the null hypothesis is rejected. It is found that there is a significant mean difference between the groups with respect to understanding of gases concepts in the favor of the students taught with conceptual change oriented instruction using hands-on activities ($\overline{X}_{EG}$= 11.81; $\overline{X}_{CG}$ = 9.21). The multivariate η^2= .210 indicates that % 21 of multivariate variance of the dependent variables is associated with the treatment factor.

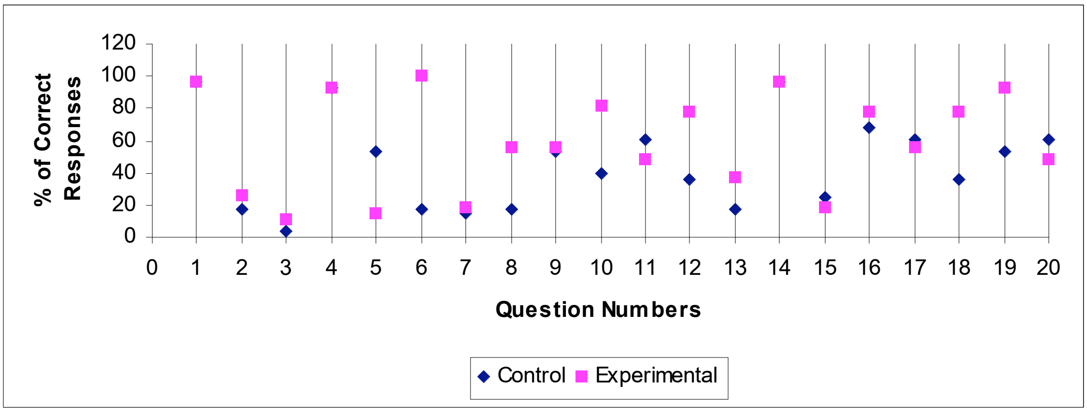


Figure 5.1 Comparison between post-GCT scores of the experimental and control group.

As seen in the Figure 5.1 there are differences in the proportion of correct responses between the two groups to the questions in the GCT. Remarkable differences are observed in the students' answers to the questions 6, 8, 10, 12, 13, 16, 18, and 19 in the favor of experimental group.

In question 6, students were asked about what there is between gas particles. Common misconception for this question is that thinking "there is air between gas particles" before the treatment (52 % of the control group and 33 % of the experimental group). But after the treatment all of the students in the experimental group respond correctly (100 % of the students') to the question in which the correct answer is there is space between gas particles, but only 18 % of the students in control group answered correctly and still 39 % of the control group students hold the same misconception after treatment.

Question 8 revealed the misconception related to gas laws in which students were asked to compare the pressures of the inflated balloon with the pressure of the same balloon when it is deflated and also with the atmospheric pressure. Before treatment 43 % of the students in the experimental group and 28 % of the students in the control group thought that the pressure of the inflated balloon is greater than the pressure of the deflated balloon. In addition 31 % of the students in the control group thought that deflated balloon have no pressure also atmospheric pressure is the greatest. After the treatment 18 % of the students in the control group answered correctly that the pressure of the inflated balloon is equal to the pressure of the deflated balloon and atmospheric pressure also equals them. In the experimental group 56 % of the students answered correctly to this question.

In question 10 conceptual stoichiometry promlem is presented. Students were asked to quess diagrams of gas molecules from a chemical equation. Prior to treatment 28 % of the students in control group and 10 % of the students in the experimental group scored correctly. After treatment most of the students responsed correctly in the experimental group (81 % of the students'), while the proportion of the students in the control group did not change significantly (39 % of the students') compared to experimental group.

Another question related to gas laws is question 12, which asks the reason why it becomes difficult to pour a liquid in a flask with a funnel after a while. This question requires application of Boyle's law. Before treatment some students respond that the water in the flask closed the entrance of the funnel (17 % of experimental group, 21 % of the control group); some others answered that the water in the flask apply upward pushing force to the water coming from the funnel (20 %

of experimental group, % 21 of the experimental group). After treatment most of the students in the experimental group (78 % of the students') changed their ideas that the decrease in the volume of the air in the flask increases the air pressure inside the flask preventing water entering from the funnel, which is the correct answer. On the other hand the proportion of the correct responses in the control group did not change significantly since 28 % of the students scored correctly before treatment and after treatment there were 36 % correct responses.

Question 13 related to the homogeneous dispersion of mixture of gases. Students were expected to quess the volumes of one-mole oxygen and one-mole nitrogen gases in a 3-liter container. Before treatment students have common misconception that gases occupy different volumes in the same container (41 % of the control group and 40 % of the experimental group). Suprisingly although it is given that the volume of container is 3-liter, most of the students scored that each gas occupy 22.4-liter volume since they are 1-mole each before the treatment. After treatment while the proportion of the correct responses decreased in the control group (18 % of the students'), correct responses of the experimental group increased to the (37 % of the students').

Question 16 dealt with what happens to a gas when heating. Before treatment 38 % of the students in the control group and 23 % of the students in the experimental group thought that the particles of the gas get bigger when heated and cause the increase in pressure. After treatment most of the students in both groups answered correctly to the question. In the control group the 68 % of the students answered correctly while 78 % of the students answered correctly in the experimental group.

The question 18 is related to the properties of gases. Before tretament students hold the misconceptions that heated air weigh more than cold air (14 % of the control group, 37 % of the experimental group), vice versa (21 % of the control group, 20 % of the experimental group), the direction of air pressure is towards downward (17 % of the control group, 10 % of the experimental group), gas pressure related to the type of gas (28 % of the control group, 10 % of the experimental group). After treatment most of the students in the experimental group remediate their misconceptions (78 % of the students'), but most of the students in the control group still hold the same misconceptions after treatment since only 36 % of the students scored correctly to this question.

Question 19 dealt with the particles when the matter changes state from solid to liquid to gas. Prior to treatment most of the students in both groups answered correctly to this question (45 % of the control group, 53 % of the experimental group). But some students hold the misconception that when the matter change state from solid to liquid to gas, the particles get bigger (28 % of the control group, 20 % of the experimental group). After treatment experimental group show remarkable achievement and 93 % of the students answered correctly to the question. In the control group the proportion of correct responses did not change significantly after treatment (54 % of the control group).

However, for the questions 5, 11 and 20 proportion of correct responses is higher in the control group. For example, question 5 related with the direction of gas pressure. Students were asked what would happen to a balloon in a closed container if the piston pushed downward a little. 54 % of the students in the control group answered correctly to this question by answering that the balloon will shrank in all directions while most of the students in the experimental group answered that the balloon will explode (70 % of the experimental group). For the question 20, students were asked to write a chemical equation from the given diagrams of particles. While 61 % of the control group students answered correctly to this question, in the experimental group 48 % of the students answered correctly after instruction.

As a result, after instruction the students in the experimental group gained the more in terms of achievement in gases concept and removing the misconceptions compare the students in the control group.

Hypothesis 3

The hypothesis 3 stated that there is no significant effect of treatment (conceptual change oriented instruction using hands-on activities versus traditional instruction) on students' attitudes toward chemistry as a school subject.

In order to determine the effect of the treatment on students' attitudes towards chemistry, follow-up ANOVA results were checked. Table 5.7 shows the results.

Table 5.7 Follow-up ANOVA Summaries for Post-ASTC

Source	SS	df	MS	F	sig. (p)	Eta Squared	Observed Power
Corrected Model	249.360	1	249.360	1.792	.186	.033	.260
Intercept	161097.651	1	161097.651	1157.690	.000	.946	1.000
Treatment	249.360	1	249.360	1.792	.186	.033	.260
Error	7375.185	53	139.154				
Total	168545.000	55					
Corrected Total	7624.545	54					

As indicated in the Table 5.7, (F (1, 53) =1.792, $p > .05$) the null hypothesis failed to rejected. The multivariate $\eta^2 = .033$ indicates that 3 % of multivariate variance of the dependent variables is associated with the treatment factor. It is found that there was no significant mean difference between students taught by conceptual change instruction using hands-on activities and traditionally designed chemistry instruction with respect to students' attitudes toward chemistry as a school subject ($\overline{X}_{EG} = 56.26$; $\overline{X}_{CG} = 52$).

5.3 Conclusions

In the light of the findings obtained by the statistical analyses, the results can be summarized as follows:

- ♣ The students taught by conceptual change oriented instruction using hands-on activities gained more understanding of gases concepts than the students taught by traditional instruction.
- ♣ Conceptual change oriented instruction using hands-on activities is more effective method than the traditional instruction in terms of eliminating misconceptions related to gases concepts.
- ♣ The conceptual change oriented instruction using hands-on activities and traditional instruction produced statistically the same attitudes toward chemistry as a school subject which means CCIH has no effect on students' attitudes toward chemistry.

CHAPTER VI

DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

6.1 Discussion

The purpose of this study was to investigate the effects of conceptual change oriented instruction using hands-on activities compared to the traditionally designed chemistry instruction on 10^{th} grade students' understanding of gases concepts and their attitudes toward chemistry as a school subject. In additon, the misconceptions related to gases concepts were investigated in the study.

According to statistical analyses results given in Chapter V, it can be concluded that the conceptual change oriented instruction using hands-on activities is more efficient to improve students' chemistry achievement and eliminate misconceptions related to gases concepts than the traditional chemistry instruction. However, the treatment did not have statistically significant effect on students' attitudes toward chemistry as a school subject.

In the present study students' understanding of gas concepts is studied. Students have a lot of misconceptions about gases concepts due to its abstract and invisible nature (Stavy, 1988; Benson et al., 1993; Brown, 1993; She, 2002). The misconceptions about gases concepts identified in this study are similar to the findings in the literature (e.g. Nakhleh & Mitchell, 1993; Hwang, 1995; Cho, Park & Choi, 2000; Lin et al., 2000; Brook et al., 2003). For example students think that particles that form the matter expand when the matter is heated and, the particles shrink when cooled. The reason for this misconception may be that students perceive gases' submicroscopic (particulate) view like its macroscopic view as they observe in their daily lives (Brook, Briggs & Driver, 1988; Krnel & Watson 1994). Therefore they tend to describe the properties of particles as in the observable substances because they observe matter expands when heated and shrink when cooled; they think that this occurance is valid for the particulate view. Some students also think that there is matter among gas particles, especially air. Novick and Nussbaum (1981) explained the underlying problem for this misconception as stating that students relate vacuum concept with air and there is air between every objects. In addition they may relate particles with dust or vapor and there is also air between them. Another misconception that students hold is about gas laws. They cannot apply the gas laws for real life situations. For example they think that the gas pressure inside the balloon is bigger when the balloon is inflated but it is smaller when it is deflated. They also think that hot air is heavier than the cold air or vice versa. Homogeneity of gas mixtures is also unclear for some students. They think that gases contain different volumes in the same container. The reason for all these misconceptions is due to the fact that they may not relate what they have learnt in science lessons to the real life situations. Students also have problems with the stoichiometry questions when asked in a conceptual way. For instance, when the chemical reactions of gases were asked using diagrams of the gas particles, they were unsuccessful. In addition some students have problems with the direction of atmospheric pressure.

Constructivism approach suggests that knowledge is constructed by the individual by making links with existing ideas through senses such as seeing, hearing, touching, smelling, and tasting during interaction with the environment (Von Glasersfeld, 1990). Therefore it can be said that students construct the concepts of gases from its observable properties. Because the particles of matter could not seen, students explain the behaviour of gases using the macroscopic nature of it.

The findings of this study indicate that the experimental group performed better than the control group in terms of acquisition of gases concepts. Therefore, conceptual change oriented instruction is effective in remediating students' misconceptions and understanding of scientific concepts related to gas. This study produced similar findings with other research studies. For example, Rollnick and Rutherford (1993) examined the effectiveness of conceptual change model on remediating misconceptions on air pressure and particles relating to gases. They concluded that conceptual change model is significantly superior on remediating alternative conceptions. In addition, Hewson and Hewson (1984) showed that conceptual change instruction causes better acquisition of scientific conceptions related to properties of matter compared to traditional instruction. The same results were supported by Fellow (1994) for nature of matter concepts. Although the experimental group gained the most in understanding of gases concepts, however, for the topics related to direction of air pressure and conceptual stoichiometry, control group students performed better than the experimental group. The underlying reasons may be revealed with an extensive study by making interviews.

The possible explanation for the effectiveness of this instruction may be that in conceptual change instruction students' preconceptions are revealed and their misconceptions are taken into account. Then, conceptual conflict is created by discussing and evaluating preconceptions of the students. In addition, students' are encouraged for conceptual restructuring in a conceptual change implemented classroom. On the other hand, in traditional instruction explanation of the facts and solving problems are presented without regarding students' existing ideas (Bodner, 1991).

The other possible explanation for effectiveness of the instruction in experimental group may be due to student-centered activities performed in the classroom. In this study hands-on activities help students to make connections between their experiences, which are macroscopic, and the topics' submicroscopic nature, which are scientific explanations. By this way abstract gas concepts become concrete in their minds. The findings of this study are in agreement with literature for the effectiveness of hands-on instruction (Bredderman, 1982; Kyle et al., 1982; Shymansky et al., 1988; Handerhan & Janet, 1994; Hardal, 2003; Türk, 2005). They found that students who are instructed by hands-on materials, achieve higher than those taught by traditional instruction. In addition, Stohr-Hunt (1996) investigated that science achievement has a positive relationship with the frequency of hands-on activities.

Although it is found that conceptual change oriented instruction is effective method in students’ understanding as supported by previous literature, it did not affect students’ attitudes towards chemistry in this study. Actually in conceptual change method students are active partcipants as they have a chance to describe, explain, and make interpretations about real world phenomena also in this method student-student interaction and learning by activities is promoted which make abstract concpets concrete. Therefore, some studies found that conceptual change oriented instruction and hands-on activities are effective in promoting positive attitudes towards science. For example Rowland (1990), Jones et al. (2003), and Bilgin (2006) investigated the effects of hands-on activities on students’ attitudes toward science and they all found that hands-on activities produce favourable feelings towards science. In this study, the reason for finding that conceptual change oriented instruction using hands-on activities have no effect on students’ attitudes toward chemistry may be that students are unfamiliar with this type of instruction. Up to time they were passive listeners, therefore the duration of instruction may be insufficient to be accustomed to an active participant in lessons and for changing their attitudes toward chemistry. In addition, according to Papanastasiou and Papanastasiou (2004) many factors affect students’ attitudes towards science, besides teaching method such as family’s educational background, aspiration, school climate etc. Maybe these factors influence students’ attitudes towards science in a negative way.

In summary, this study showed that students had difficulties in understanding gases concepts and held several misconceptions. In order to promote conceptual understanding and remediate misconceptions in gases, conceptual change oriented instruction using hands-on activities is an effective method.

6.2 Implications

This study implies the followings:

1. To promote meaningful learning, conceptual change method is an effective tool, since it considers students' prior knowledge and relates prior konowledge with new concepts.
2. Science teachers' sould be informed and encouraged to use conceptual change method how to prepare hands-on activities.
3. Science teachers should become aware of the students' misconceptions and make students become dissatisfy with their misconceptions.
4. Teachers should consider how students' conceptual understanding makes use in practical situations.
5. Conceptual problems should be given importance at lessons.
6. In order to achieve effective teaching the teaching style at lessons should be changed from "teacher-centered" to "student-centered".
7. The role of the teacher should be a facilitator and provide appropriate guidance.
8. Teachers should make the students perform hands-on activities, by this way students' understanding become concrete.

6.3 Recommendations

Based on the results, the followings can be recommended:

1. This study can be replicated with larger sample size and different high schools for a generalization to a bigger population.
2. Current study can be applied for different grade level of students and for different chemistry subjects to investigate the effectiveness of conceptual change method.
3. Conceptual change study can be carried out with small group discussions.

4. Conceptual change instruction can be enriched with worksheet, conceptual problems and conceptual assignments for the gases topic.
5. Behaviour of gases can be explained by making models of gas particles with beans or similar things.
6. Further studies can be carried out using different teaching strategies such as conceptual change texts, analogy to foster conceptual change method in gases concept.
7. Further studies can be done for a longer time period, because longer time may affect the students' attitudes towards chemistry.

REFERENCES

Abraham, M.R.,Grzybowsky, E.B., Renner, J.W., & Marek, E.A. (1992). Understandings and misunderstandings of eighty graders of five chemistry concepts found in textbooks. *Journal of Research in Science Teaching*, 29(2), 105-120.

Anderson, C.W., & Smith, E.L. (1983). How Swedish pupils, aged 12-15 years, understand light and its properties. *European Journal of Science Education*, 5(4), 387-402.

Ausubel, D. P. (1968). *Educational Psychology: A Cognitive View*. New York: Holt, Rinehart and Winston.

Ausubel, D. P., Novak, J. D., & Hanesian, H. (1978). *Educational psychology: A cognitive view.* New York: Holt, Rinehart, & Winston.

Azizoğlu, N. (2004). *Conceptual change oriented instruction and students' misconceptions in gases*. Unpublished Master Thesis, The Middle East Technical University, Ankara, Turkey.

Beeth, M. (1995) Conceptual change instruction: Some Theoretical and pedagogical issues. Paper Presented at the Annual Meeting of the National Association for Research in Science Teaching, San Francisco, CA.

Benson, D. L., Wittrock, C. M., & Baur, M. E., (1993). Students' Preconceptions of the Nature of Gases*. Journal of Research in Science Teaching*, 30(6), 587-597.

Bilgin, I. (2006). The effects of hands-on activities incorporating a cooperative learning approach on eight grade students' science process skills and attitudes toward science. *Journal of Baltic Science Education*, 1 (9), 27-37.

Bodner, G. (1991). "I have found you an argument: The conceptual knowledge of beginning chemistry graduate students." *Journal of Chemical Education*, 68 (5), 385-388.

Bredderman, T. (1982). What research says: Activity science-the evidence shows it matters. *Science and Children,* 20 (1), 39-41.

Bristow, B. R. (2000). The effects of hands-on instruction on 6th grade students' understanding of electricity and magnetism. Dissertation abstracts international, 39 (01), 30A. (University Microfilms No. AAT1400301)

Brook, A., Briggs, M., & Driver, R. (1984). Aspects of Secondary Students' Understanding of the Particulate Nature of Matter. Leeds: University of Leeds Children's Learning in Science Project. Centre for in Science and Mathematics Education .

Brook, A., Briggs, H., & Driver, R. (2003). Study of the evolution of students' initial knowledge during a teaching sequence on gases at the upper secondary school level. *Journal of Research in Science Teaching*, 30 (6), 587-597.

Brooks, M. G. and Brooks, J. G. (1999). The courage to be constructivist. *Educational Leadership*, November, 18 –24.

Brown, D. E. (1993). Refocusing core intuitions: A concretizing role for analogy in conceptual change. *Journal of Research in Science Teaching*, 30(10), 1273-1290.

Caillot, M., & Chartrain, J-L. (2001). Conceptual Change and Relation to Knowledge: The Case of Volcanism at Primary School. Paper presented at the Annual Meeting of American Educational Research Association, p. 10-14, Seattle.

Caprio, M. W. (1994). Easing into constructivism, connecting meaningful learning with student experience. *Journal of College Science Teaching*, 23(4), 210-212.

Caramazza, A, McCloskey, M., & Green, B. (1981). Naive Beliefs in 'Sophisticated' Subjects: Misconceptions About Trajectories of Objects. *Cognition,* 9, 117-123.

Carvita, S., & Hallden, O. (1994). Re-framing the problem of conceptual change. *Learning and instruction,* 4, 89-111.

Champagne, A. B., Gunstone, R. F., & Klopfer, L. E. (1983). Naive knowledge and science learning. *Research in Science and Technological Education,* 1, 173-183.

Chang, C. (2002). Does computer assisted instruction + problem solving = Improved science outcomes? A pioneer study. *Journal of Educational Research*, 95 (3) 143-150.

Cheung, K.C., & Taylor, R. (1991). Towards A Humanistic Constructivist Model of Science Learning: Changing Perspectives and Research Implications. *Journal of Curriculum Studies,* 23(1), 21-40.

Chi, M. T. H., & Roscoe, R. D. (2002). The process and challenges of conceptual change. In M. Limon & L. Mason (Eds.), "Reconsidering conceptual change: Issues in theory and practice", 3-27,. Dordrecht: Kluwer.

Chiappetta, E. L. & Koballa, T. R. (2002). *Science Instruction in the Middle and Secondary Schools*. Merril Prentice Hall, Upper Saddle River, New Jersey.

Cho, I-Y., Park, H-J., & Choi, B-S. (2000). Conceptual Types of Korean High School Students and Their Influences on Learning Style. Annual Meeting of the National Association for Research in Science Teaching, 34 p., New Orleans, LA.

Claesgens, J., Scalise, K., Draney, K., Wilson, M. & Stacey, A. (2002). Perspective of a Chemist: A Framework to promote Conceptual Understanding of Chemistry. Paper presented at the Annual Meeting of American Educational Research Association, 24 p., New Orleans, LA.

Cobb, P. (1988). The tension between theories of learning and instruction in mathematics education. *Educational Psychologist*, 23,87-103.

De Berg, K. C. (1995). Student understanding of the volume, mass, and pressure of air within a sealed syringe in different states of compression. *Journal of Research in Science Teaching,* 32 (8), 871-884.

DiSessa, A. A. (2002). Why conceptual ecology is a good idea. In M. Limon & L. Mason (Eds.), "Reconsidering conceptual change: Issues in theory and practice" 29-60, Dordrecht: Kluwer.

Doran, R. L. (1990). What research says about assessment?. *Science and Children,* 27(8), 26-27.

Driscoll, M. P., (1994). Psychology of Learning for Instruction. Allyn and Bacon: A Division of Paramount Publishing, Inc.

Driver, R., Asoko, H., Leach, J. Mortimer, E. and Scott, P. (1994). Constructing scientific knowledge in the classroom. *Educational Researcher*, 23, (7), 5-12.

Driver, R., Guesne, E., & Tiberghien, A. (1985). Children's ideas in Science. Milton Keynes: Open University Press.

Driver, R., & Easley, J. (1978). Pupils and Paradigms: A review of Literature Related to Concept Development in Adolescent Science Students. *Studies in Science Education,* 5, 61-84.

Duit, R. (1999). Conceptual change approaches in science education. In W. Schnotz, S. Vosniadou, & M. Carretero (Eds.), New Perspectives on Conceptual Change (pp. 263-282). Oxford: Pergamon.

Dykstra, D.I. J. R., Boyle, C.F., & Monarch, I. A. (1992). Studying Conceptual Change in Learning Physics. *Science Education*, 76 (6), 615-652.

Erickson, G. L. (1979). Children's conceptions of heat and temperature. *Science Education,* 63(2), 221-230.

Ernest, P. (1995). The one and the many. In L. Steffe& J. Gale (Eds.). *Constructivism in education* (pp.459-486). New Jersey: Lawrence Erlbaum Associates, Inc.

Gabel, D. L., Samuel, K. V. , Hunn, D. (1987). Understanding the particulate nature of matter. *Journal of Chemical Education*, 64(8), 695-697.

Gabel, D.L., Sherwood, R.D. & Enochs, L.(1984). Problem solving skills of high school chemistry students. *Journal of Research in Science Teaching*, 21, 221-233.

Geban, Ö, Aşkar, P., Özkan, Y. (1992). Effects of computer simulated experiments and problem solving approaches on high school students. *Journal of Educational Research*, 86, 5-10.

Geban, Ö., Ertepınar, H., Yılmaz, G., Altın, A. and Şahbaz, F. (1994). Bilgisayar destekli eğitimin öğrencilerin fen bilgisi başarılarına ve fen bilgisi ilgilerine etkisi. I. Ulusal Fen Bilimleri Eğitimi Sempozyumu: Bildiri Özetleri Kitabı, s:1 - 2, 9 Eylül Üniversitesi, izmir

George, R. (2000). Measuring change in studentsí attitudes toward science over time: an application of latent variable growth modeling. *Journal of Science Education and Technology*, 9(3), 213-225.

Gilbert, J. K., Osborne, R. J., & Fensham, P.J. (1982). Children's science and its consequences for teaching. *Science Education*, 66, 623-633.

Glasson, G. (1989). The effects of hands-on and teacher demonstrations laboratory methods on science achievement in relation to reasoning ability and prior knowledge. *Journal of Research in Science Teaching,* 26 (2), 121-131.

Griffiths, A. K., & Preston, K. R. (1992). Grade-12 students' misconceptions relating to fundamental characteristics of atoms and molecules. *Journal of Research in Science Teaching*, 29 (6), 611-628.

Fellows, N. J. (1994). A window into thinking: Using student writing to understand conceptual change in science learning. *Journal of Research in Science Teaching*, 31(9), 985-1001.

Francis, L. J. & Greer, J.E. (1999). Measuring attitude toward science among secondary school students: The affective domain. *Research in Science and Technological Education*, 17(2), 219-226.

Freedman, M.P. (1997). Relationships among laboratory instruction, attitude toward science, and achievement in science knowledge. *Journal of Research in Science Teaching*, 34 (4), 343-357.

Haidar, H. A., & Abraham, R. M. (1991). A comparison of applied and theoretical knowledge of concept based on the particulate nature of matter. *Journal of Research in Science Teaching*, 28 (10), 919-938.

Handerhan, K., & Janet, S. (1994). Beyond the GED with Physical Science. A Hands-on Science Curriculum. A 353 special project of Pennsylvania Department of Education, 98-4024, Mercer, PA

Hardal, Ö. (2003). *The Effects of Hands-on Activities on 9th Grade Students' Achievement and Attitude Towards Physics.* Unpublished Master Thesis, The Middle East Technical University, Ankara

Harding, J. & Donaldson, J. (1986). Chemistry from Issues. *School Science Review*, 68, 48-59.

Harlen, W. (1999). Purposes and procedures for assessing science process skills. *Assessment in Education,*6, 129-144.

Haury, D. L., & Rillero, P. (1994). Perspectives of Hands-on Science Teaching. 151p, ERIC Clearinghouse for Science, Mathematics and Environmental Education, Colombus, Ohio.

Herr, N. & Cunningham, J. (1999). *Hands-on Chemistry Activities with Real Life Applications Easy to Use Labs and Demonstrations for Grades 8-12*. West Nyack, N.Y.: Center for Applied Research in Education.

Herron, J. D. (1996). *The chemistry classroom: formulas for successful teaching*. Washington, DC: American Chemical Society.

Hesse, J. J. & Anderson, C. W. (1992). Students' conceptions of chemical change. *Journal of Research in Science Teaching*, 29 (3), 277-299.

Hewson, P. W., & Hewson, M. G. (1984). The role of conceptual conflict in conceptual change and the design of science instruction. *Instructional Science*, 13, 1-13.

Hewson, P.W. (1992). Conceptual change in science teaching and teacher education. *National Center of Educational Research*, Documentation, and Assessment, Madrid, Spain.

Hewson, P.W. & Hewson, M.G. (1989). Analysis and use of a task for identifying conceptions of teaching science. *Journal of Education for Teaching*, 15 (3), 191-209.

Hofstein, A. and Lunetta, V. N. (2004). The laboratory in science education: foundations for the twenty-first century. *Science Education,* 88, 28-54.

Hwang, B-T. (1995). Students' conceptual representations of Gas Volume in relation to Particulate Model of Matter. Paper Presented at The Annual Meeting of the National Associationfor research in Science Teaching, San Francisco, CA.

Hynd, C., Alvermann, D. & Qian, G. (1997). Preservice elementary school teachers' conceptual change about projectile motion: refutation text, demonstration, affective factors and relevance. *Science Education,* 81, 1-27.

Jonassen, D. (1991). Objectivism vs. Constructivism. *Educational Technology Research and Development*, 39 (3), 5-14.

Jones, M.G., Andre, T., Negishi, A., Tretter, T., Kubasko, D., Bokinsky, A., Taylor, R., and Superfine, R. (2003). Hands-on Science: The impact of haptic experiences on attitudes and concepts. Paper presented at the National Association of Research in Science Teaching Annual Meeting. Philadephia, PA.

Koballa, Jr., T.R., Crawley, F.E. & Shringley, L. (1990). A summary of research in science education. *Science Education*, 74(3), 369-381.

Koballa, Jr., T.R. (1992). Persuasion and Attitude Change in Science Education. *Journal of Research in Science Teaching*, 29(1), 63-80.

Krnel, D. & Watson, R. (1998). Survey of research related to the development of the concept of matter. *International Journal of Science Education*, 20 (3), 257-289.

Kuhn, T. S. (1970). *The structure of scientific revolutions.* Chicago: University of Chicago Press.

Kyle, W. C., Bonnstetter, R. J., Gadsden, T. Jr., & Syhmansky, J. A. (1988). What research says about hands-on science?. *Science and Children*, 25 (7), 39-40.

Lazarowitz, S. M. R. (2002). Computer simulations in the high school: Students' cognitive stages, science process skills and academic achievement in microbiology. *International Journal of Science Education*, 24(8), 803-821.

Lee, O., Eichinger, D.C., Anderson, C. W., Berkheimer, G. D., & Blakeslee, T. D. (1993). Changing middle school students' conceptions of matter and molecules. *Journal of Research in Science Teaching*, 30(3), 249-270.

Liang, L. L. & Gabel. D. L. (2005). Effectiveness of a Constructivist Approach to Science Instruction for Prospective Elementary Teachers. *International Journal of Science Education, 27(10), 1143–116.2*

Lin, H-S., Cheng, H-J,. & Lawrenz, F. (2000). The assessment of students and teachers' understanding of gas laws. *Journal of Chemical Education*, 77 (2), 235-238.

Lonning, R. A. (1993). Effects of cooperative learning strategies on students verbal nteractions and achievement during conceptual change instruction in 10th grade general science. *Journal of Research in Science Teaching*, 30(9), 1087-1101.

Lorsbach, A., & Tobin, K. (1992). Constructivism as a referent for science teaching. NARST Newsletter, 30, 5–7.

Mas, C. J. F., Perez, J. H., & Harris, H. H. (1987). Parallels between Adolescents' Conception of Gases and History of Chemistry. *Journal of Chemical Education*, 64 (7), 616-618.

McCloskey, M. (1983). Intuitive Physics. *Scientific American,* 248 (4), 122-130.

Murray, T., Schultz, K., Brown, D. & Clement, J. (1990). An analogy-based computer tutor for remediating physics misconceptions. *Interactive Learning Environments*, 1, 79–101.

Nakhleh, M. B. (1992). Why some students don't learn chemistry?. *Journal of Chemical Education*, 69, 191-196.

Nakleh, M. B. & Mitchell, R. C. (1993). Concept learning versus problem solving. *Journal of chemical Education*, 70 (3), 190-192.

Niaz, M., Aguilera, D., Maza, A., & Liendo, G. (2002). Arguments, contradictions, resistances, and conceptual change in students' understanding of atomic structure. *Science Education,* 86, 505-525.

Nieswandt, M. (2001). Problems and possibilities for learning in an introductory chemistry course from a conceptual change perspective. *Science Education*, 85 (2), 158-179.

Novak, J.D. (1977). *A theory of education.* Ithaca, NY: Cornell University Press.

Novak, J. D., & Gowin, D.B. (1984). *Learning how to learn*. New York: Cambridge University Press.

Novak, J. D., & Wandersee, J.H. (Eds.). (1990). Perspectives on concept mapping [Special issue]. *Journal of Research in Science Teaching, 27,* 922-1079.

Novick, S., & Nussbaum, J. (1978). Junior high school pupils' understanding of the particulate nature of matter: an interview study. *Science Education*, 62 (3), 273-281.

Novick, S., & Nussbaum, J.(1981). Pupil's understanding of the particle nature of matter. *Science Education*, 65, 187-196.

Nurrenbern, S. C., & Pickering, M. (1987). Concept learning versus problem solving: Is there a difference?. *Journal of Chemical Education*, 64 (6), 508-510.

Nussbaum, J., & Novak, J.D. (1976). An assessment of children's concepts of the earth utilizing structured interviews. *Science Education,* 60, 535-547.

Nussbaum, J., & Novick, A. (1982). Alternative framework, conceptual conflict and accommodation: Toward a principled teaching strategy. *Instructional Science*, 11, 183-200.

Okey, J. R., Wise, K. C. and Burns, J. C. (1982). Integrated Process Skill Test-2. (available from Dr. James R. Okey, Department of Science Education, University of Georgia, Athens, GA, 30602, USA).

Orna,V., M. (1993). *Instructional Resources for Preservice and Inservice Chemistry Teachers,* A Source Book Module*,* National Science Foundation, New Rochelle.

Osborne, F. J. (1996). Beyond Constructivism. *Science Education*, 80(1), 53-52.

Osborne, R. J. & Wittrock, M. C. (1983). Learning science: A generative process. *Science Education,* 67 (4), 489-508.

Osborne, R. J., & Wittrock, M. C. (1985). The generative process and its implications for science education. *Studies in Science Education*, 12, 59-87.

Oskamp, S. (1977). Attitudes and Opinions. Englewood, Cliffs, NJ: Prentice-Hall.

Padilla, J. M. (2004). *The science process skills*. http://www.educ.sfu.ca/narstsite/publication/research/ skill.htm [2004, November 14]

Palmer, D.H. (1999). Exploring the link between students' scientific and nonscientific conceptions. *Science Education*, 83, 639-653.

Papanastasiou, C., & Papanastasiou, E. C. (2004). Major Influences on Attitudes Toward Science. Educational Research and Evaluation, 10 (3), 239–257.

Paradis, J. & Spotz, K. (2006). *Hands-on Chemistry*. Naidenhead: McGraw-Hill Education.

Parker, V. (2000). Effects of a science intervention program on middle-grade student achievement and attitudes. *School Science and Mathematics*, 100 (5), 236-242.

Phelps, A. (1996). Teaching to enhance problem solving: It's more than just numbers. *Journal of Chemical Education*, 73 (4), 301-304.

Piaget, J. (1977). *Equilibration of* cognitive *structures*. New York: Viking Press.

Pines, A. L. & West, L. H. T. (1986). Conceptual understanding and science learning: An interpretation of research within a source of knowledge framework. *Science Education*, 70(5), 583-604.

Posner, G., Strike, K., Hewson, P., & Gertzog, W. (1982). Accommodation of a scientific conception: Toward a theory of conceptual change. *Science Education*, 66, 211–217.

Prieto, T., Watson, J. R., & Dillon, J. S. (1992). Pupils' understanding of combustion. *Research in Science Education*, 22, 331-340.

Renner, J.W. & Marek, E. A. (1988). *The Learning Cycle and Elementary School Science Teaching*. Heinemann Educational, Inc.: Portsmouth, NH.

Resnick, L.B. (1983). Mathematics and science learning: A new conception. *Science,* 220,477-478.

Richardson, V. (1997). Constructivist approaches to teacher education. Thousand Oaks, CA: Corwin Press.

Rollnick, M., & Rutherford, M. (1993). The use of conceptual change model and mixed language strategy on air pressure. *International Journal of Science Education*, 15 (4), 363-381.

Ross, R., & Kurtz, R. (1993). Making manipulatives work: A strategy for success. Arithmetic Teacher, 40(5), 254-257.

Roth, K. J. (1990). Developing meaningful conceptual understanding in science. In B.F. Jones & L. Idol (eds.), Dimensions of thinking and cognitive instruction, Hillsdale, N.J.: Science Teaching, Fontana, WI.

Rowland, P. M. (1990). Using science activities to internalise locus of control and influence attitudes towards science. Paper presented at the Annual Meeting of National Association for Research in Science Teaching, Atlanta, GA.

Sawrey, B. (1990). “Concept learning versus problem solving: Revisited.” *Journal of Chemical Education*, 67(3), 253-254.

Schmidt, H. (1997). Students' misconceptions - Looking for a pattern. *Science Education*, 81(2), 123-135.

Séré, M.-G. (1985). The gaseous state. In R. Driver, E. Guesne, & A. Tiberghien (Eds.), Children’s ideas in science (pp. 105- 123). Milton Keynes, England: Open University Press.

Séré, M.-G. (1986). Children’s conception of the gaseous state prior to teaching. *European Journal of Science Education*, 8(4), 413- 425.

She, H-C. (2002). Concepts of a higher hierarchical level require more dual situated learning events for conceptual change: a study of air pressure and buoyancy. *International Journal of Science Education,* 24 (9), 981-996.

Smith, E.L. (1990). A conceptual change model of learning science. In S. Glynn, R. Yeany. & B. Britton (Eds.), *Psychology of learning science*. Hillsdale, NJ: Lawrence Erlbaum.

Smith, J.P., diSessa, A., & Roschelle, J. (1993). Misconceptions Reconcieved: A Constructivist Analysis of Knowledge in Transition. *The Journal of the Learning Sciences*, 3 (2), 115-163.

Smith, L. E., Blakeslee, T. D. & Anderson, C. W. (1993). Teaching strategies associated with conceptual change learning in science. *Journal of Research in Science Teaching*, 30 (2), 111-126.

Stavy, R. (1988). Childrens' conception of gas. *International Journal of Science Education*, 10 (5), 553-560.

Stepans, J. I. (1991). Developmental patterns in students' understanding of physics concepts. In S. M. Glynn, R. H. Yeany, & B. K. Britton (eds.), *The psychology of learning science* (pp.89-115).

Stohr-Hunt, P. M. (1996). An analysis of frequency of hands-on experience and science achievement. *Journal of Research in science Teaching*, 33(1), 101-109.

Taber, K. S. (1995). Development of student understanding: A case study of stability and liability in cognitive structure. *Research in Science and Technological Education*, 13 (1), 89-99.

Teichert, M. A., & Stacy, A. M. (2002). Promoting understanding of chemical bonding and spontaneity through student explanation and integration of ideas. *Journal of Research in Science Teaching*, 39 (6), 464-496.

Tobin, K. (1990). Research on science laboratory activities: In pursuit of better questions and answers to improve learning. *School Science and Mathematics*, 90(5), 403-418.

Türk, Ö. (2005). *The effects of hands-on activity enriched instruction on sixth grade students' achievement and attitudes towards science*. Unpublished Master Thesis, The Middle East Technical University, Ankara

Tynjala, P. (1998). Traditional studying for examination versus constructivist learning tasks: do learning outcomes differ? *Studies in Higher Education*, 23(2), 173-190.

Uzuntiryaki, E., & Geban, Ö. (2004). Effectiveness of Instruction Based on Constructivist Approach on Students' Understanding of Chemical Bonding Concepts. *Science Education International*, 15 (3), 185-200.

Uzuntiryaki, E. & Geban, Ö. (2004). Promoting Students' Attitudes toward Chemistry Using Instruction Based on Constructivist Approach.European Association for Research on Learning and Instruction, 4th European Symposium Conceptual Change: Philosophical, Historical, Psychological, and Educational Approaches, Delphi, Greece.

Viennot, L. (1979). Spontaneous Reasoning in Elementary Dynamics. *European Journal Of Science Education,* 1, 205-221

Von Glasersfeld, E. (1984). An introduction to radical constructivism. In P. Watslawick, *The Invented Reality*, (17-40). New York: W.W. Norton&Company.

Von Glaserfeld, E. (1990). An exposition on constructivism: Why some like it radical. In R. Davis, C. Maher, & N. Noddings (Eds.), Constructivist views on the teaching and learning of mathematics (Journal of Research in Mathematics Education Monography, 4, 19-29.) Reston, VA: National Council of Teachers of Mathematics.

Von Glaserfeld, E. (1993). Questions and answers about radical constructivism. In K. Tobin (Ed.), The practice of constructivism in science education. Washington, DC: American Association for the Advancement of Science.

Von Glasersfeld, E. (1995). A constructivist approach to teaching. In L. Steffe 6 J. Gale (Eds.). (1995). *Constructivism in education*, (3-16). New Jersey: Lawrence ErlbaumAssociates, Inc.

Vosniadou, S. (1991). Designing Curricula for Conceptual Restructuring: Lessons from The Study of Knowledge Acquisition In Astronomy, *Journal of Curriculum Studies,* 23(3), 219-237.

Vosniadou, S., Ioannides, C., Dimitrakopoulou, A., and Papademetriou, E. (2001). Designing learning environments to promote conceptual change in science, *Learning and Instruction*, 11, 381-419.

Walters, Y. B. and Soyibo, K. (2001). An analysis of high school students' performance on five integrated science process skills. *Research in Science & Technological Education,* 19, 133-145.

Wandersee, J. H., Mintzes, J. J., & Novak, J. D. (1994). Research on alternative conceptions in science. In D. L. Gabel (Ed.), Handbook of research on science teaching and learning, 177–210). New York: Macmillan.

Weaver, G. C. (1998). Strategies in K-12 Science Instruction to Promote Conceptual Change. *Science Education,* 82 (4), 455–472.

West, L. H. T. & Pines, A. L. (1985). Cognitive structure and conceptual change. (Eds.) New York: Academic Press.

Westbrook, S.L. & Marek, E. A. (1992). A cross-age study of student understanding of the concept of homeostasis. *Journal of Research in Science Teaching*, 29(1), 51-61.

www.wondernet.com, Last date accessed september 2006.

Wu, Y-T and Tsai, C-C (2005) Effects of constructivist-oriented instruction on elementary school students' cognitive structures. *Journal of Biological Education*, 39, 113-119.

Yager, R. E. (1991). The constructivist learning model: Towards real reform in science education. *The Science Teacher*, 53-57.

Zoller, U., Lubezky, A., Nakhleh, M. B., Tessier, B., & Dori, Y. J.. (1995) Success on Algorithmic and LOCS vs. Conceptual Chemistry Exam Questions. *Journal of Chemical Education*, 72 (11), 987-989.

APPENDIX A

INSTRUCTIONAL OBJECTIVES

1. To identify the differences between gases, liquids and solids considering both their visible properties (macroscopic) and particles' movement (molecular).
2. To understand the conservation of mass for reactions involving gas substance.
3. To explain the behaviour of gases in terms of kinetic molecular theory of gases, including the relationships between molecular velocity and temperature.
4. To conclude that gases fill the enclosed space homogeneously.
5. To explain diffusion by giving examples from daily lives.
6. To explain pressure on the basis of kinetic theory.
7. To observe the effects of atmosferic pressure.
8. To discover direction of the atmospheric pressure.
9. To explore the relation ships between the pressure, volume, quantity and temperature of a gas.
10. To use empirical gas laws to predict how a change in one of the properties of a gas will affect the remaining properties.
11. To relate how airbags work with gas laws.
12. To relate how hot air balloons fly with Charles's law.
13. To explain cooling of a gas at molecular level.
14. To make comparison between hot air and cold air.
15. To use the ideal gas equation to analyse gas behaviour.
16. To list deficiencies in the ideal gas model that will cause real gases to deviate from behaviours predicted by the empirical gas laws.
17. To explain the concept of partial pressure in mixtures of gases.
18. To apply Dalton's law of partial pressures.
19. To explain the factors affecting the pressure measured by a manometer.

APPENDIX B

OBSERVATION CHECKLIST

	Never	Sometimes	Always	Notes
Teacher makes students remember their previous learnings when covering a new topic.	O	O	O	
Teacher engages the learner's curiosity, or challenges what the learners' thinks.	O	O	O	
Students generate ideas.	O	O	O	
The teacher takes account students' misconceptions.	O	O	O	
Teacher provides learners with support and guidance to help the learner arrive at the correct answer.	O	O	O	
The teacher emphasizes relationships between new and old content.	O	O	O	
The teacher presents information in an organized manner.	O	O	O	
Teacher relates the new content with real life situations.	O	O	O	
DURING ACTIVITY				
The teacher stresses the goals of the learning activity.	O	O	O	
Students work in small groups	O	O	O	
Students are actively engaged in the activity.	O	O	O	
Students share relevant information.	O	O	O	
Teacher encourages student -student interaction	O	O	O	
Students arrive at the target conclusions.	O	O	O	

APPENDIX C

GAZLAR KAVRAM TESTİ

1. **Kapalı bir kapta, gaz hâlde bulunan bir madde ile ilgili aşağıdakilerden hangisi doğru <u>değildir</u>?**

A) Birim zamanda kap yüzeyinin her santimetrekaresine çarpan tanecik sayısı aynıdır.

B) Gazın yaptığı basınç kabın çeperleinin her yerinde aynıdır.

C) Kap içinde herhangi bir noktada ölçülen basınç, bu gazın basıncıdır.

D) Kap içindeki gazın tabana yaptığı basınç yan yüzeylere yaptığı basınçtan daha fazladır.

E) Taneciklerin birbirleriyle yaptıkları toplam çarpma sayısı çeperlere yaptıkları toplam çarpma sayısına eşittir.

2. Üflenerek biraz şişirilip ağzı iple bağlanmış bir balon, bulunduğu ortamdan alınarak,

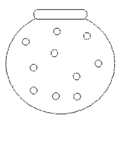
I. Aynı basınçta, daha soğuk

II. Aynı sıcaklıkta, yükseltisi daha fazla

III. Aynı sıcaklıkta, havası boşaltılmış

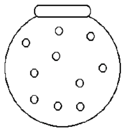
ortamlardan hangisine ya da hangilerine konulursa balonun hacminin artması beklenir?

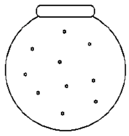
A) Yalnız I B) Yalnız II C) Yalnız III D) I ve II E) II ve III

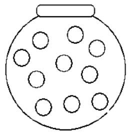
3. 

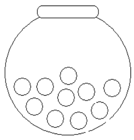
Yandaki şekil hidrojen gazının 25 ^{o}C ve 1 atm basınçtaki dağılımıdır. (Yuvarlaklar ($_o$) hidrojen gazının moleküllerini temsil etmektedir.)

Aşağıdakilerden hangisi sıcaklık -15 ^{o}C ye düşürüldüğünde gaz moleküllerinin dağılımını gösterir?

A) 

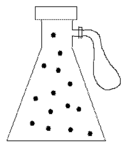
B) 

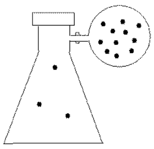
C) 

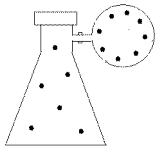
D) 

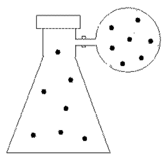
E) 

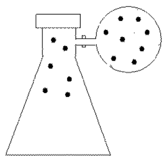
4. Hava ile dolu bir kaba şekildeki gibi bir balon bağlanmaktadır. Aradaki musluğu açıp kabı ısıttığımızda balonun şiştiği gözlemlenmektedir. **Hangi şekil balon şiştikten sonra havayı oluşturan moleküllerin dağılımını en iyi açıklar?** (Noktalar (.) havayı oluşturan molekülleri temsil etmektedir.)

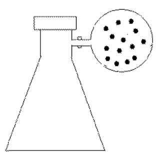


A) 

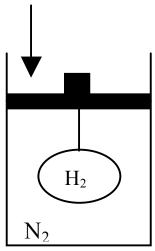
B) 

C) 

D) 

E) 

5. Şekildeki pistonlu kapta azot gazı bulunmaktadır. Pistona çelik iple bağlı elastik balonun içinde ise hidrojen gazı bulunmaktadır. **Elastik balon kabın hiçbir yüzeyine değmeyecek şekilde, piston aşağı doğru bir miktar itilirse balonun şeklinde ne gibi bir değişiklik olur?**



A) Balonun üst kısmı düzleşir.

B) Balon yanlardan büzülür.

C) Balonun alt kısmı düzleşir.

D) Balon her yerden büzülür.

E) Balon patlar.

6. Bir gazı oluşturan taneciklerin arasında ne bulunur?

A) Hava

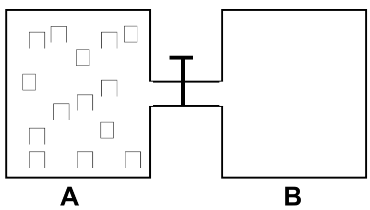
B) Su buharı

C) Hiçbirşey yoktur.

D) Başka gazlar

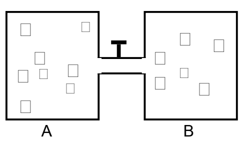
E) Yabancı maddeler (toz, kir vs.)

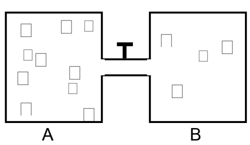
7.

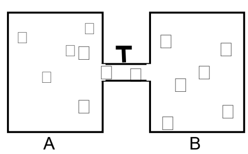


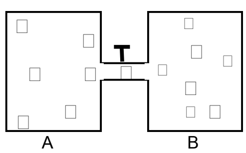
Hacimeleri eşit olan A ve B kapları bir muslukla şekildeki gibi birbirlerinden ayrılmıştır. A kabında He (□) gazı, CH4 (□) gazı ve Cl_2 (□) gazı vardır. B kabı ise boştur. Musluk açıldıktan 1 saat sonra karışım her iki kapta homojen hale gelmektedir.

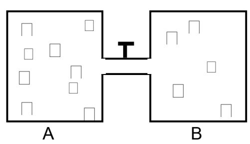
Aşağıdakilerden hangisi gaz moleküllerinin 30 dakika sonraki olası dağılımını gösterir? (Mol Kütleleri; He: 4, CH_4: 16, Cl_2: 71)

A) 

B) 

C) 

D) 

E) 

8. Atmosfer basıncının P_{atm} olduğu bir ortamda hava ile dolu bir balonun basıncı P_{dolu} olarak ölçülmektedir. Balonun ağzı açılıp sönmesi beklenmektedir ve sönmüş balonun basıncı $P_{sönmüş}$ olarak ölçülmektedir. **Aşağıdakilerden hangisinde P_{atm}, P_{dolu} ve $P_{sönmüş}$ basınçlarının ilişkisi doğru olarak verilmiştir?**

A) $P_{sönmüş} < P_{atm} < P_{dolu}$

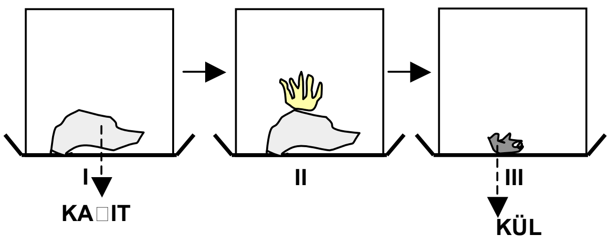
B) $P_{sönmüş} = P_{atm}$, $P_{atm} < P_{dolu}$

C) $P_{atm} = P_{dolu} = P_{sönmüş}$

D) $P_{atm} > P_{dolu}$, $P_{sönmüş}=0$

E) $P_{atm} < P_{dolu}$, $P_{sönmüş}=0$

9. Aşağıda verilen şekillerde Durum I'de bir parça kağıt cam fanusun içine konulmaktadır. Durum II'de kağıt yanmakta ve Durum III'de küller oluşmaktadır. Her üç durumda da cam fanuslar tartılmıştır. **Buna göre aşağıdakilerden hangisi doğrudur?**



A) Durum I en büyük ağırlığa sahiptir.

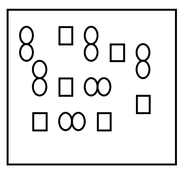
B) Durum II en büyük ağırlığa sahiptir.

C) Durum III en büyük ağırlığa sahiptir.

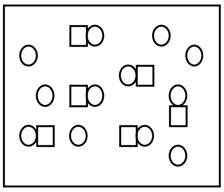
D) I ve II aynı ağırlığa sahiptir ve III'ten daha ağırdır.

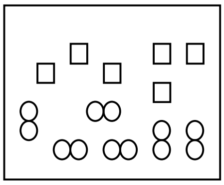
E) Hepsi de aynı ağırlığa sahiptir.

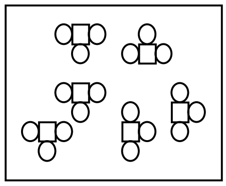
10. Kapalı bir kapta bir miktar Sülfür (□) ve Oksijen (∞) gazının karışımı şekildeki gibi gösterilmiştir. Bu gazlar aşağıdaki denkleme göre tepkimeye girmektedir. **Hangi gösterim tepkime sonucu oluşan ürüne aittir?**

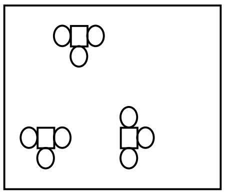


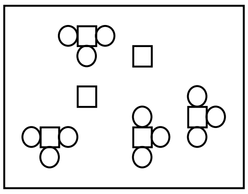
$2S + 3O_2 \lozenge 2\ SO_3$

A) 

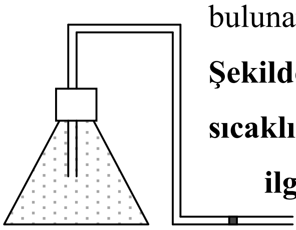
B) 

C) 

D) 

E) 

11. Şekildeki gibi içinde gaz bulunan erlen, cam tüpe bağlı olan bir tıpa ile kapatılmıştır. Çam tüpün bir ucunda bir damla cıva bulunmaktadır. Erlen 3 ^oC soğuk su bulunan behere konulduğunda cıva sola hareket ediyor; 80 ^oC sıcak su bulunan behere konulduğunda cıva sağa doğru hareket ediyor. **Şekildeki düzeneğin tamamı 25 ^oC oda sıcaklığından 5 ^oC sıcaklığındaki bir ortama götürülürse cıvanın hareketi ile ilgili aşağıdakilerden hangisi doğru olur?**



A) Hareketsiz kalır, çünkü açık hava basıncı sabittir.

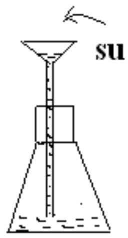
B) Önce sola sonra sağa hareket eder.

C) Sola hareket eder, sıcaklık düşünce erlendeki basınç da azalır.

D) Sağa hareket eder, sıcaklık düşünce kabın içindeki basınç azalır ve hacim artar.

E) Sağa hareket eder,sıcaklık düşünce hacim azalır ve erlendeki basınç da artar.

12. Şekilde erlen, huniye bağlı bir tıpa ile sıkıca kapatılmıştır. Huniye yavaşça su döktüğümüzde su kolayca erlene girmektedir. Fakat erlendekii su seviyesi huninin alt kısmına ulaşınca erlene su ilavesi zorlaşmaktadır. **Bunun sebebi aşağıdakilerden hangisi olabilir?**



A) Erlendeki suyun girişi kapatması

B) Suyun yerleşecek yer bulmasının zaman alması

C) Erlendeki suyun yukarı doğru itme kuvveti uygulaması

D) Erlendeki havanın basıncının artması

E) Erlendeki suyun kaldırma kuvvetinin daha fazla su ilavesini kaldıramaz duruma gelmesi

13. Oda koşullarında bulunan 1 mol oksijen ve 1 mol azot gazlarının 3 litrelik kapalı bir kaptaki hacimleri nedir?

A) Her iki gaz da ikişer litredir.

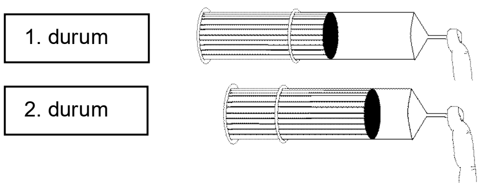
B) Her iki gaz da birer litre hacim kaplar.

C) Her iki gaz da üçer litre hacim kaplar.

D) Karışım halinde bulundukları için gazların tek başlarına hacimlerinden bahsedilemez.

E) Birer mol oldukları için hacimleri 22.4 L ‘dir.

14.



Sabit sıcaklık ve basınçta içinde hava bulunan şırınganın pistonu bir miktar itilerek içindeki hava sıkıştırılmaktadır. **Sıkıştırma sonucunda havayı oluşturan tanecikler için aşağıdaki ifadelerden hangisi doğrudur?**

A) Tanecikler birbirine yapışır.

B) Taneciklerin hepsi şırınganın ucuna toplanır.

C) Tanecikler küçülür.

D) Tanecikler arasındaki mesafe azalır.

E) Tanecikler yüksek basıçtan dolayı patlar.

15. Normal koşullarda hacmi 2 litre olan kapalı bir kaba 1 litre helyum ve 1 litre azot gazları konulduğunda, **bu kaptaki helyum ve azot gazlarının hacimleri hakkında aşağıdakilerden hangisi doğrudur?** (Gazlar arasında kimyasal tepkime gerçekleşmemektedir.)

A) Her iki gazın hacmi de birer litredir.

B) Her iki gaz da ikişer litre hacim kaplar.

C) Gazların hacimleri kapta bulunan gazların taneciklerinin sayıları ile orantılıdır.

D) Azotun moleküler ağırlığı daha fazla olduğu için azot daha çok hacim kaplar.

E) Helyum ve azot gazlarının kimyasal özelliklerine bağlıdır.

16. Gaz hâldeki bir madde ile dolu kapalı bir kap ısıtıldığında kap içindeki basıncın arttığı gözleniyor. **Aşağıdakilerden hangisinde bu olayın sebebi en doğru açıklanmıştır?**

A) Gaz hâldeki maddenin taneciklerinin büyümesi

B) Gaz hâldeki maddenin taneciklerinin ısındıkça sayısının artması

C) Isı alan gaz hâldeki maddenin ağırlaşması

D) Isı alan gaz hâldeki maddenin taneciklerinin çarpma sayısının artması

E) Isı alan gaz hâldeki maddenin taneciklerinin kabın çeperlerine yoğunlaşması

17. Pistonlu bir silindirde ideal davranıştaki X gazı sabit sıcaklıkta, piston itilerek sıkıştırılıyor. **Sıkıştırma işlemi sonunda bu gaz ile ilgili aşağıdaki yargılardan hangisi <u>yanlıştır</u>?**

A) Moleküllerin ortalama hızı azalır.

B) Moleküller arası uzaklık azalır.

C) Birim hacimdeki molekül sayısı artar.

D) Moleküllerin sayısı değişmez.

E) Basıncı artar.

18. Gazlarla ilgili aşağıdakilerden hangisi doğrudur?

A) Isıtılan hava soğuk havadan daha hafiftir.

B) Gaz basıncı, gaz hâldeki maddenin moleküllerinin içerdiği atom sayısına ve cinsine bağlıdır.

C) Gazlar kapalı bir kap içinde homojen hâlde bulunurlar.

D) Hava basıncı aşağı doğrudur.

E) Isıtılan hava soğuk havadan daha ağırdır.

19. Bir maddenin katı hâlden sıvı hâle, sıvı hâlden gaz hâle geçtikçe taneciklerinin aşağıda verilen özelliklerinden hangisi ya da hangileri değişir?

I. Kinetik enerjileri

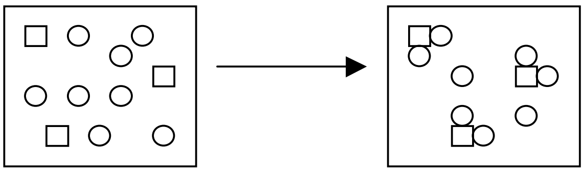
II. Büyüklüğü

III. Molekülleri arasındaki uzaklık

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

20. Birinci şekilde X (□) elementi ile Y (□) elementinin oluşturduğu karışım tanecikli yapıda gösterilmiştir. Bu elementlerin tepkimesi sonucu ikinci şekildeki durum oluşmuştur.

Buna göre tepkimenin denklemi aşağıdakilerden hangisinde doğru gösterilmiştir?



A) $8X + 3Y$◊ X_6Y_3 $+2X$

B) $3X+ 6Y$◊X_3Y_6

C) $X+ 2Y$◊ XY_2

D) $3X+ 8Y$◊ $3XY_2 + 2Y$

E) $X+ 4Y$◊$XY_2 + 2Y$

Table B.1 Gazlar Kavram Testinin Cevap Anahtarı

1	D	6	C	11	C	16	D
2	E	7	B	12	D	17	A
3	A	8	C	13	C	18	C
4	C	9	E	14	D	19	D
5	D	10	E	15	B	20	D

APPENDIX D

KİMYA DERSİ TUTUM ÖLÇEĞİ

AÇIKLAMA: Bu ölçek, Kimya dersine ilşkin tutum cümleleri ile her cümlenin karşısında Tamamen Katılıyorum, Katılıyorum, Kararsızım, Katılmıyorum ve Hiç Katılmıyorum olmak üzere beş seçenek verilmiştir. Her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneği işaretleyiniz.

	Tamamen Kat?l?yorum	Kat?l?yorum	Karars?z?m	Kat?lm?yorum	Hiç Kat?lm?yorum
1.Kimya çok sevdiğim bir alandır………………	○	○	○	○	○
2. Kimya ile ilgili kitapları okumaktan hoşlanırım	○	○	○	○	○
3.Kimyanın günlük yaşantıda çok önemli yeri yoktur	○	○	○	○	○
4. Kimya ile ilgili ders problemlerini çözmekten hoşlanırım……………………………………	○	○	○	○	○
5. Kimya konularıyla ile ilgili daha çok şey öğrenmek isterim………………………………	○	○	○	○	○
6. Kimya dersine girerken sıkıntı duyarım…………..	○	○	○	○	○
7. Kimya derslerine zevkle girerim……………	○	○	○	○	○
8. Kimya derslerine ayrılan ders saatinin daha fazla olmasını isterim…………………………	○	○	○	○	○
9. Kimya dersini çalışırken canım sıkılır………	○	○	○	○	○
10. Kimya konularını ilgilendiren günlük olaylar hakkında daha fazla bilgi edinmek isterim....	○	○	○	○	○
11. Düşünce sistemimizi geliştirmede Kimya öğrenimi önemlidir……………………………	○	○	○	○	○
12. Kimya çevremizdeki doğal olayların daha iyi anlaşılmasında önemlidir……………………	○	○	○	○	○
13. Dersler içinde Kimya dersi sevimsiz gelir……….	○	○	○	○	○
14. Kimya konularıyla ilgili tartışmaya katılmak bana cazip gelmez………………………………	○	○	○	○	○
15.Çalışma zamanımın önemli bir kısmını Kimya dersine ayırmak isterim…………………	○	○	○	○	○

APPENDIX E

BİLİMSEL İŞLEM BECERİ TESTİ

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

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

a. Her oyuncunun almış olduğu günlük vitamin miktarını.

b. Günlük ağırlık kaldırma çalışmalarının miktarını.

c. Günlük antreman süresini.

d. Yukarıdakilerin hepsini.

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

a. Arabaların benzinleri bitinceye kadar geçen süre ile.

b. Her arabnın gittiği mesafe ile.

c. Kullanılan benzin miktarı ile.

d. Kullanılan katkı maddesinin miktarı ile.

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

a. Arabanın ağırlığı.

b. Motorun hacmi.

c. Arabanın rengi

d. a ve b.

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

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

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

c. Büyük evlerin ısınma giderleri fazladır.

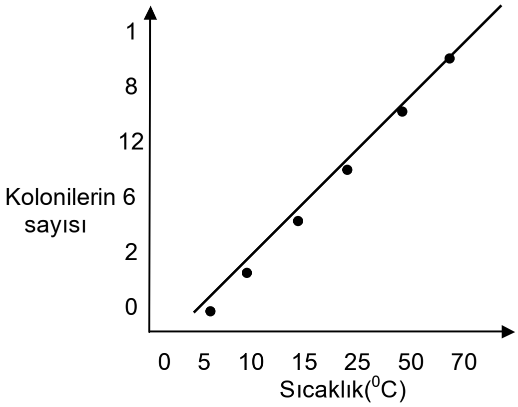
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir.

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

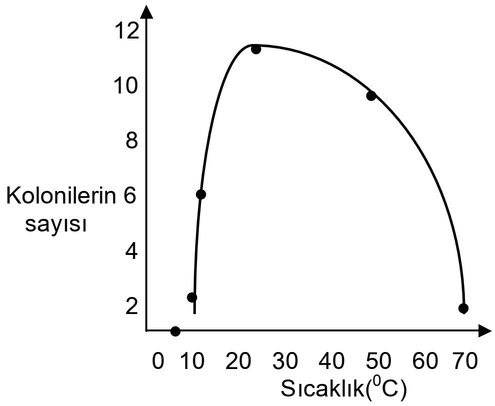
Deney odasının sıcaklığı (^{0}C)	Bakteri kolonilerinin sayısı
5	0
10	2
15	6
25	12
50	8
70	1

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?

a.



b.



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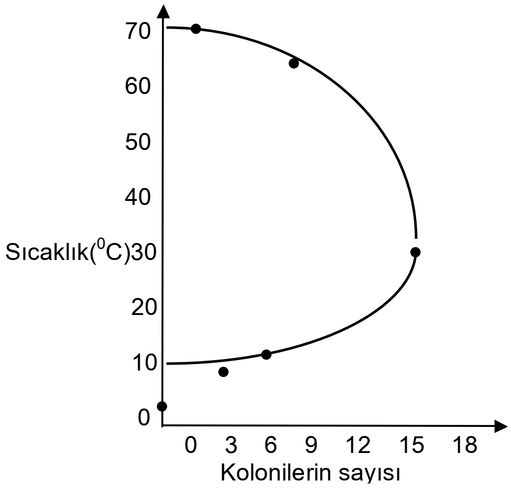

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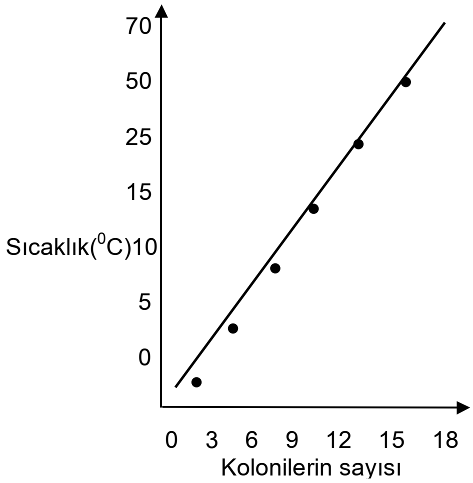


6. Bir polis şefi, arabaların hızının azaltılması ile uğraşmaktadır. Arabaların hızını etkileyebilecek bazı faktörler olduğunu düşünmektedir. Sürücülerin ne kadar hızlı araba kullandıklarını aşağıdaki hipotezlerin hangisiyle sınayabilir?

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

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

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

d. Arabalar eskidikçe kaza yapma olasılıkları artar.

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

a. Her deneyde arabanın gittiği toplam mesafe ölçülür.

b. Rampanın (eğik düzlem) eğim açısı ölçülür.

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

d. Her iki deneyin sonunda arabanın ağırlıkları ölçülür.

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

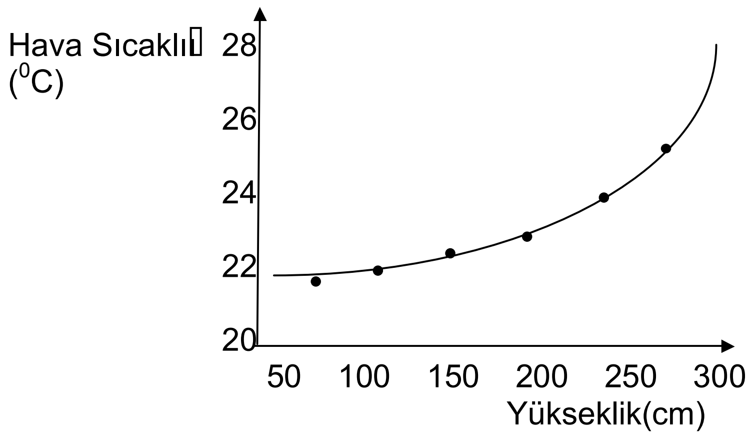
a. Tarlaya ne kadar çok gübre atılırsa, o kadar çok mısır elde edilir.

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

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

d. Mısır üretimi arttıkça, üretim maliyeti de artar.

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



a. Yükseklik arttıkça sıcaklık azalır.

b. Yükseklik arttıkça sıcaklık artar.

c. Sıcaklık arttıkça yükseklik azalır.

d. Yükseklik ile sıcaklık artışı arasında bir ilişki yoktur.

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

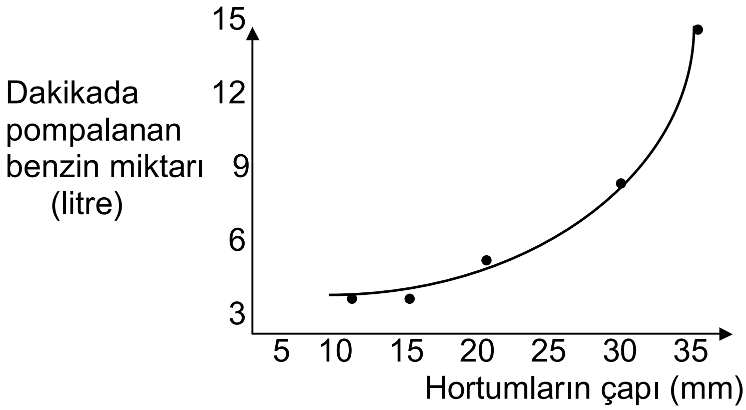
a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.

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

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

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

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi açıklamaktadır?

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

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

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

d. Pompalanan benzin miktarı azaldıkça, hortumun çapı genişler.

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

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

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

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

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

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

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

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

a. Hava sıcakken çim biçmek zordur.

b. Bahçeye atılan gürenin miktarı önemlidir.

c. Daha çok sulanan bahçedeki çimenler daha uzun olur.

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

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

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

17. Bu araştırmada sınanan hipotez hangisidir?

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

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

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

d. Kullanolan suyun miktarı arttıkça sıcaklığı da artar.

18. Bu araştırmada kontrol edilebilen değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

19. Araştımanın bağımlı değişkeni hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

20. Araştırmadaki bağımsız değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

21. Bir bahçıvan domates üretimini artırmak istemektedir. Değişik birkaç alana domates tohumu eker. Hipotezi, tohumlar ne kadar çok sulanırsa, o kadar çabuk filizleneceğidir. Bu hipotezi nasıl sınar?

a. Farklı miktarlarda sulanan tohumların kaç günde filizleneceğine bakar.

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

c. Farklı alnlardaki bitkilere verilen su miktarını ölçer.

d. Her alana ektiği tohum sayısına bakar.

22. Bir bahçıvan tarlasındaki kabaklarda yaprak bitleri görür. Bu bitleri yok etmek gereklidir. Kardeşi “Kling” adlı tozun en iyi böcek ilacı olduğunu söyler. Tarım uzmanları ise “Acar” adlı spreyin daha etkili olduğunu söylemektedir. Bahçıvan altı tane kabak bitkisi seçer. Üç tanesini tozla, üç tanesini de spreyle ilaçlar. Bir hafta sonra her bitkinin üzerinde kalan canlı bitleri sayar. Bu çalışmada böcek ilaçlarının etkinliği nasıl ölçülür?

a. Kullanılan toz ya da spreyin miktarı ölçülür.

b. Toz ya da spreyle ilaçlandıktan sonra bitkilerin durumları tespit edilir.

c. Her fidede oluşan kabağın ağırlığı ölçülür.

d. Bitkilerin üzerinde kalan bitler sayılır.

23. Ebru, bir alevin belli bir zaman süresi içinde meydana getireceği ısı enerjisi miktarını ölçmek ister. Bir kabın içine bir liter soğuk su koyar ve 10 dakika süreyle ısıtır. Ebru, alevin meydana getirdiği ısı enerjisini nasıl öiçer?

a. 10 dakika sonra suyun sıcaklığında meydana gelen değişmeyi kayeder.

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

c. 10 dakika sonra alevin sıcaklığını ölçer.

d. Bir litre suyun kaynaması için geçen zamanı ölçer.

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

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

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

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

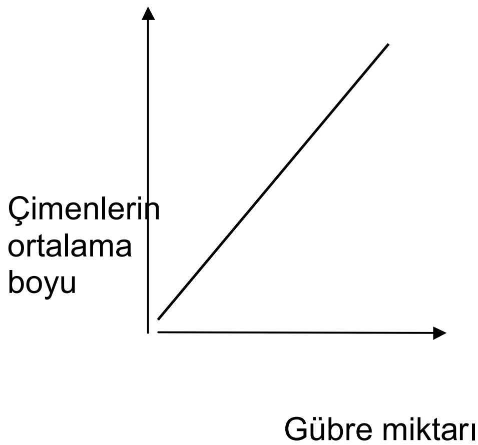
d. Herbiri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar farklı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

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

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

Tablodaki verilerin grafiği aşağıdakilerden hangisidir?

a.



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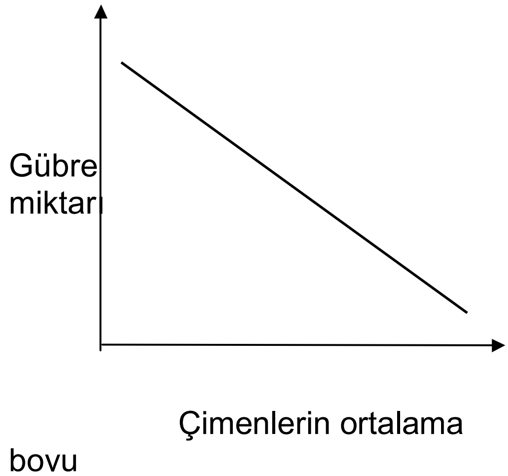
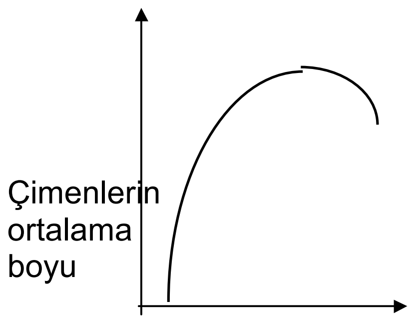


c.



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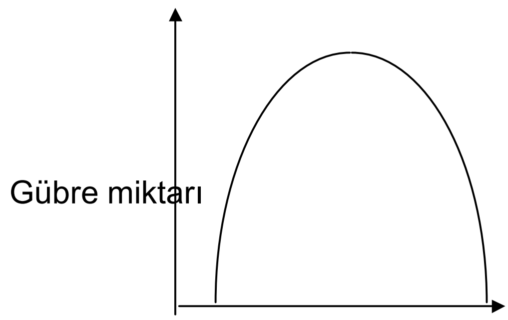


26. Bir biyolog şu hipotezi test etmek ister: Farelere ne kadar çok vitamin verilirse o kadar hızlı büyürler. Biyolog farelerin büyüme hızını nasıl ölçebilir?

a. Farelerin hızını ölçer.

b. Farelerin, günlük uyumadan durabildikleri süreyi ölçer.

c. Hergün fareleri tartar.

d. Hergün farelerin yiyeceği vitaminleri tartar.

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

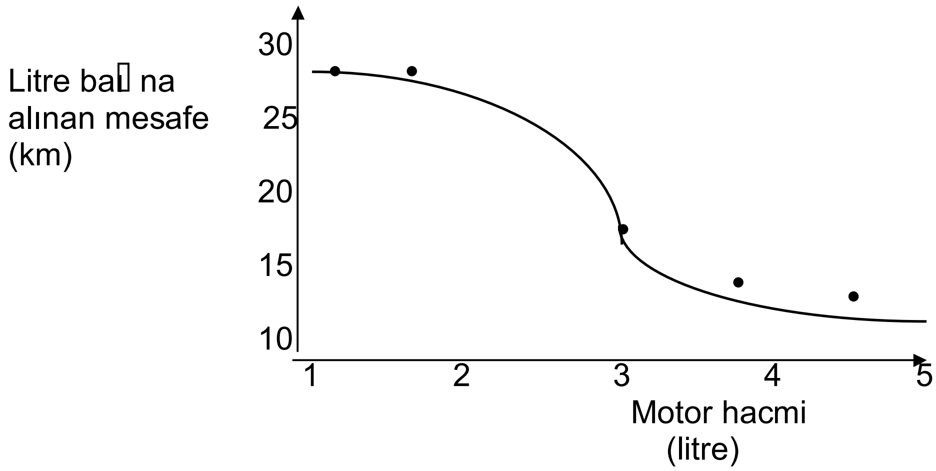
a. Daha fazla şekeri çözmek için daha fazla su gereklidir.

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

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

d. Su ısındıkça şeker daha uzun sürede çözünür.

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi gösterir?

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

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

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

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

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

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

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

29. Bu araştırmada sınanan hipotez hangisidir?

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

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

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

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

30. Bu araştırmada kontrol edilen değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

31. Araştırmadaki bağımlı değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

32. Araştırmadaki bağımsız değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

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

a. Kullanılan mıknatısın büyüklüğü üle.

b. Demir tozalrını çeken mıknatısın ağırlığı ile.

c. Kullanılan mıknatısın şekli ile.

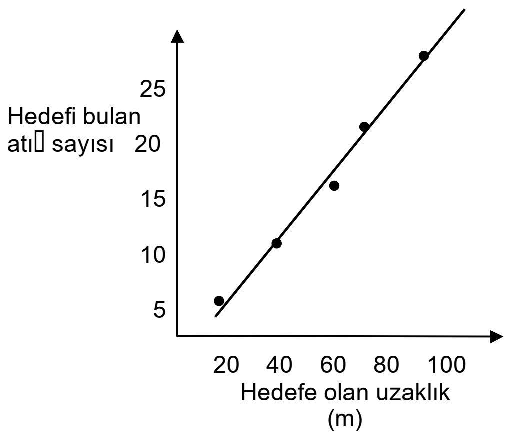
d. Çekilen demir tozlarının ağırlığı ile.

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

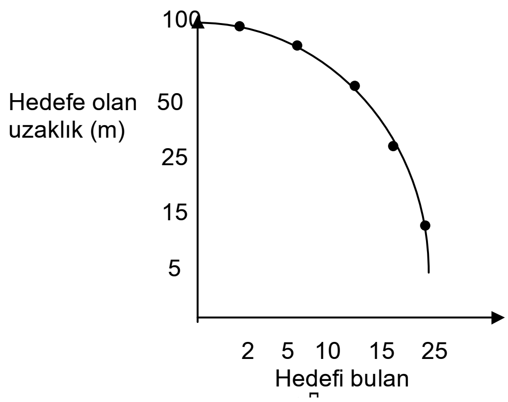
Mesafe(m)	Hedefe vuran atış sayısı
5	25
15	10
25	10
50	5
100	2

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?

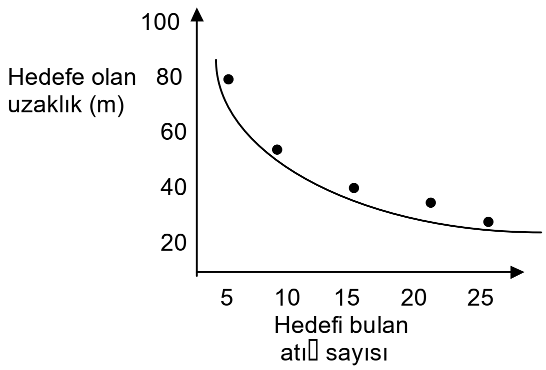
a.



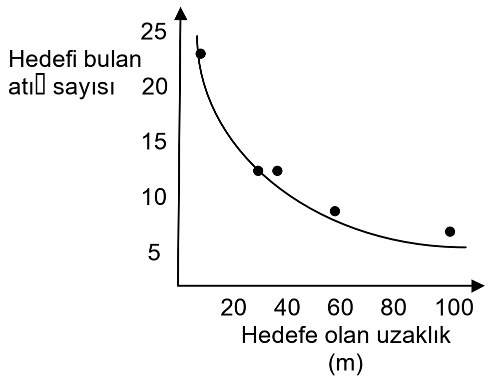
b.



c.



d.



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

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

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

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

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

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

a. TV nin açık kaldığı süre.

b. Elektrik sayacının yeri.

c. Çamaşır makinesinin kullanma sıklığı.

d. a ve c.

APPENDIX F

SAMPLE LESSON BASED ON CONCEPTUAL CHANGE METHOD USING HANDS-ON ACTIVITIES

Introduction

Teacher: Last lesson we have discussed the relation between volume and amount of gas. You learned that when we increase the amount of gas then the volume of gas increase if other variables are constant. So, you concluded that when we are blowing the balloon the pressure inside does not change. Also you infer that the pressure inside the inflated balloon is equal to the pressure inside the deflated balloon.

In this lesson we will discover the relation between pressure and temperature of a gas known as Guy-Lussac's gas law.

Dissatisfaction phase:

Teacher: What would happen to a gas in a closed container if we heat it?
(Some students thought in macroscopic level and said that if we were to heat liquid it would evaporate but nothing would happen to a gas).

Teacher: Okey, you mean that the appearence of gas wouldn't change, but what would happen in a molecular level?
(A few students explained that the size of the gas particles would increase. Some students claimed that the gas particles would rose up and gathered on the upper part of the container. And some others said that the speed of particles would increase).

Teacher: Let's test it with an activity and infer what would happen to a gas in a molecular level.

(The teacher created heterogeneous groups consisted of four or five students. And each group started to prepare apparatus according to their activity sheets that was given to them before. Students placed the empty bottle with narrow mouth, in a large container and they put coin at the mouth of a bottle that closed the opening completely. Then, the container filled with hot water. After a while students saw that the coin was jumping).

Teacher: What do you think, what would cause the coin's jumping?
(Some students again claimed that air particles in the bottle rose up and all of them gathered on the mouth of the bottle. And a few others told that the size of the air particles got bigger and they couldn't fit into the bottle anymore and they hit the coin which make it jump).

Teacher: If your argument is correct, then in summers the air in our rooms would rise up to the ceiling and we couldn't breath when sitting, could we? Or in winters when our hetaing system is on, the same thing would happen. Okey, who will refute that the particles size do not change when heating.
(Students remembered from preceding learnings and gave examples from related activities such as Boyle's law).

Teacher: If the temperature changes, causes the change in particles size, then the volume of every object would get bigger or smaller dependent on the temperature. Atoms and molecules or ions do not change their size or shape with temperature, volume, and pressure changes.
Now tell me the exact reason of coin's jumping? Answer this question with considering the variables (temperature, pressure, amount and volume) that affects the gases behaviour. Ion our activity which variables were constant and which variables were changed?
(The groups discussed the reason for a while and the teacher guided them. And they realized that the amount and the volume of gas were constant and the increase in temperature speeded up the particles, which increased the pressure of air inside the bottle, and this may cause the coin's jumping. Then the teacher started to explain the

relationship between pressure and temperature on the basis of kinetic molecular theory).

Intelligibility phase:

Teacher: When the amount of a gas keeps constant, there is a direct relation ship between the pressure and temperature of a gas in a closed container. This law is known as Gay Lussac gas law. Let's explore this relation on the basis of kinetic molecular theory.

As you know the gas particles move in all directions at different speeds at the same temperature and each particle has a different kinetic energy because of the collisions. And their average amount of kinetic energy is the temperature of that gas. Increasing temperature increases the kinetic energy of the gas particles. They start to move faster and the particles collide with eachother, with the sides of the container and with the coin more often. So we can say that frequency of collisions increases. They also hit to the sides of the bottle and to the coin with more force causing the coins jumping. Cooling the gas would have the inverse effect, making the pressure inside the bottle decreased.
(The teacher also solved quantitative questions requiring the application of Gay Lussac law).

Plausibility phase:

To test the students' acquired knowledge is applicable enough for a given situation, the teacher wanted them to do the related activity.

For the activity, students placed nylon bags over the mouths of two jars respectively and tied them. One of the nylon bags was a little bit inside and the other was a little bit outside.
Teacher: Try to get out the bag that is inside and, try to take in the bag that is outside. Why aren't we successful? When we change the tempereture of the air inside the jars let's see whether we succeed it.

(Students placed the jar that had the bag inside, to the container containing hot water. They placed the other jar to the container containing ice. And they were successful)

Teacher guided students to make them conclude as: “ When the air inside the jar heated the pressure inside increases and the particles hit the nylon bag more often with more force causing the bag go up. Likewise the pressure inside the jar would decrease when cooled and because the outside pressure becomes greater compared to the inside pressure, the outside pressure caused the nylon bag go inside.

To advance the acquisition of the pressure- temperature relation, teacher gave examples from daily lives.

Teacher: Why the lid of teapots jump when the water in it boiling or when cooking everybody witnessed to the jumping of the lid of saucepans. We can increase such examples; why the basketballs jump less in cold weathers compared to the hot weathers? These examples all can be explained by the pressure and temperature relation of the gases.
(The teacher gave students opportunity to express their ideas related to the explanations of the events. In this way the students have an opportunity to test the plausibility of the new conception).

Fruitfulness phase:

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

Teacher: Explain why is it writing on deodorant containers as “ It should not be thrown away on fire even it is empty” or “It should not be left in the sun”. What can be the danger for these kinds of situations? We will discuss your answers on this assignment the next lesson.

APPENDIX G

HANDS-ON ACTIVITIES

DIFFUSION OF GASES

1. ETKİNLİK

Amaç: Gazlarda difüzyon olayını keşfetmek.

Araç ve gereç

Kokusu keskin olan parfüm, kolonya, sirke gibi maddeler

Bir parça bez

Bunları Yapalım

- ♣ Bezi, kolonya veya sirkeye batıralım.
- ♣ Bezi şişeden çıkarıp kolonya veya sirke şişelerinin ağzını hemen kapatalım.
- ♣ Bezi bir süre sınıfın tam ortasında bekletelim.
- ♣ Kokuyu alan öğrenciler parmak kaldırsın.
- ♣ Her öğrenci için kokuyu alıncaya kadarki geçen süreyi ve öğrencilerin kokuya olan uzaklıklarını kaydedelim.
- ♣ Kokunun her öğrenciye yayılma oranını, öğrencinin kokuya olan uzaklığını kokuyu alıncaya kadarki geçen süreye bölerek hesaplayalım.

Sonuca Varalım

1. Hangi öğrenciler kokuyu en önce algıladı? Sizce hangi öğrenciler kokuyu daha keskin algılar?
2. Kolonyanın veya sirkenin kokusunu nasıl algıladık?
3. Daha sıcak bir havada aynı deneyi gerçekleştirseydik, kokuyu daha kısa sürede mi yoksa daha uzun sürede mi algılardık? Neden?
4. Neden çiçeklerin kokusunu sıcak günlerde soğuk günlere göre daha keskin hissederiz?

2. ETKİNLİK

Amaç: Gaz hâldeki maddelerin taneciklerinin ortalama hızlarını karşılaştırmak.

Araç ve Gereç

50 cm boyunda iki ucu açık cam boru, 2 adet deliksiz lastik tıpa, 2 adet toplu iğne, cetvel, saat camı, derişik HCl çözeltisi, derişik NH_3 çözeltisi, pamuk

Bunları Yapalım

- ♣ İki mesnet ile cam boruyu yere paralel olarak bağlayalım.
- ♣ Saat camı üzerinde, küçük pamuk parçalarından birine HCl, diğerine NH_3 çözeltilerinden 2-3 damla damlatalım.
- ♣ Pamukları toplu iğne ile lastik tıpalara batırarak tutturalım. Her iki tıpayı aynı anda borunun uçlarına sıkıca takalım. Saatimize bakarak not edelim.
- ♣ Cam borunun içerisinde oluşan beyaz renkli NH_4Cl halkasının meydana geldiği anı saate bakarak kaydedelim.

Sonuca Varalım

Olayın denklemi: $HCl + NH_3$ ◊ NH_4Cl

gaz gaz katı

- ♣ Oluşan NH_4Cl ün pamuklara olan mesafesini cetvel ile ölçerek yazalım.
- ♣ Hız=yol/zaman eşitliğini kullanarak her bir gazın hızını hesaplayalım.
- Amonyum klorür bileşiği hangi uca daha yakın oluştu? Neden?
- Neden amonyum klorür, cam borunun tam ortasında oluşmamıştır?

APPENDIX H

MAGNITUDE AND DIRECTION OF AIR PRESSURE

3. ETKİNLİK

Amaç: Hava basıncının yönünü kavramak.

Araç ve Gereç

Su bardağı, su, kağıt

Bunları Yapalım

- Bardağı ağzına kadar su ile dolduralım.
- Bardağın ağzını kağıt ile kapatalım ve bardağı hızlıca ters çevirelim.

Sonuca Varalım

- Bardağı ters çevirdiğimizde ağzındaki kağıt neden düşmedi?

4. ETKİNLİK

Amaç: Hava basıncının büyüklüğünü kavramak

Araç ve gereç

Gazete, tahta cetvel

Bunları Yapalım ve Sonuca Varalım

- Bir sayfa gazeteyi düz bir sıraya serelim.
- Cetveli ¼ ü sıranın dışında kalacak şekilde gazetenin altına yerleştirelim.
- Cetvelin dışarıda kalan kısmından yavaş yavaş aşağı doğru itelim.

Gazete kağıdı kalktı mı? Neden?

- Cetveli eski konumuna getirelim.
- Gazeteyi düzleştirelim.
- Cetvelin dışarıda kalan kısmına hızlı bir şekilde yumruk vuralım.

Bu durumda gazete kağıdı kalktı mı? Neden?

Gazete kağıdını neden düzleştirdik?

APPENDIX I

CHARLES' LAW (V-T)

5. ETKİNLİK

Amaç: Gazların sıcaklıkları ile hacimleri arasındaki ilişkiyi tanecik boyutunda kavramak.

Araç ve gereç

500 mL'lik plastik şişe, sıvı deterjan, su, kağıt veya plastik bardak,
buz, kase

Bunları Yapalım

Bir çay kaşığı sıvı deterjan ile iki çay kaşığı suyu kağıt bardak içinde karıştırarak köpük elde edelim.

Plastik şişenin ağzını hazırladığımız solüsyona daldıralım ve şişenin ağzında baloncuk oluşmasını sağlayalım.(şişeyi yavaşça yana yatırarak solüsyona daldıralım.)

- Şişeyi sıcak su bulunan kaseye yerleştirelim.

  Bir süre sonra köpük nasıl bir şekil aldı?
- Daha sonra bu şişeyi buz dolu kaseye yerleştirelim.

  Bir süre sonra şişenin ağzındaki köpük nasıl bir şekle sahip oldu?

Sonuca Varalım

- Köpüğün her iki durumda da şeklinin değişmesinin sebebi nedir?
- Şişeyi sıcak su bulunan kaseye ya da buz dolu bir kaseye koyduğumuzda şişedeki havayı oluşturan taneciklerin büyüklüğü hakkında ne söyleyebiliriz?
- Şişe sıcak su bulunan kaseye ve buz bulunan kaseye konulduğunda şişedeki havayı oluşturan taneciklerin görünümünün nasıl olacağını çizimle gösterelim.
- Etkinlikte hangi değişkenlerin sabit kaldığını ve hangilerinin değiştiğini oluşturacağımız bir çizelgede belirtelim.

6. ETKİNLİK

Amaç: Sıcak hava ile soğuk soğuk havnın kütlelerini karşılaştırmak

Araç ve Gereç

1 adet erlenmayer, hassas terazi, ısıtıcı

Bunları yapalım ve Sonuca Varalım

- Boş bir erlenmayeri deliksiz bir tıpayla sıkıca kapatalım.
- Öğrencilerden erlenmayerin içinde hava bulunduğu bilgisi edinildikten sonra erlenmayeri hassas bir terazi ile tartalım.
- Daha sonra aynı erleni tıpasını çıkarmadan bir dakika kadar ısıtalım.
- Isıttığımız erlenin ağırlığı hakkında ne söyleyebiliriz?
- Isıttığımız erleni tartalım. Erlenin ilk ve son durumdaki ağırlıklarını karşılaştıralım.

APPENDIX J

BOYLE’S LAW (P-V)

8. ETKİNLİK

*Amaç: Gazlarda, basınç ve hacim arasındaki ilişkiyi keşfetmektir***.**

Araç ve gereç

İğnesiz Şırınga, bir kaç adet kitap, oyun hamuru

Bunları yapalım

- Şırıngaya hava çekelim ve ucunu oyun hamuruyla kapatalım.
- Pistonun ucundaki değeri okuyalım ve bir çizelge oluşturarak bu değeri çizelgeye kaydedelim.
- Şırıngayı düz bir zemine yerleştirelim. Pistonun üstüne bir kitap koyalım ve şırıngadaki havanın son hacmini çizelgemize kaydedelim.
- Pistona bir kitap daha koyalım ve şırıngadaki havanın hacmini tekrar kaydedelim.
- Doğru sonuç elde etmek için deneyi bir kaç kez tekrarlayalım.
- Elde ettiğimiz sonuçlarla basınç –hacim grafiği çizelim.
- Kitapları şırıngadan kaldırdığımızda şırıngadaki havanın hacmine ne olacağını gözlemleyelim.

Sonuca varalım

- Etkinliğimizdeki değişkenler nelerdir? Bu değişkenlerden hangileri değişti, hangileri sabit kaldı?
- Grafikten elde ettiğimiz sonuçlara göre gazın basıncı ve hacmi arasında nasıl bir ilişki bulunmaktadır?
- Etkinlikte gözlemlediğimiz gaz basıncı ve hacmi arasındaki ilişkiyi tanecik boyutunda açıklayalım.
- Kitapları pistondan kaldırdığımızda, pistonu çekmememize rağmen şırıngadaki havanın genişleme sebebini açıklayalım.
- Şırıngadaki havayı sıkıştırdığımızda taneciklerin hareketi hakkında ne söyleyebiliriz?
- Şırıngadaki havayı sıkıştırdığımızda havayı oluşturan taneciklere ne olur?

APPENDIX K

DALTON'S LAW (P – n)

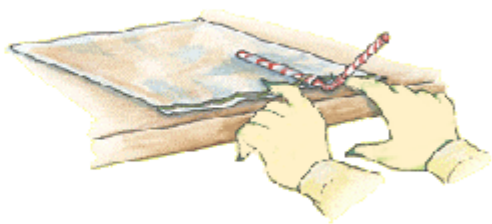
9. ETKİNLİK

*Amaç: Gazlarda, basınç ve miktar arasındaki ilişkiyi keşfetmektir***.**

Araç ve gereç

Ağzı fermuarlı plastik buzdolabı poşeti, pipet, kitap

Bunları yapalım



- Plastik poşete şekildeki gibi pipeti yarısına kadar yerleştirelim ve poşetin ağzını kapatalım.
- Poşetten hava kaçmasını engellemek için pipetin yanlarına parmaklarımızla bastıralım.
- Poşetin üstüne bir kitap yerleştirelim ve poşete pipetle hava üfleyelim.
- Kitaba ne oldu? İki kitap kaldırmayı deneyin. Bu şekilde kaç kitap kaldırabileceğinizi deneyin.

Sonuca varalım

- Etkinlikteki değişkenleri ve hangi değişkenlerin sabit kaldığını, hangilerinin değiştiğini belirtelim. Kitapları hangi kuvvet kaldırıyor olabilir?
- Poşetteki havanın basıncı ile gazın miktarı arasında nasıl bir ilişki bulunmaktadır?
- Etkinlikte gerçekleşen olayı tanecik boyutunda açıklayalım.

APPENDIX L

AVOGADRO’S LAW (V, n)

10. ETKİNLİK

Amaç: Gazlarda hacim ve madde miktarı arasındaki ilişkiyi keşfetmek.

Araç- Gereçler

50 mL erlenmayer, elastik balon, su, mezura, etüv

Bunları Yapalım

- Erlene 50 mL su koyalım.
- Balonun içindeki havayı elimizle boşaltalım ve erlenin ağzına bu balonu geçirelim.
- Erleni alttan yavaş yavaş ısıtalım.
- Birkaş dakika sonra balonun çevresini ölçelim.

Sonuca Varalım

- Su ısındıkça balonda ne gibi bir değişiklik gözlendi? Bunun sebebi ne olabilir?
- Balonun hacminin bir süre sonra artmasını tanecik boyutunda nasıl açıklarız?
- Erlendeki suyun tamamı buharlaşıncaya kadar suyu ısıtsaydık balon patlarmıydı? Neden?
- Gazların tanecik sayısı ile hacimleri arasında nasıl bir ilşki vardır?

APPENDIX M

GUY LUSSAC'S LAW (P-T)

11. ETKİNLİK

*Amaç: Gazlarda, basınç ve sıcaklık arasındaki ilişkiyi keşfetmektir***.**

Araç ve Gereç

Uzun boyunlu şişe, madenî para, geniş bir kap, sıcak su

Bunları yapalım

♣ Geniş bir kabın içine uzun boyunlu boş bir şişe yerleştirelim.

♣ Şişenin ağzına ise deliği tümüyle kapatacak madenî bir para koyalım.

♣ Kabın içini sıcak suyla dolduralım.

Sonuca Varalım

♣ Bir süre sonra paranın zıplama sebebini açıklayalım.

♣ Şişedeki havanın ısınması sırasında havayı oluşturan taneciklerin büyüklüğü hakkında ne söyleyebilirriz?

♣ İçinde su kaynayan demliğin kapağı, yada yemek pişerken tencere kapakları neden zıplar?

12. ETKİNLİK

*Amaç: Gazlarda, basınç ve sıcaklık arasındaki ilişkiyi keşfetmektir***.**

Araç ve Gereç

İki adet büyük boy kavanoz, buzdolabı poşeti

Bunları yapalım

- ♣ Kavanozların ağızlarına buzdolabı poşeti geçirelim.
- ♣ Kavanozlardan birisinin ağzını, poşet bir miktar içeride kalacak şekilde, diğer kavanozu da poşet bir miktar dışarıda kalacak şekilde sıkıca bağlayalım. (Poşetleri hava kaçırmayacak şekilde sıkıca bağlayalım.)
- ♣ Poşetlerin bağlarını çözmeden, içeride olan poşeti dışarı çıkarmaya, dışarıda olan poşeti de içeri sokmaya çalışalım.

Sonuca Varalım

- ♣ İçeride olan poşeti neden dışarı çıkaramadık? Dışarıda olan poşeti neden içeri sokamadık?
- ♣ Poşetleri içeride veya dışarıda tutan sebep nedir?
- ♣ Verilen durumu kavanozların sıcaklığını değiştirerek gerçekleştirebilir miyiz? Neden?