EFFECTS OF CONCEPTUAL CHANGE ORIENTED INSTRUCTION ON UNDERSTANDING OF GASES CONCEPTS

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ABSTRACT

EFFECTS OF CONCEPTUAL CHANGE ORIENTED INSTRUCTION ON UNDERSTANDING OF GASES CONCEPTS

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The main purpose of the study was to compare the effectiveness of conceptual change oriented instruction accompanied with computer animations and traditionally designed chemistry instruction on 10th grade students' understanding, achievement and retention of gases concepts and attitudes towards chemistry as a school subject. Also students' views about nature of science were investigated.

Quasi experimental design was used in this study. 67 tenth grade students from two intact classes of a chemistry course taught by the same teacher in Sokullu High School were enrolled. The study was conducted during the first semester of 2008- 2009 academic year. The classes were randomly assigned as experimental and control groups. While control group students were taught by traditionally designed chemistry instruction, the experimental group students were instructed with conceptual change oriented instruction accompanied with computer animations.

Gases Misconception Test (GMT) was administered to 198 high school students to investigate their misconceptions in gases concepts before the study. Gases Concepts

Test (GCT), Gases Achievement Test (GAT), and Attitude Scale toward Chemistry (ASTC), were administered to both groups as a pre-test and post-test to assess students' understanding and achievement of gases concepts, and students' attitudes toward chemistry respectively. Science Process Skills Test was given at the beginning of the study to determine students' science process skills. Gases Retention Test (GRT) was administered to both groups 2 months after treatment to assess their retention. Moreover Turkish version of Views on Science- Technology- Society (T- VOSTS) was used at the end of the study to investigate students' views about nature of science. Moreover, classroom observations and student interviews were conducted.

The hypotheses were tested by using analyses of covariance (ANCOVA) and two- way analyses of variance (ANOVA). The results indicated that instruction based on conceptual change approach caused significantly better acquisition of the scientific conceptions, achievement and retention related to gases concepts than traditionally designed chemistry instruction. Science process skill was determined as a strong predictor in the concepts related to gases. Moreover instruction based on conceptual change approach improved students' attitudes as a school subject. However no significant effect of gender difference on students' understanding, achievement and attitudes toward chemistry as a school subject was found. Finally experimental group students' views about some characteristics of nature of science were determined as more realistic than control group students.

Keywords: Misconceptions, Conceptual Change Approach, Computer Animations, Gases, Attitude toward Chemistry, Science Process Skills, Nature of Science

ÖZ

KAVRAMSAL DEĞİŞİM YAKLAŞIMININ GAZLAR KONUSUNU ANLAMAYA ETKİSİ

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Bu çalışmanın başlıca amacı, bilgisayar animasyonları destekli kavramsal değişim yaklaşımına dayalı öğretim yönteminin 10. sınıf öğrencilerinin gazlar konusunu anlamalarına, başarılarına ve hatırlamalarına ve kimyaya karşı tutumlarına etkisini geleneksel kimya öğretim yöntemi ile karşılaştırarak incelemektir.

Bu çalışma, Sokullu Lisesinde, aynı öğretmenin kimya derslerinde bulunan 67 onuncu sınıf öğrencilerinin katılımı ile 2008- 2009 öğretim yılının ilk döneminde gerçekleşmiştir. Sınıflar deney grubu ve kontrol grubu olarak rastgele seçilmiştir. Kontrol grubundaki öğrencilere geleneksel kimya öğretim yöntemi uygulanırken, deney grubundaki öğrencilere bilgisayar animasyonları destekli kavramsal değişim yaklaşımına dayalı öğretim yöntemi uygulanmıştır.

Çalışma başlamadan önce 198 lise öğrencisine gazlar kavram yanılgıları testi uygulanarak, öğrencilerin konu ile ilgili kavram yanılgıları belirlenmiştir. Gazlar kavram testi, gazlar başarı testi ve kimya tutum ölçeği öğrencilere ön-test ve son-test olarak

dağıtılarak öğrencilerin gazlar konularını anlamaları, başarıları ve kimyaya karşı olan tutumları değerlendirilmiştir. Öğrencilerin bilimsel işlem becerilerini belirlemek üzere bilimsel işlem beceri testi çalışmanın başında öğrencilere uygulanmıştır. Gazlar konusunun işlenişinden 2 ay sonra gazlar kavram testi tekrar uygulanarak öğrencilerin konuyu hatırlamaları değerlendirilmiştir. Öğrencilerin bilimin doğası hakkındaki görüşlerini değerlendirmek amacıyla bilimin doğası hakkında görüşler anketi öğrencilere verilmiştir. Ayrıca bu çalışmada sınıf gözlemleri ve öğrenci görüşmeleri yapılmıştır.

Araştırmanın hipotezleri ortak değişkenli varyans analizi (ANCOVA) ve iki yönlü çok degişkenli varyans analizi (ANOVA) kullanılarak test edilmiştir. Analiz sonuçları, kavramsal değişim yaklaşımının öğrencilerin gazlar konusunu anlamalarında, başarılarında ve hatırlamalarında daha etkili olduğu ve kimya dersine yönelik daha olumlu tutuma yol açtığı belirlenmiştir. Öğrencilerin bilimsel işlem becerileri, öğrencilerin gazlar konusunu anlamalarında belirleyici bir unsur olduğu tespit edilmiştir. Bununla birlikte, cinsiyet farkının gazlar konusunu anlama ve kimya dersine yönelik tutuma bir etkisinin olmadığı görülmüştür. Son olarak deney grubundaki öğrencilerin bilimin doğası hakkındaki görüşlerinin daha gerçekçi olduğu belirlenmiştir.

Anahtar Kelimeler: Kavram Yanılgıları, Kavramsal Değişim Yaklaşımı, Bilgisayar Animasyonları, Gazlar, Kimya Dersine Karşı Tutum, Bilimsel İşlem Becerileri, Bilimin Doğası

To my husband, İBRAHİM…

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TABLE OF CONTENTS

ABSTRACT iv
ÖZ vi
DEDICATION viii
ACKNOWLEDGEMENTS ix
TABLE OF CONTENTS x
LIST OF TABLES xiv
LIST OF SYMBOLS xvii
CHAPTERS 1
1. INTRODUCTION 1
1.1 Purpose 4
1.2 Significance of the study 5
1.3 Definition of the Terms 7
2. REVIEW OF LITERATURE 8
2.1. Constructivism 9
2.2. Conceptual Change Approach 11
2.3. Implication of Conceptual Change Approach 16
2.4. Students' Misconceptions in Chemistry 22
2.5. Students' Misconceptions in Gases Concepts 25
2.6. Algorithmic Understanding or Conceptual Understanding? 33
2.7. Computer Animations 35
2.8. Nature of Science 38
2.9. Attitude 44
3. PROBLEMS AND HYPOTHESES 50
3.1 The Main Problem and Sub-problems 50
3.1.1 The Main Problem 50
3.1.2 The Sub-problems 50

3.2 Hypothesis 52
4. DESIGN OF THE STUDY 54
4.1 The Experimental Design of the Study 54
4.2 Population and Subjects 55
4.3 Variables 56
4.3.1 Independent Variables 56
4.3.2 Dependent Variables 57
4.4 Instruments 57
4.4.1 Gases Misconception Test 57
4.4.2 Gases Concept Test 58
4.4.3 Gases Achievement Test 60
4.4.4 Science Process Skill Test (SPST) 61
4.4.5 Attitude Scale toward Chemistry (ASTC) 61
4.4.6 Views on Science Technology Society 62
4.4.7 Interview 65
4.4.8. The Classroom Observations 66
4.5 Treatment 67
4.6 Computer Animations 71
4.7 Treatment Fidelity and Treatment Verification 73
4.8 Internal Validity Threats 74
4.9 Analysis of the Data 77
4.9.1 Descriptive Statistics 77
4.9.2 Inferential Statistics 77
4.10 Assumptions and Limitations 78
4.10.1 Assumptions of the Study 78
4.10.2 Limitations of the Study 78
5. RESULTS AND CONCLUSIONS 79
5.1. Descriptive Statistics 79
5.2. Inferential Statistics 82
5.2.1. Null Hypothesis 1 82

5.2.2. Null Hypothesis 2 89
5.2.3 Null Hypothesis 3 91
5.2.4 Null Hypothesis 4 92
5.2.5 Null Hypothesis 5 94
5.2.6 Null Hypothesis 6 94
5.2.7 Null Hypothesis 7 94
5.2.8 Null Hypothesis 8 95
5.2.9 Null Hypothesis 9 96
5.2.10 Null Hypothesis 10 96
5.3. Analyses of Misconception Test 98
5.4. Analysis of Interview Questions 104
5.5. The Classroom Observations........ 111
5.6. Analysis of T-VOSTS Test 113
5.7 Conclusions 143
6. DISCUSSION AND RECOMMENDATIONS 145
6.1. Summary of the Study 145
6.2. Discussion of the Results 146
6.3. Implications 154
6.4 Recommendations 156
REFERENCES 158
APPENDICES 173
A. INSTRUCTIONAL OBJECTIVES 174
B. GAZLAR KAVRAM TESTİ........ 176
C. GAZLAR BAŞARI TESTİ........ 185
D. BİLİMSEL İŞLEM BECERİ TESTİ........ 188
E. KİMYA DERSİ TUTUM ÖLÇEĞİ........ 202
F. BİLİMİN DOĞASI HAKKINDAKİ GÖRÜŞLER ANKETİ (VOSTS-TR)........ 203
G. OBSERVATION CHECKLIST 222
H. A SAMPLE LESSON PLAN BASED ON CONCEPTUAL CHANGE METHOD ABOUT PRESSURE TEMPERATURE RELATIONSHIP........ 223

I. PROPERTIES OF SOLIDS- LIQUIDS- GASES 228
J. KINETIC THEORY OF GASES 230
K. VOLUME OF GASES AND PARTIAL PRESSURES OF GASES 231
L. DIFFUSION OF GASES 232
M. PRESSURES OF GASES 233
N. BOYLE'S LAW 234
O. CHARLE'S LAW 235
P. GAY- LUSSAC'S LAW 236
R. AVOGADRO'S PRINCIPLE 237
S. RELATIONSHIP BETWEEN MOLES OF GAS AND ITS PRESSURE 238

LIST OF TABLES

TABLES

Table 4.1 Research Design of the Study………………………………………… 55

Table 4.2 Taxonomy of GCT's Questions that Include Students' Misconceptions About Gases Concepts………………………………………………………………......59

Table 4.3 Items of T-VOST and Categories of the Alternatives……………………..64

Table 5.1 Descriptive Statistics Related to the Gases Concept Test (GCT), Gases Achievement Test (GAT), Gases Retention Test (GRT), Science Process Skill Test (SPST) and Attitude Scale toward Chemistry (ASTC) Scores of Students in Control Group (CG) and Experimental Group (EG)……………………………….....……80

Table 5.2 Test of Between-Subject Effect……………………………………......83

Table 5.3 Correlation between Post-Concept Test Scores and SPST Scores………....84

Table 5.4 ANCOVA Summary…………………………………………………......84

Table 5.5 Percentages of Students' Answers for Item 2……………………………...86

Table 5.6 Percentages of Students' Answers for Item 25………………………….....89

Table 5.7 Test of Between-Subject Effect…………………………………….....90

Table 5.8 Correlation between Post-concept Test Scores and SPST Scores…………90

Table 5.9 ANCOVA Summary…………………………………………………......91

Table 5.10 Test of Between-Subject Effect…………………………………..92

Table 5.11 Test of Between-Subject Effect…………………………………......93

Table 5.12 ANOVA Summary (Attitude)…………………………………………… 95

Table 5.13 Test of Between-Subject Effect…………………………………..97

Table 5.14 Correlation between Retention Test Scores and SPST Scores…………...97

Table 5.15 ANCOVA Summary……………………………………………...…98

Table 5.16 Students' Misconceptions in the First Question…………………………99

Table 5.17 Students' Misconceptions in the Second Question………………………99

Table 5.18 Students' Misconceptions in the Third Question………………………..100

Table 5.19 Students' Misconceptions in the Fourth Question……………………….101

Table 5.20 Students' Misconceptions in the Fifth Question…………………………....102
Table 5.21 Students' Misconceptions in the Sixth Question…………………….........103
Table 5.22 Students' Misconceptions in the Seventh Question……………...………103
Table 5.23 Percentage of Students' Responses to Item 1……………………………114
Table 5.24 Percentage of Students' Responses to Item 2……………………………115
Table 5.25 Percentage of Students' Responses to Item 3……………………………117
Table 5.26 Percentage of Students' Responses to Item 4……………………………118
Table 5.27 Percentage of Students' Responses to Item 5……………………………119
Table 5.28 Percentage of Students' Responses to Item 6……………………………120
Table 5.29 Percentage of Students' Responses to Item 7……………………………121
Table 5.30 Percentage of Students' Responses to Item 8……………………………123
Table 5.31 Percentage of Students' Responses to Item 9……………………………124
Table 5.32 Percentage of Students' Responses to Item 10…………………………..125
Table 5.33 Percentage of Students' Responses to Item 11…………………………..126
Table 5.34 Percentage of Students' Responses to Item 12…………………………..127
Table 5.35 Percentage of Students' Responses to Item 13…………………………..128
Table 5.36 Percentage of Students' Responses to Item 14…………………………..129
Table 5.37 Percentage of Students' Responses to Item 15…………………………..131
Table 5.38 Percentage of Students' Responses to Item 16…………………………..132
Table 5.39 Percentage of Students' Responses to Item 17…………………………..133
Table 5.40 Percentage of Students' Responses to Item 18…………………………..134
Table 5.41 Percentage of Students' Responses to Item 19…………………………..135
Table 5.42 Percentage of Students' Responses to Item 20………………………….136
Table 5.43 Percentage of Students' Responses to Item 21………………………….137
Table 5.44 Percentage of Students' Responses to Item 22………………………….139
Table 5.45 Percentage of Students' Responses to Item 23………………………….140
Table 5.46 Percentage of Students' Responses to Item 24………………………….141
Table 5.47 Percentage of Students' Responses to Item 25………………………….142

LIST OF FIGURES

FIGURES

Figure 5.1 Comparison between Post-GCT Scores of the Experimental and Control Group……………………………………………………………………………85

LIST OF SYMBOLS

GCT: Gases Concept Test

GAT: Gases Achievement Test

GRT: Gases Retention Test

ASTC: Attitude Scale toward Chemistry

SPST: Science Process Skill Test

T-VOSTS: Turkish Version of Views on Science Technology Society

CCOI: Conceptual Change Oriented Instruction

TDCI: Traditionally Designed Chemistry Instruction

CG: Control Group

EG: Experimental Group

N: Number of Students

f: Effect Size

df: Degrees of Freedom

SS: Sum of Squares

MS: Mean Square

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

p: Significance Level

F: F Statistics

t: t Statistics

CHAPTER 1

INTRODUCTION

As a human being we usually try to make sense how the world works. In our endeavor, we try to make predictions, establish relationships, find data supporting hypothesis and verify personally constructed explanations. The main aims of science education are to make students aware of their self constructed meanings, provide students variety of experiences to facilitate their explanation and interpretation about life and give them opportunity to come to scientifically accepted conclusions.

The notion that students come to class with well established understanding about natural world is widely accepted. These understandings may facilitate or hinder students' consequent learning of new scientific conceptions (Hewson, 1982). According to constructivism new knowledge builds on the existing knowledge. Unfortunately, not all the time, this existing knowledge is in tandem with the formal concept that is constructed and agreed by scientists. So, students' preexisting knowledge might be at variance with formal concept.

Students' preconceptions that are not consistent with the scientifically accepted ones are named as misconceptions. In different studies these alternative views are named as "preconception" (Ausubel, 1968; Benson, Wittrock, & Baur, 1993), "naïve conception" or "naïve beliefs" (Caramaza, McCloskey & Green, 1981), "intuitive ideas" (Hynd, McWhorter, Phares & Suttles, 1994), "intuitive science" (Preece, 1984), "children's science" (Gilbert, Osborne, & Fensham 1982; Stenhouse, 1986), "children's scientific intuitions" (Sutton, 1980), "alternative conception" (Gilbert & Swift, 1985; Niaz, 2001; Palmer, 2001; Taber, 2001; Dykstra, Boyle, & Monarch, 1992). Since these misconceptions hinder the meaningful understanding of scientific conceptions, researchers have tried to understand the sources of them, and investigate the effective instructional strategies to remediate these misconceptions.

Conceptual change approach is a very effective strategy to promote conceptual understanding. It does not see the learning as a process of getting the facts about the natural world. According to conceptual change approach, learning occurs as a result of the interaction between what the student is taught and his current ideas. In their conceptual change theory Posner et al. (1982) tried to explain how “people’s central, organizing concepts change from one set of concepts to another set, incompatible with the first” (p. 211). In conceptual change there are two phases. In assimilation, the existing concepts are used to deal with new phenomena. However, in accommodation, students’ existing concepts are insufficient to grasp new phenomenon. So, these existing concepts must be replaced or reorganized with adequate ones (Posner et al., 1982). Posner et al. (1982) stated four conditions for accommodation:

- There must be dissatisfaction with existing conceptions
- A new conception must be intelligible
- A new conception must appear initially plausible
- A new concept should suggest the possibility of fruitful research program

In the literature there are lots of strategies developed to promote conceptual change approach in science classrooms and most of them were found to be effective when the aim is meaningful understanding.

Chemistry is one of the topics where students’ have a lot of misconceptions. Many students solve the numerical problems without learning the concept. The chemical concepts and principles which involve the three levels of representation (symbolic level, particulate level, and macroscopic level) are the most difficult ones for students to learn. Students can overcome this difficulty with the instructions which help them to learn to visualize chemical phenomena and principles at all three levels. Visualization linking connections among the three levels develops understanding in chemistry. Students likely have a misconception when they cannot understand a chemical phenomenon at all three levels. The most commonly encountered subject areas where students have misconceptions are mole concept (Griffiths & Preston, 1992; Harrison & Treagust, 1996), chemical equations (Ben-Zvi, Eylon & Silberstein, 1987; Garnett, Hackling, Vogiatzakis & Wallace, 1992), , chemical equilibrium (Banerjee, 1991; Bergquist & Heikkinen, 1990; Gussarsky & Gorodetsky, 1990; Chiu, Chou & Liu, 2002; Hackling & Garnett, 1985; Huddle & Pilay, 1996), bonding (Peterson & Treauget, 1989; Nicoll, 2001), electrochemistry (Garnett & Treagust, 1992a; Garnett & Treagust, 1992b; Ogude & Bradley, 1994; Sanger & Greenbowe, 1997), acids-bases (Çakır, Uzuntiryaki & Geban, 2002; Cros, Chastrette & Fayol, 1988; Ross & Munby, 1991).

Gases concepts is one of the most important chemistry topics where students have a lot of misconceptions. Understanding gases concepts need well established knowledge about particulate nature of matter, states of matter, and phase change. Moreover it forms the basis of many other chemistry topics such as chemical reactions, chemical equilibrium and solubility. One of the main reasons of students' misconceptions in gases concepts is that they cannot visualize the particulate nature of gases and link these understanding with macroscopic level. Computer animations can help students overcome difficulties arising from visualization and facilitate their understanding of scientific concepts.

Animations have two basic functions namely, enabling function and facilitating function (Mayer, 2001). Gobert (2000) stated that dynamic representations such as three dimensional animations provide visual explanations for scientific phenomenon that is impossible to observe directly. Also computer animations might lead to decrease in cognitive load and support active learning (Urhahne, Nick, & Schanze, 2009).

Science process skill was also determined as an important factor affecting students understanding in science. Science process skills involve identifying variables and hypotheses, designing investigations, graphing and exploring data, explaining results and drawing conclusions. In this study, the contribution of students' science process skills to student' understanding of gases concepts was examined.

Students' attitude toward science is also critical in developing meaningful understanding of scientific concepts. Besides taking cognitive factors into account, Koballa and Glynn (2007) argued that effective science instruction should include some elements to improve students' attitudes toward science.

Developing an adequate understanding of NOS was given increased attention in response to a call for reform in many countries (e.g., the National Science Education Standards of the USA, the British National Curriculum of the United Kingdom). Although science has an enormous effect on people's life, many individual have lack of understanding about how scientific enterprise operates. The reason of this poor understanding is that, education systems generally based on simply memorization of facts and concepts which are underestimate knowledge generation process. Also science textbooks and science teachers do not give an opportunity to students to think how science functions (McComas, Clough, & Almazroa, 1998).

1.1 Purpose

The purposes of the study were to: (1) determine students' misconceptions about gases concepts; (2) compare the effectiveness of conceptual change oriented instruction accompanied with animations and traditional instructional on students' understanding of gases concept; (3) compare the effectiveness of conceptual change oriented instruction accompanied with animations and traditional instructional on students' achievement of gases concept; (4) compare the effectiveness of conceptual change oriented instruction accompanied with animations and traditional instructional on students' retention of gases concept; (5) compare the effectiveness of instruction based on conceptual change accompanied with animations and instruction based on traditional method with respect to students' attitudes toward chemistry as a school subject; (6) investigate the effect of gender on students' understanding and achievement of gases concepts and their attitudes toward chemistry as a school subject; (7) determine students' views about nature of science

1.2 Significance of the study

Students' prior knowledge plays a critical role in their subsequent learning. Students come to class with their prior conceptions which are often in conflict with scientifically accepted one and what teachers expect them to learn. In the literature there are lots of evidences that students' prior knowledge may prevent their learning. So determination of students' misconceptions is very crucial when the aim is meaningful learning. In this study students' misconceptions about gases concepts were investigated through literature review and misconception test and detailed misconception list was presented. Noticing students' possible misconceptions, science teachers can check their students' prior conception before instruction about gases concepts. Given the impact of prior knowledge on learning, curriculum developers can make use of determined misconceptions when designing activities.

Persistence to the traditional instruction is one of the well-known characteristics of misconceptions. So designing an instruction that helps to eliminate students' misconception is fundamental. In this study a strategy based on conceptual change model accompanied with computer animations was designed and implemented. This strategy focused on identification and elimination of misconceptions. Also with the help of the computer animations students were facilitated to learn to visualize chemical phenomena and principles at all three levels of representation (symbolic, particulate, and macroscopic). A detailed description of the instruction was presented and effectiveness of it was discussed in this study. Conceptual change oriented instruction caused better understanding, achievement and retention of gases concepts than traditional instruction.

Teachers can use this method in their classrooms to promote conceptual change in students. Moreover, this study can give some clues to curriculum developers about how to eliminate students' misconceptions in gases concepts.

Students' attitudes were determined as a key factor in their chemistry achievement. This study can be seen as an evidence for the positive effect of conceptual change oriented instruction on students' attitudes. To increase students' attitudes toward chemistry, teachers can use similar activities that were used in this study.

Developing an adequate understanding about nature of science concepts is one of the major aims of science education. The results of the previous studies showed that both students and teachers possess inappropriate views of NOS (Lederman, 1992). This study also investigated the students' views about NOS and identified some commonly hold naïve beliefs of students. Since, students' lack of understanding about NOS concepts have been attributed to science curricular materials and instructional practices (Meichtry, 1993), both teachers and curriculum developers can use these findings by taking into account them in designing instructions and curriculums.

1.3 Definition of the Terms

The constitutive and operational definition of important terms will be given in this section.

Conceptual change oriented instruction: An instruction in which subjects are introduced to students on the basis of constructivism which was proposed Postner et al. (1982).

Traditional instruction: An instruction in which subjects are introduced to students mainly with lecturing method.

Constructivism: A theory in which students construct their own knowledge and knowledge cannot be transferred into the student.

Assimilation: Existing concepts are used to deal with new phenomena (Duit & Treagust, 1998).

Accommodation: Existing knowledge is insufficient to grasp new phenomena so individual must replace or reorganize their central concepts (Duit & Treagust, 1998).

Misconception: Conceptions which are inconsistent with the commonly accepted scientific consensus.

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

Nature of science: Science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development (Lederman, 2007).

Computer animation: Images in motion (Mayer, 2001).

Gases: The form of matter that is an easily compressible fluid (Ebbing & Gommon, 2005).

CHAPTER 2

REVIEW OF LITERATURE

In this chapter nine main topics namely, constructivism, conceptual change approach, implication of conceptual change approach, students' misconceptions in chemistry, students' misconceptions in gases concepts, algorithmic understanding and conceptual understanding in chemistry, computer animations, nature of science and attitude were reviewed by the researcher.

Under the first topic the meaning of constructivism, principles of and criticism about it were discussed. Also characteristics of constructivist learning environment and constructivist teaching approaches were mentioned. Conceptual change model developed by Posner, Strike, Hewson, and Gertzog (1982) were discussed in the light of constructivism in the second part. Types of conceptual change (assimilation and accommodation), conditions for accommodation (dissatisfaction, intelligibility, plausibility and fruitfulness) and components of conceptual change model (status and conceptual ecology) were reviewed. Criticism to original conceptual change model and revisions were also addressed.

In the third part, implications of conceptual change model to educational settings were mentioned. Usage of different methods and strategies (refutation/conceptual change text, analogy, concept maps, cooperative learning, and demonstrations) and exemplar studies conducted by using these strategies were given.

Fourth title included discussions about definition, importance, characteristics and some sources of students' misconceptions. Also reference studies about students' misconceptions in different chemistry topics were presented. Moreover the possible reasons of students' difficulties in learning chemistry were stated briefly. Since this study dealt with specifically gases concepts, studies about students' misconceptions in gases concepts were analyzed in the fifth part. Under the sixth part, types of understanding in chemistry (algorithmic and conceptual) and discrepancies between students performance on different levels of understanding in gases concepts were discussed. Some of the studies showing this difference were examined. In parallel with the aim of this study, functions and effectiveness of computer animations were mentioned in the seventh title. Also researches about the effectiveness of computer animations on students' understandings were pointed out.

In the eighth part definition, characteristics and importance of nature of science were reviewed. Moreover researches about students' understanding in nature of science, instructional strategies to improve this understanding and sources of students' misconceptions in NOS were analyzed. The last title dealt with students attitudes toward science. Definitions of attitude and relationship between attitude- achievement, attitude-gender, and attitude-grade level were examined.

2.1. Constructivism

Constructivist view of learning has become the most powerful theory during the two last decades (Ernest, 1993; Tobin, 1993). Piaget's genetic epistemology is highly effective in the construction of constructivism, which emphasized that knowledge can not be separated from knowing.

According to constructivist point of view, knowledge cannot be transferred into the student; instead students construct their own knowledge. Constructivism involves two principles; psychological and epistemological.

Psychological principle explains that knowledge cannot be directly transferred from teachers to students. Students do not receive knowledge in a passive way; instead they construct their own meaning. Epistemological principle is about reality. In constructivism reality is determined in a subjective way. Since individual constructs knowledge in a subjective way, outside reality either does not exist or if exist cannot be known by the individual. So reality is determined in a personal or subjective way (von Glasersfeld, 1990). Constructivist put the notion of viability in place of outside reality. Rather than searching for absolute truth, constructivism searches for usefulness and viability of knowledge in different context.

According to Treagust, Duit, and Fraser (1996) criticism on constructivism focused on four issues; "constructivism is simply common sense, it has epistemological flaws, it leads to the denial of the existence of physical world, and excessive focus on the individual does not take social issues into account" (p. 6).

Jonassen (1991) argued that constructivist learning environment should include the following elements;

1. Based on the learning context, a real world environment should be presented.
2. Realistic approaches should be provided to solve real-world problems.
3. The role of the instructor should be a guider.
4. Content should be presented by giving multiple representations and perspectives.
5. Instructor and students should discuss the goals and objectives.
6. The learning environment and materials should be presented in a way that they facilitate learners to interpret the multiple perspective of the content.
7. Learners should be controller and mediator of the learning process.

According to constructivism new knowledge builds on the existing knowledge. This is done in two ways: one is assimilation and the other is accommodation. In assimilation individuals assimilate new knowledge into their existing cognitive structures. And in accommodation, individuals reconstruct their existing cognitive structures to what is outside. In both ways, new knowledge is integrated or connected with prior knowledge. So, from this point of view, what the learner already knows is very crucial. In literature, it is known that students do not come to class with an empty mind even though they are not introduced to the concept in consideration before. They have some knowledge about the concept prior to the formal instruction. The source of this knowledge is their daily life experience and the language. Not all the time, this prior knowledge is in tandem with the formal concept that is constructed and agreed by scientists. So, students' preexisting knowledge might be at variance with formal concept. This variance can cause some difficulties in students' learning process. These difficulties should be consciously addressed in classes by the teachers. The most commonly known strategy suggested by Piaget is to create cognitive conflict, or disequilibrium. Some researchers (Vosniadou, 2001; Schmidt, Baumgartner, & Eybe, 2003; Michael, 2002) focused on students' prior knowledge and the misconceptions that students bring to classes. They advanced Piaget's notion of disequilibrium and their attempts resulted in constructivist teaching strategies each considering students' prior knowledge. These approaches are namely, conceptual change model (Posner, Strike, Hewson, & Gertzog, 1982), learning cycle approach (Stepans, Dyche, & Beiswenger, 1988), Driver's constructivist teaching sequence (Driver & Oldham, 1986), and bridging analogies approach (Brown & Clement, 1989).

In this study conceptual change approach which is based on constructivist principle was used. In the following section conceptual change approach was discussed.

2.2. Conceptual Change Approach

According to constructivism, learners construct their own knowledge actively. To understand and acquire scientists' interpretation of phenomena, they use their existing knowledge. If their existing knowledge is not compatible with the scientific one, they may have to change their minds, instead of adding new knowledge. From this point of view, development of a model of learning as conceptual change is reasonable (Hewson, 1988). According to conceptual change approach, as learner encounters a new knowledge which is not compatible with his previous knowledge he uses his conceptual ecology to decide whether the new knowledge is rational, believable, internally consistent and have explanatory and predictive power. So an individual decides that the new knowledge is worth of learning only when these criteria are met.

Conceptual change approach does not see the learning as a process of getting correct responses or a set of behavior. Learning occurs as a result of the interaction between what the student is taught and his current ideas. So this interaction plays a critical role in determining what is to be learned. Students accept and comprehend ideas only when they are seen as intelligible and rational. Thus from the conceptual change perspective learning is a rational activity (Posner et al., 1982).

In their conceptual change theory Posner et al. (1982) tried to explain how "people's central, organizing concepts change from one set of concepts to another set, incompatible with the first" (p. 211). Their analyses revealed two types of conceptual change, assimilation and accommodation. In assimilation, which is also called weak knowledge structuring or conceptual capture (Duit& Treagust, 2003), existing concepts are used to deal with new phenomena. In accommodation or radical knowledge structuring students' existing knowledge is insufficient to grasp new phenomena so they must replace or reorganize their central concepts.

Posner et al. (1982) argued the analogous patterns of conceptual change learning and contemporary views of philosophy of science. Like the assimilation phase in conceptual change learning, scientific endeavor is done against the background of central commitments that organize research. Similar to accommodation, when scientists challenge their basic assumptions, central commitments require modification.

There are four conditions that were specified by Posner et al. (1982) for accommodation:

1. There must be dissatisfaction with existing conceptions: To make major changes in knowledge structure students first believe that minor one does not work. Changing old concept with the new one requires a condition that old one encounters a difficulty and new conception that is intelligible and plausible is available. Anomalies are one of the main sources of dissatisfaction. As the students think the anomaly seriously, they become more dissatisfied and are ready for accommodation. Producing dissatisfaction with the presentation of anomalies necessitates that; students should understand why the situation represents an anomaly, students should believe necessity of reconciliation of situation with their existing conceptions, students should try to reduce inconsistencies among the beliefs they hold and they should realize assimilation of new knowledge into existing structures is impossible.

2. A new conception must be intelligible: Students must know the meaning of new conception, construct a coherent representation of it and see that it is internally consistent. Analogies and metaphors can be used to confirm the intelligibility of the new concept.

3. A new conception must appear initially plausible: Students must bring together new conception with the other existing conception without any problem. For a conception to be plausible it should be consistent with other knowledge and theories, one's epistemological commitments, it should have a capacity to solve problems generated by its predecessors and students should believe it to be true.

4. A new conception should suggest the possibility of a fruitful research program: A new conception must provide explanatory and predictive power. A fruitful concept both resolves its predecessors' anomalies and also leads new insights.

Posner et al. (1982) and Hewson (1988) determined two major components of conceptual change model. The first component is "status". The status of an idea is a degree to which he knows and accepts it and determined by its intelligibility, plausibility and fruitfulness to that person. According to conceptual change model learning occurs when the status of a new concept rises. This only happens when the learner dissatisfied with his existing knowledge (lower status) and finds the new concept understandable, acceptable and useful (higher status).

The second component is the person's "conceptual ecology" a phrase borrowed from Stephan Toulmin. Conceptual ecology is used to explain all the knowledge that a person holds, which may be epistemological commitments, metaphysical beliefs about the world, analogies and metaphors that might serve to structure new information. An individual's conceptual ecology plays a critical role in determining the status of a concept. When the learner encounters a new knowledge, he uses his existing knowledge (conceptual ecology) to determine whether the new conception is intelligible, plausible and fruitful (Hewson & Thorley, 1989). So selection of a new concept to be learned highly depends on one's conceptual ecology.

In their studies Abd-El-Khalick and Akerson (2004) criticized the usage of term "conceptual ecology" and instead of it they recommended "learning ecology". According to these researchers conceptual ecology is restricted to the cognitive domain. However learning ecology includes cognitive, affective, motivational, contextual, social, and cultural domains.

In the late 1980's the criticism to original conceptual change model has emerged. The first criticism came from Solomon (1987) who argued that conceptual change model was highly cognitive and ignored the social dimension of learning. She claimed that personal and social construction of knowledge complement with each other. Therefore learning and teaching strategies should emphasize both individual and social aspects of learning.

Pintrich, Marx, and Boyle (1993) criticized the model by claiming that it is highly rational and "cold". They emphasized that conceptual change model did not consider the influence of students' motivational construct in learning process. They recommended that conceptual change is mediated by four motivational constructs namely, goals, values, self-efficacy and control beliefs. Posner et al. (1982) claimed that learning is a rational activity and paid attention to what learning is, instead of factors affecting learning. However Pintrich et al. (1993) said that what learning depends on is as important as what learning is. Also Palmer (2003) stated that motivation is an important factor in the construction of knowledge and the process of conceptual change.

Cobern (1996) added another critique about the assumption that scientific conceptions are superior to other conceptions in understanding the world. He argued that all the activities in conceptual change classrooms are designed according to this principle. However, very few students share the idea of the superiority of scientific conceptions. According to him, conceptual change model demands learners from making decision about the concepts within the scientific framework and accept scientific concepts without any questions. He recommended that students should be given opportunities to construct knowledge with others ways such as social sciences, philosophy and religion.

The last criticism came from Aikenhead and Jegede (1999) about culture. They argued that in conceptual change model students are expected to construct scientific concepts meaningfully although these concepts conflict with their previous knowledge, beliefs, values, norms and life- worlds. However this is not easy process for students and they generally invent different ways. So they recommended that to reduce students' isolation from science, culturally sensitive curricula and teaching methods should be developed.

Hewson, Beeth and Thorley (1998) revised the conceptual change model and addressed some of the issues mentioned above. The view of learning was modified and the importance given the cognitive conflict was reduced. They claimed that knowledge is personally constructed but socially mediated. Besides this, they put four general guidelines for conceptual change;

1. Classroom discourse should include the explicit ideas about students' and teachers' thoughts about the target concept.
2. Classroom discourse should be made explicitly metacognitive.
3. Students and teachers should explicitly discuss the status of concepts in terms of intelligibility, plausibility and fruitfulness.
4. Justification for ideas and status decision should be explicit component of curriculum.

These revisions may propose a solution for socially based criticism, but culturally based criticism still waits their response.

Although there are different models of conceptual change developed by various researchers (Posner et al., 1982; Vosniadou, 1992; diSessa, 1993; Chi, Slotta & deLeeuw, 1994) in this study the model developed by Posner et al. (1982) was utilized. In the following section implications of conceptual change approach to classroom settings were discussed.

2.3. Implication of Conceptual Change Approach

Conceptual change approach is based on the assumptions of constructivist theory. So, the importance of students' prior knowledge in learning, active participation of students into learning environment, teachers' role as a guide and facilitator to students' learning are the key features of conceptual change instructions.

In the literature there are lots of strategies developed to promote conceptual change approach in science classrooms. The usage of conceptual change or refutational texts is one of those strategies. Hynd, McWhorter, Phares and Suttles (1994) defined refutation texts as "texts that refute commonly held naive concepts. They are designed to make readers aware of the inadequacy of their intuitive ideas, directly stating that commonly held intuitive ideas do not explain certain phenomena" (p. 934). Moreover in conceptual change text students are asked to predict what would happen in a given situations related to science concepts, before being presented with information that demonstrates the inconsistency between common misconceptions and scientific conceptions (Chamber & Andre, 1997). Palmer (2003) stated that both refutational texts and conceptual change texts were very effective in students understanding of concept of ecological role in nature.

Çakır, Yürük and Geban (2002) investigated the effect of conceptual change text oriented instruction and traditional instruction on students' understanding of cellular respiration concepts. According to results of the study the conceptual change text-oriented instruction was found to cause a significantly better acquisition of scientific conceptions and elimination of alternative conceptions than the traditional instruction.

The study carried out by Alparslan, Tekkaya and Geban (2003) aimed to investigate effect of conceptual change instruction on grade 11 students' understanding of respiration. They used conceptual change texts for experimental group students and traditional instruction for control group students. The results of the study revealed that conceptual change instruction dealing with students' misconceptions caused greater achievement in the understanding of respiration concepts. Researchers claimed that the reason of greater success in experimental group students was due to the nature of activities that they engaged. These activities facilitated students to revise their prior knowledge and struggle with their misconceptions.

Another strategy used to promote conceptual change is analogy. An analogy may be viewed as a statement of comparison on the basis of similarities between the structures of two domains. An analogy is used as explanatory tool by putting new concepts and principle into familiar terms. Analogy serves a creative function when it stimulates the solution of existing problems, the identification of new problem and the generation of hypothesis (Glynn & Takahashi, 1998). Analogical reasoning can be successful if students are familiar with the analog domain. Students must see the connection between the analog and target concept to achieve analogical reasoning (Gabel & Samuel, 1986). Effective analogies motivate students, clarify students' thinking, help students to overcome misconceptions, and give students ways to visualize abstract concepts (Orgill & Thomas, 2007).

Sarantopoulos and Tsaparlis (2004) investigated the effectiveness of using chemical analogies on 10th and 11th grade students understanding of modern atomic theory, periodic table of elements, chemical bonds, solutions, acids, bases and salts. In the control group, units were instructed with traditionally designed science instruction, while, in experimental group, units were instructed with analogies. The result of the study showed that students instructed with analogies performed better than students in the control group.

Using graphic organizer is the other strategy to promote conceptual change. Concept mapping is one of the mostly used graphic organizers. Novak (1990b) defined concept maps as tools for organizing and representing knowledge. He stated that in the concept maps concepts usually enclosed in circles or boxes and relationships between concepts or propositions indicated by a connecting line between two concepts (nodes).

Çetingül and Geban (2005) conducted a research to investigate the effectiveness of conceptual change text oriented instruction accompanied with analogies on tenth grade students' understanding of acids and bases concepts. The researchers designed the instruction and conceptual change text in order to convince the students that some situations which they understand are actually analogous to other situations which they misunderstand. The results of the study showed that students taught with conceptual text oriented instruction accompanied with analogies performed better than students taught with traditional instruction. The researchers concluded that instructions that facilitate analogical thinking and conceptual change were very effective in students understanding of acids and bases concepts.

Cooperative learning is also commonly used with conceptual change. In cooperative learning, students work together to achieve an academic goal. Johnson and Johnson (1992) proposed five elements of cooperative learning groups as face to face interaction, individual accountability, positive interdependence, cooperative social skills and group processing.

Bilgin and Geban (2006) examined the effect of cooperative learning based on conceptual change strategy on 10th grade students understanding of chemical equilibrium. 87 tenth grade students from two intact classes of a chemistry course instructed by the same teacher were involved in the study. The classes were randomly assigned as experimental group which was instructed with cooperative learning approach based on conceptual change conditions and control group which was instructed with traditional instruction. Chemical Equilibrium Concept Test and Chemical Equilibrium Achievement Test were used to assess students' conceptual understanding and achievements related to computational problems respectively. According to results of the study students taught with cooperative learning based on conceptual change instruction had better understanding and achievement of computational problems than students taught with traditional chemistry instruction.

To facilitate conceptual change demonstrations can also be used. Benson, Wittrock, and Baur (1993) argued that in order to promote the desired conceptual changes simple, visible, and believable demonstrations that stimulate cognitive conflict can be used.

Azizoğlu (2004) conducted a study to investigate the effectiveness of conceptual change oriented instruction accompanied by demonstrations on 10th grade students understanding of gases concepts. The results of the study showed that conceptual change oriented instruction caused a significantly better understanding of gases concepts than traditionally designed chemistry instruction.

Brandt, Ellen, Hellemans, and Heerman (2001) investigated the effect of visualization on students' construction of integrated knowledge structure in the domain of electrochemistry by examining the gain scores of 132 final year students from ten classes in the three secondary schools. The results of the study revealed the positive effect of visualization on learning achievement of students.

Hewson and Hewson (1983) conducted a study to examine students' alternative conceptions and effect of instructional strategies in learning scientific concepts of mass, volume, and density. Experimental group students were instructed with conceptual change oriented instruction by using special instructional strategy and materials which explicitly dealt with students' alternative conceptions and control group students were instructed with traditional strategy and materials. According to pre and post test results, experimental group students acquired significantly larger improvement in scientific conceptions.

Smith, Blakeslee, and Anderson (1993) were examined the teaching strategies associated with conceptual change by observing thirteen 7th grade life science teachers. The teaching units were photosynthesis, cellular respiration and matter cycling in ecosystems. The teachers were randomly assigned groups as four teachers attending workshops about conceptual change, five teachers attending no workshops but using curriculum materials prepared by research project staff and four teachers attending workshops and using curriculum materials. The results of the study indicated that in order to use conceptual change strategies effectively the teachers needed support. Also specially designed instructional materials both help teachers to implement conceptual change strategies and improve students' success in learning. The researchers claimed that traditional textbooks and commercially available materials do not incorporate with conceptual change teaching strategies so cannot support teachers in implementing these strategies.

Atasoy, Akkuş and Kadayıfçı (2009) were investigated the effectiveness of a conceptual change approach and traditional instruction on tenth-grade students' conceptual understanding chemical equilibrium. 44 tenth-grade students participated in the study. During the six-week implementation a conceptual change approach was applied in the experimental group whereas traditional instruction was followed in the control group. According to results of the study the conceptual change approach was statistically more effective than traditional instruction in terms of students' conceptual understanding.

Özmen, Demircioğlu, and Demircioğlu (2009) examined the effect of conceptual change texts accompanied with computer animations on 11th grade students' understanding and alternative conceptions related to chemical bonding.While the comparison group taught with traditional instruction, the experimental group received conceptual change text accompanied with computer animations instruction. The researchers used seven conceptual change texts and sixteen computer animations during the implementation. Chemical bonding achievement test including 18 two-tier multiple-choice items was applied as pre-test, post-test and delayed test to collect data. The results of the study showed that, performance of students in the experimental group was greater than those of in control group in post-test and delayed test.

Taştan, Yalçınkaya and Boz (2008) compared the effectiveness of conceptual change text instruction over traditional instruction on students' understanding of energy in chemical reactions. The subjects of the study were 60 10th grade students. One of the classes was randomly assigned as the experimental group where conceptual change text instruction was used, and the other as the control group where traditional teaching method was used. In order to assess students' understanding energy concept test was used. Also students' attitude was measured by Attitude Scale towards Chemistry. According to results of the study students in the experimental group got significantly higher scores in energy concept test than students in the control group. Nevertheless, there was no statistically significant difference between the experimental and control group in terms of students' attitude towards chemistry.

To investigate how a teacher can support and facilitate conceptual change in students' thinking Beeth and Hewson (1997) observed Sister Gertrude's classroom. Researchers presented features of instruction that support students' conceptual change as follows; teacher plans the curriculum including conceptions of science, learning and scientific epistemology, the students are aware of the curricular expectation of teacher, the teacher makes students to express and discuss their ideas and the teacher facilitates students to engage social and conceptual practices.

2.4. Students' Misconceptions in Chemistry

At the end of the nineteenth century, researchers started to deal with students' preconceptions in science. However it is the middle of 1970's that students' conceptions in science and mathematics were highly investigated (Treagust, Duit, & Fraser, 1996).

Vosniadou (2001) stated that "science learning is characterized by misconceptions" (p. 179). From the constructivist point of view students hold variety of conceptions about the natural world and how it works. Among these conceptions, the ones which are inconsistent with the commonly accepted scientific consensus are named misconceptions. However from the students' point of view, these conceptions make more sense for them than scientifically accepted ones. So interpret and integrate new knowledge, the students make use of their prior conceptions even though they are not consistent with the scientific ones. When these prior knowledge includes misconceptions, their integrative and interpretive function lead to misinterpretation of the new knowledge (Hewson & Hewson, 1988). Therefore in any teaching effort, students' misconceptions should be taken into account.

It is as important as studying learning difficulties that using these findings in practice. According to Eylon (1988) these needs four steps; determination of misconceptions, investigation of their sources, treatment of them by designing appropriate teaching practices and evaluation of the effectiveness of implementation. These steps emphasized the need of cooperation among researchers, curriculum developers, decision makers and teachers.

In the literature there are many studies investigating students' informal conceptions and they were named differently by different researchers. Some of the terms are "preconception" (Ausubel, 1968; Benson, Wittrock, & Baur, 1993), "misconceptions" (Brown, 1992; Chambers & Andre, 1997; Din, 1998; Gonzalez, 1997; Griffiths, 1994; Griffiths & Preston, 1992; Lawson & Thompson, 1988; Michael, 2002; Schmidt, 1997), "naïve conception" or "naïve beliefs" (Caramaza, McCloskey & Green, 1981), "intuitive ideas" (Hynd, McWhorter, Phares & Suttles, 1994), "intuitive science" (Preece, 1984), "children's science" (Gilbert, Osborne, & Fensham 1982; Stenhouse, 1986), "children's scientific intuitions" (Sutton, 1980),"intuitive conceptions" (Lee & Law, 2001), "alternative conception" (Gilbert & Swift, 1985; Niaz, 2001; Palmer, 2001; Taber, 2001; Dykstra, Boyle, & Monarch, 1992), "alternative frameworks" (Gonzalez, 1997; Kupier, 1994; Taber, 1999), "folk theories" (Medin & Atran, 1999), "spontaneous knowledge" (Pines & West, 1986), and "naïve theories" (Resnik, 1983).

There are some general characteristics of misconceptions. For example misconceptions are in conflict with the scientifically accepted explanations and they are generally less precise, less consistent and more context specific. Moreover they show regularity across different students and a consistency within individual student's responses. Unfortunately students' misconceptions are resistant to change even after traditional instruction (Hewson& Hewson, 1988; Taber, 2001; Boujaoude, 1991).

To overcome misconceptions sources of them should be determined. A number of studies tried to identify sources of students' misconceptions. Students' prior knowledge (Teichert & Stacy, 2002), textbooks (Uhlik, 2004), language (Papageorgiou& Sakka, 2000), type of the instruction (Haidar, 1997), teachers (Valaniges, 2000), terminology used by teachers and textbooks (Schmidt, Baumgartner, & Eybe, 2003) are some of the determined sources of misconceptions.

Reviewing all the researches on students' misconceptions in chemistry is beyond the scope of this study, however, it is important to note that investigations done by many researchers reveled that students hold misconceptions on a variety of topics at all grade levels. A research literature shows that students hold many misconceptions on a variety of topics in chemistry. These topics are gases (Mas, Perez, & Harris, 1987; Stavy, 1990; Nurrenbern, & Pickering, 1987), mole concept (Griffiths & Preston, 1992; Harrison & Treagust, 1996), nature of matter (Andersson, 1990; Gabel, Samuel & Hunn, 1987; Renstrom, Andersson & Marton, 1990), chemical and physical changes (Ben-Zvi, Eylon, & Silberstein, 1987), entropy (Frazer, 1980), chemical equations (Ben-Zvi, Eylon & Silberstein, 1987; Garnett, Hackling, Vogiatzakis & Wallace, 1992), , chemical equilibrium (Banerjee, 1991; Bergquist & Heikkinen, 1990; Gussarsky & Gorodetsky, 1990; Chiu, Chou & Liu, 2002; Hackling & Garnett, 1985; Huddle & Pilay, 1996), bonding (Peterson & Treauget, 1989; Nicoll, 2001), electrochemistry (Garnett & Treagust, 1992a; Garnett & Treagust, 1992b; Ogude & Bradley, 1994; Sanger & Greenbowe, 1997), acids-bases (Çakır, Uzuntiryaki & Geban, 2002; Cros, Chastrette & Fayol, 1988; Ross & Munby, 1991), thermochemistry (Boo, 1998), molecular geometry and polarity (Furio & Calatayud, 1996), and solubility equilibrium (Raviolo & Alexander, 2001).

The chemical concepts and principles which involve the three levels of representation are the most difficult ones for students to learn. These three levels are; the symbolic level (chemical formulas, equations and mathematical relationships), the particulate level (sketches of atoms, molecules and ions), the macroscopic level (observable chemical processes in the laboratory) (Bowen & Phelps, 1997; Gabel, 1993). Gabel (1993) stated that problems at particulate levels are the most difficult ones for the students, and they are the best indicators of conceptual understanding. Students can overcome this difficulty with the instructions which help them to learn to visualize chemical phenomena and principles at all three levels. Visualization linking connections among the three levels develops understanding in chemistry. Students likely have a misconception when they cannot understand a chemical phenomenon at all three levels.

2.5. Students' Misconceptions in Gases Concepts

Even though conceptual understanding is a major objective in science courses, most students of all ages have difficulty in understanding scientific concepts and possess some intuitive knowledge. During the last three decades a considerable amount of researches have investigated gases concepts held by students and teachers at different level.

Reviewing the researches on students' conceptions on gases concepts, done by many researchers revealed similar results indicating that students have many misconceptions about gases. The scope of these researches varied from determining students' misconceptions at different grades, examining the teachers' misconceptions, investigating the relationship between students' understanding of concepts and its parallels in the history of chemistry and exploring the effectiveness of teaching strategies in remedying these misconceptions.

Benson, Wittrock, and Baur (1993) tried to investigate learner constructed concepts related to nature of gases stored in subject memories. The subject included 1098 students from second graders to university chemistry students. Researchers made a demonstration for elementary, junior high and senior students. Demonstration was described but not performed for university students. In the demonstration researchers showed two identical airtight flasks. Both flasks were opened to the air in the room and then closed. The first flask was left in this condition and by the help of a large syringe half of the air was removed from the second flask. The researchers told the participants to look at two flasks with "magic magnifying spectacles" and draw the sketches of the air in the flask. Drawings were classified in four groups as continuous/concentrated (CC), continuous/ expanded (CE), particulate/ concentrated (PC), and particulate/ expanded (PE) distributions. The scientifically correct one is PE distribution. The other 3 categories revealed the following misconceptions;

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

A chi-square analysis showed a significant relationship between preconception and grade level, as the grade level of children increased their misconception decreased.

Pereira and Pestana (1991) investigated 13–18 years old pupils' representations of models of water in three states. According to results of the study students have a misconception such as, the size of the particles increase as phase change occurs from solid to liquid and gas. They consider the size of particles as being smallest in the solid, increasing in the liquid and increasing even more in the gas. Similar to these findings Griffiths and Preston (1992) report that grade 12 pupils think that the size of molecules changes across different phase changes.

Stavy (1990) investigated children's (ages 9-15) understanding of change of matter from liquid or solid phase to gas phase and reversibility of this process. Students were presented the change of state from liquid to invisible gas (using acetone) in a closed container and from solid to visible gas (using iodine). At the end of the each task students were interviewed. In the first task students were shown two identical test tubes each containing one drop of acetone. The acetone in one of the test tubes was heated until it evaporated completely. The students were asked about the conservation of matter, conservation of properties of matter, conservation of weight and reversibility of this process. In all these questions students were asked to state their answers and explain the reasons. In the second task, students were shown two identical test tubes each containing identical sizes of iodine crystals. The iodine in one of the test tubes was heated until it turned to purple gas. Again the students were asked the same questions in the first task. Students' answers revealed the following misconceptions;

- Gas has no weight
- Liquid always weights more than gas
- Gas is not matter so it cannot be changed back into liquid.

According to Stavy (1990) grade four and five students only could understand the solid state of matter but not gaseous or liquid state.

Hwang (1995) investigated the development of the concept of gas volume in junior high, senior high, and university Taiwanese students. 1029 students were involved in the study. The conception test related to gas volume and particulate nature of gas were administered to students at the end of the teaching unit concerning gases. Students' answers revealed the following misconceptions;

- Volume of a gas is the size of the particles
- The gas can diffuse freely, gases have not volume.
- The volumes of different gases are proportional to their particle numbers in a container

It was also found that as the students' grade level increased their misconception decreased.

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

Novick and Nussbaum (1978) investigated 14 year old Israeli pupils understanding of particulate nature of gases. They interviewed with 150 pupils from nine urban schools. The interview was based on three phenomena and involved eight particular questions or tasks. Each phenomenon was the focus for probing the understanding of followings; a gas is composed of invisible particles, gas particles are evenly scattered in a closed system, there is empty space between gas particles, particles of a gas are in intrinsic motion and when two different gaseous substances interact to form a third substance, we picture this as the joining together of different kinds of particles. They found that 64% of the pupils suggested that air is made up of particles. When asked to choose the best visual representation of the structure of air out of a given set of alternatives, 78% choose the diagram which represented the particulate form of air. Some of the misconceptions identified among students are as follows:

- Particles are not scattered evenly in a closed container but that they were concentrated in some part of the confined space.
- There are “dust and other particles” or “other gases such as nitrogen or oxygen” or “air, dirt and germs” or “unknown vapors” between the particles of gases.
- The gases particles want to rise
- The gases particles weigh very little and therefore rise
- Air floats in the space because of its low specific gravity

A few years later, the same researchers conducted a study with students at different age levels. Novick and Nussbaum (1981) tried to find out how students’ conception of gases changed as they grow older. The sample included 576 pupils ranging from elementary school through university. According to results of the study percentage of pupils who provided scientifically accepted ideas increased with age. Also the majority of pupils claimed that air is made up of particles, but a minority of them demonstrated the internalization of the idea of empty space between particles and intrinsic particle motion.

Çalık and Ayas (2005) compared the level of understanding related to gases concept of eighth grade students and student teachers. Two tier open ended question and group discussion method were used to gather data. In the first part of the open ended question they asked “what the term gas reminds you when you hear it?” and in the second part, they asked to draw oxygen molecules filled into a flask. The questions were administered to 50 eighth grade students and 50 student teachers in their final year in the science education department. According to results of the study none of the student teachers and eight graders had a sound understanding for the first question. Only 36% of student teachers and 24% of eighth graders made a correct drawing in the second question. In general there were similar alternative conceptions by both the students and the student teachers despite more instruction on these topics in the education of the student teachers. The incorrect answers to the questions revealed the following misconceptions;

- Gas has constant volume but not constant mass
- Intermolecular bond is the longest in gas phase

The possible reason of these misconceptions was explained as the abstract nature of the concept, inappropriate daily life explanation and misuse of analogies.

Lin, Cheng, and Lawrenz (2000) used 4 conceptual problems to investigate common misconceptions of students and teachers about gas laws. Two of the items were related to Boyle’s law, one about Charles’s law and the other is about that molecular behavior of gases. 119 11^{th} grade students and 36 high school chemistry teachers were asked to answer these questions. The answer of the questions showed that students and teachers hold same misconceptions. They failed to use PV=nRT formula, they cannot explain Boyle’s law and they failed to distinguish between “system” and “surrounding”. Study revealed three major misconceptions of kinetic theory:

- The atmospheric pressure pushed gas molecules down to keep them together at the bottom of the flask.
- Gas molecules rise and stay away from heat.
- Molecules expand when temperature rises.

Studies about the relationship between students' concepts and history of science showed a great parallel. For instance, in his study Niaz (2000) investigated the relationship between students' understanding of gases and its parallels in the history of science. He showed a figure representing a steel tank holding hydrogen gas at 20^0C and 3 atm pressures and asked to represent the distribution of hydrogen molecules at -20^0C to fifty nine science major freshman students. Only 10 students draw the distribution correctly and 3 of them can provide adequate justification. Results obtained showed that students held ideas that gases molecules arrange in the form of regular lattices which are consistent with those most chemist held until about 1860. Students' answers revealed the following misconceptions:

- Gas molecules do not occupy all the space available in a vessel
- When temperature of gas decreases, it occupies lesser volume; molecules unite among themselves, shrink and tend to form groups.
- Attractive forces between gas molecules increases as the temperature decreases.

Moreover Mas, Perez and Harris(1987) conducted a study to make comparison between the concepts of gases the pupils hold and the history of chemistry which is based on the hypothesis of genetic epistemology, that is learning of scientific concepts by a student often parallels the historical development of the science. They prepared a test consisting of two questionnaires of four questions each. The test was administered to 1198 pupils at the age of 12 to 18. First questionnaire included the questions about the experiment of total vaporization of liquid in a closed container. Students are asked about conservation of substance, of weight, of mass and the conceptions of gas which rise out of liquid when it is boiled. In the second questionnaire students are asked to predict what would happen to the weight of various substances when they undergo a chemical processes which involves disappearance of material due to gas formation. Analyses of the results indicate that in every age group although students understand conservation of substance they have difficulties in understanding conservation of weight. Also they found that students though that liquids lost mass and weight when they vaporized so they rise. Researchers claimed that students' conceptions resemble the Aristotelian notions of gases (which rest on the idea that only things that fall down have weight).

In order to bring the work on misconceptions about gases concepts that students' hold to the stage at which it is useful in practice, several attempts were made. Quite a few researchers designed instructions to overcome students' misconceptions and investigated the effectiveness of them as explained in the following paragraphs.

Liu (2006) investigated the effectiveness of probeware-based hands on laboratory and internet- based computer modeling laboratory on students understanding of gas laws. 33 high school chemistry students were involved in the study. Students' understanding was assessed by one pretest and two posttests. Tests included short constructed response type questions. Results showed that combined probeware-based hands-on laboratory and internet-based computer modeling laboratory are more effective than either the probeware-based hands-on laboratory or the internet-based computer modeling laboratory alone to help students develop understanding of gas law.

Şenocak, Taşkesenligil and Sözbilir (2007) conducted a study to investigate the effect of Problem Based Learning on prospective primary science teachers' learning of gases concept. 101 first year undergraduate students enrolled in General Chemistry II course involved in the study. There are 50 students in experimental group and 51 students in control group. They used gases diagnostic test composed of 22 multiple choice questions which reflects students misconception in gases reported in the literature. Before treatment the mean score of students in experimental and control group was 14.45 and 13.89 respectively. This means that even prospective science teacher have misconceptions in gases concept. At the end of the treatment they found that students in experimental group achieved significantly higher than those of control group.

The study conducted by Hwang and Chiu (2004) explored the students misconceptions in gases concept and effectiveness of instructional activities by presenting a demonstration with computer simulation was investigated. 296 subjects in Grade 5-8 (age 11-12 through 14-15) in Taiwan were involved in the study. An open-ended questionnaire and picture drawing question was administered to the subjects. A statistically significant difference revealed that teaching activity in this research by the computer- simulated demonstration could obviously benefit students' conceptual change in learning of particulate theory of gases. Also the following misconceptions are determined;

- Students perceived the gas as a continuous medium, rather than as an aggregation of particles. Therefore, it could be the reasons for students to have misconception of gases.
- Many students also hold a static rather than kinetic conception of the particulate model of gas. In other words, even though they have learned it in school, the particulate theory does not become useful for most of the students.
- Gas was NOT distributed homogeneously in the whole container, and is DEPENDENT on the position of the bottle.
- Two gases homogeneously mixed but NOT distributed in the whole space.

Gürses, Doğar, Yalçin and Canpolat (2002) investigated the effect of conceptual change oriented instruction on 7th grade students understanding of gases concepts. They assigned students experimental and control group randomly. In the experimental group conceptual change oriented instruction was used. Whereas traditional instruction was used in the control group. They used gases concepts test which include 29 open ended questions. According to results of the study students instructed with conceptual change oriented instruction got higher scores than students instructed with traditional instruction. Analyses of the interview revealed that students have following misconceptions about gases;

- Gases are evaporated substance
- There is no air in a closed container
- Gases do not mix

As it is seen from the literature the students at various grade levels have many misconceptions about gases concepts. In this study, these determined misconceptions were used both in designing the instruction and computer animations and developing the gases concept test.

2.6. Algorithmic Understanding or Conceptual Understanding?

Conceptual change is very difficult to accomplish. Actually research has shown that most instruction is highly ineffective when the aim is conceptual change (Driver and Easly, 1978; Roth, Smith, and Anderson 1983). Fellows (1994) stated that generally students memorize facts or use algorithms to pass their exams without learning the theories. However, when the learning task demands describing, explaining, and making interpretations about real world phenomena, their memorized knowledge becomes useless.

Suits (2000) defined two types of understanding in chemistry, algorithmic understanding and conceptual understanding. There are stages of algorithmic understanding. First students use standard algorithm to solve a particular problem. At this stage, since the students use step by step procedure they learn routine procedures. So, standard algorithm cannot develop critical thinking skills. In the second stage, students use their own algorithm, an invented algorithm, to solve more complex problems. An invented algorithm needs to combine concept and algorithmic understanding by using appropriate strategy. Unlike algorithmic understanding, conceptual understanding requires the use of a more sophisticated solution strategy because the problem under consideration is unfamiliar. To acquire conceptual understanding learners must comprehend the three levels of representation for chemical principle (symbolic level, particulate level, macroscopic level), and are able to use invented algorithms and develop conceptual knowledge.

Alao and Guthrie (1999) defined conceptual understanding by utilizing breadth and depth of knowledge. Breadth is defined as “the extent of knowledge that is distributed and represents the major sectors of a specific domain” and depth as “the knowledge of scientific principles that describes the relationship among concepts” (p. 244).

A number of studies indicated the discrepancies between students’ performance on mathematical tasks used to describe behaviors of gases and their conceptual understanding that underlines these tasks. Many research studies have investigated college students’ achievement in solving numerical problems about gas laws and conceptual understanding of a gaseous substance (Sawrey, 1990; Nakhleh, 1993; Nakhleh & Mitchell, 1993). These researches showed that although many students could perform well in mathematical problems, a few of them could perform conceptual problems.

In their study Nurrenbern and Pickering (1987) applied a test including both conceptual and traditional questions to 331 university students. This test was about gas laws and stoichiometry including only multiple choice questions. They found that students have far greater success in answering traditional questions than the concept questions about gases. Also they found that students have difficulties in understanding that gases occupy the entire volume of the container; gases have no definite volume and the idea of reduced pressure of a gas at constant volume.

Similarly Sawrey (1990) applied the same tests to 285 freshmen chemistry students. She found that students have a difficulty in solving concept problems. Although 87.72 % of the students correctly answer the traditional questions only 31.23 % of the 285 students can solve concept problems about gas laws.

De Berg (1995) examined college students understanding of relationships between pressure and volume of air compressed in a syringe. Paper and pencil test including qualitative and quantitative task was used. 101 college students were asked to predict the volume or pressure of gas in a syringe given the value of other. 65% of the students could use inverse proportion between pressure and volume of a gas. Students answered correctly to qualitative tasks also answered correctly to quantitative ones. Roughly 55% of the students who answered the quantitative problems correctly could not answer the qualitative ones.

In the light of the previous research results, this study also aimed to investigate and compare students' achievement in solving numerical problems and conceptual understanding in gases concepts.

2.7. Computer Animations

The importance of integrating technologies into science teaching and learning is highly recognized among many researchers (Linn& His, 2000). For better understanding in chemistry, visual representation of phenomenon is necessary (Habraken, 1996). Using technologies in classrooms helps students overcome difficulties arising from visualization (Ferk, Blejec, & Gril, 2003), facilitate their understanding of scientific concepts (de Jong & van Joolingen, 1998) and enable students- centered learning environments (Brush& Saye, 2000).

Mayer (2001) defined multimedia as the presentation of learning materials by using both pictorial and verbal elements. Animations that has been defined as images in motion, is one of the important combination of multimedia (Dwyer & Dwyer, 2003). According to

Mayer and Moreno (2002) animation is pictorial presentation of materials and it portrays apparent movement.

Gobert (2000) stated that dynamic representations such as three dimensional animations provide visual explanations for scientific phenomenon that is impossible to observe directly. Also computer animations might lead to decrease in cognitive load and support active learning (Urhahne, Nick, & Schanze, 2009). Thinking the cognitive load, animations have two basic functions (Mayer, 2001);

1. Enabling function: Animation reduce cognitive load of learning task to allow cognitive processing that would otherwise impossible.
2. Facilitating function: Animation reduce cognitive load of task that would otherwise demand high mental effort.

Marbach-Ad, Rotbain and Stavy (2008) argued that from the constructivist point of view students' learning difficulties and misconceptions in science can be overcame by using models and visualizations. Graphics visualizations and animations are very effective in giving dynamic nature of molecules or molecular interactions. This nature and interactions can only be shown in a static manner in text-based presentations. Urhahne et al. (2009) investigated the success of three dimensional simulations in students' understanding of chemical structures and their properties. They compared the effectiveness of three dimensional simulations with two dimensional illustrations concerning the modification of carbon. According to results of the study three dimensional simulations were more effective for younger students who lack the experience of learning with different visual representation format in chemistry.

Rieber (1990) warned that, in order to use computer animation in an effective way, the attention of the students should be drawn to the relevant motion taking place in the animation. Large, Beheshti, Breulex and Renaud (1996) made a distinction between animation function as procedural information and descriptive information. Their studies showed that animation enhance the comprehension of procedural text more than descriptive text. So the usage of animations is more effective in procedural content that requires motion.

Similar but more depth analyses came from ChanLin (1998) about this distinction. ChanLin (1998) investigated how different visual treatments (no graphics, still graphics, animated graphics) influenced students with different prior knowledge level (high, low) in learning procedural and descriptive knowledge. According to results of the study, in learning procedural knowledge there was no significant difference among any two treatments in the low prior knowledge group, while in the high prior knowledge group still graphic treatment was better than control group. In learning descriptive facts, animation and still graphic treatments were better for low prior knowledge group and for high prior knowledge group only animation group was better than control group.

Because of its potential to deal with higher-order learning outcomes, science educators believe that computer animations enhance teaching and learning of science concepts (Ellis, 1984; Marks, 1982). Williamson and Abraham (1995) conducted a study to investigate the effectiveness of computer animations in students' explanations of chemical phenomenon. There were two experimental groups and one control group. One of the experimental groups viewed the animations during the lectures and the other experimental group viewed animations both during the lectures and in discussion sessions. The control group did not see the animations. The results of the study showed that both of the experimental groups gained higher conceptual understandings than control group.

Marbach-Ad et al. (2008) tried to determine the contribution of computer animations and illustration activities on students' achievement in molecular genetics. The control group received traditional instruction and one experimental group received instruction integrated with computer animation and the other experimental group received instruction integrated with illustration. The results of the study revealed that students in the experimental groups improved their understanding in molecular genetics. Moreover the results of the open-ended questions showed that computer animation activity were more effective than illustration activity.

There are inconsistent findings among various studies related to effectiveness of computer animations. Failure of using animation may due to complexity of the textual materials (Large, 1996), students' prior knowledge (Blissett & Atkins, 1993), discrete comprehension of animations (Schwartz, 1999), difficulty of perceiving animations (Pani, Jeffres, Shippey, & Schwartz, 1996).

Tversky, Morrison and Betrancourt (2002) argued that two principles should be satisfied for successful animations:

> *1. Congruence Principle: The structure and content of the external representation should correspond to the desired structure and content of the internal representation. For example, since routes are conceived of as a series of turns, an effective external visual representation of routes will be based on turns.*
>
> *2. Apprehension Principle: The structure and content of the external representation should be readily and accurately perceived and comprehended. For example, since people represent angles and lengths in gross categories, finer distinctions in diagrams will not be accurately apprehended. In the case of routes, exact angles of turns and lengths of roads are not important (p. 257-258).*

Studies about computer animations gave an idea that, they facilitate students' understanding of scientific phenomena. So in this study the effectiveness of conceptual change oriented instruction accompanied with computer animations on students' achievement and understanding of gases concepts was investigated.

2.8. Nature of Science

Nature of science is a very broad term used to explain what science is, how science functions, what the role of society is in scientific enterprise, and how scientific community operates (McComas, Clough& Almazroa, 1998). According to Lederman

(2007) NOS is “the epistemology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development” (p.833). Although there is a disagreement among philosophers, historians and science educators on the definition of NOS (Alters, 1997), there is a general agreement on characteristics of NOS at K-12 level (Abd- El- Khalick, 2004). These characteristic are:

1. Scientific knowledge is subject to change.
2. Scientific knowledge is empirically based.
3. Scientific knowledge involves personal background, biases and/or is theory-laden.
4. Scientific knowledge necessarily involves human inferences, creativity and imagination.
5. Scientific knowledge is culturally embedded.
6. There is a distinction between observation and inferences.
7. There is a distinction between scientific laws and theories.

Many researchers emphasized the weight of understanding in nature of science. It was 1960 that nature of science was determined as a major aim of science teaching by the National Society for the Study of Education. Matthews (1994) has argued that teacher education program should include nature of science because NOS knowledge facilitates the implication of conceptual change models by teachers in their instruction. Moreover Driver, Leach, Miller and Scott (1996) propose five arguments about why understanding of NOS is important;

1. Utilitarian view: NOS is important for understanding science and following technological improvement.
2. Democratic view: NOS is necessary in making decisions about socio scientific issues.
3. Cultural view: NOS is necessary to accept and appreciate scientific enterprises as a part of culture.
4. Moral view: NOS facilitates understanding of scientific community’s and society’s norms.

5. Science learning view: NOS helps the learning of science subject. Parallel with this view, Songer and Linn (1991) showed that students having dynamic view of science can better understand the thermodynamic concepts than students having static view of science.

Given the importance of nature of science understanding, the assessment of students', teachers' and scientists' conceptions of NOS has been a main point for science education research over the years. Without any doubt, there is plenty evidence for students' misunderstanding about the nature of science issues (Lederman, 1992; Meyling, 1997; Kang, Scharmann& Noh, 2005; Ryan & Aikenhead, 1992). McComas (1998) defined misconceptions in science and named them as "myths of science". According to him lack of philosophy of science content in teacher education programs, inefficacy of these programs in providing real science experiences for pre-service science teachers and textbooks are some of the main sources of the misconceptions. These myths are:

Myth1. Hypotheses become theories that in turn become laws.
Myth2. Scientific laws and other such ideas are absolute.
Myth3. A hypothesis is an educated guess.
Myth4. A general and universal scientific method exists.
Myth5. Evidence accumulated carefully will result in sure knowledge.
Myth6. Science and its method provide absolute proof.
Myth7. Science is procedural more than creative.
Myth8. Science and its method can answer all questions.
Myth9. Scientists are particularly objective.
Myth10. Experiments are the principle route to scientific knowledge.
Myth11. Scientific conclusions are reviewed for accuracy.
Myth12. Acceptance of new scientific knowledge is straightforward.
Myth13. Science models represent reality.
Myth14. Science and technology are identical.
Myth15. Science is a solitary pursuit.

Fleeming (1988) used Views on Science-Technology-Society questionnaire (VOSTS) to assess undergraduate chemistry students' views about the interaction among science, technology and society issues. The result of the study revealed that participant students' conceptions of NOS were very naïve and similar to high school students' views.

Kang, Scharmann and Noh (2005) investigated Korean 6th, 8th, and 10th graders on five constructs of NOS which are purpose of science, definition of scientific theory, nature of models, tentativeness of scientific theory and origin of scientific theory. The researchers concluded that most of the students held absolutist/ empiricist perspective about NOS. Although there were no differences in the distribution of responses among the grade levels, a difference between Korean students and those of Western countries were found in some questions.

Students' lack of understanding about nature of science concepts have been attributed to science curriculum, curricular materials, instructional practices, students' science background, teachers' views of NOS, language, and cultural beliefs and values. Researches about culture showed that students and teachers in non-European countries were determined to view science as close to technology, necessary for future careers and development of countries, and not related to daily life (BauJaude& Abd- El-Khalick, 1995; Jegede& Ogawa, 1999).

Abd-El Khalick (2004) investigated 153 collage students' views of NOS also explored the relationship between these views and students' academic and background variables. To assess students' NOS views, he used Views of Nature of Science Questionnaire Form C (VNOS-C) and interviews. The aspects of NOS focused in this study were tentative, empirical, inferential, creative, and theory-laden nature of scientific knowledge, the lack of single scientific method, the aim and structure of scientific experiments, the logic of hypothesis and theory testing, and validity of observationally based scientific disciplines. According to results of the study, students' NOS views were not related to their gender, class standing, and science backgrounds. Moreover most of the students held naïve beliefs about most of the aspects stated above.

Forawi (2000) examined the effect of curriculum reflecting instructional strategies related to teaching the NOS, science curricular content and teachers' views of NOS on students' understanding of NOS by using pre-test post-test nonequivalent control group design. The results of the study revealed that teachers holding high understanding of NOS reflected the instrumentalist nature of science in their thinking. Also students who were taught by these teachers performed better than other students who were taught by teachers with lower understanding.

Schoneweg and Rubba (1993) investigated the effect of science- technology- society (STS) and physics courses on students' views about STS interaction. 16 selected items from Views on Science-Technology-Society (VOSTS) questionnaire were used as pre and post tests. Data were collected from 260 students 122 of whom attended physics course and 138 of them attended STS course. The results of the study showed that each group mean score remained stable over the semester. In STS group, although some students gained more realistic view about some aspects of STS interaction, in other aspects students developed misunderstandings. So in general STS course seem to have no positive effect on students' views about science-technology- society interaction.

Although BSCS (Biological Science Curriculum Study) was expected to improve students' NOS understanding, Meichtry (1992) found no positive effect of the program. According to researcher, students' NOS views were very robust and resistance to change. Since the program did not consider students' existing knowledge about NOS, students could not develop more realistic knowledge.

Various approaches have been undertaken to enhance students' understanding of nature of science. Generally most of these studies argued the effectiveness of implicit versus explicit (integrated or non-integrated) instructional context. Previous researches showed that explicit instruction was more effective than implicit one in improving students' learning of NOS. However the success of explicit instruction was found limited. It is empirically shown that, implicit instruction, in which focus is on science base activities and NOS beliefs are at the background, was not effective in students' learning about NOS concepts (Abd-El-Khalick & Lederman, 2000). An investigation done by Moss (2001) corroborated this finding. He observed the changes in students' view about nature of science over the course of an academic year. The results of the study revealed that although students participated in the project based course their conceptions did not change significantly over the year. He contended that nature of science instruction should be explicit.

When the researchers came to same conclusion that explicit instruction are more effective, they argued the success of integrated and non-integrated explicit instruction. Khishfe and Lederman (2006) defined the integrated approach as explicit instruction of NOS as embedded within the content. In contrast, non-integrated approach involves explicit instruction of NOS through activities without intentionally relating it to the content.

Khishfe and Lederman (2006) investigated the effectiveness of integrated and non-integrated approaches on ninth grade students' views of NOS. During six week, students engaged with global warming unit and NOS. According to results of the study, students' NOS views improved regardless of whether NOS instruction was embedded within the content. The researchers conducted a similar study one year later and investigated the relationship between explicit instructional context (integrated or non-integrated) and students' learning of NOS across 3 disciplines (chemistry, biology, environmental). For each discipline, there were two intact groups taught by the same teacher. The only difference between intact groups was the content of NOS instruction; either integrated or non-integrated. The results showed that explicit instructional context both integrated and non- integrated approach improved students' views of NOS across discipline. Also there was no practical significance in students' views of NOS between the intact groups (integrated and non-integrated) across disciplines. So the researches argued that it was impossible to claim that explicit teaching of NOS as integrated would lead to more improvement in learning about NOS.

In this study 10th grade students' understanding on nature of science and the science-technology-society interaction was examined. Moreover, the difference between the views of students who taught with conceptual change oriented instruction and traditional instruction was compared.

2.9. Attitude

There is an increasing recognition in science education community that learning of scientific concepts is more than a cognitive process. Students' interest, self concept and attitude toward science are also critical in developing meaningful understanding of scientific concepts.

Given the impact of attitude on science learning, some researchers investigated effect of instructional strategies (Freedman, 2002), age (George, 2000), gender (Barmby, Kind & Jones, 2008) and grade level (Pell & Jarvis, 2001) on students' attitude toward different school subjects, and effect of attitude on students' achievement (Mattern and Schau, 2002). The other researchers dealt with the development of an instrument for measuring science related attitudes. Among these researchers there is a disagreement on the definition of attitude. On the one hand, the conceptualization of attitude as including there components; affective, behavioral and cognitive is dominant. On the other hand the attitude is thought with only affective domain and behavioral and cognitive component are disregarded (Francis& Greer, 1999).

Social psychologists have long viewed attitudes as having three components: the cognitive, the affective, and the behavioral. The *cognitive* component is a set of beliefs about the attributes of the attitudes' object and its assessment is performed using paper-and-pencil tests (questionnaires). The *affective* component includes feelings about object and its assessment is performed using psychological indices (heart rate). Finally, the *behavioral* component pertains to the way people act toward the object and its assessment is performed with directly observed behaviors (Eagly & Chaiken, 1993).

Attitude is generally defined as the predisposition to respond positively or negatively to things, places, people or ideas (Simpson, Koballa, Oliver& Crawley, 1994). Although there is a wide range of attitudes' definitions, all of them agree that an attitude is the tendency to think, feel, or act positively or negatively toward objects in our environment (Eagly & Chaiken, 1993; Petty, 1995).

Different researchers operationalized attitude in various ways to investigate the relationship between science achievement and attitudes toward science. Simpson and Oliver (1990) identified sub-constructs of attitude that are related to achievement; attitude toward science, achievement motivation and science self concept. Achievement motivation and self concepts were determined as significant predictors of science achievement. Marsh (1992) used self- concepts as a sub-construct of attitude and found a relationship between achievement and self- concepts. Mattern and Schau (2002) searched the causal relationship between attitude toward science and science achievement by identifying the affect, cognitive competence and value as a sub-constructs of attitude. They found a cross-effect between attitude and achievement. A study conducted by Webster and Fisher (2000) used data collected as a part of the Third International Mathematics and Science Study (TIMSS). The analyses of data revealed that attitudes towards science have strong effect on science achievement.

However the results of Nieswandt (2006) study contradict with previous ones. He differentiated attitude from self- concept and interest as a separate psychological construct and investigated the effect of them on understanding of chemical concepts. The results of the study showed that attitude toward chemistry have no effects on conceptual understanding.

Attitude researches show contradictory results about gender issue. Also results of many studies revealed that student' attitudes toward science decline as they progress through grades. Francis and Greer (1999) developed an instrument to assess students' science related attitudes. The questionnaire including 62 science- related items was administered to 2129 pupils in their third, fourth and lower sixth years. According to the results of the study males had more positive attitude towards science than females and that younger students had more positive attitudes toward science than older students.

Part of a project aimed to improve students' achievement in science, Pell and Jarvis (2001) reported developmental stages of attitudes of students aged from 5-11 years. The results of the study revealed that both boys' and girls' eagerness for science decline progressively with age alongside a similar decline in their perception that science is difficult.

Barmby et al. (2008) carried out a research to investigate the variation of attitudes toward science over the first three years of secondary schooling and with gender. The questionnaire used in this study included the following six constructs about attitude; learning science in schools, practical work in science, science outside of the school, importance of science, self-concept in science and future participation in science. 932 pupils participated in the study. According to results of the study attitudes toward science declined as they progressed through secondary school and this decline was more pronounced for female students.

Dahindsa and Chung (2003) dealt with the gender issue in a different perspective. They investigated the attitudes toward and achievement in science of Grade 9 students in single-sex and coeducational schools in Brunei. According to results of the study, there was a difference in attitudes towards and achievement in science between two types of schools. Also, in a single sex schools the girls performed better in science than boys despite their attitudes being only marginally better. Moreover the attitudes toward and achievement in science of the girls in a single sex school were moderately better than of the girls in coeducational schools. Finally there were no significant sex difference in attitudes toward and achievement in science in coeducational schools.

George (2000) investigated how latent variable growth modeling can be utilized to examine change in students' attitudes toward science over the middle and high school years. The results of the study showed that students' attitudes towards science generally decline over the middle and high school years, moreover science self-concept, teacher encouragement of science and peer attitudes were found significant predictors of students' attitudes. However variables related to parent was found statistically nonsignificant predictors. Also it was found that boys begin higher attitudes towards science than girls. But the decline in attitudes toward science was faster for the boys. This final result contradicts with the findings of Barmby et al. (2008).

With a few exceptional studies (Hobbs & Erickson, 1980; Morel & Lederman, 1998), the decline in students' attitudes toward science is obvious in most of the researches. George (2000) claimed that the reason of this decline is due to the science courses that students take. Moreover Koballa and Glynn (2007) explained it by the inability of students in distinguishing their attitudes toward science from their attitudes toward school.

Jones, Howe and Rua (2000) examined the effect of gender difference on sixth grade students' attitudes and experiences related to science. 437 students were surveyed about perceptions of science and scientists, out of school science experiences, science topics of interest and characteristics of future jobs. Results of the study marked that males reported more extracurricular experiences on science than females. Also more females reported that science was difficult to understand than males. Moreover more males reported that science is more suitable for boys.

Kesamong and Taiwo (2002) investigated the relationship among junior secondary school students' cultural beliefs, their attitudes towards science and their science achievement. Randomly selected 395 students from eleven junior secondary schools were involved in the study. Three instruments namely socio-cultural scale, attitudinal scale, and science achievement tests were used for data collection procedure. According to results of the study, the relationship between students' socio-cultural background and their achievement in and attitude towards science was found negative. However, there was a positive relationship between students' attitudes toward science and their achievement in science.

Finally Holland, Verplanken, and Knippenberg (2002) investigated the directions of attitude- behavior relationship. They tried to answer the question that under which circumstance attitude influence our behavior and under which attitudes are inferred from behavior. Their study is important to determine the cause- effect relationship between science achievement and attitude towards science. The results of the study showed that, strong attitudes guide behavior, while weak attitudes follow behavior.
In this study it was also investigated whether conceptual change oriented instruction accompanied with computer animations produces positive attitudes toward chemistry compared to traditionally designed instruction. Also the difference between male and female students' attitudes toward chemistry as a school subject was examined.

The summary of the related literature showed that students' misconceptions have been and continuous to be of critical importance in their subsequent learning. Nevertheless these misconceptions are robust and resistant to traditional instruction. Chemistry is one of the subjects where students have lots of misconception. Among the other concepts of chemistry, students have many difficulties in understanding of gases concepts because of its abstract nature. Therefore, to promote meaningful understanding, determining students' misconceptions and designing an instruction accordingly is very crucial. As it was summarized in the literature, conceptual change model developed by Posner et al. (1982) was found to be very effective in eliminating students' misconceptions and facilitating conceptual understanding. Moreover computer animations were shown to have a capacity to improve the teaching of difficult and abstract science concepts. Thus, in this study, instruction based on conceptual change method accompanied with computer animations was developed to facilitate meaningful learning in gases concepts. Furthermore, in the literature it was seen that attitude plays a significant role in students learning. So in this study the effect of conceptual change instruction on students' attitude toward chemistry as a school subject was investigated. Finally given the importance of nature of science in science teaching, this study examined students' views on nature of science and science- technology-society interaction.

CHAPTER 3

PROBLEMS AND HYPOTHESES

In this chapter, two main problems, ten sub problems and ten hypotheses were stated.

3.1 The Main Problem and Sub-problems

3.1.1 The Main Problem

1. What are the effects of conceptual change oriented instruction accompanied with computer animations and gender differences on 10^{th} grade students' understanding, achievement and retention of gases concepts and students' attitude toward chemistry as a school subject?
2. What are the views of students about the nature of science concepts?

3.1.2 The Sub-problems

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

2. Is there a significant mean difference between the effects of conceptual change oriented instruction and traditionally designed chemistry

instruction on students’ achievement in gases concepts when science process skills is controlled as a covariate?

3. Is there a significant mean difference between males and females with respect to students’ understanding of gases concepts when science process skill is controlled as a covariate?

4. Is there a significant mean difference between males and females with respect to students’ achievement in gases concepts when science process skill is controlled as a covariate?

5. Is there a significant effect of interaction between gender differences and treatment with respect to students’ understanding of gases concepts when science process skill is controlled as a covariate?

6. Is there a significant effect of interaction between gender differences and treatment with respect to students’ achievement in gases concepts when science process skill is controlled as a covariate?

7. Is there a significant difference between the effects of conceptual change oriented instruction and traditionally designed chemistry instruction on students’ attitudes toward chemistry as a school subject?

8. Is there a significant mean difference between males and females with respect to students’ attitudes toward chemistry as a school subject?

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

10. Is there a significant mean difference between the effects of conceptual change oriented instruction and traditionally designed chemistry instruction on students' retention in gases concepts?

3.2 Hypothesis

H_o1: There is no significant mean difference between post-test mean scores of students taught with conceptual change oriented instruction and students taught with traditionally designed chemistry instruction in students' understanding of gases concepts when science process skills is controlled as a covariate.

H_o2: There is no significant mean difference between post-test mean scores of students taught with conceptual change oriented instruction and students taught with traditionally designed chemistry instruction in students' achievement in gases concepts when science process skill is controlled as a covariate.

H_o3: There is no significant mean difference between post-test mean scores of males and females on their understanding of gases concepts when science process skill is controlled as a covariate.

H_o4: There is no significant mean difference between post-test mean scores of males and females on their achievement in gases concepts when science process skill is controlled as a covariate.

H_o5: There is no significant effect of interaction between gender difference and treatment on students' understanding of gases concepts when science process skill is controlled as a covariate.

H_o6: There is no significant effect of interaction between gender difference and treatment on students' achievement in gases concepts when science process skill is controlled as a covariate.

H_o7: There is no significant mean difference between students taught with conceptual change oriented instruction and students taught with traditional instruction with respect to their attitudes towards chemistry as a school subject.

H_o8: There is no significant mean difference between males and females with respect to their attitudes toward chemistry as a school subject.

H_o9: There is no significant effect of interaction between gender difference and treatment on students' attitudes toward chemistry as a school subject.

H_o10: There is no significant mean difference between the effects of conceptual change oriented instruction and traditionally designed chemistry instruction on students' retention in gases concepts when science process skill is controlled as a covariate.

CHAPTER 4

DESIGN OF THE STUDY

This chapter is devoted to detailed description of research design, population and sample, instruments used to collect data, treatment, data analyses method, treatment fidelity and treatment verification, internal validity threats and assumption and limitation of the study.

4.1 The Experimental Design of the Study

In this study non-equivalent control group design as a part of quasi experimental design was used (Gay & Airasian, 2000). Since school administration had already formed the groups at the beginning of the semester, random assignment of individuals to the group could not be possible. However one of the classes was randomly assigned as experimental group and the other class was assigned as control group.

Conceptual change oriented instruction was used in the experimental group and traditionally designed chemistry instruction was used in control group. Both groups were instructed by the same teacher who is a very experienced chemistry teacher. She was informed about the aim of the study, conceptual change oriented instruction and computer animations before the treatment. There were two 45-minute sessions per week for each group and the treatment was conducted over seven weeks.

Before the treatment to check whether the groups were equal in understanding in gases concepts, achievement in gases concepts and attitudes toward chemistry Gases Concept

Test, Gases Achievement Test and Attitude toward Chemistry were given to both groups. Moreover to check students' intellectual abilities Science Process Skill Test was administered to groups at the beginning of the treatment. Table 4.1 presents the design of the study.

Table 4.1 Research Design of the Study

Groups	Pre-test	Treatment	Post-test
EG	GCT GAT ASTC SPST	CCOI	GCT GAT ASTC VOSTS
CG	GCT GAT ASTC SPST	TDCI	GCT GAT ASTC VOSTS

The meanings of the abbreviations in the table are presented below:

EG: Experimental Group
CG: Control Group
GCT: Gases Concept Test
GAT: Gases Achievement Test
ASTC: Attitude Scale toward Chemistry
SPST: Science Process Skill Test
CCOI: Conceptual Change Oriented Instruction
TDCI: Traditionally Designed Chemistry Instruction
VOSTS: Views on Science Technology Society Questionnaire

4.2 Population and Subjects

Target population of the study was identified as all tenth grade students in Ankara which is the capital city of Turkey. Nevertheless it is not easy to contact with target population, accessible population was defined. All tenth grade students in Çankaya districts in Ankara were defined as accessible population. The results of this study will be generalized to accessible population.

The subjects of this study consisted of 67 tenth grade students (30 male and 37 female) from two intact classes of a chemistry course taught by the same teacher in Sokullu High School in the first semester of 2008-2009 academic year. The classes were randomly assigned as control and experimental group. In the experimental group, which was exposed to conceptual change oriented instruction, there are 34 students (17 female and 17 male), while in the control group, which was instructed with traditional methods, the number of the participants was 33 (20 female and 13 male). Students' ages ranged from 15 to 16 years old.

4.3 Variables

There are eight variables in this study, three of them are determined as independent variables and five of them are determined as dependent variables.

4.3.1 Independent Variables

The independent variables of this study were types of instruction methods which were conceptual change oriented instruction and traditionally designed chemistry instruction, gender and science process skills test scores. The types of instruction and gender were taken as categorical variables. Categorical variables differ qualitatively not in degree, amount or quantity (Fraenkel& Wallen, 2006). Science process skill test score was considered as quantitative variable. Quantitative variables change in some degree and show how much of the variable an individual possess (Fraenkel& Wallen, 2006).

4.3.2 Dependent Variables

The dependent variables of this study were students' understanding of gases concepts which was measured by Gases Concept Test, students' achievement in gases concepts which was measured by Gases Achievement Test, students' retention in gases concepts which was measured by Gases Retention Test, students' attitudes toward chemistry as a school subject which was measured by Attitude Scale toward Chemistry, and students' views on nature of science and science- technology- society relationships which was measured by Views on Science Technology Society Test. Views on Science Technology Society Test scores was considered as categorical variable, all of the other variables were considered as quantitative variable.

4.4 Instruments

The instruments used in this study were gases misconception test, gases concept test, gases achievement test, science process skill test, attitude scale toward chemistry and views on science technology society questionnaire. Moreover semi-structured interviews were conducted with students from both control and experimental groups. Nonsystematic classroom observations were carried out in the experimental and control groups by the researcher.

4.4.1 Gases Misconception Test

This test developed by researcher and applied a year before the actual study. It includes seven open ended questions. For each questions students were asked to write their responses and the reasons of them. In the literature there were many misconceptions that students' hold about gases concepts determined by researchers. This test was used in order to check whether the students had these misconceptions and reveal students' other misconceptions about gases concepts. The determined misconceptions in this test were reflected in distracters of gases concept test. The content of the test included gas properties, distribution of gas particles at different temperatures, diffusion of gases, gas laws, partial pressures of gases and ideal gases which was determined by examining textbooks, instructional objectives of gases unit and related literature. For content validity, the test was examined by a group of expert teachers and by the course teacher for the appropriateness of the questions to the instructional objectives.

The test was administered to 103 10th grade and 95 11th grade students from four different high schools in the Spring Semester of 2007-2008 Academic year. To detect students' misconceptions researcher and one expert in chemistry education analyzed students' answers separately. Misconceptions and percentage of students having these misconceptions were determined with a consensus.

4.4.2 Gases Concept Test

This test was developed by the researcher. The purpose of the test was to assess students' understanding of gas properties, distribution of gas particles at different temperatures, diffusion of gases, gas laws, partial pressures of gases and ideal gases. The test included 25 multiple choice items consisting of one correct answer and four distracters. Distracters reflected students probably misconceptions on gases concepts defined in related literature (Benson et al. 1993; Lin et al. 2000; Niaz 2000; Pereira and Pestana 1991; Azizoğlu, 2004) and revealed in the analyses of gases misconception test.

During the developmental stage of the test, the instructional objectives of gases concepts were stated (see Appendix A) by considering national curriculum. Then students' misconceptions in gases concepts were determined by examining related literature and analyzing students' answers to gases misconception test. Finally the test items were constructed in a way that each question reflects students' misconceptions on gases concepts. The taxonomy of the misconceptions and the corresponding questions are given in Table 4.2.

Table 4.2 Taxonomy of GCT's Questions that Include Students' Misconceptions about Gases Concepts

MISCONCEPTIONS	ITEMS
Molecules increase in size with change of state from solid to liquid to gas.	1
Gases are lighter than liquids so the mass of the substance decreases with change of state from solid to liquid to gas.	1, 8
Gas particles take the shape of container with change of state from solid to liquid to gas.	1
Gas pressure depends on the shape of the container.	2
The particles in a gas are unevenly scattered in any enclosed space.	3, 5, 9, 15, 16, 17
When the air is compressed, the particles stick together	13
The air particles are all pushed to the end of the syringe.	13
In compressed air the particles are compacted like a solid and do not move.	13
Air neither has mass nor can it occupy space.	8
Matter exists between atoms.	25
Gases behave ideally at room temperature	23
Gas behavior is similar to liquid behavior.	7
When the air is compressed temperature increases because kinetic energies of the particles increase.	4
Misuse of Charles's law	6,
Misuse of Ideal Gas Law	10, 12, 14, 18
Heated gas weights less	20
The conditions that gases behave ideally depend on the nature of the gas.	23
Gases behave ideally at low temperature and high pressure.	11
When the air is compressed size of the molecules decreases because of the decrease in volume.	13

Before the treatment the test was piloted and some corrections were made. The test was administered to 170 tenth grade students in two different public high schools and one private high school in Turkey. Cronbach- alpha reliability of the test was calculated as 0.76. The content validity of the test was provided by the chemistry teachers and chemistry education experts for the appropriateness of the questions to the instructional objectives. Also the test was controlled with respect to its grammatical aspects and understandability and it was used as an evidence for face validity in validity issue.

This test was given to experimental and control groups as pre-test to examine students' misconceptions before the treatment and post-test to assess effect of treatments on students' understanding of gases concepts. Each correct answer is given 1 point and total possible score was 25 (see Appendix B).

4.4.3 Gases Achievement Test

In order to assess students' achievement in numerical problems about gases concepts, GAT was developed by researcher. The content of the test was determined by examining instructional objectives of gases concepts in parallel with gases concept test. The test includes 15 multiple choice questions with one correct answer and four distracters. Each correct answer is given 1 point and total possible score was 15 (see Appendix C). Item 1, 3, 6, 7 were related to partial pressures of gases; item 2, 5, 8 were related to volumes of gases; item 4 and 14 were related to diffusion of gases; 9, 10, 11, 12, 13, 15 were related to ideal gas laws. Those questions required students to make some numerical calculations by using appropriate formula to the given situations.

Pilot test of Gases Achievement Test was conducted before the treatment. The questions were administered to 170 tenth grade students in two different public high schools and one private high school in Turkey. The Chronbach-alpha reliability of the test was found to be 0.82. To examine content validity and appropriateness, the items were evaluated by chemistry teachers and chemistry education expert.

The test was given to both groups as pre-test to assess student' achievement in gases concepts before the treatment and as post-test to determine effect of treatments on students' achievement on gases concepts.

4.4.4 Science Process Skill Test (SPST)

The test was developed by Okey, Wise and Burns (1982). It was translated and adopted into Turkish by Geban, Aşkar, and Özkan (1992). The aim of the test was to measure intellectual abilities of students related to identifying variables, stating and identifying hypotheses, operationally defining and designing investigations, graphing and interpreting data. This test consisted of 36 four-alternative multiple choice questions. The reliability of the test was found to be 0, 85. This test was given the students in both experimental and control group before the treatment. Each correct answer is given 1 point and total possible score was 36 (see Appendix D).

4.4.5 Attitude Scale toward Chemistry (ASTC)

This scale was developed by Geban, Ertepinar, Yilmaz, Altın, and Şahbaz, (1994) to measure students' attitudes toward chemistry as a school subject (see Appendix E). The test was given to both groups as posttest and pretest to analyze the effect of instruction on students' attitude. This scale consists of 15 items in 5-point likert type scale: fully agree, agree, undecided, disagree, and fully disagree. Total possible ASTC scores range from 15 to 75. The reliability was found to be 0.83. While lower scores show negative attitudes toward chemistry, higher scores show positive attitudes toward chemistry.

4.4.6 Views on Science Technology Society

VOSTS which is originally developed by Aikenhead, Fleming and Ryan (1989) included 114 multiple choice items related to various science- technology- society topics. This item pool was developed empirically with grade 11 and 12 Canadian students over six-year period. Each item in VOSTS is assigned a five digit code. The first digit shows the major section:

1. Science and technology,
2. Influence of society on science/technology,
3. Left blank for future category,
4. Influence of science and technology on society,
5. Influence of school science on society,
6. Characteristics of scientist,
7. Social construction of scientific knowledge,
8. Social construction of technology,
9. Nature of scientific knowledge.

The second two digits correspond to topic number within the major section. The fourth digit refers to the item number within the topic and the last digit differentiates items that have slight variations in meaning or wording.

The alternatives in the VOSTS were not derived from a theory or researchers views, rather they were derived empirically from the domain of students' viewpoints. So the instrument does not convey students' ideas in numerical scores by assigning 1 for true answer and 0 for wrong answer. Hence in their study Bradford, Rubba and Harknes (1995) categorizes alternatives reflecting different views as realistic, has merit and naïve. The alternatives in the Realistic (R) category reflect the most proper and contemporary view on nature of science for that specific item. Has Merit (HM) category involves alternatives reflect a number of valid but not realistic points about nature of science. Alternatives in the last category of Naïve (N) reflect inappropriate and not valid views about nature of science.

The instrument used in this study was the Turkish version of Views on Science-Technology- Society (T-VOSTS) which is translated and adopted by Doğan Bora, Aslan and Çakıroglu (2006) and the reliability was found as 0.72 (see Appendix F). T-VOSTS contained twenty five items selected from six major sections of VOSTS item pool;

- Science and technology (Item 1)
- Influence of society on science/technology (Items 2 and 3)
- Influence of science and technology on society (Items 4, 5 and 6)
- Characteristics of scientist (Items 7, 8 and 9)
- Social construction of scientific knowledge (Items 10 and 11)
- Nature of scientific knowledge (Other items)

In this study the evaluation of students' responses were made by using the categorization systems of Doğan Bora et al. (2006). The following table summarized the item numbers, corresponding code in the original VOSTS item pool, topics related to each item and categories of alternatives.

Table 4.3 Items of T-VOST and Categories of the Alternatives

Number of item in T-VOSTS	Code in VOSTS item pool	Topic	Scores of Alternatives		
			R	HM	N
1	10111	Defining science	C	A,B, D, F, G	E, H
2	20411	Ethics	B,D	A, C, E	F, G
3	20711	Public influence on scientist	D,F	A, B, E	C, G
4	40111	Social responsibility of scientists	D,E	C, G	A, B, F
5	40213	Contribution of social decision	D	A, C	B, F, E, G
6	40431	Resolution of social and practical problems	A	C, D	B, E
7	60211	Standards/values that guide scientists at work and home	B,C	D	A, E, F
8	60411	Abilities needed to do science	B,C	D, E	A
9	60511	Gender effect on the process and product of science	E, F	G	A, B, C, D
10	70412	Professional interaction in the face of competition	E	A, D	B, C
11	70511	Social interactions	A	B, C, D	E
12	90111	Nature of observations	A,B	C, D	E
13	90211	Nature of scientific models	F	E, G	A,B, C, D
14	90311	Nature of classification schemes	C,D	E	A,B,F
15	90411	Tentativeness of scientific knowledge	A,B	D	C, E
16	90511	Hypothesis, theories and laws	D		A,B,C
17	90521	Hypothesis, theories and laws	E	A,C,D	B, F
18	90541	Hypothesis, theories and laws	A,C	B, D	E,F

Table.4.3 (continued)

Number of item in T-VOSTS	Code in VOSTS item pool	Topic	Scores of Alternatives		
			R	HM	N
19	90621	Scientific approach to investigations	C	A, B	D, E
20	90651	Scientific approach to investigations	C	B, D	A, E
21	90711	Precision and uncertainty in scientific/technological knowledge	A,D	B,C	E
22	91011	Epistemological status of scientific knowledge	E	A, C	B, D
23	91012	Epistemological status of scientific knowledge	F	C, E	A,B,C
24	91013	Epistemological status of scientific knowledge	E	B, C	A,D,F
25	91111	Paradigms versus coherence of concepts across disciplines	A	C,D,E	B

4.4.7 Interview

A semi-structured interview schedule was designed by the researcher. In semi-structured interviews interviewer determines interview questions beforehand, but can ask follow up questions and can ask new questions depending on the situation. The main aim of the interview was to investigate nature and reasons of students' misconceptions in gases concepts. Also the effect of treatment on remediation of students' misconceptions was analyzed deeply by comparing the answers of experimental and control group students. The questions in the interview were prepared according students' responses in gases concept test and common misconceptions found in the literature related to the gases concepts. The 7 questions were related to gas properties, distribution of gas particles at different temperatures, diffusion of gases, gas laws, partial pressures of gases and ideal gases. Before applying interview in the main study as a pilot it was applied to 3 tenth grade students and 2 eleventh grade students. The main purpose of the pilot was to check whether questions are ambiguous or not and check the effectiveness of the interview questions in gaining information about students' misconceptions about gases concepts. After the pilot, necessary corrections were made related to the questions. In the study 12 students (6 from experimental group and 6 from control group) were interviewed at the end of the treatment. Students were selected with respect to their scores on post-concept test. According to post-concept test scores students in experimental and control group were categorized as high achievers, middle achievers and low achievers. From each group 6 students were chosen randomly in a way that students reflect three categories of achievement. Each interview took approximately 40 minutes and all individually conducted interviews were audio taped.

4.4.8. The Classroom Observations

The main aim of classroom observation was to observe the implementation of treatment in the experimental and control group. In the experimental group implementation of conceptual change oriented instruction accompanied with computer animations and in the control group implementation of traditionally designed chemistry instruction was analyzed carefully. Also the interaction between teacher and students, participation of students to the lessons and classroom environment was observed. During each observation naturalistic approach was followed and the researcher sat silently and took notes about the implementation process. Also an observation checklist that consisted of 15 items with 3 point Likert type scale (Yes/ No/ Partially) was used during the observation. (see Appendix G).

4.5 Treatment

This study was conducted over seven weeks during the first semester of 2008-2009 academic years. Total 67 students from two 10th grade classes participated in the study. Classes were randomly assigned as control and experimental groups. Experimental group students were instructed with conceptual change oriented instruction accompanied with computer animations whereas control group students were instructed with traditionally designed chemistry instruction. Both groups were instructed by the same chemistry teacher throughout the treatment. Before the treatment she was trained about conceptual change oriented instruction. For each topic a detailed lesson plans appropriate the conceptual change approach were prepared by the researcher (See Appendix H). Before each session corresponding lesson plan and computer animations which were also prepared by researcher were explained to the classroom teacher. Furthermore the teacher was informed about students' possible misconception about the concept. The researcher did not spend much effort to explain traditional instruction to her because she has already experienced with it.

During the treatment experimental and control groups covered the same subject matters and used the same textbook. The same quantitative problems were solved in experimental and control groups. Also the teacher assigned the same homework to both groups. The classroom instruction was two 45-minutes sessions in a week and gases topic was covered as a part of regular curriculum. The concepts covered were properties of gases, volume of gases, kinetic theory of gases, pressure of gases, diffusion of gases, gas laws (Charles Law, Boyle's Law, Gay-Lussac's Law, and Avogadro's Principle), ideal gas law and partial pressures of gases.

Before the treatment Gases Concept Test, Gases Achievement Test, Attitude Scale toward Chemistry and Science Process Skill Test were administered to both groups as a pre test. Gases Concept Test and Gases Achievement Test were used in order to examine students' level of understanding and their achievement in solving numerical problems about gases concepts before the treatment respectively. The aim of using Attitude Scale toward Chemistry as a pre-test was to measure students' attitudes toward science as a school subject. Science Process Skill Test was administered to assess students' level of science process skills. Also Gases Concept Test, Gases Achievement Test, and Attitude Scale toward Chemistry were administered as a post- test to examine the effect of treatment. Adopted version of Views on Science- Technology- Society (T-VOSTS) was administered to both groups after treatment to obtain information about students' views on nature of science concepts. 2 months after treatment GCT was administered again as a GRT to both groups to assess their retention on gases concepts.

Traditionally designed chemistry instruction was used in the control group. This method was mainly based on lecturing and discussion. During the treatment the teacher explained the topic, wrote the key concepts and formulas on the board and made students to write them on their notebooks. When explaining the subject the teacher did not consider students' previous knowledge and their misconceptions. If students did not understand the concept, the teacher gave extra explanations or created discussion environment. However none of them forced students to think about their concepts. During discussions teacher directed students to find correct answers. Students were accustomed to take the correct answer from the teacher and memorize them. When the topic included algorithmic questions, the teacher solved first two or three problems on the board and to check students' understanding asked them similar problems. Generally the teacher wrote the problem on the board and gave them a two or three minutes. A few hardworking students were solving the problem faster than others, and the teacher mostly selected these students to solve the problem on the board. The rest of the class copied the solution from the board.

To make summary sometimes teacher asked conceptual questions, but these question did not include any interpretation. Students mostly answered them by using their memorized knowledge. For example when summarizing the concept of Charles Law the teacher asked "What is the relation between temperature and volume". One of the students replied the question as we increase the temperature of a gas its volume also increases. At the end of the lesson, the teacher assigned them homework questions.

In the experimental group conceptual change oriented instruction developed by Posner et al. (1982) accompanied with computer animation was used. For each sub-topic of gases, teacher tried to accomplish Posner et al's (1982) conditions of dissatisfaction, intelligibility plausibility and fruitfulness. The instruction mainly based on revealing students' misconceptions, replacing them with scientific conceptions and relating their prior conceptions with the new concept.

Each lesson in experimental group started with a question asked by teacher. The aims of these questions were to activate students' prior conceptions or misconceptions about the concepts. Generally after this question, different answers emerged and a disagreement among students occurred. The teacher guided this discussion until students were aware of their knowledge fails to explain the situation. For example when the teacher was explaining Gay-Lussac's Law she started to lesson by asking "What would happen to gas particles if we heat it in a closed container?" Students gave different answers such as particles expand or particles accumulate at the top of the container. After getting students' alternative conceptions the teacher asked additional questions to make students dissatisfied with their conceptions. For instance the teacher asked if the particles of gas accumulate at the top of the container what is there at the bottom. By asking similar questions the teacher aimed that students notice their misconceptions (dissatisfaction).

After this discussion the lesson continued with the scientific explanation of the concept. The teacher explained the subject on the computer animations. For example when explaining the relation between temperature and volume, the teacher showed the related animation. In this animation there is a container with movable piston, a thermometer, an apparatus showing pressure of the container and a heater at the bottom of the container. Thorough the animation pressure is shown at constant (1 atm). Also the students can see the particles of gas in the container. The particles are in constant motion, collide with each other and wall of the container. The temperature of the container can be changed with the help of a button. When teacher press the button the heater run and the temperature increase is seen from the thermometer. Teacher can also decrease the temperature. When teacher press the button to increase the temperature, the particles of the gas start to move faster, collide with each other and the wall of the container more frequently. As the gas particles hit the top of the container more, the piston move upward and the volume of the container increases. If the teacher decreases the temperature the movement of gas particles slows down. They collide with each other and top of the container less and piston move upward so the volume of the container decreases. After students engaged with this animation, teacher asked conceptual questions. These questions emphasized students' misconceptions and aimed to show why they were wrong. This discussion continued until students reach scientific explanation of the concepts. For instance the teacher explained that "As you see from the animation gas particles move in different directions at different speeds. If we increase the temperature the energy of gas particles also increases and they start to move faster and collide with each other and sides of the container more. So as the frequency of hit of the particles to the upper side of the container increases, the volume of the container increases until the pressure inside the container become equal the outside pressure. This is known as Charles Law". Also if the concepts include some formulations, numerical problems were solved by teacher or students (intelligibility). Throughout the implementation the computer animations were used to accomplish intelligibility phase. For each concept the teacher used corresponding animation to show the intelligibility of the concept to the students.

To enhance students' understanding of the concepts the teacher presented a new situation or daily life examples. For example after explaining the pressure and temperature relation the teacher said that basketballs jump less in cold weathers and asked students to state the reason of this situation. By this way students got an opportunity to test the plausibility of the new concept (plausibility).

At the end of the lesson teacher gave homework. For example about diffusion of gases students assigned homework that “What is the reason that different gases have different diffusion rates? Are there any gases having the same diffusion rates?”(fruitfulness).

4.6 Computer Animations

There are ten animations related to gas concepts. The content of the animation were prepared by researcher and they were designed by a professional instructional designer. All of the animations were examined by three experts in chemistry education, two instructional designers and classroom teacher.

The first animation was related to properties of gases. On the screen there were three substances. One of them is in solid state, the other one is in liquid state and the other in gaseous state. Students can see the particles of each substance with the help of magnifier. When using this animation the teacher warned students that actually the particles of substance are colorless and we cannot see them with any magnifier. When the teacher took the magnifier on the gaseous substance students saw that particles are in constant motion, collide with each other and hit the wall of the container (See Appendix I).

The second animation was related to kinetic theory of gases. There was a closed container filled with HCl gas. Students can see the movement of gas molecules. The molecules were in constant motion, moved in all direction with different speeds, collide with each other elastically (See Appendix J).

The third animation was related to volume of gases and partial pressures of gases. There were two non reactant gases in a closed container separated with each other with a moveable barrier. When teacher removed the barrier, particles of two gases mixed with each other. Students can see that gas particles distributed the container homogenously and completely filled the container. Also particles of two gases mixed in all proportion (See Appendix K).

The fourth animation was related to diffusion of gases. There was a cylinder and two gases (NH_3 and HCl). Hydrogen chloride and ammonia gases were sent to a test tube from two sides to observe formation of ammonium chloride solid. Students can see that particles of ammonia gases moved faster than that of hydrogen chloride by the help of magnifier (See Appendix L).

The fifth animation was related to pressures of gases. There was a closed-end manometer. Teacher can change the pressure to see the height of the gas on the columns. Or by the same way the height of the gas on the columns can be changed to observe pressure (See Appendix M).

The sixth animation was related to the Boyle's Law. Students were shown a container filled with a gas. Students can see the particles of gas in the container. The particles are in constant motion, collide with each other and wall of the container. Thorough the animation temperature is shown at constant. The volume of the container can be changed with the help of a button. When teacher press the button force was applied to the top of the container, volume of the container decreased gradually and particles of gas started to collide with each other and the wall of the container more frequently. From the apparatus students saw the increase in pressure (See Appendix N).

The seventh animation was related to the Charles' Law. On the screen container with movable piston, a thermometer, an apparatus showing pressure of the container and a heater at the bottom of the container were seen. Thorough the animation pressure is shown at constant (1 atm). The temperature of the container can be changed with the help of a button. When teacher press the button the heater run and the temperature increase is seen from the thermometer. When teacher press the button to increase the temperature, the particles of the gas start to move faster, collide with each other and the wall of the container more frequently. As the gas particles hit the top of the container more, the piston move upward and the volume of the container increases (See Appendix O).

The eighth animation was related to the pressure and temperature relation in gases. A closed container filled with gas. At constant volume, temperature of the system can be increased with the help of heater. When the temperature increased, students saw that the particles of the gas start to move faster collide with each other and hit wall of the container more frequently. So the pressure of the gas increased at the cursor (See Appendix P).

The ninth animation was related to Avogadro's Principle. There is a gas in a container with movable piston. The pressure and temperature of the system were shown as constant. From the gas tank extra gas can be added to the container by the help of button. As the number of gas particles increased, the frequency of collision between particles and hit of the particles to the wall of the container increased, and the volume also increased (See Appendix R).

The tenth animation was related to relation between moles of gas and pressure. The closed container was filled with gas. The volume and temperature of the system held constant through the animation. As the extra gas added from the gas tank to the container, the particles started to collide with each other and hit the wall of the container more frequently. So students could see the increase in pressure from the cursor (See Appendix S).

4.7 Treatment Fidelity and Treatment Verification

Treatment fidelity provide researcher to ensure that another factor except treatment is not responsible the difference in the dependent variable before study is conducted (Borrelli et al., 2005; Detrich, 1999; Hennessey & Rumrill, 2003). A criterion list that explains the methods for both EGs and CGs was formed. This criterion list involved not only what should be required in both EGs and CGs but also involved what should not be required in the methods implemented in both EGs and CGs. In the next step to ensure treatment fidelity, a lesson plan that integrated with the criterion list and objectives of the lesson was prepared. One chemistry professor, one chemistry education professor, two research assistant from chemistry education department, and two teachers reviewed the activities (see Appendix F) and the instruments whether they were appropriate for the purpose of the study. Their feedbacks were taken into consideration. The last step to ensure treatment fidelity was to train the teacher with respect to lesson plan and activities that implemented in both EGs and CGs.

Treatment verification provides researcher to ensure that treatment was implemented as defined in the study (Shaver, 1983). An observation checklist that consisted of 15 items with 3 point Likert type scale (Yes/No/Partially,) was formed. Researcher and a research assistant from chemistry education rated this checklist. The minimum criterion was determined as at least 75% of the items were expected to be marked as average or above to say that the treatment was implemented as intended. Moreover, teacher and some students were interviewed to evaluate whether the treatment was implemented as expected. The interviews confirmed the checklist results which indicated that treatment was done as it was expected.

4.8 Internal Validity Threats

Cook and Campbell (1979) defined internal validity as the ability that one can infer existing of a causal relationship between two variables. If a research study is internally valid, it can be concluded that any observed relationship between two or more variables is unambiguous, rather than influenced by any other factors (Fraenkel & Wallen, 2006). These uncontrolled factor affecting performance on the dependent variables are named as the threats to internal validity of an experiment (Gay & Airasian, 2000). Cook and Campbell (1979) and Gay and Airasian (2000) defined the threats to internal validity as history, maturation, testing, instrumentation, statistical regression, differential selection of participants, mortality and selection-maturation interaction. Fraenkel and Wallen (2006) talked about also location and attitudes of subjects.

History means any unplanned events occurred during treatment and can affect responses of students (Gay & Airasian, 2000). If the time interval between pre-tests and post-tests measurement of the dependent variables is long, the probability of occurrence such an event increases. During the treatment, the researcher participated all of the lessons and observed students. Also the researcher took information from the counselor teachers about the students. Occurrence of any unexpected event was not detected during the treatment. So it can be said that history threat was controlled.

Maturation means possible changes in students due o passing of time rather than intervention (Fraenkel & Wallen, 2006). The treatment was lasted seven weeks, which is not too long to anticipate significant physiological or psychological changes in students, and the instruments were administered to both groups in the regular classrooms in the same week. As a result maturation threat was controlled.

Testing means the improvement in students' post-test scores because of having taken a pre-test (Fraenkel & Wallen, 2006). Johnson and Christensen (2004) argued that if a test is administered to second time, you become familiar with it and may remember your prior responses and can correct your errors. In this study the time between pre and post tests was seven weeks. It is assumed that this time was sufficient for desensitization.

Instrumentation threat occurs if unreliable or inconsistent measurements were used which may cause invalid assessment of performance (Gay & Airasian, 2000). The pre and post tests used in this study for both groups were the same and their reliabilities were sufficiently high. Therefore it can be said that instrumentation was controlled. Also Fraenkel and Wallen (2006) said that data collector characteristics and data collector bias may be a threat to internal validity. Since the researcher collected all the data from both groups in a standardize condition, these threats were controlled.

Statistical regression of subject refers that when already formed groups were used, post-test scores differences between groups may be due to their initial differences (Gay & Airasian, 2000). To control this threat students' understanding and achievement in gases concepts and their attitudes toward chemistry and science process skills were controlled with pretests.

Mortality means lose of some subjects during the treatment (Fraenkel & Wallen, 2006). In this study none of the students dropped out of the study.

Selection-maturation interaction means that one of the groups may benefit more or less from the treatment or have an advantages or disadvantages because of maturation, history or testing factors (Gay & Airasian, 2000). Since all of these three factors were controlled, selection- maturation interaction was not a threat to internal validity.

Location mentioned by Fraenkel and Wallen (2006) refers that students' responses may be affected from the location where data are collected or treatment is carried out. Students were given all the instruments and treatment was implemented in the regular classrooms so this was not a threat to internal validity.

Attitude of subjects may be a threat related to their view about study (Fraenkel & Wallen, 2006). Students were convinced that none of the treatment was novel or superior to one another. However there may be students in the experimental group who thought that they receive special treatment. This view may cause an increase in their post-tests performance.

4.9 Analysis of the Data

To analyze the raw data obtained from this study, SPSS was used both for descriptive and inferential purposes.

4.9.1 Descriptive Statistics

Mean, range, maximum and minimum values, standard deviation, skewness, kurtosis, frequency tables and bar graphs were used for the data obtained from students in experimental and control groups.

4.9.2 Inferential Statistics

Independent sample t-tests were used to check the equality of groups in the scores of gases concept test, gases achievement test, attitude scale toward chemistry and science process skill test before treatment. In the line of the results of the t-test science process skill was determined as a covariate.

Analysis of Covariance (ANCOVA) and Analysis of Variance (ANOVA) were used for inferential statistics. ANCOVA was used to determine effectiveness of two different instructional methods and gender difference on students' understanding, achievement and retention related to gases concepts by controlling the effect of students' science process skills as a covariant. Two-way ANOVA was used to test the effect of treatment on students' attitudes toward chemistry as a school subject. Also this test was used to examine the gender effect on students' attitudes toward chemistry as a school subject.

4.10 Assumptions and Limitations

4.10.1 Assumptions of the Study

1. The teacher was not biased during the treatment.
2. There was no interaction between groups.
3. The tests were administered under standard conditions
4. The classroom observations were performed under standard conditions.
5. Student interviews were conducted under standard conditions.
6. The participants of the study answered the questions of instruments sincerely and accurately.

4.10.2 Limitations of the Study

1. The subjects of the study were limited to 67 tenth grade students a a public high school in Ankara.
2. The study was limited to gases concepts in chemistry.
3. Because of administration procedures, the subjects were not randomly assigned to the groups.

CHAPTER 5

RESULTS AND CONCLUSIONS

In this chapter, analyses of the hypotheses given in Chapter III and T- VOST test were given. Moreover, the results of student interviews, and classroom observations were stated. The first section included descriptive statistics about pre and post test. In the second section inferential statistics about hypotheses were specified. Analyses of Misconception Test were given in the third section, analyses of interviews were presented in the fourth section and analyses of classroom observation were explained in the fifth section. Analyses of 25 items of T-VOST were summarized in the sixth section. The last section stated the conclusion by considering the findings of research.

5.1. Descriptive Statistics

In Table 5.1 descriptive statistics related to students' gases concept pre- and post- test scores, gases achievement pre- and post test scores, gases retention test scores, science process skills test scores and attitude scale toward chemistry pre- and post test scores of students in the experimental and control groups were given.

Table 5.1 Descriptive Statistics Related to the Gases Concept Test (GCT), Gases Achievement Test (GAT), Gases Retention Test (GRT), Science Process Skill Test (SPST) and Attitude Scale toward Chemistry (ASTC) Scores of Students in Control Group (CG) and Experimental Group (EG)

Group	Test	N	Min	Max	Mean	SD	Skewness	Kurtosis
CG	Pre-GCT	33	2	13	6.91	2.64	.224	-.236
	Post-GCT	33	6	18	10.67	3.12	.644	-.060
	Pre-GAT	33	1	8	2.75	1.50	1.564	3.645
	Post-GAT	33	1	13	6.36	2.76	.479	.200
	GRT	33	2	17	10.03	3.38	-.187	-.425
	SPST	33	13	25	17.82	3.23	.454	-.690
	Pre-ASTC	33	10	51	29.33	9.16	.139	-.059
	Post-ASTC	33	17	70	34.73	11.60	1.132	1.891
EG	Pre-GCT	34	3	13	8.03	2.58	.214	-.806
	Post-GCT	34	10	21	15.62	2.80	-.040	-.885
	Pre-GAT	34	1	6	2.92	1.37	.167	-.710
	Post-GAT	34	6	14	9.94	2.50	.120	-1.159
	GRT	34	7	20	15.25	3.06	-.114	-.340
	SPST	34	15	28	21.68	2.89	-.133	.175
	Pre-ASTC	34	10	51	28.76	9.23	.137	.101
	Post-ASTC	34	20	61	41.65	11.66	-.333	-.765

Students’ pre-gases concept test scores range from 2 to 13 with a mean of 6.91 in the control group and range from 3 to 13 with a mean of 8.03 in the experimental group. The higher test scores show better understanding in gases concept. The difference in the mean pre-gases concept test scores of students in the control and experimental group is 1.12. When the post-gases concept test scores of students were examined they range from 6 to 18 with a mean of 10.67 in the control group and range from 10 to 21 with a mean of 15.62 in the experimental group. The mean score increase of 7.59 in the experimental group is higher than the mean score increase of 3.76 in the control group.

Pre-gases achievement test scores of control group students range from 1 to 8 and 1 to 6 for experimental group students with higher scores mean better solving numerical problems about gases concepts. The mean pre-gases achievement test scores of control and experimental groups’ students are 2.75 and 2.92 respectively. While the mean post-gases achievement test scores of students in the control group is 6.36 and 9.94 for those in the experimental group. The mean score increases are 3.61 for control group 7.02 for experimental group.

Control group students' scores in gases retention test range from 2 to 17 with a mean of 10.03 and experimental group students' scores in gases retention test range from 7 to 20 with a mean of 15.25. Higher scores show better retention in gases concepts. When the students' gases retention test scores taken in the account, it is seen that retention of students in the experimental group is better than the students in the control group.

Students' science process skills test scores range from 13 to 25 for control group, 15 to 28 for experimental group and greater scores indicate higher abilities in solving science problems. The mean of science process skills test score is 17.82 in the control group and 21.68 in the experimental group. The difference in the scores shows that experimental group students have higher abilities in solving science problems.

As shown in the Table 5.1 before the treatment students' attitude scale toward chemistry scores range from 10 to 51 with a mean of 29.33 in the control group and range from 10 to 51 with a mean of 28.76 in the experimental group. The higher test scores mean more positive attitude toward chemistry. After the treatment the mean scores of student in attitude scale toward chemistry are 34.73 for control group, 41.65 for experimental group.

Also when the skewness and kurtosis values of all test scores are examined it can be seen that all of them range from -4 to +4 which is the indication of normal distribution.

5.2. Inferential Statistics

In this section analysis of ten null hypotheses stated in chapter III is presented. Analysis of variance (ANOVA) and analysis of covariance (ANCOVA) were used to test hypothesis at a significance level of .05. Statistical analyses were performed by using the SPSS/PC (Statistical Package for Social Sciences for Personal Computers).

Before carrying out the ANOVA and ANCOVA analyses, independent sample t-test analyses were performed to check whether there was a significant mean difference between experimental and control groups with respect to students' understanding of gases concepts measured by gases concept test, achievement in gases concept measured by gases achievement test, attitude towards chemistry measured by attitude scale toward chemistry and science process skills measured by science process skill test before the treatment.

The results of independent sample t-test analyses showed that there was no significant mean difference between the CCOI group and TDCI group in terms of students' understanding in gases concepts ($t(65) = -1.759$, $p = .083$), achievement in gases concepts ($t(65) = -438$, $p = .663$), and their attitude toward chemistry ($t(65) = 2.253$, $p = .801$), before the treatment. However a significant difference was found between the two groups with respect to science process skills ($t(65) = -5.153$, $p = .00$).

5.2.1. Null Hypothesis 1

The first hypothesis stated that there is no significant mean difference between post-test mean scores of students taught with conceptual change oriented instruction and students taught with traditionally designed chemistry instruction in students' understanding of gases concepts when science process skills is controlled as a covariate. To test this hypothesis analysis of covariance (ANCOVA) was conducted. Before the analysis assumptions of ANCOVA were tested.

The first assumption is the univariate normality. From the skewnees and kurtosis values given in Table 5.1 we can say that gases concept test scores are normally distributed. The second assumption is independent observation. It is assumed that standardized conditions were provided during test administrations. Also both researcher and the classroom teacher made observation when the tests were administered. So it is safe to say that participant did not influence each other. For the equality of variances assumption, Levene's Test of Equality was used. The results showed that equality of variance assumption is met ($F(1, 65) = .161$, $p>.05$)

The fourth assumption is that there should not be a custom interaction between independent variable and covariate. It is seen in Table 5.2 that there is no custom interaction between science process skill test scores of students and treatment ($F(1, 1) = 1.027$, $p>.05$)

Table 5.2 Test of Between-Subject Effect

Source	df	SS	MS	F	p
Treatment	1	.004	.004	.000	.983
SPST	1	.173	.173	.019	.891
Treatment*SPST	1	9.350	9.350	1.027	.315
Error	62	573.528	9.104		

The last assumption requires a significant correlation between dependent variable and covariate. To check this assumption correlation between gases concept test scores and science process skill test scores of students was calculated and shown in Table 5.3. The result showed that the correlation is significant

Table 5.3 Correlation between Post-concept test scores and SPST scores

		Post-concept	SPST
	Pearson Correlation	1	.327**
Post-concept	Sig.	.	.007
	N	67	67
	Pearson Correlation	.327**	1
SPST	Sig.	.007	.
	N	67	67

After checking all the assumption ANCOVA was run. The results are summarized in table 5.4

Table 5.4 ANCOVA Summary

Source	df	SS	MS	F	P
Covariate (SPST)	1	1.074	1.074	.116	.734
Gender	1	9.130	9.130	.987	.324
Treatment	1	301.244	301.244	32.555	.000
Gender*Treatment	1	.001	.001	.000	.990
Error	62	573.708	9.253		

The results showed that there was a significant mean difference between post test mean scores of students taught with conceptual change oriented instruction and students taught with traditionally designed chemistry instruction in students' understanding of gases concepts when science process skills is controlled as a covariate, $F(1, 62)=32.555$, $p< .05$. The CCOI group scored significantly higher than TDCI group ($\overline{X}$ (CCOI) = 15.62, $\overline{X}$ (TDCI) = 10.67).

Figure 5.1 shows the proportions of correct responses to the questions in the post-test for two groups.

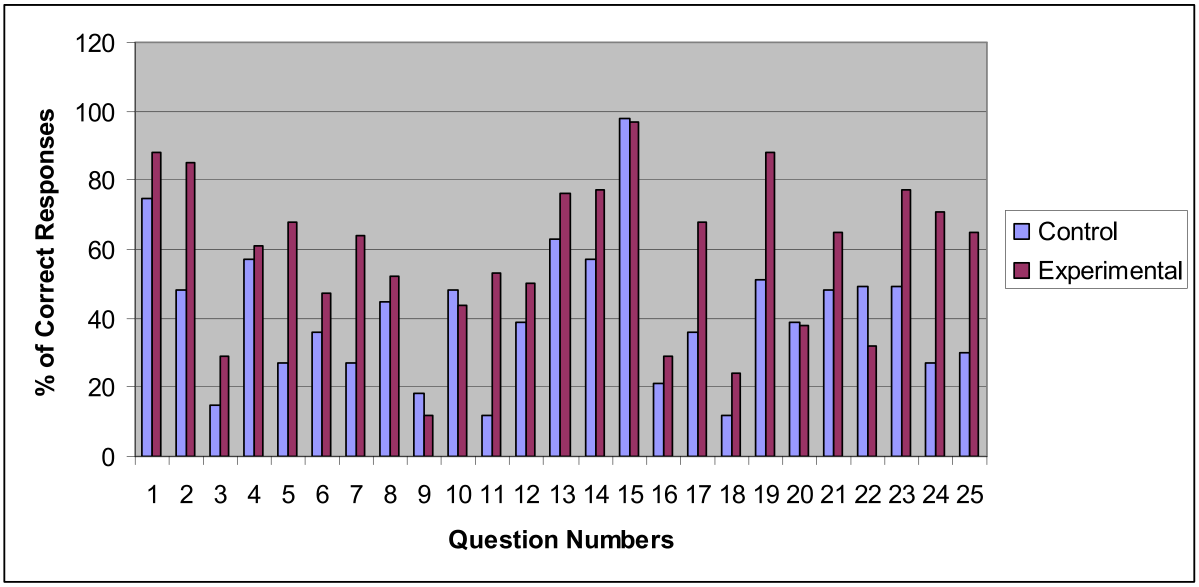


Figure 5.1 Comparison between post-GCT Scores of the Experimental and Control Group

It is seen from Figure 5.1 that there were dramatic differences in the proportion of correct responses between two groups to the questions 2, 5, 7, 11, 19, 24 and 25 in the gases concept test.

Students were asked which one of the given statements is true for gas pressure in the second question. Before the treatment most of the students (55.8% for experimental group, 69.7% for control group) thought that gas pressure depends on the shape of the container. After treatment 85.3% of the students in the experimental group correctly choose the alternative that gases exert pressure equally all around the container, however this percent is only 48.5% in the control group. The misconceptions that this item measured and the percentages of experimental and control group students' selection of alternatives in the post-test are given below:

Table 5.5 Percentages of Students' Answers for Item 2

Question 25: What are there between gas particles?	Percentage of students' responses (%)	
	Experimental Group	Control Group
Alternative A Heavier gases exert more pressure	8.8	24.2
Alternative B Gases pressure is related to response that they gave because of the force exerted on them	2.9	12.1
Alternative C* Gases exert pressure equally all around the container *Correct Alternative	85.3	48.5
Alternative D Gas pressure depends on the shape of the container.	0	6.1
Alternative E Gases exert pressure when they are heated	2.9	9.1

In the 5th questions students were asked to choose correct representation of gas particles when the gas heated. In the experimental group 67.6% of the students, in the control group 27.3% of the students gave the correct answer after the treatment. Before the treatment the percentage of students giving the correct answer was 8.8% in experimental group, 9.2% in the control group. 27.3% of the students in the control group had a misconception that gas particles go to upper part of the container when the gas heated.

Question 7 asked that which one of the given statement is true related to properties of gases. Before the treatment 11.8% of the students in the experimental group, 15.2% of the students in control group choose the correct alternative that gases have particular nature. However after the treatment in the experimental group the percentage was 64.7, and 27.3 in the control group. The most common misconception in the control group students was that, 30.3% of them could not realize that gases distribute the container homogenously while, 11.7% of the students in the experimental group had this misconception after the treatment.

Question 13 asked that what happen to the molecules of air compressed in a syringe. According to post-test results proportion of the correct responses were 57.6% for the control group and 76.6% for the experimental group. The most common misconceptions seen in the control group were gases molecules shrink after compressing (24.2%) and gas moleules stick each other (15.2%). While in the experimental group the most common misconception was gas molecules stop moving after compression (20.6%).

Students were asked in the 14th question to compare the avarage kinetic energies and speeds of N_2 gases at diffenerent temperatures (one of them was at 10^oC and the other one at 100^oC), in the same volume, and pressure. The most commonly encountered misconception before the treatment was they have the same average kinetic energies. The percentage of students who answered this item correctly in the post-test was 79.4 in experimental group, and 57.5 in the control group. 17.6% of the experimental group students and 21.2% of the control group students showed the misconception that although they are at different temperatures, they have the same average kinetic energies.

In question 17 students were asked the represent the distribution of gas particles at 60 ^oC. Post-test results showed that 67.7% of the experimental group students represented the gas particles correctly, while this percentage was only 36.4 for control group. However 17.6% of the students in the experimental group and 27.3% of the students in the control group had a misconception that gas particles collected at the top of the container. Also some of the students thought that gas particles accumulated at the middle of the container (5.9% of the experimental group students and 12.1% of the control group students). Although there were no students in the experimental group having a misconception that particles stick to wall of the container, 6.1% of the control group students had this misconception.

Students were asked under which conditions gases behave ideally in the 23th question. Before the treatment the most commonly held misconception among students was that gases behave ideally at high temperature and high pressure. According to post test results the percentage of students giving correct answer was 79.4 and 45.6 for experimental and control group respectively. After the treatment, 8.8% of the experimental group students and 27.3% of the control group students still had a misconception that high temperature and high pressure causes ideal behavior of gases. Moreover 8.8% of the students in the experimental group and 18.2% of the students in the control group thought that the conditions that gases behave ideally depends on the nature of gases.

Question 24 was mainly about diffusion of gases. Students were asked to compare the diffusion rates of He, CH_4, and SO_2 gases. In this question, before the treatment, 27.3% of the students in control group and 24.6% of the students in experimental group answered this question correctly. After the treatment, while the percentage of the students who selected the correct answer in the control group was 30.3 which is very close to the percentage in pretest, however the percentage of the students who selected the correct response in experimental group increased to 70.6%. Some of the students had a misconception that gases having bigger molecular weight diffuse faster than that of having smaller molecular weight (11.8% for experimental group and 27.3% for control group).

Students were asked that what is there between gas particles in question 25. Before the treatment 39.4% of the students in the control group and 55.9% of the students thought that there is air between gas particles. Also in the literature it is the most common misconception for this question (Novick &Nussbaum, 1978). The misconceptions that this item measured and the percentages of experimental and control group students' selection of alternatives in the post-test are given below:

Table 5.6 Percentages of Students' Answers for Item 25

Question 25: What are there between gas particles?	Percentage of students' responses (%)	
	Experimental Group	Control Group
Alternative A Air	20.6	51.2
Alternative B Water vapor	8.8	3
Alternative C Other gases	2.9	9.1
Alternative D* Nothing *Correct Alternative	58.9	30.3
Alternative E Unknown matters (dirt and germs)	8.8	6.1

These results showed that the students in experimental group who were thought with conceptual change oriented instruction had better understanding in gases concepts than those in the control group who were thought by traditional instruction.

5.2.2. Null Hypothesis 2

The second hypothesis stated that there is no significant mean difference between post-test mean scores of students taught with conceptual change oriented instruction and students taught with traditionally designed chemistry instruction in students' achievement in gases concepts when science process skills is controlled as a covariate. To test this hypothesis analysis of covariance (ANCOVA) was conducted. Before the analysis assumptions of ANCOVA were tested.

The first assumption is the univariate normality. In Table 5.1 skewness and kurtosis values are given and it is seen that gases achievement test scores are normally distributed. The second assumption is independent observation. It is assumed that standardized conditions were provided during test administrations. For the equality of variances assumption, Levene's Test of Equality was used. The results showed that equality of variance assumption is met (F (1, 65) = .001, p>.05).

The fourth assumption is that there should not be a custom interaction between independent variable and covariate. It is seen in Table 5.7 that there is no custom interaction between science process skill test scores of students and treatment (F (1, 1) = .001, p>.05)

Table 5.7 Test of between-Subject Effect

Source	df	SS	MS	F	p
Treatment	1	4.530	4.530	.632	.430
SPST	1	.046	.046	.006	.937
Treatment*SPST	1	.005	.005	.001	.980
Error	63	451.465	7.166		

The last assumption requires a significant correlation between dependent variable and covariate. To check this assumption correlation between gases achievement test scores and science process skill test scores of students was calculated and shown in Table 5.8. The result showed that the correlation is significant.

Table 5.8 Correlation between Post-concept Test Scores and SPST Scores

		Post-achievement	SPST
	Pearson Correlation	1	.298**
Post-achievement	Sig.	.	.014
	N	67	67
	Pearson Correlation	.298**	1
SPST	Sig.	.014	.
	N	67	67

After checking all the assumption ANCOVA was run. The results are summarized in Table 5.9.

Table 5.9 ANCOVA Summary

Source	df	SS	MS	F	P
Covariate (SPST)	1	.033	.033	.005	.946
Gender	1	.403	.403	.055	.815
Treatment	1	155.197	155.197	21.338	.000
Gender*Treatment	1	.097	.097	.013	.909
Error	62	450.948	7.273		

The results showed that there was a significant mean difference between post test mean scores of students taught with conceptual change oriented instruction and students taught with traditionally designed chemistry instruction in students' achievement of gases concepts when science process skills is controlled as a covariate, $F(1, 62) = 21.338$, $p < .05$. The CCOI group scored significantly higher than TDCI group ($\overline{X}$ (CCOI) = 9.94, $\overline{X}$ (TDCI) = 6.36).

5.2.3 Null Hypothesis 3

The third null hypothesis stated that there is no significant mean difference between post-test mean scores of males and females on their understanding of gases concepts when science process skills is controlled as a covariate. To test this hypothesis analysis of covariance (ANCOVA) was conducted. Before the analysis assumptions of ANCOVA were tested.

The first assumption is the univariate normality. In Table 5.1 skewnees and kurtosis values are given and it is seen that gases achievement test scores are normally distributed. The second assumption is independent observation. It is assumed that standardized conditions were provided during test administrations. For the equality of variances assumption, Levene's Test of Equality was used. The results showed that equality of variance assumption is met ($F(1, 65) = .015$, $p > .05$).

The fourth assumption is that there should not be a custom interaction between independent variable and covariate.   It is seen in Table 5.10 that there is no custom interaction between science process skill test scores of students and gender ($F(1, 1) = .860$, $p>.05$).

Table 5.10 Test of between-Subject Effect

Source	Df	SS	MS	F	P
Gender	1	15.920	15.920	1.162	.285
SPST	1	77.259	77.259	5.638	.021
Gender *SPST	1	11.791	11.791	.860	.357
Error	63	863.289	13.703		

The last assumption requires a significant correlation between dependent variable and covariate. To check this assumption correlation between gases concept test scores and science process skill test scores of students was calculated and shown in Table 5.3. The result showed that the correlation is significant

After checking all the assumption ANCOVA was run. The results are summarized in Table 5.4

The results revealed that there was no significant mean difference between female and male students with respect to understanding gases concepts, $F(1, 62) = .987$, $p>.05$. The mean post-test scores were 12.62 for females and 13.86 for males.

5.2.4 Null Hypothesis 4

The fourth null hypothesis stated that there is no significant mean difference between post-test mean scores of males and females on their achievement in gases concepts when science process skills is controlled as a covariate. To test this hypothesis analysis of covariance (ANCOVA) was conducted. Before the analysis assumptions of ANCOVA were tested.

The first assumption is the univariate normality. In Table 5.1 skewnees and kurtosis values are given and it is seen that gases achievement test scores are normally distributed. The second assumption is independent observation. It is assumed that standardized conditions were provided during test administrations. For the equality of variances assumption, Levene's Test of Equality was used. The results showed that equality of variance assumption is met (F (1, 65) = .556, p>.05).

The fourth assumption is that there should not be a custom interaction between independent variable and covariate. It is seen in Table 5.11 that there is no custom interaction between science process skill test scores of students and gender (F (1, 1) = 3.546, p>.05).

Table 5.11 Test of between-Subject Effect

Source	Df	SS	MS	F	P
Gender	1	30.710	30.710	3.370	.071
SPST	1	40.857	40.857	4.483	.038
Gender *SPST	1	32.314	32.314	3.546	.064
Error	63	574.183	9.114		

The last assumption requires a significant correlation between dependent variable and covariate. To check this assumption correlation between gases achievement test scores and science process skill test scores of students was calculated and shown in Table 5.8. The result showed that the correlation is significant.

After checking all the assumption ANCOVA was run. The results are summarized in Table 5.9

The results revealed that there was no significant mean difference between female and male students with respect to achievement in gases concepts, F (1, 62) = .055, p>.05. The mean post-test scores were 8.08 for females and 8.30 for males.

5.2.5 Null Hypothesis 5

The fifth null hypothesis stated that there is no significant effect of interaction between gender difference and treatment on students' understanding of gases concepts when science process skill is controlled as a covariate. To test this hypothesis analysis of covariance (ANCOVA) was run. Table 5.4 also gives the interaction effect on understanding of gases concepts. The findings showed that there was no significant interaction effect between gender and treatment on students' understanding of gases concepts, $F (1, 62) = 000$, $p >.05$

5.2.6 Null Hypothesis 6

The sixth null hypothesis stated that there is no significant effect of interaction between gender difference and treatment on students' achievement in gases concepts when science process skill is controlled as a covariate. To test this hypothesis analysis of covariance (ANCOVA) was run. Table 5.9 also gives the interaction effect on understanding of gases concepts. The findings showed that there was no significant interaction effect between gender and treatment on students' achievement of gases concepts, $F (1, 62) = .013$, $p >.05$

5.2.7 Null Hypothesis 7

The seventh null hypothesis stated that there is no significant mean difference between students taught with conceptual change oriented instruction and students taught with traditional instruction with respect to their attitudes towards chemistry as a school subject. In order to test the hypothesis two-way analysis of variance (ANOVA) was performed. Before the analysis assumptions of ANOVA were tested.

The first assumption is the univariate normality. In Table 5.1 skewnees and kurtosis values are given and it is seen that attitude toward chemistry scores are normally distributed. The second assumption is independent observation. It is assumed that standardized conditions were provided during test administrations. For the equality of variances assumption, Levene's Test of Equality was used. The results showed that equality of variance assumption is met ($F(1, 63) = .710$, $p>.05$).

After checking all assumption two-way ANOVA was run. Table 5.12 summarizes the results of this analysis.

Table 5.12 ANOVA Summary (Attitude)

Source	df	SS	MS	F	p
Treatment	1	961.229	961.229	7.528	.009
Gender	1	22.247	22.247	.171	.681
Treatment*Gender	1	563.968	563.968	4.325	.062
Error	63	8215.760	130.409		

The results indicated that there was a significant mean difference between students taught through conceptual change oriented instruction and traditionally designed chemistry instruction with respect to attitudes toward chemistry as a school subject, $F(1, 63) = 7.528$, $p < .05$. The experimental group students got significantly higher scores on attitude scale toward chemistry than control group students ($\overline{X}$ (CCOI) = 41.65, $\overline{X}$ (TDCI) = 34.73).

5.2.8 Null Hypothesis 8

The eighth null hypothesis stated that there is no significant mean difference between males and females with respect to their attitudes toward chemistry as a school subject. In order to test the hypothesis two-way analysis of variance (ANOVA) was performed. Table 5.12 shows the effect of gender difference on students' attitudes. The results showed that there was no significant mean difference between female and male students with respect to their attitudes toward chemistry as a school subject, $F(1, 63) = .171$, $p > .05$

5.2.9 Null Hypothesis 9

The ninth null hypothesis stated that there is no significant effect of interaction between gender difference and treatment on students' attitudes toward chemistry as a school subject. In order to test the hypothesis two-way analysis of variance (ANOVA) was performed. Table 5.12 also gives the interaction effect on attitudes toward chemistry as a school subject. The findings showed that there was no significant interaction effect between gender and treatment on students' attitudes toward chemistry as a school subject, $F(1, 63) = 4.325$, $p > .05$.

5.2.10 Null Hypothesis 10

The tenth null hypothesis stated that there is no significant mean difference between the effects of conceptual change oriented instruction and traditionally designed chemistry instruction on students' retention in gases concepts when science process skills is controlled as a covariate. To test this hypothesis analysis of covariance (ANCOVA) was conducted. Before the analysis assumptions of ANCOVA were tested.

The first assumption is the univariate normality. From the skewnees and kurtosis values given in Table 5.1 we can say that gases concept test scores are normally distributed. The second assumption is independent observation. It is assumed that standardized conditions were provided during test administrations. For the equality of variances assumption, Levene's Test of Equality was used. The results showed that the equality of variance assumption is met ($F(1, 65) = .466$, $p > .05$).

The fourth assumption is that there should not be a custom interaction between independent variable and covariate. It is seen in Table 5.13 that there is no custom interaction between science process skill test scores of students and treatment (F (1, 1) = 1.234, p>.05)

Table 5.13 Test of between-Subject Effect

Source	Df	SS	MS	F	p
Treatment	1	.4.289	.4.289	.411	.524
SPST	1	9.055	9.055	.868	.355
Treatment*SPST	1	12.866	12.866	1.234	.271
Error	63	657.109	10.430		

The last assumption requires a significant correlation between dependent variable and covariate. To check this assumption correlation between retention test scores and science process skill test scores of students was calculated and shown in Table 5.14. The result showed that the correlation is significant

Table 5.14 Correlation between Retention Test Scores and SPST Scores

		Retention	SPST
	Pearson Correlation	1	.298**
Retention	Sig.	.	.014
	N	67	67
	Pearson Correlation	.298**	1
SPST	Sig.	.014	.
	N	67	67

After checking all the assumption ANCOVA was run. The results are summarized in Table 5.15

Table 5.15 ANCOVA Summary

Source	Df	SS	MS	F	p
Covariate (SPST)	1	7.259	7.259	.693	.408
Treatment	1	68.592	68.592	6.552	.013
Error	64	669.975	10.468		

The results showed that there was a significant mean difference between the mean scores of students taught with conceptual change oriented instruction and students taught with traditionally designed chemistry instruction in students' retention test scores when science process skills is controlled as a covariate, $F(1, 64)=6.552$, $p< .05$. The CCOI group scored significantly higher than TDCI group ($\overline{X}$ (CCOI) = 15.25, $\overline{X}$ (TDCI) = 10.03).

5.3. Analyses of Misconception Test

This test was used to explore whether the students had misconceptions specified in the literature and reveal students' further misconceptions about gases concepts. In the first question students were asked to determine which properties of a substance do change when it goes from liquid to solid state. The misconceptions appeared in this question and the percentages of students' having these misconceptions are given below:

Table 5.16 Students' Misconceptions in the First Question

Which properties of a substance do change when it goes from liquid to solid state?	Percentages of students' responses (%)
Gas particles take the shape of container.	24.2
Size of the particle increases.	35.4
Distance between gas particles decreases due to increase in the size of the particles.	29.1
Kinetic energy of the particles decrease because of the decrease in mass.	18.3
Volume of the substance decreases because gases occupy less space than liquids.	30.4
Gases have no mass.	44.7
Gases are lighter than liquids so the mass of the substance decreases.	16.8

The second question was related to gas pressure. Students were asked to state opinions about what gas pressure is, how it is measured, factors affecting gas pressure. Table 5.17 shows the misconceptions appeared in this question and the percentages of students' having these misconceptions.

Table 5.17 Students' Misconceptions in the Second Question

What do you know about gas pressure?	Percentages of students' responses (%)
Gas pressure depends on the shape of the container.	45.1
Gas pressure acts downward only.	38.5
Gases exert pressure only when they are compressed.	28.3
Gases exert pressure only in the closed container.	21.5

In the third question students were wanted to predict volumes of 1 mol oxygen and 1 mol helium gases in a 2 liter closed container and draw distribution of the gas particles in that container . In the following table misconceptions appeared in this question, examples of their drawings and the percentages of students' having these misconceptions are given:

Table 5.18 Students' Misconceptions in the Third Question

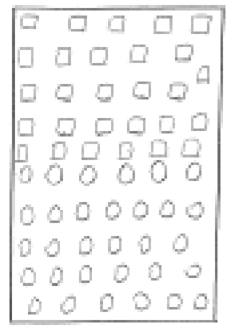
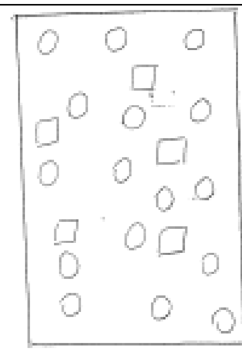
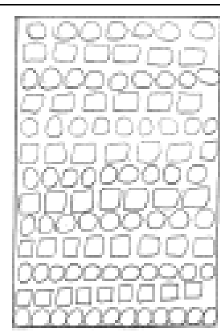
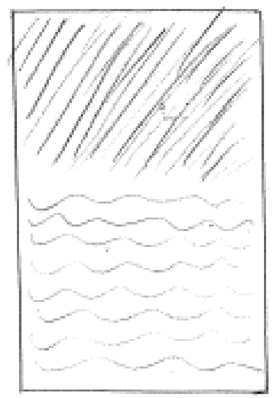
Students' misconceptions	Examples of students' drawing	Percentages of students' responses (%)
Oxygen gas at the bottom of the container, and both gases occupy 1 lt volume		16.4
Molecular weight of oxygen gas is four times greater than that of helium. So oxygen occupies 1.6 lt and helium 0.4lt volume.		34.9
Particles of gases distributed in a sequence.		22.5

Table 5.18(continued)

Students’ misconceptions	Examples of students’ drawing	Percentages of students’ responses (%)
Continuous drawing		12.3

In the forth question students were asked to draw the distribution of gas particles at two different temperatures. In the first situation students were wanted to draw representation of hydrogen gas particles at 25^{o}C and 1 atm in a closed container. In the second situation they supposed to draw representation of hydrogen gas particles if the temperature will decrease to -15^{o}C. In the following table misconceptions appeared in this question, examples of their drawings and the percentages of students’ having these misconceptions are given:

Table 5.19 Students’ Misconceptions in the Fourth Question

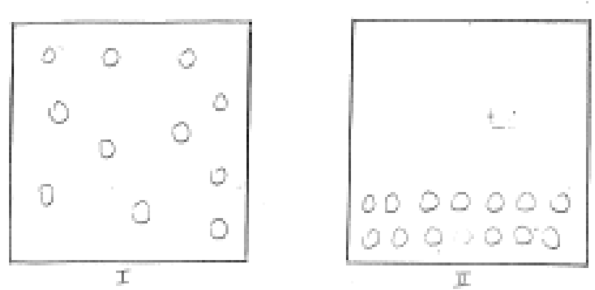
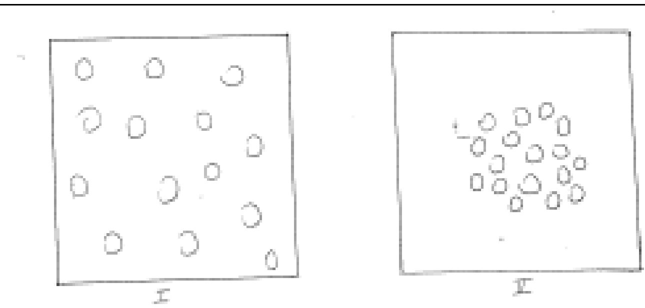
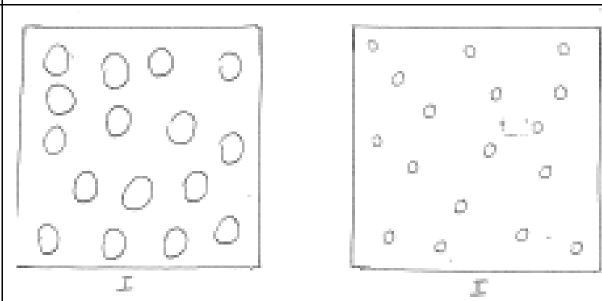
Students’ misconceptions	Examples of students’ drawing	Percentages of students’ responses (%)
Gas particles distributed at the bottom of the container non-homogeneously.		45.6

Table 5.19 (continued)

Students' misconceptions	Examples of students' drawing	Percentages of students' responses (%)
Gas particles accumulate in the middle of the container non-homogeneously.		32.3
Gas particles shrink and distributed homogenously.		14.7

The fifth question was related to ideal gases. Students were asked to state what they know about ideal gases. The misconceptions appeared in this question and the percentages of students' having these misconceptions are given below:

Table 5.20 Students' Misconceptions in the Fifth Question

What do you know about ideal gases?	Percentages of students' responses (%)
Gases behave ideally at room temperature.	8.5
The conditions that gases behave ideally depend on the nature of the gas.	26.5
Gases behave ideally at low temperature and high pressure.	36.2
Ideal gases do not give any chemical reactions.	38.5
Gases behave ideally at 0 atm. Because at 0 atm gas particles do not move.	6.9

In the sixth question students were asked to predict how the properties of a gas changes when it is compressed in a container with moveable piston. Table 5.27 shows the misconceptions appeared in this question and the percentages of students' having these misconceptions.

Table 5.21 Students' Misconceptions in the Sixth Question

How the properties of a gas do change when it is compressed in a container with moveable piston?	Percentages of students' responses (%)
Size of the molecules decreases because of the decrease in volume.	33.4
Temperature increases because kinetic energies of the particles increase.	24.3
The particles are compressed and they do not move.	17.9
The particles of gas accumulate at the bottom of the container.	44.3
The gas weights more.	27.5

In the last question students were asked to explain how the properties of a gas changes when it is heated in a container with moveable piston. The misconceptions appeared in this question and the percentages of students' having these misconceptions are given below:

Table 5.22 Students' Misconceptions in the Seventh Question

How the properties of a gas do change when it is heated in a container with moveable piston?	Percentages of students' responses (%)
PV value decrease because it is inversely proportional to T	34.0
Both pressure and volume increase	21.4
Heated gas weights less.	39.7
Gas particles expand.	41.5
Gas particles accumulate at the top of the container.	46.3

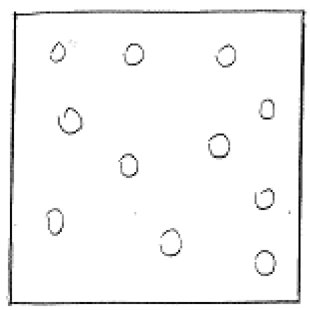
5.4. Analysis of Interview Questions

In the first question, students were asked to state which properties of a substance change and which do not change when it goes from liquid to gases state at constant temperature. All students in the experimental group could give the correct answer by explaining the reason. The following is an excerpt of Hasan who is a low achiever in the experimental group. Although he is low achiever, it is apparent from the excerpt that he constructed necessary understanding.

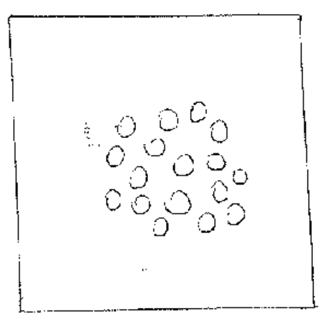
Hasan: The size and shape of the particles do not change, actually only in the chemical reactions when the bonds between atoms are broken or new bonds are formed, the size of the molecules get bigger or smaller. However it is a phase change and it is a physical change. The distance between particles increases, because the given energy makes the particles move faster. The mass and chemical properties of the substance do not change because it is a physical change. Also the volume of a substance increases, because when we give heat, particles start to move faster, and collide with each other and the wall of the container more.

In the control group high achiever students gave the similar answers. However middle and low achiever students in the control group had some misconceptions. From their answers it is seen that they could not understand the properties of gases. In their answers it is common that they cannot visualize the particulate nature of gases. For example, a low achiever student thought that the particles of gases change and take the shape of the container. When the reason was asked student explain that gases take the volume of the container. If the gases composed of particles, then these particles should take the shape of the container. Unlike gases solids have definite shapes and the shape of their particles does not change. Also a middle achiever student said that the mass of the substance decreases, because gases are volatile so they are lighter than substance in liquid and solid state. This misconception may result from students' misinterpretation of their daily life experiences.

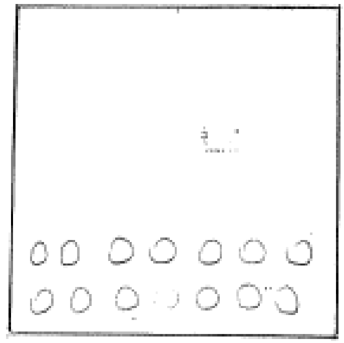
In the second question students were asked to draw representation of gas particles at different temperatures in a closed container when the pressure is held at 1 atm. When students draw the representation of gas particles at 125^{o}C and 1 atm all of them used particulate and homogenous distribution. When the researcher asked the distribution of the same particles if temperature decreases at 25^{0}C, all of the students in the experimental group represented the particles properly. Here is an example of a middle achiever student in experimental group.



However none of the students in the control group correctly represented the distribution of particles at 25^{0}C. Some of the students thought that when the temperature decreases the gas particles shrink and gathered at the middle of the container. An example of such drawing is shown below:



Also three students in the control group, two of them are low achievers and one is middle achievers, represented the particles at 25^{0}C in a way that all particles collected bottom of the container. When the reason was asked they said that the ability of gases particles to move decreases as temperature decreases. So they accumulate at the bottom of the container. Last drawing example is the following:



The third question was related to diffusion of gases. All of the students in experimental group and high achievers in control group could define diffusion of gases. However when students were asked to give a daily life example for diffusion of gases only one high achiever student explained properly. Here is an excerpt that shows she has a meaningful understanding on the concept:

Interviewer: What does diffusion of gases mean?
Filiz: It is a property of gases which means all gases can diffuse into one another and form homogenous mixtures.
Interviewer: Ok. Can you give a daily life example for diffusion of gases?
Filiz: Imm. If I spray a perfume in the corner of this room, the odor of this perfume can be detected at the other corner of the room in a few second. There is an air that is a gas in this room and the liquid perfume evaporates and goes to gas phase. If I can smell the perfume at the other corner of the room it shows gas particles diffuse into one another.

The other students did not give an example which may result from they could not link the concept with their daily life experiences.

Middle achiever students in control group remembered the formulation of gas diffusion and said that diffusion rate of gases is inversely proportional to molecular weight of gases. However they could not explain the meaning of gas diffusion. When their answers to question related to diffusion of gases in achievement test were controlled, it is seen that both of them gave the correct answer. It shows that students did necessary calculation without having meaningful understanding of the concept.

Low achiever students in control group could not say anything about the concept.

In the fourth question students were asked that there is helium gas in a closed container at 50^0C, if we decrease the temperature at 25 ^{0}C which properties of gases would change. All of the students in the experimental group could state the correct answer by giving meaningful explanation. Students said that at constant volume if we decrease the temperature of a gas, the pressure and kinetic energy of that gas also decrease, however mole of the gas and shape and size of the molecules do not change. When the researcher asked the reason of their explanation, they gave meaningful answer by using kinetic molecular theory and ideal gas law. Here is an excerpt of Tolga who is a low achiever in the experimental group.

Tolga: When you decrease the temperature, the pressure and kinetic energy of the gas would also decrease.

Interviewer: Why do you think like that?

Tolga: Gases are composed of particles and these particles move around the container. If we decrease the temperature the speed of the particles decreases so the kinetic energy of the particles also decreases. Also particles start to collide with each other and the wall of the container less which decreases the pressure of the gas.

Interviewer: Which properties of the gas do not change when we decrease the temperature?

Tolga: It is a closed container and we do not add or remove any gas. So the moles of the gas do not change. Also the shape and size of the particles also do not change.

High and middle achiever students in the control group could correctly predict the properties of the gas that change or do not change with decreasing temperature. However when they were explaining the reason of their answer they used only ideal gas equation. This showed that all of them memorize the equation, but they could not interpret the logic behind that formula. The following is an excerpt of Mine who is a middle achiever in the control group.

Mine: Volume is constant and we decrease the temperature. Ok. Pressure will decrease; mole of the gas will stay constant.
Interviewer: Why?
Mine: From the ideal gas equation we know that temperature and pressure of the gas are directly proportional.
Interviewer: Why are they directly proportional?
Mine: Because they are at the opposite size of the equation. So they are directly proportional?
Interviewer: What do you think why they are at the opposite size of the equation?
Mine: I do not know.

Low achiever students in the control group could not give the correct answer. They could not construct meaningful understanding about the gas laws. Although both of them know the ideal gas equation, they could not establish the correct relationship among the variables. It may result from students' inefficacy in solving mathematical equations.

The fifth question was related to gas laws. Students were asked that there are 2 moles NH_3 gas at 273K in a container with movable piston. If we add 1 mole extra NH_3 and increase temperature, which properties of the gas change and which do not change. Only high and middle achiever students in the experimental group could give the correct answer by stating that pressure would stay constant and volume of the gas would increase with explaining the reason properly. This shows that they constructed necessary understanding about gas laws and ideal gas law. Low achiever students in the experimental group could find the correct answer with some clues. When the question was asked they could not notice how pressure of the gas is affected in a container with movable piston. However when it is emphasized, both of them gave the correct explanation. It is clear from the following excerpt that when they are warned, they found logical explanations:

Hasan: If we increase temperature and moles of gas, gas particles start to move faster and collide with each other and wall of the container more frequently so both pressure and volume of the gas increase.
Interviewer: Then, what would happen if the container was closed?
Hasan: Ok. Let me think a little bit, I think I confused something. If the container were closed the volume would not change and the pressure would increase because the particles start to move faster and collide with each other and wall of the container more frequently. However this is not a closed container so only the volume would increase and pressure would not change. The pressure of the gas should always equal to outside pressure. So until the pressures become equal, the volume of the gas increases.

High and middle achiever students in the control group stated that both pressure and volume of the gas would increase. Although the researcher reminded that it is not a closed container, the students could not give accurate explanation to the question. As it is mentioned before these students can use the ideal gas equation properly, but they could not develop necessary understanding about ideal gas law. So when they encountered a different situation, they failed to adopt their knowledge to new situation.

Low achiever students in the control group could not establish the correct relationship among the variables in the ideal gas equation. Both of them stated that pressure and volume of the gas should change in some way but they could not decide how they change.

In the sixth question students was asked about partial pressures how they can calculate partial pressures of two different gases in a closed container. All students in the experimental group could explain the meaning of partial pressure and list the necessary properties to calculate partial pressures of gases. The following is an excerpt of Burak who is a middle achiever in the experimental group. It is obvious from the excerpt that he constructed necessary understanding about partial pressure of gases.

Burak: If there are more than one nonreacting gases in a closed container, the pressure of that gas mixture is equal to sum of the individual pressures exerted by each gas alone. Each gas exerts pressure in the mixture the same as the gas would be alone in the container. The pressure is the partial pressure of that gas.

Interviewer: Suppose there are He and CO_2 gases in a closed container. How can we calculate the partial pressures of the gases?

Burak: We should know the total pressure and mole fraction of the gases.

Interviewer: What is mole fraction?

Burak: It is the ratio of the number of moles of one gas to total number of moles of gases.

All of the students in the control group knew how they can calculate the partial pressures of gases. However when it is asked to define meaning of the partial pressure, they could not explain it. When the answers of the students to quantitative question about partial pressure of gases were examined it is seen that only high achiever students found the correct answer. Although middle and low achiever students knew the formula; they could not make the necessary calculations.

In the last question students were asked to define ideal gases. All of the students in experimental group and high achiever students in the control group stated that gases behave ideally at high temperature and low pressure. An example of an excerpt showing below is a middle achiever student from experimental group:

Metin: Gases behave ideally at high pressure and low pressure. Theoretically there is no attractive forces exist between the particles of ideal gases. Normally none of the gases behave ideally. Deviation from ideal behavior is negligible at high temperatures and low pressures.

Middle achiever students in the control group knew the property of ideal gas, but they confused the condition necessary for gases to behave ideally. The following is an excerpt of Sinan who is a middle achiever in the control group.

Sinan: Actually there is no ideal gas in the nature. There is no attractive or repulsive force between the molecules of ideal gases. Also ideal gas law is applicable only for ideal gas. When we make calculation with ideal gas we ignore the deviations.
Interviewer: Under which conditions gases behave ideally?
Sinan: At high pressure and temperature.
Interviewer: Why?
Sinan: Because under these conditions gas particles do not close to each other so, there are no forces among them.

One of the low achiever student in the control group thought that gases behave ideally at room temperature. The other one stated that noble gases are actually ideal gases. From their answers it is apparent that they could not develop necessary understanding about ideal gas concept.

5.5. The Classroom Observations

In this study, the treatment was conducted over seven weeks in a public high school in Ankara. The researcher attended all the 45 minutes sessions of both experimental and control groups. The main purpose of the classroom observation was treatment verification. The implementation of the treatment, students' reactions to the implementation, their involvement to the lesson and interaction between students and teacher was observed. During observations the researcher sit one of the back desk in the classroom silently, took notes in the line of the aim of observation. She did not involve the lessons in no way.

Both groups followed the same chemistry curriculum and were instructed by the same teacher. Properties of gases, volume of gases (molar volume), kinetic theory of gases, gas diffusion, pressure of gases, gas laws, ideal gas law and partial pressures of gases concepts were covered over seven weeks period in experimental and control groups.

In the experimental group students were instructed with conceptual change oriented instruction. The teacher used ten animations prepared by researcher during the lessons. The animations were shown to accomplish one of four different conditions of conceptual change approach. Although students hesitated to contribute the classroom discussion at the beginning of the treatment, after the second week they became more active. In the first week when their opinions were asked only two or three students talked and the rest of the class were waiting the explanation of teacher. However the teacher encouraged students to discuss and especially at the dissatisfaction phase of the conceptual change, she tried to take opinions of different students each time. Nevertheless there were four students who did not talk in any lesson during the treatment. It was observed that the teacher had some difficulties when using computer and overhead projector but she guided classroom discussions very successfully. Moreover the teacher had some classroom management problems such as noise while watching the first two animations. In the following lessons, the students were familiar with the animations and conceptual change approach and gave up making noise when they were discussing and watching the animations. From students' interest it can be concluded that animations were motivating for them.

The control group students were instructed with traditional method. The teacher used lecturing method and at the end of each lesson, questions related to subject were solved by her. Throughout the lesson, the teacher presented the subject, asked questions to students and discussed the key concepts. She frequently used blackboard for emphasizing the key concepts, gases equations, ideal gas formula, and solving problems. She also used textbook during the instruction while presenting the subject. It is observed that students were more willing to solve numerical problems. In control group students got used to take notes so they waited teacher to make them write what she says. There was much noise in the control group than in the experimental group. Students in this group generally were unwilling to discuss and participating lessons and they bored very easily. So they started to talk with each other. The teacher spent lots of time to warn them to be quite. However when the students did not understand the subject, they did not hesitate to ask questions and the teacher gave extra explanations. Sometimes the teacher gave them numerical questions as homework. Most of them solved the questions before coming to class.

Based on the observation results, it can be concluded that conceptual change oriented instruction accompanied with animations was more effective than traditionally designed chemistry instruction in making students more active, taking their attention to the lesson and effecting their attitudes toward chemistry positively.

5.6. Analysis of T-VOSTS Test

Item1 (Defining Science)

The first item was concerning the definition of science. As shown in Table 5.23, 45.5 % of the students in the control group and 26.5% of the students in the experimental group have realistic view about science. One of the myths described by McComas (1998) is that science and technology are identical. This myth is reflected on the alternatives E and F. The students selecting alternative F are equal in control and experimental groups and constituted 53.8% of the whole sample. According to 41.6 % of the students who selected alternative B science is only a body of knowledge. Researchers examining science textbooks concluded that most of the text emphasized science as a body of knowledge (Phillips & Chiappetta, 2007; Chiapetta et al., 1993; Irez, 2009).

Interestingly alternatives A, E and G were not selected by any students. There were very few students (11.7% of experimental group and 9.10% of the control group) thinking science as indefinable.

Table 5.23 Percentage of Students' Responses to Item 1

Defining science is difficult because science is complex and does many things. But MAINLY science is:			
EG%	**CG%**		**Alternative**
0.00	0.00	*A*	*a study of fields such as biology, chemistry and physics.*
26.5	15.1	*B*	*a body of knowledge, such as principles, laws and theories, which explain the world around us (matter, energy and life).*
26.5	45.5	<u>C</u>	<u>exploring the unknown and discovering new things about our world and universe and how they work.</u>
5.9	3.00	*D*	*carrying out experiments to solve problems of interest about the world around us.*
0.00	0.00	E	inventing or designing things (for example, artificial hearts, computers, space vehicles).
29.4	27.3	*F*	*finding and using knowledge to make this world a better place to live in (for example, curing diseases, solving pollution and improving agriculture).*
0.00	0.00	*G*	*an organization of people (called scientists) who have ideas and techniques for discovering new knowledge.*
11.7	9.10	H	No one can define science

Experimental Group:
<u>Realistic: 26.5</u> *Has Merit: 61.8* Naive: 11.7

Control Group:
<u>Realistic: 45.5</u> *Has Merit: 45.4* Naive: 9.10

Item 2 (Influence of Society on Science/Technology)

The second item was asked to reveal students' opinions about the influences of religious and ethical views of the culture on the scientific researches. 44.1% of the students in the experimental group and 54.6% of the students in the control group had a naive view that religious or ethical views do not influence scientific research.

Alternatives A, B, C, D and E show the collectivist and sociological nature of scientific researchers. It is seen in Table 5.24 that 55.9% of the students in the experimental group and 45.4% of the students in the control group held this view.

Percentage of students' holding realistic view was nearly equal in experimental and control groups (23.6%for experimental group, 21.1% for control group).

Table 5.24 Percentage of Students' Responses to Item 2

Some cultures have a particular viewpoint on nature and man. Scientists and scientific research are affected by the religious or ethical views of the culture where the work is done.			
EG%	**CG%**		**Alternative**
			Religious or ethical views DO influence scientific research:
2.9	3.00	A	*because some cultures want specific research done for the benefit of that culture.*
11.8	6.1	<u>B</u>	<u>because scientists may unconsciously choose research that would support their culture's views.</u>
8.8	6.1	C	*because most scientists will not do research which goes against their upbringing or their beliefs.*
11.8	15.0	<u>D</u>	<u>because everyone is different in the way they react to their culture. It is these individual differences in scientists that influence the type of research done.</u>
20.6	15.2	E	*because powerful groups representing certain religious, political or cultural beliefs will support certain research projects, or will give money to prevent certain research from occurring.*

Table 5.24 (continued)

Some cultures have a particular viewpoint on nature and man. Scientists and scientific research are affected by the religious or ethical views of the culture where the work is done.			
EG%	**CG%**		**Alternative**
			Religious or ethical views do NOT influence scientific research:
17.6	27.3	F	because research continues in spite of clashes between scientists and certain religious or cultural groups (for example, clashes over evolution and creation).
26.5	27.3	G	because scientists will research topics which are of importance to science and scientists, regardless of cultural or ethical views.

Experimental Group:
Realistic: 23.6 *Has Merit: 32.3* Naive: 44.1

Control Group:
Realistic: 21.1 *Has Merit: 24.3* Naive: 54.6

Item 3 (Influence of Society on Science/Technology)

The third item was about the effect of community and upbringing on producing scientist. 41.2 % of experimental group students and 45.4 % of control group students choose alternatives D and F showing that science is a collectivist and sociological endeavor. This view is consistent with contemporary views.

The percentage of students holding naïve belief was 14.7% for experimental group and 6.1% for control group. Table 25 shows that 20.6% of the students in experimental group and 39.4% of the students in control group thought that as well as upbringing ability, intelligence and interest in science are also important.

Table 5.25 Percentage of Students' Responses to Item 3

Some communities produce more scientists than other communities. This happens as a result of the upbringing which children receive from their family, schools and community.			
EG%	**CG%**		**Alternative**
			Upbringing is mostly responsible:
17.6	6.1	*A*	*because some communities (for example, industrial towns such as Sudbury) place greater emphasis on science than other communities.*
5.9	3.00	*B*	*because some families encourage children to question and wonder.*
5.9	0.00	C	because some teachers or schools offer better science courses or encourage students to learn more than other teachers or schools.
11.8	18.2	D	because the family, schools and community all give children with an ability in science the encouragement and opportunity to become scientists.
20.6	39.4	*E*	*It's difficult to tell. Upbringing has a definite effect, but so does the individual (for example, intelligence, ability and a natural interest in science).*
			Intelligence, ability and a natural interest in science are mostly responsible:
29.4	27.2	F	in determining who becomes a scientist. However, upbringing has an effect.
8.8	6.1	G	because people are born with these traits.

Experimental Group:
Realistic: 41.2 *Has Merit: 44.1* Naive: 14.7

Control Group:
Realistic: 45.4 *Has Merit: 48.5* Naive: 6.1

Item 4 (Influence of Science/Technology on Society)

Item 4 investigated the participants' opinions about the social responsibilities of scientist. Most of the students in the experimental group (70.6%) and 48.5% of the control group students believed that scientist are concerned with all the effects of their experiments. None of the students in both group thought that scientist can not know all the long term effects of their discoveries.

Only 8.8 % of the experimental group students and 12.10 % of the students realized that scientists are concerned but they have little control over how their discoveries are used for harm which reflects realistic view. As shown in Table 5.26 that more than half of the students have rational but not realistic ideas. Also it is interesting that percentage of students having naïve believes is much higher than percentage of students having realistic believes for both groups.

Table 5.26 Percentage of Students' Responses to Item 4

Most Turkish scientists are concerned with the potential effects (both helpful and harmful) that might result from their discoveries.			
EG%	**CG%**		**Alternative**
0.00	3.00	A	Scientists only look for beneficial effects when they discover things or when they apply their discoveries.
11.8	15.2	B	Scientists are most concerned with the possible harmful effects of their discoveries.
70.6	48.5	*C*	*Scientists are concerned with all the effects of their experiments.*
0.00	0.00	<u>D</u>	<u>Scientists are concerned but they can't possibly know all the long-term effects of their discoveries.</u>
8.80	12.10	<u>E</u>	<u>Scientists are concerned but they have little control over how their discoveries are used for harm.</u>
8.80	18.2	F	It depends upon the field of science. For instance, in medicine or in military research, Turkish scientists are highly concerned. However, in nuclear power Turkish scientists are least concerned.
0.00	3.00	*G*	*Scientists may be concerned, but that doesn't stop them from making discoveries for their own fame, fortune, or pure joy of discovery.*

Experimental Group:
<u>Realistic: 8.80</u> *Has Merit: 70.6* Naive: 20.6

Control Group:
<u>Realistic: 12.1</u> *Has Merit: 51.5* Naive: 36.4

Item 5 (Influence of Science/Technology on Society)

Item 5 involves different viewpoints about decision makers for future biotechnology. Alternative D reflects the realistic viewpoint by stating that science has collectivist and sociolological aspects. Table 27 shows that the percentage of control group students having realistic view was much higher than that of experimental group students. In the control group 45.4% of the students and in the experimental group 32.4% of the students supported that the decision should be made equally. There were no students in the experimental group and only 3% of the students in the control group thought that government should decide on future biotechnology.

According to alternative A and B scientist and engineers are the primary decision makers. It is surprising that none of the students in the control group and very few in the experimental group choose alternative B. Students who thought scientist and engineers as decision makers selected alternative A (23.5% of experimental group and 30.3% of control group).

Table 5.27 Percentage of Students' Responses to Item 5

Scientists and engineers should be the ones to decide on future biotechnology in Turkey (for example, recombinant DNA, gene splicing, developing ore-digging bacteria or snow-making bacteria, etc.) because scientists and engineers are the people who know the facts best.			
EG%	**CG%**		**Alternative**
			Scientists and engineers should decide:
23.5	30.3	*A*	*because they have the training and facts which give them a better understanding of the issue.*
5.80	0.00	B	because they have the knowledge and can make better decisions than government bureaucrats or private companies, both of whom have vested interests.
14.7	6.1	*C*	*BUT the public should be involved — either informed or consulted.*
32.4	45.4	<u>D</u>	<u>The decision should be made equally; viewpoints of scientists and engineers, other specialists, and the informed public should all be considered in decisions which affect our society.</u>
0.00	3.00	E	The government should decide because the issue is basically a political one
11.8	9.10	F	The public should decide because the decision affects everyone;
11.8	6.10	G	The public should decide because the public serves as a check on the scientists and engineers. Scientists and engineers have idealistic and narrow views on the issue and thus pay little attention to consequences.

Experimental Group:

Realistic: 32.4	*Has Merit: 38.2*	Naive: 29.4

Control Group:

Realistic: 45.4	*Has Merit: 36.4*	Naive: 18.2

Item 6 (Influence of Science/Technology on Society)

Item 6 investigated whether students believed scientists can solve any practical everyday problem best or not. As it is seen from Table 5.28, there was a significant difference between the viewpoints of students in the experimental and control groups. The percentage of experimental group students having realistic view was 73.5, whereas it is only 33.3 in the control group.

However most of the students in the control group (76.7%) claimed that scientists are not better than others in solving everyday problems. This percentage was only 26.5 for experimental group. According to 21.2% of the control group students and 5.9% of the experimental group students, scientist are probably worse at solving practical problems because of working in a complex abstract world.

Table 5.28 Percentage of Students' Responses to Item 6

Scientists can solve any practical everyday problem best (for example, getting a car out of a ditch, cooking, or caring for a pet) because scientists know more science.			
EG%	**CG%**		**Alternative**
73.5	33.3	A	Scientists are better at solving any practical problem. Their logical problem-solving minds or specialized knowledge give them an advantage.
			Scientists are no better than others:
5.90	6.10	B	because science classes help everybody learn enough problem-solving skills and knowledge to solve practical problems.
0.00	3.00	*C*	*because a scientist's education doesn't necessarily help with practical things.*
14.7	36.4	*D*	*because in everyday life scientists are like everyone else.*
5.90	21.2	E	Scientists are probably worse at solving any practical problem because they work in a complex abstract world, far removed from everyday life.

Experimental Group:
Realistic: 73.5 *Has Merit: 14.7* Naive: 11.8

Control Group:
Realistic: 33.3 *Has Merit: 39.4* Naive: 27.3

Item 7 (Characteristics of Scientists)

This item investigates the views of students about the personal characteristics of scientist for doing the best science. In the alternatives A, B and C the best scientists should be very open-minded, logical, unbiased and objective in their work. Moreover according to alternative C as well as these characteristics other personal traits such as imagination, intelligence and honesty are needed. Alternative B and C reflect the realistic view. Table 5.29 showed that more than half of the students in both groups had a realistic view (79.5% for experimental group, 66.6% for control group).

It is noticing that none of the students in experimental and control groups believed that the best scientist do not display these personal characteristics. Also there were no students in experimental group and very few in the control group (3%) claiming that scientist can be closed-minded, biased and subjective in their works because they are so deeply involved, interested or trained in their fields.

8.80 % of the experimental group students and 12.1 % of the control group students held naïve believes about the characteristics of best scientist.

Table 5.29 Percentage of Students' Responses to Item 7

The best scientists are always very open-minded, logical, unbiased and objective in their work. These personal characteristics are needed for doing the best science.			
EG%	**CG%**		**Alternative**
			The best scientists display these characteristics
8.80	12.1	A	otherwise science will suffer.
32.4	33.3	B	because the more of these characteristics you have, the better you'll do at science.
47.1	33.3	C	these characteristics are not enough. The best scientists also need other personal traits such as imagination, intelligence and honesty.

Table 5.29 (continued)

			The best scientists do NOT necessarily display these personal characteristics:
0.00	3.00	*D*	*because the best scientists sometimes become so deeply involved, interested or trained in their field, that they can be closed-minded, biased, subjective and not always logical in their work.*
11.7	18.2	*E*	*because it depends on the individual scientist. Some are always open-minded, objective, etc. in their work; while others can be come closed-minded, subjective, etc. in their work.*
0.00	0.00	F	these characteristics are NOT necessary for doing good science.

Experimental Group:
Realistic: 79.5 *Has Merit: 11.7* Naive: 8.80

Control Group:
Realistic: 66.6 Has Merit: 21.2 Naive: 12.1

Item 8 (Characteristics of Scientists)

Item 8 was concerned with scientists' family life or social life. The alternatives mainly emphasize 3 different viewpoint; scientists' work takes away them from family and social life (alternative A), it depends on person (alternatives B and C) and they have normal family and social life (alternative D and E).

The percentages of students selected each of these alternatives were similar in experimental and control groups. 70.6 % of the students in the experimental group and 66.6 % of the students in the control group thought that it depends on person which reflects realistic view.

Almost 16.5% of the total students held a naïve belief and 15% of them held rational but not realistic view.

Table 5.30 Percentage of Students' Responses to Item 8

Scientists have practically no family life or social life because they need to be so deeply involved in their work.			
EG%	**CG%**		**Alternative**
14.7	18.3	A	scientists need to be very deeply involved in their work in order to succeed. This deep involvement takes away from one's family and social life.
26.5	24.2	<u>B</u>	<u>it depends on the person. Some scientists are so involved in their work that their families and social lives suffer. But many scientists take time for family and social things.</u>
44.1	42.4	<u>C</u>	<u>at work scientists look at things differently than other people, but this doesn't mean they have practically no family or social lives.</u>
			Scientists' family and social lives are normal:
11.8	12.1	D	*otherwise their work would suffer. A social life is valuable to a scientist.*
2.90	3.00	E	*because very few scientists get so wrapped up in their work that they ignore everything else.*

Experimental Group:
<u>Realistic: 70.6</u>		*Has Merit: 14.7*		Naive: 14.7

Control Group:
<u>Realistic: 66.6</u>		*Has Merit: 15.1*		Naive: 18.3

Item 9 (Characteristics of Scientists)

In the ninth item, students were asked whether gender difference have an effect on the scientific discoveries or not. 35.3% of the students in the experimental group and 51.5% of the students in the control group believed that there is no difference between female and male scientists in the discoveries they make because women and men scientists are educated in the same way, but women were not given adequate opportunity. However 20.6% of experimental group students and 15.2% of control group students thought that women and men have different instinct and viewpoint because of their nature.

According to 23.5% of the experimental group students and 12.1% of the control group students, any differences between men and women are due to differences between individuals. Also there were no students in both groups thinking that men are better at engineering and mechanics than women. As it is shown in Table 5.31 the number of students holding realistic view in control group students is higher than that of experimental group (44.1% of experimental group, 63.6% of control group).

Table 5.31 Percentage of Students' Responses to Item 9

There are many more women scientists today than there used to be. This will make a difference to the scientific discoveries which are made.			
EG%	**CG%**		**Alternative**
Scientific discoveries made by women will tend to be different than those made by men.			
2.9	6.1	A	because women and men have different interest
8.8	3.00	B	because women and men discover regarding their needs(cellulite cream, razor, etc.)
20.6	15.2	C	because women and men have different instinct and viewpoint because of their nature
0.00	0.00	D	Men would make better discoveries because men are better at engineering and mechanics than women
There is NO difference between female and male scientists in the discoveries they make:			
35.3	**51.5**	**E**	because women and men scientists are educated in the same way. However the fact that women were not given adequate opportunity from past to present have obstructed emergence of women's abilities in this area
8.80	**12.1**	**F**	women and men are equally intelligent. Women and men are the same in terms of what they want to discover in science
23.5	**12.1**	**G**	*any differences in their discoveries are due to differences between individuals. Such differences have nothing to do with being male or female.*

Experimental Group:
Realistic: 44.1 *Has Merit: 23.5* Naive: 32.3

Control Group:
Realistic: 63.6 *Has Merit: 12.1* Naive: 24.3

Item 10 (Social Construction of Scientific Knowledge)

The tenth item was asked to reveal students' thought about competition between scientists and breaking the rules of science. Table 5.32 showed that very few students in both groups thought that scientists do not compete (20.6% of the experimental group students and 15.2% of the control group students). Half of the experimental group students and 21.2% of control group student believed scientists break the rules of science to achieve success.

There are very few students in both groups that realize science is not different from other professions (17.6% of the experimental group students and 9.1% of the control group students). 54.6% of the students in the control group held naïve belief and 64.7% of the students in the experimental group held rational belief.

Table 5.32 Percentage of Students' Responses to Item 10

Scientists compete for research funds and for who will be the first to make a discovery. Sometimes fierce competition causes scientists to act in secrecy, lift ideas from other scientists, and lobby for money. In other words, sometimes scientists break the rules of science (rules such as sharing results, honesty, independence, etc.).			
EG%	**CG%**		**Alternative**
			Sometimes scientists break the rules of science:
47.1	21.2	*A*	*because this is the way they achieve success in a competitive situation. Competition pushes scientists to work harder.*
11.8	15.2	B	In order to achieve personal and financial rewards. When scientists compete for something they really want, they'll do whatever they can to get it.
			Sometimes scientists break the rules of science:
2.9	39.4	C	In order to find the answer. As long as their answer works in the end, it doesn't matter how they got there.
17.6	9.1	*D*	*It depends. Science is no different from other professions. Some will break the rules of science to get ahead and others will not.*
20.6	15.2	E	<u>Most scientists do not compete. The way they really work, and the best way to succeed, is through cooperation and by following the rules of science.</u>

Experimental Group:
<u>Realistic: 20.6</u> *Has Merit: 64.7* Naive: 14.7

Control Group:
<u>Realistic: 15.2</u> *Has Merit: 30.3* Naive: 54.6

Item 11 (Social Construction of Scientific Knowledge)

Item 11 was related to effects of scientists' social contacts on the content of scientific knowledge. 32.4 % of the experimental group students and 30.3 % of the control group students chose alternative A reflecting realistic view. One third of the students in both groups had an instrumentalist view about science and believed that scientist can change their research with respect to the needs of society.

The percentage of students who thought social contacts do not influence the content of scientific knowledge was 8.8 in experimental group and 24.2 in the control group.

Table 5.33 Percentage of Students' Responses to Item 11

A scientist may play tennis, go to parties, or attend conferences with other people. Because these social contacts can influence the scientist's work, these social contacts can influence the content of the scientific knowledge he or she discovers.			
EG%	**CG%**		**Alternative**
			Social contacts influence the content of what is discovered:
32.4	30.3	<u>A</u>	<u>because scientists can be helped by the ideas, experiences, or enthusiasm of the people with whom they socialize.</u>
8.8	3.00	*B*	*because social contacts can serve as a refreshing or relaxing break from work; thus revitalizing a scientist.*
32.4	33.3	*C*	*because scientists can be encouraged by people to apply or change their research to a new area relevant to the needs of society.*
17.6	9.1	*D*	*because social contacts allow scientists to observe human behavior and other scientific phenomena.*
8.8	24.2	E	Social contacts do NOT influence the content of what is discovered because a scientist's work is unrelated to socializing.

Experimental Group:
<u>Realistic: 32.4</u> *Has Merit: 58.8* Naive: 8.8

Control Group:
<u>Realistic: 30.3</u> *Has Merit: 45.4* Naive: 24.2

Item12 (Nature of Scientific Knowledge)

The twelfth item was asked to investigate students' opinion about whether scientific observations made by different scientist differ if the scientists believe different theories or not. The fist two alternatives claim that it differs and the last three ones claim it does not differ.

73.5 % of the experimental group students and 66.7% of the control group students choose alternatives A and B and believed that scientific observation made by different scientist can change. These alternatives reflect realistic view.

Percentage of students holding naive view and claiming observations are exactly same because they are facts is very few in both groups (5.9% for experimental group and 6.1% for control group).

Table 5.34 Percentage of Students' Responses to Item 12

Scientific observations made by competent scientists will usually be different if the scientists believe different theories.			
EG%	**CG%**		**Alternative**
20.6	30.3	<u>A</u>	<u>yes, because scientists will experiment in different ways and will notice different things.</u>
52.9	36.4	<u>B</u>	<u>yes, because scientists will think differently and this will alter their observations.</u>
11.8	6.1	*C*	*scientific observations will not differ very much even though scientists believe different theories. If the scientists are indeed competent their observations will be similar.*
8.8	21.2	*D*	*no, because observations are as exact as possible. This is how science has been able to advance.*
5.9	6.1	E	no, observations are exactly what we see and nothing more; they are the facts.

Experimental Group:
<u>Realistic: 73.5</u>　　*Has Merit: 20.6*　　Naive: 5.9

Control Group:
<u>Realistic: 66.7</u>　　*Has Merit: 27.3*　　Naive: 6.1

Item 13 (Nature of Scientific Knowledge)

In item 13 realities of scientific models was investigated. According to alternatives A, B, C and D scientific models are copies of reality. However in the alternatives E, F and G they are not copies of reality.

It is seen in Table 5.35 that most of the students in control and experimental groups believed that scientific models are copies of reality (73.5% for experimental group, 69.6% for control group). This results shows that students in both groups held naive beliefs and had some misconceptions about scientific models.

Only 17.6 % of the students in the experimental group and 12.1% of the students believed that scientific model are not copies of reality because they change.

Table 5.35 Percentage of Students' Responses to Item 13

Many scientific models used in research laboratories (such as the model of heat, the neuron, DNA, or the atom) are copies of reality.			
EG%	**CG%**		**Alternative**
			Scientific models ARE copies of reality:
0.00	3.00	A	because scientists say they are true, so they must be true.
23.5	24.2	B	because much scientific evidence has proven them true.
26.5	21.2	C	because they are true to life. Their purpose is to show us reality or teach us something about it.
23.5	21.2	D	scientific models come close to being copies of reality, because they are based on scientific observations and research.
			Scientific models are NOT copies of reality:
2.9	12.1	*E*	*because they are simply helpful for learning and explaining, within their limitations.*
17.6	12.1	<u>F</u>	<u>because they change with time and with the state of our knowledge, like theories do.</u>
5.9	6.1	*G*	*because these models must be ideas or educated guesses*

Experimental Group:
<u>Realistic: 17.6</u>   *Has Merit: 8.8*   Naive: 73.5

Control Group:
<u>Realistic: 12.1</u>   *Has Merit: 18.2*   Naive: 69.6

Item 14 (Nature of Scientific Knowledge)

Item 14 was mainly about the classification schemes. In the alternatives 2 different viewpoints are mentioned; classification schemes matched the way nature really is or there are many ways of classification.

Alternatives C and D reflects the realistic view by stating there are more than one way of classifying nature. The percentage of students selecting these alternatives in the experimental group is higher than that of control group (61.7%for experimental group and 42.4% for control group).

Almost half of the students in the control group and 35.2% of the experimental group students held naïve belief about the classification scheme by selecting alternatives A, B or F.

Table 5.36 Percentage of Students' Responses to Item 14

When scientists classify something (for example, a plant according to its species, an element according to the periodic table, energy according to its source, or a star according to its size), scientists are classifying nature according to the way nature really is; any other way would simply be wrong.			
EG%	**CG%**		**Alternative**
29.4	12.1	A	Classifications match the way nature really is, since scientists have proven them over many years of work.
2.9	6.1	B	Classifications match the way nature really is, since scientists use observable characteristics when they classify.
23.5	24.2	<u>C</u>	<u>Scientists classify nature in the most simple and logical way, but their way isn't necessarily the only way.</u>
38.2	18.2	<u>D</u>	<u>There are many ways to classify nature, but agreeing on one universal system allows scientists to avoid confusion in their work.</u>
2.9	6.1	E	*There could be other correct ways to classify nature, because science is liable to change and new discoveries may lead to different classifications.*
2.9	33.3	F	Nobody knows the way nature really is. Scientists classify nature according to their perceptions or theories.

Experimental Group:

<u>Realistic: 61.7</u> *Has Merit: 2.9* Naive: 35.2

Control Group:

<u>Realistic: 42.4</u> *Has Merit: 6.1* Naive: 51.5

Item 15 (Nature of Scientific Knowledge)

Scientific knowledge has a tentative character. This item was asked to investigate students' opinion about tentativeness of the scientific knowledge.

Most of the students in both groups believed that scientific knowledge changes and choose alternative A or B. (82.3% for experimental group and 75.7% for control group). Although these alternatives give different explanation for being subject to change of scientific knowledge, both of them reflect realistic view.

In the experimental group percentage of students having rational and naïve ideas is equal (8.80 % have naïve ideas, 8.80 % have rational ideas). In the control group the percentage of students having naïve beliefs (18.2) is higher than percentage of students having rational beliefs (6.1).

Abd-El-Khalick (2004) reported that 90% of the college students held naïve beliefs about the tentative character of NOS.

Also Table 5.37 revealed that there were no students in the experimental group believing that scientific knowledge is absolute and does not change.

Table 5.37 Percentage of Students' Responses to Item 15

Even when scientific investigations are done correctly, the knowledge that scientists discover from those investigations may change in the future.			
EG%	**CG%**		**Alternative**
64.7	63.6	A	Scientific knowledge changes: because new scientists disprove the theories or discoveries of old scientists. Scientists do this by using new techniques or improved instruments, by finding new factors overlooked before, or by detecting errors in the original "correct" investigation.
17.6	12.1	B	Scientific knowledge changes: because the old knowledge is reinterpreted in light of new discoveries. Scientific facts can change.
8.80	0.00	C	Scientific knowledge APPEARS to change because the interpretation or the application of the old facts can change. Correctly done experiments yield unchangeable facts.
8.80	6.1	*D*	*Scientific knowledge APPEARS to change because new knowledge is added on to old knowledge; the old knowledge doesn't change.*
0.00	18.2	E	Knowledge can change in time, but scientific knowledge is absolute and does not change.

Experimental Group:
Realistic: 82.3 *Has Merit: 8.80* Naive: 8.80

Control Group:
Realistic: 75.7 *Has Merit: 6.1* Naive: 18.2

Item 16 (Nature of Scientific Knowledge)

Item 16 investigated the views of students about the relationship between hypotheses, theories and laws. According to McComas (1998), one of the myths of science is that hypotheses become theories that in turn become laws. The analyses of students' responses for this question showed that this misconception is very common among students.

Most of the students in experimental and control group believed that there is a hierarchical relationship between hypotheses, theories and laws (94.0% for the control group and 88.2% for the experimental group). This result is consistent with the study that showed 97% of the students thought simplistic and hierarchical relationship between scientific theories and laws (Abd-El-Khalick, 2004).

11.8% of the experimental group students and 6.10% of the control group students realized that hypotheses, theories and laws are different types of ideas.

Table 5.38 Percentage of Students' Responses to Item 16

Scientific ideas develop from *hypotheses* to *theories,* and finally, if they are good enough, to being scientific *laws.*			
EG%	**CG%**		**Alternative**
76.5	75.8	A	Hypotheses can lead to theories which can lead to laws because a hypothesis is tested by experiments, if it proves correct, it becomes a theory. After a theory has been proven true many times by different people and has been around for a long time, it becomes a law.
8.80	6.10	B	Hypotheses can lead to theories which can lead to laws because it is a logical way for scientific ideas to develop.
2.90	12.1	C	Theories can't become laws because they both are different types of ideas. Theories are based on scientific ideas which are less than 100% certain, and so theories can't be proven true. Laws, however, are based on facts only and are 100% sure.
11.8	6.10	<u>D</u>	<u>Theories can't become laws because they both are different types of ideas. Laws describe things in general. Theories explain these laws. However, with supporting evidence, hypotheses may become theories (explanations) or laws (descriptions).</u>

Experimental Group:

<u>Realistic: 11.8</u>	*Has Merit: 0.00*	Naive: 88.2

Control Group:

<u>Realistic: 6.10</u>	*Has Merit: 0.00*	Naive: 94.0

Item 17 (Nature of Scientific Knowledge)

Item 17 was related to scientific assumptions. It is stated in this question that when developing new theories or laws, scientists need to make certain assumptions about nature. Students were asked about the trustiness of these assumptions. According to alternatives A, B and C assumptions must be true; alternative D it depends; alternative E it does not matter and alternative F scientists do not make assumptions.

Table 5.39 shows that students having realistic view are very few. Only 5.9% of the experimental group students and 3% of the control group students choose alternative E. 70.5% of the students in the experimental group and 69.7% of the students in the control group held rational view about assumptions.

Percentage of students having naïve belief is nearly equal in both groups (23.5% for experimental group and 27.3% for control group). These students believed that either assumption must be correct otherwise society would have serious problems or scientists do not make assumptions.

Table 5.39 Percentage of Students' Responses to Item 17

When developing new theories or laws, scientists need to make certain assumptions about nature (for example, matter is made up of atoms). These assumptions *must be true* in order for science to progress properly.			
EG%	**CG%**		**Alternative**
			Assumptions MUST be true in order for science to progress:
38.2	27.3	*A*	*because correct assumptions are needed for correct theories and laws. Otherwise scientists would waste a lot of time and effort using wrong theories and laws.*
14.7	12.1	B	otherwise society would have serious problems, such as inadequate technology and dangerous chemicals.
14.7	18.2	*C*	*because scientists do research to prove their assumptions true before going on with their work.*
17.6	24.2	*D*	*it depends. Sometimes science needs true assumptions in order to progress. But sometimes history has shown that great discoveries have been made by disproving a theory and learning from its false assumptions.*
5.9	3.00	E	it doesn't matter. Scientists have to make assumptions, true or not, in order to get started on a project.
8.8	15.2	F	scientists do not make assumptions. They research an idea to find out if the idea is true. They don't assume it is true.

Experimental Group:

<u>Realistic: 5.9</u> *Has Merit: 70.5* Naive: 23.5

Control Group:

<u>Realistic: 3.00</u> *Has Merit: 69.7* Naive: 27.3

Item 18 (Nature of Scientific Knowledge)

In item 18 students were asked whether scientific theories should be complex or not. Very few students in both groups selected alternatives E or F reflecting naive belief by stating that scientific theories are usually complex (11.7% of the students in the experimental group and 9.1% of the students in the control group). 17.6% of the students in the experimental group and 9.1% of the students in control group believed that the language of good scientific theories is simple. Also approximately 25% of the students in experimental and control group students thought that complexity of language depends on the theory. The percentage of students thinking how deeply you want to get into the explanation affects the complexity of theories nearly equal in both groups (39.4% for control group and 38.2 % for experimental group).

Table 5.40 Percentage of Students' Responses to Item 18

Good scientific theories explain observations well. But good theories are also *simple* rather than *complex.*			
EG%	**CG%**		**Alternative**
17.6	9.1	<u>A</u>	<u>good theories are simple. The best language to use in science is simple, short, direct language.</u>
38.2	39.4	*B*	*it depends on how deeply you want to get into the explanation. A good theory can explain something either in a simple way or in a complex way.*
23.5	27.3	<u>C</u>	<u>it depends on the theory. Some good theories are simple, some are complex.</u>
8.8	15.2	*D*	*good theories can be complex, but they must be able to be translated into simple language if they are going to be used.*
2.9	6.10	E	theories are usually complex. Some things cannot be simplified if a lot of details are involved.
8.8	3.00	F	most good theories are complex. If the world was simpler, theories could be simpler.

Experimental Group:

<u>Realistic: 41.1</u> *Has Merit: 47* Naive: 11.7

Control Group:
Realistic: 36.4 *Has Merit: 54.6* Naive: 9.10

Item 19 (Nature of Scientific Knowledge)

Item 19 was asked to investigate students' opinions about whether best scientists are those who follow the steps of scientific methods or not. Half of the students in experimental group and 36.4% of the control group students claimed that most scientists will follow the steps of the scientific method. Similar to this finding, the existence of a "universal and stepwise method" is determined to be one of the most encountered misconceptions about nature of science (McComas, 1998).Percentage of students having realistic point of view was 23.5 for experimental group and 27.3 for control group. According to these students although scientific method is useful it does not ensure results. So scientist will also use originality and creativity. On the other hand 11.7% of the students in the experimental group and 15.2% of the students in the control group did not believe the necessity of using scientific methods. They thought that scientist can use any methods that might get favorable results or many scientific discoveries were made by accident.

Table 5.41 Percentage of Students' Responses to Item 19

The best scientists are those who follow the steps of the scientific method.			
EG%	**CG%**		**Alternative**
50.0	36.4	*A*	*the scientific method ensures valid, clear, logical and accurate results. Thus, most scientists will follow the steps of the scientific method.*
14.7	21.2	*B*	*the scientific method should work well for most scientists; based on what we learned in school.*
23.5	27.3	C	the scientific method is useful in many instances, but it does not ensure results. Thus, the best scientists will also use originality and creativity.
2.9	6.10	D	the best scientists are those who use any method that might get favorable results (including the method of imagination and creativity).
8.8	9.10	E	many scientific discoveries were made by accident, and not by sticking to the scientific method.

Experimental Group:
Realistic: 23.5 *Has Merit: 64.7* Naive: 11.7

Control Group:
Realistic: 27.3 *Has Merit: 57.6* Naive: 15.2

Item 20 (Nature of Scientific Knowledge)

When students were asked about errors, it was seen that their answers vary among alternatives. Alternative C reflecting realistic view was chosen from control group students more than experimental group students (11.8% for experimental group and 24.2% for control group students). 38.2% of the experimental group students and 27.3% of the control group students though that some errors can slow the advance of science but others can lead to a new discovery. This view reflects rational but not realistic view.

The results revealed that the percentage of students holding naïve belief in experimental group is higher than in control group. 41.1% of the students in experimental group and 33.3% of the students in the control group choose alternative A or E. According to 8.80 % of experimental group students and 15.2% of control group students errors slow the advance of science.

Table 5.42 Percentage of Students' Responses to Item 20

Scientists should NOT make errors in their work because these errors slow the advance of science.			
EG%	**CG%**		**Alternative**
17.6	9.1	A	errors slow the advance of science. If scientists don't immediately correct the errors in their results, then science is not advancing.
8.80	15.2	*B*	*errors slow the advance of science. New technology and equipment reduce errors by improving accuracy and so science will advance faster.*
11.8	24.2	C	errors CANNOT be avoided, so scientists reduce errors by checking each others' results until agreement is reached.
38.2	27.3	*D*	*some errors can slow the advance of science, but other errors can lead to a new discovery or breakthrough. If scientists learn from their errors and correct them, science will advance.*
23.5	24.2	E	errors most often help the advance of science. Science advances by detecting and correcting the errors of the past.

Experimental Group:

Realistic: 11.8	*Has Merit: 47*	Naive: 41.1

Control Group:

Realistic: 24.2	*Has Merit: 42.5*	Naive: 33.3

Item 21 (Nature of Scientific Knowledge)

Item 21 was related to certainty of predictions. Alternatives A, B, C and D gave different explanations for why predictions are never certain. In alternative E it is stated that predictions are certain, only as long as there is accurate knowledge and enough information. In Table 5.43 it is seen that remarkable higher percentage of students in control group (75.8) than in control group (52.9) held realistic view. These students thought that; no one can predict the future for certain because there is always room for error or scientists never have all the facts.

According to 35.3% of the experimental group students and 12.1% of the control group students predictions will always change as new discoveries are made. Approximately 7.5% of all students believed that if there is accurate knowledge and enough information predictions are certain and choose alternative E. This alternative reflects naïve believe about the accuracy of scientific knowledge.

Table 5.43 Percentage of Students' Responses to Item 21

Even when making predictions based on accurate knowledge, scientists and engineers can tell us only what *probably* might happen. They cannot tell what will happen for certain.			
EG%	**CG%**		**Alternative**
			Predictions are NEVER certain:
44.1	66.7	A	because there is always room for error and unforeseen events which will affect a result. No one can predict the future for certain.
35.3	12.1	*B*	*because accurate knowledge changes as new discoveries are made, and therefore predictions will always change.*
2.9	6.1	*C*	*because a prediction is not a statement of fact. It is an educated guess*
8.8	9.1	D	because scientists never have all the facts. Some data are always missing.
8.8	6.1	E	it depends. Predictions are certain, only as long as there is accurate knowledge and enough information.

Experimental Group:

<u>Realistic: 52.9</u>	*Has Merit: 38.2*	Naive: 8.8

Control Group:

<u>Realistic: 75.8</u>	*Has Merit: 18.2*	Naive: 6.1

Item 22 (Nature of Scientific Knowledge)

Item 22 was asked to investigate students' thought about whether scientists discover scientific laws or not. Alternatives A, B and C reflects an ontological view supported by the logical positivists, alternative D is an erroneous view that media uses and alternative E is an epistemological viewpoint with the contemporary literature.

Table 5.44 shows that percentage of students holding realistic view was higher in control group than in experimental group (26.5% for experimental group and 33.3% for control group). None of the students in control group and 2.9% of the students in the experimental group thought that scientist discover scientific laws but they invent the methods to find those laws.

44.1% of the experimental group students and 39.4% of the control group students held naïve belief by supporting that scientists discover scientific laws because laws are based on experimental facts or some scientists may stumble onto a law by chance, thus discovering it, but other scientists may invent the law from facts they already know.

Table 5.44 Percentage of Students' Responses to Item 22

For this statement, assume that a gold miner "discovers" gold while an artist "invents" a sculpture. Some people think that scientists *discover* scientific LAWS. Others think that scientists *invent* them. What do you think?			
EG%	**CG%**		**Alternative**
			Scientists discover scientific laws:
26.5	27.3	*A*	*because the laws are out there in nature and scientists just have to find them.*
35.3	18.2	B	because laws are based on experimental facts.
2.9	0.00	*C*	*but scientists invent the methods to find those laws.*
8.8	21.2	D	Some scientists may stumble onto a law by chance, thus discovering it. But other scientists may invent the law from facts they already know.
26.5	33.3	<u>E</u>	<u>scientists invent laws, because scientists interpret the experimental facts which they discover. Scientists don't invent what nature does, but they do invent the laws which describe what nature does.</u>

Experimental Group:
<u>Realistic: 26.5</u> *Has Merit: 29.4* Naive: 44.1

Control Group:
<u>Realistic: 33.3</u> *Has Merit: 27.3* Naive: 39.4

Item 23 (Nature of Scientific Knowledge)

Similar to item 22, item 23 was asked to investigate students' opinion about whether scientists discover scientific hypotheses or invent them. Although 26.5% of the experimental group students held realistic view about scientific laws, none of them held realistic view about scientific hypotheses. The percentage of control group students choosing alternative F was only 18.2.

58.8% of the students in the experimental group and 42.4% of the students in the control group selected alternative A, B or D which reflects ontological views. Students believing that scientists invent the methods to find the hypotheses or invent hypotheses because a hypothesis is an interpretation of experimental facts were composed of the 44.1% of the experimental group and 27.2% of the control group.

Table 5.45 Percentage of Students' Responses to Item 23

For this statement, assume that a gold miner "discovers gold" while an artist "invents" a sculpture. Some people think that scientists *discover* scientific HYPOTHESES. Others think that scientists *invent* them. What do you think?			
EG%	**CG%**		**Alternative**
			Scientists discover an hypothesis:
26.5	18.2	A	because the idea was there all the time to be uncovered.
23.5	21.2	B	because it is based on experimental facts.
8.8	3.00	*C*	*but scientists invent the methods to find the hypothesis.*
5.9	15.2	D	Some scientists may stumble onto an hypothesis by chance, thus discovering it. But other scientists may invent the hypothesis from facts they already know.
			Scientists invent an hypothesis:
35.3	24.2	*E*	*because a hypothesis is an interpretation of experimental facts which scientists have discovered.*
0.00	18.2	<u>F</u>	<u>because inventions (hypotheses) come from the mind — we create them.</u>

Experimental Group:
<u>Realistic: 0.00</u> *Has Merit: 44.1* Naive: 58.8

Control Group:
<u>Realistic: 18.2</u> *Has Merit: 27.2* Naive: 42.4

Item 24 (Nature of Scientific Knowledge)

Item 24 was asked to investigate whether scientific theories are invented or discovered. The percentage of students holding realistic view was very close in each group (29.4% for experimental group, 24.2% for control group). According to 23.5% of the experimental group students and 36.4% of the control group students, scientists discover a theory because it is based on experimental facts. Approximately 33% of the total students held naïve belief about the nature of scientific theory.

Table 5.46 Percentage of Students' Responses to Item 24

For this statement, assume that a gold miner "discovers" gold while an artist "invents" a sculpture. Some people think that scientists *discover* scientific THEORIES. Others think that scientists *invent* them. What do you think?			
EG%	**CG%**		**Alternative**
			Scientists discover a theory:
17.6	9.1	A	because the idea was there all the time to be uncovered.
23.5	36.4	*B*	*because it is based on experimental facts.*
11.8	9.1	*C*	*But scientists invent the methods to find the theories.*
5.9	6.1	D	Some scientists may stumble onto a theory by chance, thus discovering it. But other scientists may invent the theory from facts they already know.
			Scientists invent a theory:
29.4	24.2	<u>E</u>	<u>because a theory is an interpretation of experimental facts which scientists have discovered.</u>
11.8	15.2	F	because inventions (theories) come from the mind — we create them.

Experimental Group:
<u>Realistic: 29.4</u> *Has Merit: 35.3* Naive: 35.3

Control Group:
<u>Realistic: 24.2</u> *Has Merit: 45.5* Naive: 30.4

Item 25 (Nature of Scientific Knowledge)

In item 25 students were asked that can scientists studying different fields understand each others' work. According to alternatives A and B it is difficult for scientists in different fields to understand each other and they gave different explanation for it. According to alternative C, D and E it is fairly easy**.**

The results revealed that approximately half of the students in both group had a realistic idea (47.1% of the experimental group students and 45.5% of the control group students). 35.3% of experimental group students and 36.4% of the control group students selected alternatives C, D or E and believed that scientist in different fields can understand each other easily. The rest of the students (17.6% of experimental group students and 18.2% of the control group students) who selected alternative B thought that it is difficult for scientists in different fields to understand each other because scientists must make an effort to understand the language of other fields which overlap with their own field.

Table 5.47 Percentage of Students' Responses to Item 25

Scientists in different fields look at the same thing from very different points of view (for example, H+ causes chemists to think of acidity and physicists to think of protons). This makes it difficult for scientists in different fields to understand each others' work.			
EG%	**CG%**		**Alternative**
			It is difficult for scientists in different fields to understand each other:
47.1	45.5	<u>A</u>	<u>because scientific ideas depend on the scientist's viewpoint or on what the scientist is used to.</u>
17.6	18.2	B	because scientists must make an effort to understand the language of other fields which overlap with their own field.
			It is fairly easy for scientists in different fields to understand each other:
20.6	6.1	*C*	*because scientists are intelligent and so they can find ways to learn the different languages and points of view of another field.*
0.00	3.00	*D*	*because they have likely studied the various fields at one time.*
14.7	27.3	*E*	*because scientific ideas overlap from field to field. Facts are facts no matter what the scientific field is.*

Experimental Group:		
<u>Realistic: 47.1</u>	*Has Merit: 35.3*	Naive: 17.6
Control Group:		
<u>Realistic: 45.5</u>	*Has Merit: 36.4*	Naive: 18.2

5.7 Conclusions

The following conclusions can be derived from the results the obtained by the statistical analyses,

1. The conceptual change oriented instruction caused a significantly better acquisition of scientific conceptions related to gases concepts and elimination of misconceptions than the traditionally designed chemistry instruction. However students' post gases concept test scores and interview results showed that students in both groups have continued to hold some misconceptions related to gases concepts.

2. The conceptual change oriented instruction caused a significantly better achievement related to gases concepts than the traditionally designed chemistry instruction. Although in the classroom observation it was seen that students instructed with traditionally designed chemistry instruction were more willing to solve numerical problems, they got lower scores in post achievement test than students instructed with conceptual change oriented instruction.

3. Gender difference has no significant effect on students' understanding of gases concepts, students' achievement in gases concepts and students' attitudes toward chemistry.

4. The conceptual change oriented instruction produced higher positive attitudes towards chemistry as a school subject than traditionally designed chemistry instruction. Classroom observations also revealed the same results. It was observed that students taught with conceptual change oriented instruction were more active, willing to participate classroom discussions and motivated than students taught with traditionally designed chemistry instruction.

5. More than half of the students had a misconception that scientific models are the copies of reality. They claimed that scientific models have proven by scientific evidence or they are true to life or they are based on scientific observations and research.

6. Almost all students thought that there is a hierarchy among hypothesis, theories and laws. They thought that hypotheses can lead to theories which can lead to laws.

7. Only very few students in experimental and control groups accepted that scientists have to make assumptions, true or not, in order to get started on a project. Most of them thought that scientists need to make true assumptions in order for science to progress properly.

8. Most of the students held a realistic view about tentative character of scientific knowledge. According to them scientific knowledge changes because new scientists disprove the theories or discoveries of old scientists.

9. The percentage of students having realistic view was higher in the experimental group in the items 2, 6, 7, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 24, 25. However in the items 1, 3, 4, 5, 9, 20, 21, 22, 23 the percentage of students having realistic view was higher in control group.

CHAPTER 6

DISCUSSION AND RECOMMENDATIONS

In this chapter the summary of the study, discussion of the results obtained in Chapter V implications of the results and some recommendations for further studies was presented.

6.1. Summary of the Study

Before conducting the main study, the misconceptions of the students' on gases concepts were examined through the related literature. Also Gases Misconception Test was prepared by the researcher and applied to 103 10th grade and 95 11th grade students a year before the study. According to the results of this misconception test and in the light of related literature the tests, activities, and lesson plans used in this study were prepared. The main aims of the study were to investigate the effectiveness of conceptual change oriented instruction accompanied with computer animations on 10th grade students understanding and achievement of gases concepts and attitudes towards chemistry as a school subject. Also students' views about nature of science and interactions of science- technology- society issues were examined. In order to explore given problems, a quasi experimental design was used. Two intact classes of a chemistry course consisted of 67 tenth grade students were participated in the study. The experimental group including 34 students was exposed to conceptual change oriented instruction, while the control group including 33 students was instructed with traditional methods. The study was conducted over seven weeks. At the beginning of the study GCT, GAT, ASTC and SPST were administered to both groups as a pretest to examine the differences between groups. T-test analyses were used to analyses of the results obtained from these tests. Moreover to examine the effect of treatment GCT, GAT, and

ASTC were administered as a post- test. Adopted version of Views on Science-Technology- Society (T-VOSTS) was administered to both groups after treatment to obtain information about students' views on nature of science concepts. 2 months after treatment GCT was administered again as a GRT to both groups to assess their retention on gases concepts. In order to analyze the results ANCOVA and two- way ANOVA were used.

The results of independent sample t-test analyses showed that there was no significant mean difference between the CCOI group and TDCI group in terms of students' understanding in gases concepts, achievement in gases concepts, and their attitude toward chemistry, before the treatment. However a significant difference was found between the two groups with respect to science process skills. Therefore science process skills were controlled as a covariate.

6.2. Discussion of the Results

It is generally accepted that learning is the result of the interaction between students' current ideas or concepts and what they are taught. Researches about learning consistently showed that students generally come to classroom with well-established understandings about how and why everything behaves as they do (Posner, Strike, Hewson, & Gertzog, 1982; Resnik, 1983). Unfortunately most of the time these well-established understandings are not consistent with the scientifically accepted ones. So these conceptions are generally thought as a major source of students' learning difficulties (Hewson &Hewson, 1983). Vosniadou (2001) stated that "science learning is characterized by misconceptions" (p. 179). Giving the impact of students' misconceptions on learning, this study investigated students' misconceptions in gases concepts. Before the main study the researcher prepared GMT and applied to 198 high school students. The analyses of the misconception test revealed that students hold variety of misconceptions about gases concepts. Some of the observed misconceptions were the same misconceptions as detected by previous researchers (Pereira and Pestana

1991; Hwang and Chiu, 2004; Mas, Perez and Harris, 1987). For example in their study Pereira and Pestana (1991) found that students thought that when a substance goes from liquid to gas state the size of the particles increase. According to results of misconception test 35.4% of the students thought similar way. Also the results of the misconception test revealed that students perceived the gas as a continuous medium, rather than as an aggregation of particles. This finding was corroborated with the findings of Hwang and Chiu (2004). Mas, Perez and Harris (1987) stated that students though that liquids lost mass and weight when they vaporized so they rise. A similar result was found in the misconception test. 16.8% of the students thought that gases are lighter than liquids. Nevertheless, some new misconceptions not seen in the literature were found out. These misconceptions are;

- Gas particles take the shape of the container.
- Gases exert pressure only when they are compressed.
- Ideal gases do not give any chemical reactions.
- The conditions that gases behave ideally depend on the nature of gases.
- When the gas is compressed in a closed container, the particles cannot move.

Misconceptions of students can be seen as a key factor for a successful instruction. In order to make use of these misconceptions in designing effective instruction Eylon (1988) mentioned four steps; determination of misconceptions, investigation of their sources, treatment of them by designing appropriate teaching practices and evaluation of the effectiveness of implementation. So the main purpose of this study was to investigate the effectiveness of conceptual change oriented instruction accompanied with computer animations on 10th grade students' understanding of gases concepts. Based on the statistical analyses results given in Chapter V, it can be concluded that conceptual change oriented instruction accompanied with computer animations caused significantly better acquisition of gases concepts and remediation of misconceptions than traditionally designed chemistry instruction ($\overline{X}$ (CCOI) = 15.62, $\overline{X}$ (TDCI) = 10.67). This result was also supported by the analyses of interview questions.

In this study conceptual change oriented instruction was used in the experimental group. The instruction focused on revealing students' misconceptions, replacing them with scientific conceptions and relating their prior conceptions with the new concept. At the beginning of the instruction the teacher asked a question to initiate students' prior conceptions or misconceptions about the concepts. Students shared their ideas in a discussion environment. The teacher guided this discussion until students were aware of that they have different ideas and their knowledge fails to explain the situation. The aim of this discussion was to make students notice their misconceptions (dissatisfaction). Instruction continued with the scientific explanation of the concept by using computer animations. During students' engagement in computer animations teacher asked conceptual questions. These questions focused students' misconceptions and aimed to show why they were wrong. By discussing students' misconceptions the teacher made students reach scientific explanation of the concepts and see the internal consistency of the explanations (intelligibility). Also numerical problems were solved by teacher or students if the concepts include some formulations. In order to show the consistency of knowledge with the other knowledge the teacher presented a new situation or daily life examples. By this way students got an opportunity to test the plausibility of the new concept (plausibility). The lesson ended with a homework question prepared for showing students explanatory power of the newly learned concepts (fruitfulness).

However in the control group traditionally designed chemistry instruction was used. This instruction was mainly based on lecturing method. The teacher explained the topic and wrote the important concepts and formulations on the board. Students generally listened the teacher and copied the board on their notebooks. If they did not understand the concept, the teacher gave extra explanations or created discussion environment. During discussions teacher directed students to find correct answers. When the topic included algorithmic questions, the teacher solved first two or three problems on the board and to check students' understanding asked them similar problems. During the instruction the teacher did not consider students' previous knowledge and their misconceptions.

The result of this study that showed conceptual change oriented instruction accompanied with computer animation was effective in students' understanding scientific concepts was collaborated with many studies in the literature (Azizoğlu, 2004; Ipek, 2007; Chamber & Andre, 1997; Sarantopoulos and Tsaparlis, 2004; Hewson and Hewson, 1983).

Actually the effectiveness of conceptual change oriented can be explained by variety of factors. Firstly students' misconceptions were taken into account during the instruction. We know from literature that successful instruction needs explicit considerations of misconception (Hewson& Hewson, 1983). Also students were not passive listener instead they actively involved in learning process. Moreover the instruction accompanied with computer animations help students to visualize gases concepts and principles at all three levels of representation namely the symbolic level, the particulate level, and the macroscopic level. Bowen & Phelps (1997) stated that the chemical concepts and principles such as gases which involve the three levels of representation are the most difficult ones for students to learn. So it is not surprising that students hold a number of misconceptions in gases concepts. Gases topic requires well established understanding of particulate nature of matter, meaning of chemical formulas, equations and mathematical relationships and observable chemical processes. In this study comprehension in symbolic, particulate, and macroscopic level representation was facilitated by conceptual change instruction accompanied with computer animations. Gabel (1993) argued that problems at particulate levels are the best indicators of conceptual understanding and they are most difficult ones for the students. Instructions which help them to learn to visualize chemical phenomena and principles at all three levels, may assist students overcome this difficulty. Taken above in the consideration and results of this study, using conceptual change oriented instruction accompanied with animations to overcome students' misconceptions seems very reasonable.

However it was seen from the analyses of GCT and interviews that although conceptual change oriented instruction caused better understanding of gases concepts and remediation of misconceptions, experimental group students still hold some misconceptions about gases even after the instruction. This finding is consistent with the literature that students' misconceptions are robust and resistant to change even after formal instruction (Taber, 2001; Hewson& Hewson, 1988; Boujaoude, 1991).

Suits (2000) defined two types of understanding in chemistry, algorithmic understanding and conceptual understanding. Generally students memorize facts or use algorithms to pass their exams without learning the theories (Fellows, 1994). Studies on this issue indicated the dichotomy between students' performance on mathematical tasks used to describe behaviors of gases and their conceptual understanding that underlines these tasks. So the other purpose of this study was to investigate the effect of conceptual change oriented instruction accompanied with computer animations on students' achievement of gases concepts. The results show that student in the experimental group got significantly higher scores on achievement test than those of in control group ($\overline{X}$ (CCOI) = 9.94, $\overline{X}$ (TDCI) = 6.36). Actually to develop conceptual understanding learners must comprehend the three levels of representation for chemical principle and are able to use invented algorithms. So there is a one way relationship between conceptual and algorithmic understanding. It is expected that better conceptual understanding might implies better algorithmic understanding. But the reverse might not true all the time. I mean better algorithmic understanding might not imply better conceptual understanding. The results of this study indicated that students in the experimental group got significantly higher scores both in concept test and achievement test about gases.

The analyses of post-GCT, post-GAT, classroom observations and interviews together showed that students had greater success in answering algorithmic questions than the concept questions about gases. For instance some of the students who could not respond the conceptual questions about the diffusion of gases in the interview question, found the correct answer in post-GAT. Also the 24^{th} question in post-GCT was also related to diffusion of gases. 28.5% of the control group and 70.6% of the experimental group students could correctly answer this question. The percentage of students giving the correct answer of the 4^{th} question which needed calculations about gases diffusion in post-GAT was 68.2 for control group and 89.4 for experimental group. A similar finding was detected from the classroom observations. Although some of the students could not explain the relationship between temperature and pressure, they could solve the problems about it. For example the 6^{th} question in the post- GCT was related to temperature- pressure relationship of gases. 36.4% of the control group students and 47.4% of the experimental group students could explain the P-T relationship. However 56.2% of the control group and 79.2% of the experimental group students gave the correct answer to the 12^{th} question which was about ideal gas laws of post-GAT. This finding implied that students memorize knowledge and equations but they may not make interpretations. In fact, Nurrenbern and Pickering (1987), Sawrey (1990) and De Berg (1995) found similar results.

One of the purposes of the study was to investigate whether there was a significant difference male and female students with respect to their understanding and achievement of gases concept test. There are contradictory results about the relationship between gender and understanding and achievement in chemistry. Some of the researches concluded that gender difference was effective in understanding and achievement in chemistry (Chambers and Andre 1997). However on the contrary to these findings and supported by this research, some other researches showed gender difference was not effective (Greenfield 1996; Azizoğlu 2004). The results of this study indicated that there was no significant mean difference between male and female students. The mean post-GCT scores were 12.62 for females and 13.86 for males and the mean post-GAT scores were 8.08 for females and 8.30 for males. Moreover the interaction between gender and treatment had no significant effect on students’ understanding and achievement in gases concepts.

On the contrary to the view that learning is only a cognitive activity, it is now accepted that students' attitude toward science is also very influential in learning process. So the other aim of this study was to investigate the effect of conceptual change oriented instruction on students' attitudes toward chemistry as a school subject. The result showed that conceptual change oriented instruction was more effective than traditionally designed chemistry instruction with respect to students' attitude toward chemistry ($\overline{X}$ (CCOI) = 41.65, $\overline{X}$ (TDCI) = 34.73). This result was supported by classroom observations. During the observation experimental group students seemed more willing to discuss and eager to learn. Although some of the researchers claimed that attitude development is a long process and there are other factors (educational background, family, school climate) besides teaching method affecting students attitude (Papanastasiou& Papanastasiou, 2004), the result of this study is supported by Sungur and Tekkaya (2003) and Gedik (2001).

Moreover the effect of gender on students' attitude toward chemistry as a school subject was investigated in this study. The result showed that that there was no significant mean difference between female and male students with respect to their attitudes toward chemistry as a school subject. Also no significant interaction effect between gender and treatment on students' attitudes toward chemistry as a school subject was found. In the literature there are contradictory results about gender issue in attitude researches. Dahindsa and Chung (2003) found no significant sex difference in attitudes toward and achievement in science in coeducational schools. However Barmby et al. (2008) showed that attitudes toward science declined as students progressed through secondary school and this decline was more pronounced for female students.

Furthermore control and experimental group students' retention on gases concepts was analyzed. 2 months after treatment GCT was administered again as a GRT to both groups to assess their retention on gases concepts. According to the results of this study the students taught with conceptual change oriented instruction scored significantly higher than students taught with traditionally designed chemistry instruction in retention test. ($\overline{X}$ (CCOI) = 15.25, $\overline{X}$ (TDCI) = 10.03). A slight difference between experimental group students score on post-GCT and GRT ($\overline{X}$ (GCT) = 15.62, $\overline{X}$ (GRT) = 15.25,) showed that students' knowledge about gases concepts were persistent.

Although science has an enormous effect on people's life, many individual have lack of understanding about how scientific enterprise operates. This lack of understanding motivates many researchers to deal with students' conceptions about nature of science and the relationship between science- technology- society. These researches revealed that students hold many naïve about nature of science. (Lederman, 1992; Meyling, 1997; Kang, Scharmann& Noh, 2005; Ryan & Aikenhead, 1992). The final aim of this study was to investigate the views of students about the nature of science concepts. The evaluation of students' responses to the T-VOSTS items were made by using the categorization systems of Doğan Bora et al.(2006) reflecting different views as realistic, has merit and naïve. According to the results of this study 73.5% of experimental group and 69.6% of control group students held naïve beliefs about scientific models that they believed scientific models are the copies of reality. This misconception is the 13th myth of McComas (1998). Moreover approximately all of the students (88.2% for experimental group and 94% for control group) thought that hypotheses become theories and theories become laws when they are supported. This is the other myth mentioned by McComas (1998).
The reason of this poor understanding might be that education systems generally based on simply memorization of facts and concepts which are underestimate knowledge generation process. Also science textbooks and science teachers do not give an opportunity to students to think how science functions.

However it can be seen from the analyses that most of the students held very realistic views about characteristics of scientists, nature of the predictions, and tentative character of scientific knowledge. Researchers consistently found that in order to develop students understanding about nature of science concepts, explicit instructions should be developed (Schoneweg and Rubba, 1993; Khishfe and Lederman, 2006; Abd-El-Khalick & Lederman, 2000).

6.3. Implications

Based on the findings, the following implications can be offered;

1. Students' prior knowledge is very important in the learning of new concepts. Their misconceptions may hinder the acquisition of new knowledge. So the teachers should consider their misconceptions in designing teaching strategies. Teachers should determine students' misconceptions before the instruction investigate the sources of them and prepare instruction to remediate these misconceptions.

2. One of the sources of students' misconceptions is teachers. Thus teachers should continuously check their knowledge in order to not cause any misconceptions in students' mind.

3. The other source of students' misconceptions is textbooks. Both writers of these books and the classroom teacher should be aware of the importance of textbooks in students learning and careful about the knowledge written in the book.

4. The main aim of science education is to enhance meaningful understanding of scientific concepts. Conceptual change approach is accepted to serve this purpose. The curriculum developers, textbook writers and teachers should be aware of the importance of conceptual change in science education.

5. Students have many difficulties in learning chemistry. The main reason of this difficulty is that students cannot comprehend the chemistry concepts in symbolic, particulate, and macroscopic levels. Instructions which help students to learn to visualize chemical phenomena and principles at all three levels, may assist students overcome this difficulty.

6. Usage of technology is very effective in demonstrating the three levels of representations of chemical phenomena. Also when they are used effectively they save time. Instructional designers should prepare materials for different topics in science and guidebooks showing how to use these materials for teachers.

7. Students' understanding in science is highly affected by science process skills. So both teachers and families should create environment that facilitate improvement of students' science process skills.

8. Holding realistic views about nature of science are necessary in making decisions about socio scientific issues, understanding scientific concepts and following technological improvements. However both students and teachers hold many naïve ideas about nature of science. Therefore to develop students understanding in nature of science issues explicit instructions should be designed.

9. Science instructions should include some affective elements besides cognitive ones. Students' attitudes, motivations and self- efficacy affect their science learning. Thus any teaching strategy should aim to develop these affective factors. Also teacher support, family environment, and peer instruction are determined key factors for students' attitude and motivation. Teacher education programs should

include some lessons for the importance of affective factors and teachers should inform families about it.

6.4 Recommendations

Based on the results, the researcher offered the following for future studies;

1. Similar studies can be conducted to investigate the effect of conceptual change oriented instruction to other chemistry topics and different grade levels.

2. The study can be conducted at different type of high schools and with larger sample size to increase the generalization of results.

3. Future researches could be conducted for longer period of time with the inclusion of other topics to see the long term effects of conceptual change oriented instruction on students understanding and achievement.

4. Some of the constructs such as motivation, self efficacy other than attitude could be investigated in future researches.

5. Further studies can be conducted to investigate the effect of micro world on students understanding and achievement in gases concepts.

6. Effect of computer animations integrated with other constructivist methods on students understanding and achievement of scientific concepts can be investigated.

7. Further researches can be conducted to investigate the effectiveness of conceptual change oriented instruction with different teaching strategies such as cooperative learning or problem based learning in remediation of students' misconceptions, their understanding and achievement in gases concepts and attitudes toward chemistry as a school subject.

8. Pre-service and in-service science teachers' views about nature of science and science- technology- society issues can be investigated.

9. A conceptual change oriented instruction which explicitly deal with NOS issues can be designed and the effectiveness of it in developing students' understanding can be investigated.

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APPENDIX A

INSTRUCTIONAL OBJECTIVES

1. To state the properties of gases
2. To differentiate the properties of gases that of solids and liquids both at molecular and macroscopic level.
3. To compare the mass of gases and liquids.
4. To infer that gas molecules completely fill the container and take its shape.
5. To explain the compressibility of gases based upon kinetic theory.
6. To conclude that the volume of gas molecules is negligible compared to the volume of space in which they move.
7. To describe the pressures of gases based upon kinetic theory.
8. To analyze gas laws with respect to kinetic theory.
9. To predict what would happen to gas molecules when the gas is cooled.
10. To explain diffusion of gases.
11. To determine the factors that affect gas pressures.
12. To identify the volumes of gases in a closed container.
13. To infer the results of change in gas pressure for a given experimental setting.
14. To draw the best representation of distribution of gas molecules in a closed container.
15. To relate the pressure of gases with the volume of gases in a closed container.
16. To describe the conditions under which the real gases behavior approximates ideal gas behavior.
17. To convert information given in a graphical form to a statement
18. To explain Dalton's Law.
19. To use Dalton's law to calculate partial pressures of gases in a mixture.

20. To combine gas laws in solving problems.
21. To relate average speed of gas molecules to kinetic theory.
22. To explore the relationship between the properties of gases.
23. To interpret ideal gas law to predict gas behavior.
24. To select appropriate gas law to solve numerical problems.
25. To use Avogadro's Law to calculate the volume of a given gas.
26. To compute gas pressure this is measured by manometer and barometer.
27. To describe the space between gas molecules.
28. To predict what would happen to gas molecules when the gas is compressed.

APPENDIX B

GAZLAR KAVRAM TESTİ

Aşağıda gazlar konusu ile ilgili 25 çoktan seçmeli sorudan oluşan bir test bulunmaktadır. Lütfen soruları dikkatli bir şekilde okuduktan sonra uygun seçeneği işaretleyiniz.

1. Sabit sıcaklıkta, kapalı bir kapta sıvı halden gaz hale geçen bir madde için aşağıdakilerden hangisi doğrudur?

a) Moleküller kabın şeklini alır.
b) Moleküller genleşir.
c) Gazlar sıvılardan daha hafif olduğundan kütle azalır.
d) Sıvı halden gaz hale geçerken basınç artacağından hacim azalır.
e) Moleküllerin arasındaki boşluk artar.

2. Gaz basıncı ile ilgili aşağıda verilen yargılardan hangisi doğrudur?

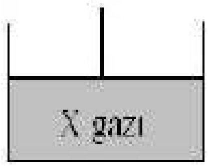
a) Daha ağır gazlar daha fazla basınç uygular.
b) Gaz basıncı gazların üzerine uygulanan etkiye verdikleri tepkidir.
c) Gazlar bulundukları kabın her yerine aynı basıncı yaparlar.
d) Gaz basıncı bulunduğu kabın şekline bağlıdır.
e) Gaz basıncı gazların ısıtılması ile oluşur.

3. Oda koşullarında 2 litrelik kapalı bir kapta bulunan 1 mol oksijen ve 1 mol helyum gazlarının hacimleri nedir?

a) İkisi de birer litre hacim kaplar.
b) Oksijenin mol kütlesi büyük olduğundan daha çok yer kaplar.
c) İkisi de 22,4 litre hacim kaplar.
d) İkisi de ikişer litre hacim kaplar.
e) Helyum oksijenden 4 kat daha hızlı hareket edeceğinden, 4 kat fazla hacim kaplar.

4. Aşağıdaki şekilde bir kapta bulunan X gazı gösterilmiştir.

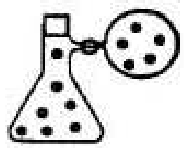
Eğer piston aşağıya doğru itilirse X gazı ile ilgili aşağıda verilen ifadelerden hangisi doğrudur?

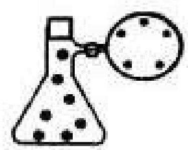


a) Birim zamanda birim yüzeye çarpan molekül sayısı artar, çünkü hacim azalırken basınç artar.
b) Sıcaklığı artar, çünkü kinetik enerji artar.
c) Moleküllerin büyüklüğü azalır, çünkü hacim azalır
d) Moleküllerin ortalama kinetik enerjisi artar, çünkü hacim azalır.
e) Basıncı değişmez, çünkü X gazının basıncı her zaman açık hava basıncına eşittir.

5. Hava ile dolu bir kaba şekilde gösterildiği gibi bir balon bağlanmaktadır. Daha sonra aradaki musluk açılarak kap ısıtılmakta ve balon şişmektedir.

Balon şiştikten sonra kaptaki ve balondaki havanın dağılımını en iyi açıklayan şekil hangisidir?


a)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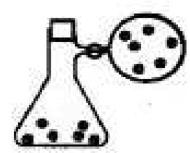
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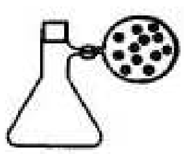
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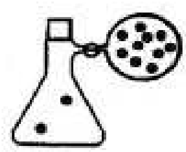
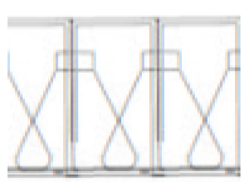

e)

6. Şekilde verilen sistemde cam borunun içinde bir damla cıva bulunmaktadır. Kabın içindeki sıcaklık ve basınç değişimine bağlı olarak cıva damlası sağa ya da sola hareket etmektedir.

Eğer düzenek, sıcaklığı 26 ^{o}C olan bir odadan sıcaklığı 5^{o}C olan başka bir odaya götürülürse cıva damlacığının hareket yönü ile ilgili verilen ifadelerden hangisi doğrudur?



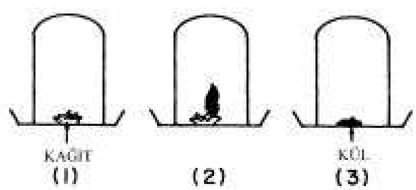
a) Hareket etmez, çünkü basınç her zaman açık hava basıncına eşittir.
b) Önce sola sonra sağa doğru hareket eder.
c) Önce sağa sonra sola doğru hareket eder.
d) Sağa doğru hareket eder, çünkü sıcaklık düşünce hacim artar.
e) Sola doğru hareket eder, çünkü sıcaklık düşünce kabın içindeki basıncı azalır.

7.Gazlarla ilgili verilen ifadelerden hangisi <u>yanlıştır</u>?

a) Aynı sıcaklıkta bütün gazların ortalama kinetik enerjileri aynıdır.
b) Gaz basıncı, gazın moleküllerinin içerdiği atom sayısına ve cinsine bağlıdır.
c) Gazlar tanecikli yapıya sahiptir.
d) Gaz basıncı, birim hacimdeki tanecik sayısına bağlıdır.
e) Gazlar, bulundukları kabın her tarafına yayılırlar.

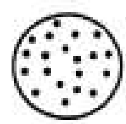
8. Aşağıda verilen şekilde Durum 1'de bir parça kağıt cam fanusun içine konmaktadır. Durum 2'de kağıt yakılmakta ve Durum 3'te küller oluşmaktadır.

1, 2 ve 3 durumlarında herşey tartıldığına göre, sonuç aşağıdakilerden hangisinde doğru verilmiştir?

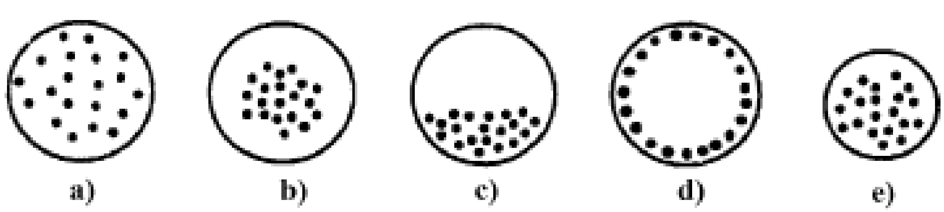


a) Durum 1 daha büyük ağırlığa sahiptir.
b) Durum 2 daha büyük ağırlığa sahiptir.
c) Durum 3 daha büyük ağırlığa sahiptir.
d) 1 ve 2 aynı ağırlığa sahip ve 3'ten daha ağırdır.
e) Hepsi de aynı ağırlığa sahiptir.

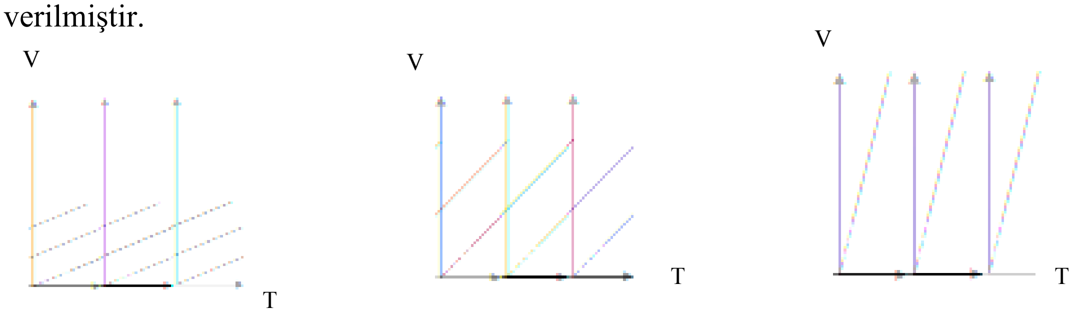
9. Aşağıdaki şekil 20 ^oC ve 3 atm basınçta hidrojen gazı ile dolu silindir şeklindeki çelik bir tankın enine kesitidir. Noktalar, tanktaki bütün hidrojen moleküllerinin dağılımını temsil etmektedirler.



Sıcaklık –5 ^oC'ta düşürüldüğünde aşağıdaki şekillerden hangisi kapalı çelik tanktaki hidrojen moleküllerinin muhtemel dağılımını göstermektedir?



10. Aşağıda aynı miktarda gazın farklı basıçlardaki mutlak sıcaklık hacim grafikleri verilmiştir.



Buna göre, P_1, P_2 ve P_3 basınçları arasındaki ilişki aşağıdakilerden hangisinde doğru verilmiştir?

a) $P_1 = P_2 = P_3$
b) $P_1 < P_2 < P_3$
c) $P_2 < P_1 < P_3$
d) $P_3 < P_2 < P_1$
e) $P_2 < P_3 < P_1$

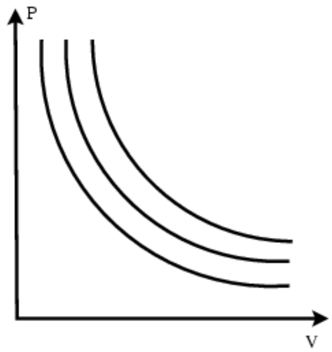
11. Aşağıdaki kapların üçünde de H_2 gazı bulunmaktadır.

Bu gazlar ideal gaz davranışına göre nasıl dizilir?

I	II	III
P= 1atm T= 0 ^{0}C	P= 1atm T= 25 ^{0}C	P= 0,1atm T= 25 ^{0}C

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

12. Belirli bir gaza ilişkin yapılan üç deneyde basınç- hacim grafiği yandaki gibi bulunmuştur.



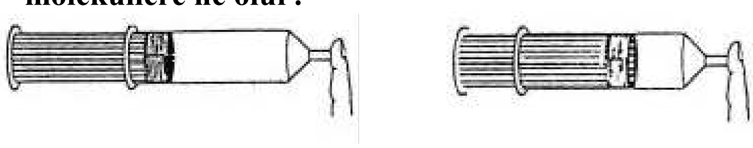
Bu üç deney ile ilgili verilen:

I. Deneyler farklı sıcaklıkta yapılmış olabilir.
II. Deneylerde farklı miktarda gaz kullanılmış olabilir.
III. Deneylerde hem sıcaklık hem de miktarlar farklı olabilir.

bilgilerinden hangileri doğrudur?

a) Üçü de doğrudur.
b) Üçü de yanlıştır.
c) I ve II doğru, III yanlıştır.
d) III doğru, I ve II yanlıştır.
e) I doğru, II ve III yanlıştır.

13. Hava ile dolu bir şırınganın ucu kapatılmakta ve şırınganın pistonu havayı sıkıştıracak şekilde itilmektedir. Bu sıkıştırma sonucunda havayı oluşturan moleküllere ne olur?

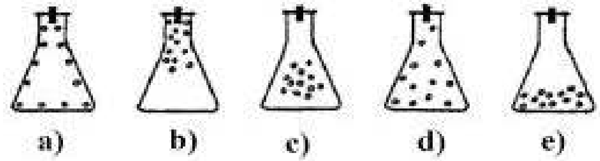


a) Moleküllerin hepsi şırınganın ucuna toplanır.
b) Moleküller birbirine yapışırlar.
c) Moleküller küçülürler.
d) Sıkıştırılan moleküllerin hareketi durur.
e) Moleküller arasındaki mesafe azalır.

14. Birer litre hacimdeki iki kapta N_2 gazı vardır. Birinci kabın sıcaklığı 100 ^{0}C, ikincisinin sıcaklığı 10 ^{0}C ve her ikisinin de basıncı birer atmosfer olduğuna göre aşağıdaki ifadelerden hangisi doğrudur?

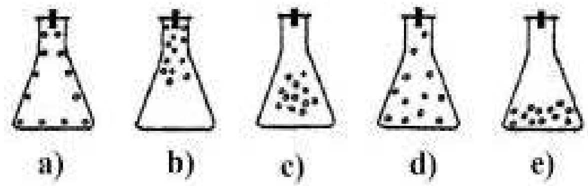
a) Birinci kapta daha çok sayıda molekül vardır.
b) Her iki kaptaki moleküllerin ortalama kinetik enerjileri birbirine eşittir.
c) Birinci kaptaki moleküllerin ortalama kinetik enerjisi, ikinci kaptakinden küçüktür.
d) Her iki kaptaki moleküllerin ortalama hızları birbirine eşittir.
e) Birinci kaptaki moleküllerin ortalama hızı, ikinci kaptakinden büyüktür.

15. 25 ^{o}C'de havayı oluşturan parçacıkların kap içindeki dağılımını en iyi gösteren şekil hangisidir?



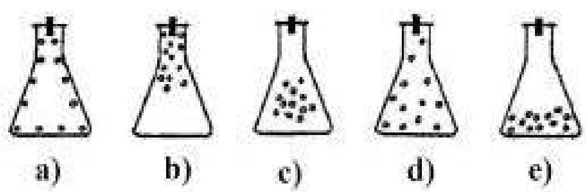
16. Su banyosuna buz ilave edilerek kaptaki sıcaklık 0 ^{o}C'ye kadar düşürülmektedir**.**

Sıcaklık değişiminin havayı oluşturan parçacıkları etkileyecek kadar bekledikten sonra parçacıkların kap içindeki dağılımını en iyi gösteren şekil hangisidir?



17. Isıtıcı yardımıyla su banyosundaki su ısıtılarak gazı içeren kabın sıcaklığı 60 ^{o}C'ye yükseltilmektedir.

Bu durumda parçacıkların kap içindeki dağılımını en iyi gösteren şekil hangisidir?



18. Sabit hacimli bir kapta X gazı bulunmaktadır.

Belirli bir sıcaklıkta basıncın azaldığı gözlemlendiğine göre,

I. Gaz ayrışmaktadır.
II. Kaptaki gaz moleküllerinin sayısı azalmaktadır.
III. Daha çok sayıda atom içeren moleküller oluşmaktadır.

ifadelerinden hangisi ya da hangileri doğrudur?

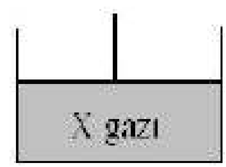
a) Yalnız I b) Yalnız II c) Yalnız III
d) II ve III e) I, II, ve III

19. Bir kapta, eşit kütleli ve molekül kütleleri bilinen X ve Y gazları bulunmaktadır.

X ve Y' nin kısmi basınçlarını hesaplayabilmek için aşağıdakilerin hangisinin bilimesi yeterlidir?

a) Sıcaklığın
b) Kabın hacminin
c) Karışımın toplam basıncının
d) Gazların toplam kütlesinin
e) Sıcaklık ve toplam kütlenin

20. Yandaki şekilde görülen pistonlu kapta bulunan X gazının aşağıda verilen özellikleri, sıcaklık artırılırsa nasıl değişir?



	Derişimi	Hacim	Basıncı	Mokeküllerin ortalama kinetic enerjileri
a)	Artar	Artar	Artar	Artar
b)	Azalır	Artar	Değişmez	Artar
c)	Değişmez	Azalır	Azalır	Azalır
d)	Azalır	Azalır	Artar	Değişmez
e)	Artar	Artar	Artar	Değişmez

21. H_2 ve O_2 gazlarının ortalama hızları ile ilgili,

I. 25 ^oC deki H_2, 25 ^oC deki O_2 den daha hızlıdır.
II. 100 ^oC deki H_2, 25 ^oC deki O_2 den daha yavaştır.
III. 100 ^oC deki H_2, 25 ^oC deki H_2 den daha yavaştır.

yargılarından hangisi ya da hangileri doğrudur? (H=1, O=16)

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

22. Üç özdeş elastik balondan biri X, biri Y, diğeri ise Z gazı ile eşit hacimli olacak şekilde, oda koşullarında doldurulmuştur. Aynı ortamda, bir süre sonra, gazların balon çeperlerinden sızması nedeniyle balonların hacimleri (V) değişmiş ve $V_x < V_y < V_z$ olmuştur.

Buna göre, balonlardaki gazlar için,

I. Son durumda Y nin mol sayısı X inkinden küçüktür.
II. Yayılma (difüzyon) hızı en büyük olan X tir.
III. Molekül kütlesi en büyük olan Z dir.

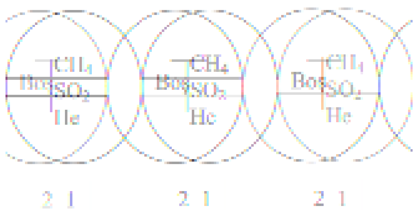
yargılarından hangileri doğrudur?

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

23. Aşağıda verilen koşulların hangisi gerçek bir gazın ideal gaz davranışı göstermesine sebep olur?

a) Yüksek basınç ve yüksek sıcak
b) Düşük basınç ve düşük sıcaklık
c) Düşük basınç ve yüksek sıcaklık
d) Normal koşullar
e) Gazın cinsi

24. Şekilde 1. kaptaki gazların mol sayıları eşittir. Musluk kısa bir süre için açılıp kapatılıyor.



I. 2. kaptaki SO_2 molekülleri en fazladır.
II. 1. kaptaki He kütlesi en fazladır.
III. 1. kaptaki gazların kısmi basınçları, $P_{He} < P_{CH4} < P_{SO2}$ şeklindedir.

Bu yargılardan hangisi ya da hangileri doğrudur? (He= 4, CH_4= 16, SO_2=64)

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

25. Bir gazı oluşturan atomların/moleküllerin arasında ne vardır?

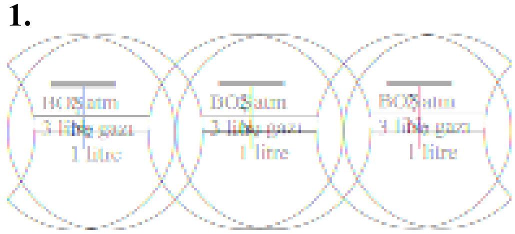
a) Hava
b) Su buharı
c) Başka gazlar
d) Hiç bir şey yoktur
e) Yabancı maddeler (toz, kir gibi)

APPENDIX C

GAZLAR BAŞARI TESTİ

Aşağıda gazlar konusu ile ilgili 15 çoktan seçmeli sorudan oluşan bir test bulunmaktadır. Lütfen soruları dikkatli bir şekilde okuduktan sonra uygun seçeneği işaretleyiniz

1.



1. kap 2.kap

Sabit sıcaklıkta musluk açılıp kaba N_2 gazının geçişi sağlanıyor. Sistem dengeye geldiğinde II. kaptaki basınç kaç atmosferdir?

a) 2 b) 3/2
c) 4/3 d) 2/3
e) 1/2

2. Normal koşullarda 89,6 L hacim kaplayan NO gazı 273 ^{0}C sıcaklık ve 2 atm basınç altında kaç litre hacim kaplar?

a) 89,6 b) 44,8 c) 22,4 d) 11,2 e) 33,6

3. Kapalı ve sabit hacimli bir silindirin içindeki 8 gr H_2 üzerine eşit kütlede CH_4 gazı ilave edilerek sistemin sıcaklığı 27 ^{0}C den 127 ^{0}C ye çıkıyor. Kaptaki son basınç 9 atm olduğuna göre kapta yanlız H_2 gazı varken basınç kaç atm dir? (C: 12, H: 1)

a) 2 b) 3 c) 4 d) 5 e) 6

4. SO_3 gazının 40 saniyede geçtiği bir borudan aynı koşullarda Ne gazı kaç saniyede geçer?
(S: 32, O: 16, Ne: 20)
a) 10 b) 20 c) 40 d) 60 e) 80

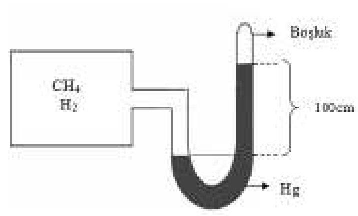
5. 32 gram SO_2 gazının bulunduğu bir kap, aynı şartlar altında 16 gram X_2 gazı ile dolabildiğine göre, X in atom kütlesi kaçtır? (O: 16, S: 32)

a) 14 b) 16 c) 18 d) 32 e) 48

6. Eşit kütledeki He ve CH_4 gazlarının oluşturduğu bir karışımın toplam basıncı 25P olduğuna göre, He gazının kısmi basıncı kaç P dir? (H: 1, He: 4, C: 12)

a) 3P b) 5P c) 10P d) 12P e) 20P

7.



32 gram CH_4 ve 6 gram H_2 gazlarını içeren karışımın basıncı manometre ile şekildeki gibi ölçülmüştür. **Buna göre CH_4 gazının kısmi basıncı kaç cmHg dir?** (C: 12, H: 1)

a) 20 b) 30 c) 40 d) 60 e) 80

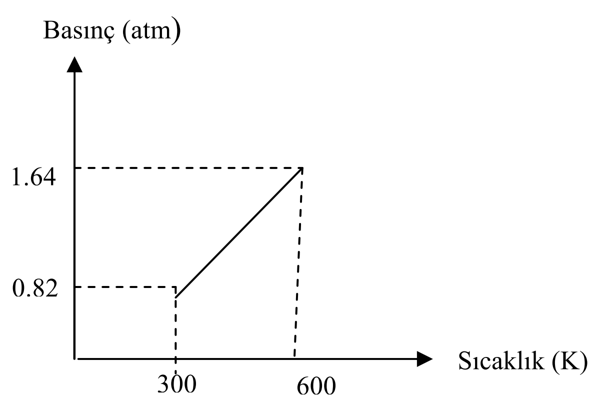
8. Gaz halindeki XO_3 bileşiğinin normal koşullar altında 11,2 litresinde 12 gram X elementi bulunmaktadır. Buna göre XO_3 gazının molekül kütlesi kaçtır? (O: 16)

a) 44 b) 46 c) 64 d) 72 e) 110

9. Bir gazın hacmi yarıya düşürülüp, mol sayısı iki katına ve mutlak sıcaklığı dört katına çıkartılırsa basıncı ilk basınca göre ne olur?

a) 16 katına çıkar b) 1/16 sına düşer c) 4 katına çıkar d) 1/4 üne düşer e) 12 katına çıkar

10. Üç litrelik bir kapta bulunan 5,6 gram XO_2 gazının basınç- sıcaklık grafiği aşağıda verilmiştir.



Buna göre X in atom kütlesi kaçtır? (O = 16)

a) 12 b) 14 c) 24 d) 26 e) 28

11. Sabit hacimli bir kaptaki gazın 0 ^{0}C deki basıncı 0,5 atm dir. Kaba aynı sıcaklıkta 1 mol gaz eklendiğinde aynı sıcaklıkta basınç 1,5 atmosfere çıkıyor. Kabın hacmi kaç litredir?

a) 5,6 b) 11,2 c) 22,4 d) 33,6 e) 44,8

12. 0,1 mol hidrojen gazının 27 ^{0}C ve 3 atm basınçta hacmi 600 mL dir. Hacim sabit tutulup sıcaklık -3 ^{0}C ye düşürülürse son basınç kaç atm olur?

a) 2,3 b) 2,7 c) 2,9 d) 3,4 e) 4,3

13. 27 ^{0}C sıcaklıkta ve 0,164 atm basınçta 15 litre hacim kaplayan CH_4 gazı kaç moldür?

a) 0,1 b) 0,5 c) 1,5 d) 1,8 e) 2,3

14. CO_2 gazının aynı sıcaklıkta difüzyon hızı, X_4O_5 gazınınkinin iki katıdır. Buna göre X in kütle numarası kaçtır?(C: 12, O: 16)

a) 12 b) 18 c) 22 d) 24 e) 28

15. 8 gram CH_4 gazının 127 ^{0}C ve 4,1 atmosfer basınçta hacmi kaç litredir?
(CH_4: 16)

a) 2 b) 4 c) 6 d) 8 e) 10

APPENDIX D

BİLİMSEL İŞLEM BECERİ TESTİ

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

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

a. Her oyuncunun almış olduğu günlük vitamin miktarını.

b. Günlük ağırlık kaldırma çalışmalarının miktarını.

c. Günlük antrenman süresini.

d. Yukarıdakilerin hepsini.

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

a. Arabaların benzinleri bitinceye kadar geçen süre ile.

b. Her arabanın gittiği mesafe ile.

c. Kullanılan benzin miktarı ile.

d. Kullanılan katkı maddesinin miktarı ile.

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

a. Arabanın ağırlığı.

b. Motorun hacmi.

c. Arabanın rengi

d. a ve b.

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

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

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

c. Büyük evlerin ısınma giderleri fazladır.

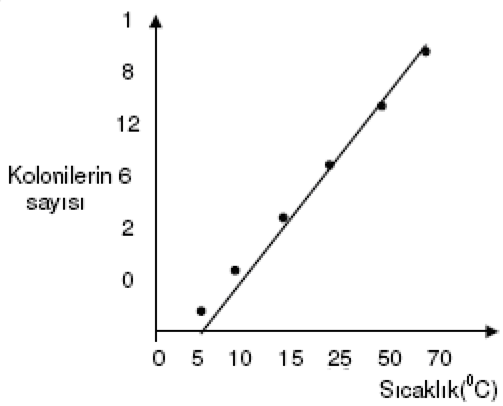
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir.

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

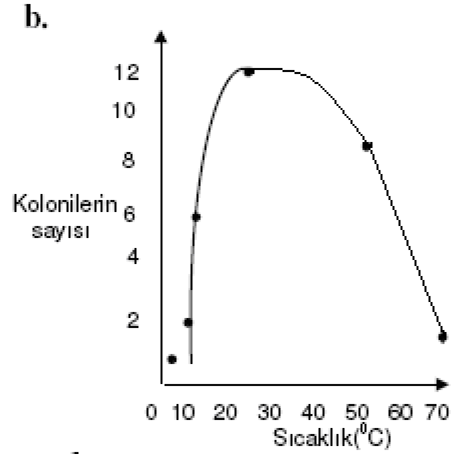
[illegible]	[illegible]	[illegible]	[illegible]
5	0	5	0
10	2	10	2
15	6	15	6
25	12	25	12
50	8	50	8
70	1	70	1

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?

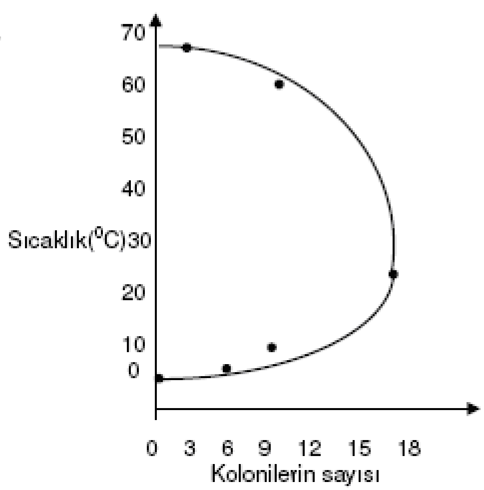
a.



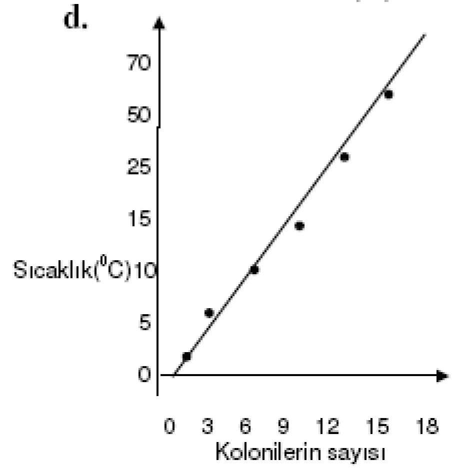
b.



c.



d.



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

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

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

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

d. Arabalar eskidikçe kaza yapma olasılıkları artar.

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

a. Her deneyde arabanın gittiği toplam mesafe ölçülür.

b. Rampanın (eğik düzlem) eğim açısı ölçülür.

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

d. Her iki deneyin sonunda arabanın ağırlıkları ölçülür.

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

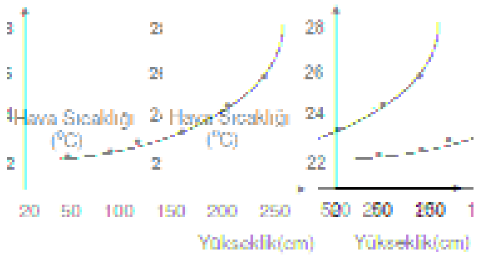
a. Tarlaya ne kadar çok gübre atılırsa, o kadar çok mısır elde edilir.

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

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

d. Mısır üretimi arttıkça, üretim maliyeti de artar.

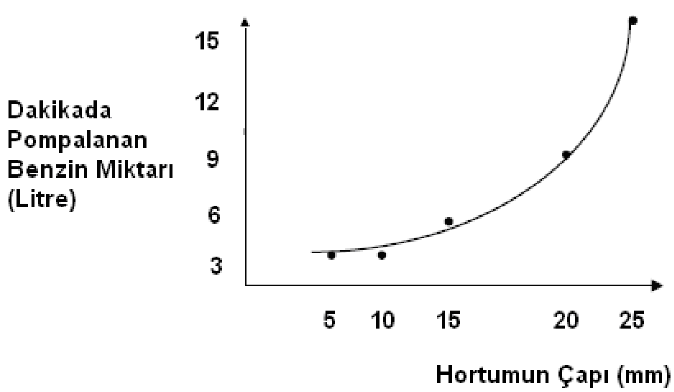
9. Bir odanın tabandan itibaren değişik yüzeylerdeki sıcaklıklarıylala ilgili bir çalışma yapılmış ve elde edilen veriler aşağıdaki grafikte gösterilmiştir. Değişkenler arasındaki ilişki nedir?



a. Yükseklik arttıkça sıcaklık azalır.
b. Yükseklik arttıkça sıcaklık artar.
c. Sıcaklık arttıkça yükseklik azalır.
d. Yükseklik ile sıcaklık artışı arasında bir ilişki yoktur.

10. Ahmet, basketbol topunun içindeki hava arttıkça, topun daha yükseğe sıçrayacağını düşünmektedir. Bu hipotezi araştırmak için, birkaç basketbol topu alır ve içlerine farklı miktarda hava pompalar. Ahmet hipotezini nasıl sınamalıdır?
a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.
b. İçlerinde farlı miktarlarda hava olan topları, aynı yükseklikten yere bırakır.
c. İçlerinde aynı miktarlarda hava olan topları, zeminle farklı açılardan yere vurur.
d. İçlerinde aynı miktarlarda hava olan topları, farklı yüksekliklerden yere bırakır.

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi açıklamaktadır?

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

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

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

d. Pompalanan benzin miktarı azaldıkça, hortumun çapı genişler.

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

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

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

12. Araştırmada aşağıdaki hipotezlerden hangisi sınanmıştır?

a. Toprak ve su ne kadar çok güneş ışığı alırlarsa, o kadar ısınırlar.

b. Toprak ve su güneş altında ne kadar fazla kalırlarsa, o kadar çok ısınırlar.

c. Güneş farklı maddeleri farklı derecelerde ısıtır.

d. Günün farklı saatlerinde güneşin ısısı da farklı olur.

13. Araştırmada aşağıdaki değişkenlerden hangisi kontrol edilmiştir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Her bir kovanın güneş altında kalma süresi.

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

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

16. Can, yedi ayrı bahçedeki çimenleri biçmektedir. Çim biçme makinesiyle her hafta bir bahçedeki çimenleri biçer. Çimenlerin boyu bahçelere göre farklı olup bazılarında uzun bazılarında kısadır. Çimenlerin boyları ile ilgili hipotezler kurmaya başlar. Aşağıdakilerden hangisi sınanmaya uygun bir hipotezdir?
a. Hava sıcakken çim biçmek zordur.
b. Bahçeye atılan gürenin miktarı önemlidir.
c. Daha çok sulanan bahçedeki çimenler daha uzun olur.
d. Bahçe ne kadar engebeliyse çimenleri kesmekte o kadar zor olur.

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

17. Bu araştırmada sınanan hipotez hangisidir?

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

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

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

d. Kullanılan suyun miktarı arttıkça sıcaklığı da artar.

18. Bu araştırmada kontrol edilebilen değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

19. Araştırmanın bağımlı değişkeni hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

20. Araştırmadaki bağımsız değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.

b. Her bardağa konulan su miktarı.

c. Bardakların sayısı.

d. Suyun sıcaklığı.

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

a. Farklı miktarlarda sulanan tohumların kaç günde filizleneceğine bakar.

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

c. Farklı alanlardaki bitkilere verilen su miktarını ölçer.

d. Her alana ektiği tohum sayısına bakar.

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

a. Kullanılan toz yada spreyin miktarı ölçülür.

b. Toz yada spreyle ilaçlandıktan sonra bitkilerin durumları tespit edilir.

c. Her fidede oluşan kabağın ağırlığı ölçülür.

d. Bitkilerin üzerinde kalan bitler sayılır.

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

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

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

c. 10 dakika sonra alevin sıcaklığını ölçer.

d. Bir litre suyun kaynaması için geçen zamanı ölçer.

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

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

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

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

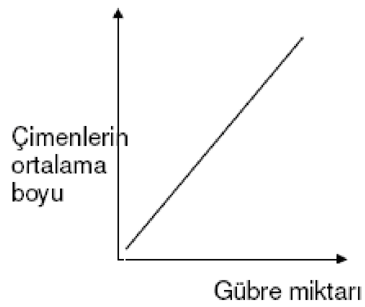
d. Her biri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar farklı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

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

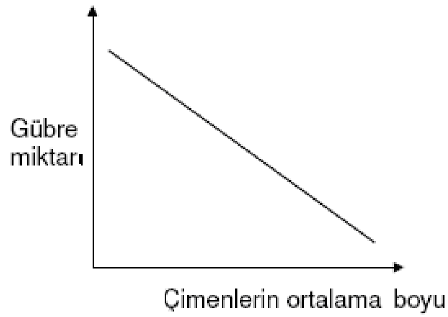
Gübre miktarı (kg)	Çimenlerin ortalama boyu (cm)
10	7
30	10
50	12
80	14
100	12

Tablodaki verilerin grafiği aşağıdakilerden hangisidir?

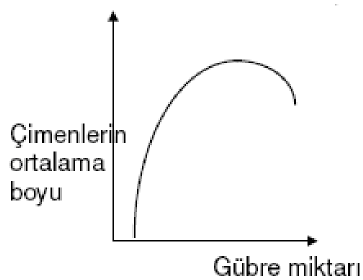
a.



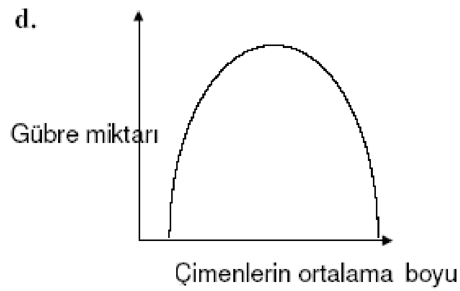
b.



c.



d.



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

a. Farelerin hızını ölçer.

b. Farelerin, günlük uyumadan durabildikleri süreyi ölçer.

c. Her gün fareleri tartar.

d. Her gün farelerin yiyeceği vitaminleri tartar.

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

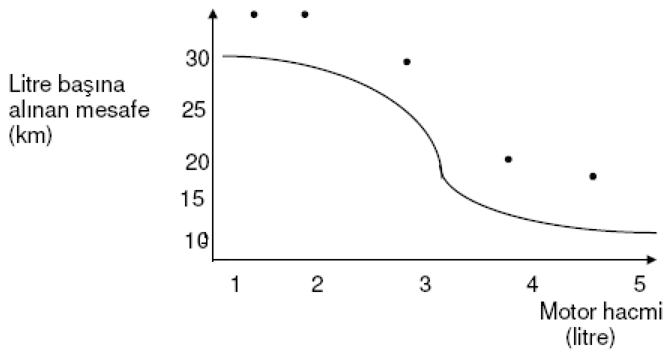
a. Daha fazla şekeri çözmek için daha fazla su gereklidir.

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

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

d. Su ısındıkça şeker daha uzun sürede çözünür.

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi gösterir?

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

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

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

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

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

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

29. Bu araştırmada sınanan hipotez hangisidir?

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

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

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

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

30. Bu araştırmada kontrol edilen değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki toprak miktarı.

d. Çürümüş yaprak karıştırılan saksı sayısı.

31. Araştırmadaki bağımlı değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki toprak miktarı.

d. Çürümüş yaprak karıştırılan saksı sayısı.

32. Araştırmadaki bağımsız değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki toprak miktarı.

d. Çürümüş yaprak karıştırılan saksı sayısı.

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

a. Kullanılan mıknatısın büyüklüğü ile.

b. Demir tozlarını çeken mıknatısın ağırlığı ile.

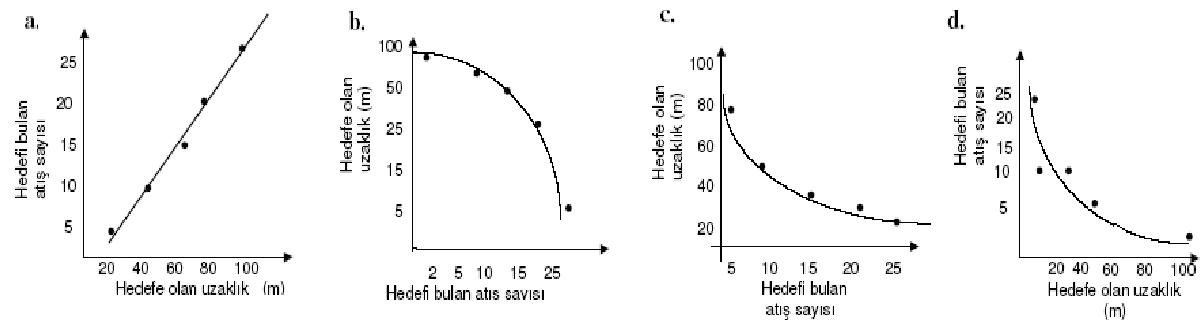
c. Kullanılan mıknatısın şekli ile.

d. Çekilen demir tozlarının ağırlığı ile.

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

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

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?



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

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

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

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

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

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

a. TV nin açık kaldığı süre.

b. Elektrik sayacının yeri.

c. Çamaşır makinasını kullanma sıklığı.

d. a ve c.

APPENDIX E

KİMYA DERSİ TUTUM ÖLÇEĞİ

AÇIKLAMA: bu ölçekte, kimya dersine ilişkin tutum cümleleri ile her cümlenin karşısında “Tamamen Katılıyorum”, “Katılıyorum”, “Karasızım”, “Katılmıyorum” , “hiç Katılmıyorum” olmak üzere beş seçenek verilmiştir. Her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneği işaretleyiniz.

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

APPENDIX F

BİLİMİN DOĞASI HAKKINDAKİ GÖRÜŞLER ANKETİ (VOSTS-TR)

Bu anket, lise 10. sınıf öğrencilerinin "**bilimin doğası"** konusuna yönelik düşüncelerini ortaya çıkarmak amacıyla hazırlanmıştır. Bu anketteki her soru, **bilimin doğası** konusunda temel görüş bildiren bir cümle ile başlamaktadır. Konu hakkındaki farklı görüş veya durumlar seçeneklerde sıralanmıştır. Her soru için düşüncenize uygun olan **BİR TEK SEÇENEĞİ daire içine alarak** işaretleyiniz. Size uygun bir seçenek yoksa, kendi görüşlerinizi lütfen soruların sonlarında verilen boşluklara yazınız. **Bu ankette doğru yanıt yoktur.** Bu araştırmada amaç, sizin bilimin doğası konusundaki görüşlerinizi öğrenmektir.

1. Bilimi tanımlamak zordur; çünkü bilim, karmaşıktır ve değişik birçok konuyla ilgilenmektedir. ***(Lütfen A'dan H'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).***
<u>Fakat bilim asıl olarak:</u>
A. Fizik, kimya ve biyoloji gibi konularda çalışmaktadır.
B. Yaşadığımız dünyayı açıklayan prensipler, kanunlar ve teoriler gibi bilgi birikimidir.
C. Dünyamız ve evren hakkında bilinmeyen yeni şeyleri araştırmak, keşfetmektir.
D. Yaşadığımız dünya ile ilgili problemleri çözmek için deneyler yapmaktır.
E. Birşeyler icat etmek ya da tasarlamaktır (yapay kalpler, uzay araçları gibi).
F. Bu dünyayı daha iyi bir duruma getirmede gerekli olan bilgiyi bulmak ve kullanmaktır (hastalıkları
tedavi etmek, kirliliği çözümlemek gibi).
G. Bilim insanlarının yeni bilgileri keşfetmek üzere bir arada oldukları organizasyondur.
H. Hiç kimse bilimi tanımlayamaz.
Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız
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2. Bazı toplumların, doğa ve insan üzerine belirli görüşleri vardır. Bilim insanları ve bilimsel araştırmalar, çalışmanın yapıldığı yerdeki kültürün *dinî ya da ahlâkî* görüşlerinden *etkilenirler.*

(Lütfen A'dan G'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

<u>Dinî ya da ahlâkî görüşler bilimsel araştırmaları etkiler;</u>
A. Çünkü bazı toplumlar kendi yararları için araştırmaların yapılmasını isterler.
B. Çünkü bilim insanları kendi kültürlerinin bakış açısını destekleyen araştırmaları seçebilirler.
C. Çünkü bilim insanlarının çoğu kendi kültürlerine uymayan araştırmaları yapmazlar.
D. Çünkü her toplumun kültürü yapılan araştırmaların türünü etkiler.
E. Çünkü belirli kültürel inanışı temsil eden güçlü gruplar, belirli araştırma projelerini destekleyecek ya da engelleyecektir.

<u>Dinî ya da ahlâkî görüşler bilimsel araştırmaları etkilemez;</u>
F. Çünkü araştırmalar, bilim insanları ve kültürel gruplar arasındaki tartışmalara rağmen devam eder (Örneğin; evrim).
G. Çünkü bilim insanları kültürel ve ahlaki görüşleri dikkate almaksızın araştırma yapacaklardır.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.
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3. Bazı toplumlar daha çok bilim insanı yetiştiriyor. Bu durum, ailelerin, okulun ve toplumun çocukları *yetiştirme tarzından* kaynaklanmaktadır.

(Lütfen A'dan G'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

Yetiştirme tarzı çok önemli bir faktördür;

A. Çünkü bazı toplumlar diğerlerine göre bilime daha fazla önem verirler.
B. Çünkü bazı aileler çocuklarını soru sormaya ve meraka teşvik ederler.
C. Çünkü bazı okullar ve öğretmenler öğrencileri daha çok araştırmaya teşvik ederler.
D. Çünkü aile, okullar ve toplum çocuklara bilimsel beceri kazandırır; bilim insanı olmak için cesaret ve
fırsat verir.
E. Bir şey söylemek zordur. Yetiştirme tarzı etkilidir, ama kişinin zekâ, yetenek ve bilime olan ilgi gibi özellikleri de önemlidir.
**F. Kimin bilim insanı olacağını belirlemede zekâ, yetenek ve bilime olan doğal ilgi daha
etkilidir**.Fakat yetiştirme tarzının da etkisi vardır.
**G. Kimin bilim insanı olacağını belirlemede zekâ, yetenek ve bilime olan doğal ilgi daha
etkilidir**.Çünkü insanlar bu özelliklerle doğarlar.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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4. Birçok Türk bilim insanı, buluşlarının doğuracağı sonuçların potansiyel etkileriyle (yararlı ve zararlı) ilgilenmektedir.

(Lütfen A'dan G'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

A. Bilim insanları buluşları gerçekleştirirken, **sadece faydalı yönleri** ile ilgilenirler.
B. Bilim insanları buluşlarının olası **zararlı etkilerini** önlemek için daha fazla çalışırlar.
C. Bilim insanları deneylerinin **bütün etkileri** ile ilgilidirler.
D. Bilim insanları buluşlarının **uzun vadeli etkilerinin tümünü tahmin edemezler.**
E. Bilim insanları buluşlarının tehlikeli amaçlar için kullanılıp kullanılmayacağını **pek fazla kontrol edemezler.**
F. Buluşların yararlı ve zararlı etkileri bilimin dallarına bağlıdır. Örneğin, Tıp ve askeri alanlarda çalışan Türk bilim insanları buluşlarının etkileriyle daha çok ilgilenirken, nükleer güç alanında çalışanlar daha az ilgilenirler.
G. Bilim insanları deneylerinin etkilerini dikkate alabilir, fakat bu durum onların, ünleri veya zevkleri için buluş yapmalarını engellemez.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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5. Türkiye'de biyoteknolojinin geleceği üzerine karar verenler, gerçekleri en iyi bildikleri için bilim insanları ve mühendisler olmalıdır (Örneğin: Genleri değiştirilmiş organizmalar, genom projesi, insan kopyalama).

(Lütfen A'dan G'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz)

<u>Bilim insanları ve mühendisler karar vermelidir.</u>
A. Çünkü onların bu konuda eğitimleri ve bilgileri vardır.
B. Çünkü bilim insanları bürokratlardan veya özel şirketlerden daha iyi karar verebilirler.
C. Fakat toplum da bilgilendirilerek veya danışılarak bu sürece katılmalıdır.
D. Fakat karar toplumu etkileyeceğinden uzmanların ve bilgilendirilmiş toplumun da görüşleri **eşit** oranda dikkate alınmalıdır.
E. Hükümetin karar vermesi gerekir; çünkü bu konu temelde politiktir.
F. Halk karar vermelidir. Çünkü karar herkesi etkileyecektir.

G. Toplumun karar vermesi gerekir. Çünkü, bilim insanları ve mühendisler konu hakkında idealist bir bakış açısına sahiplerdir ve bu nedenle sonuçlarına pek fazla dikkat etmezler.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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6. Bilim insanları karşılaştıkları gündelik problemleri en iyi şekilde çözebilirler (örneğin bir arabayı hendekten çıkarma, yemek yapma ya da evcil bir hayvana bakma).

(Lütfen A'dan E'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

<u>Çünkü bilim insanları, diğer insanlardan daha bilgilidirler.</u>

A. Çünkü problem çözme becerileri ve bilgileri bu konuda onlara avantaj sağlar .

<u>Bilim insanları gündelik problemleri çözmede diğer insanlardan daha iyi değillerdir;</u>

B. Çünkü fen bilgisi dersleri herkese yeterli problem çözme becerisi ve bilgisi kazandırır.

C. Çünkü genelde bilim insanlarının aldıkları eğitim günlük sorunları çözmede yardımcı ***olmaz.***

D. Çünkü gündelik yaşamda bilim insanları da herkes gibidir.

E. Bilim insanları herhangi bir gündelik problemi çözmede büyük bir ihtimalle diğer insanlardan daha kötüdür ,çünkü onlar gündelik yaşamdan uzak olarak çalışırlar.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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7. Başarılı bilim insanları çalışmalarında daima çok *açık fikirli, mantıklı, önyargısız* ve *tarafsızdırlar*. Bu kişisel özellikler bilimi en iyi şekilde uygulamak için gereklidir.

(Lütfen A'dan F'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

Başarılı bilim insanları bu özellikleri taşırlar.

A. Aksi halde bilim kötüye gidecektir.
B. Çünkü bu özellikleri ne kadar fazla taşırsanız, bilimi o kadar iyi yaparsınız.
C. Bu özellikler yeterli değildir. Başarılı bilim insanlarının hayal gücü, zeka ve dürüstlük gibi diğer kişisel özelliklere de sahip olmaları gerekir.

Başarılı bilim insanlarının bu kişisel özelliklere sahip olması şart değildir;

D. Çünkü bazen en iyi bilim insanları, çalışmalarında subjektif, önyargılı ve yeni fikirlere açık olmayabilirler.
E. Çünkü bu kişisel olarak bilim insanlarına bağlıdır. Bazıları çalışmalarında daima açık fikirli, tarafsız iken bazıları dar görüşlü ve taraflıdır.
F. Bilimde başarılı olmak için, bilim insanlarının bu kişisel özelliklere sahip olması **şart değildir.**

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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***8.* Çalışmalarıyla, çok yoğun uğraşmaları gerektiğinden *bilim insanlarının ne aile ne de sosyal yaşantıları vardır*.**

(Lütfen A'dan E'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

A. Bilim insanlarının başarılı olmak için, çalışmalarıyla çok yoğun uğraşmaları onları ailelerinden ve sosyal hayattan uzaklaştırır.
B. Bu kişiye bağlıdır. Bazı bilim insanları aile ve sosyal etkinliğe vakit ayırırlarken bazıları ayıramazlar.
C. Bilim insanlarının çalışmaları diğer insanlardan farklıdır ama; bu aile ve sosyal yaşantısı olmadığı anlamına gelmez.

Bilim insanlarının aile ve sosyal hayatları normaldir.

D. Bilim insanı için sosyal hayat önemlidir, aksi takdirde çalışma performansı azalır.

E. Çünkü çok az bilim insanı çalışmaları dışında ***herşeyi*** gözardı edecek kadar işlerine yoğunlaşır.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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9. Bugün, bilimle uğraşan kadın sayısı eskiye oranla çok daha fazladır. Bu, yapılan bilimsel buluşlarda bir farka neden olur.

(Lütfen A'dan G'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

Kadın ve erkek bilim insanlarının yaptıkları keşifler *farklı olacaktır*;

A. Çünkü kadın ve erkeklerin ilgi alanları farklıdır (Çocukluklarında farklı oyuncaklarla oynadıkları gibi).

B. Çünkü kadınlar ve erkekler buluş yaparken ihtiyaçlarını göz önünde bulunduracaklardır (Selülit kremi, traş makinesi vb).

C. Çünkü doğaları gereği kadınlar farklı hafızaya, içgüdüye ve farklı bakış açılarına sahiptir..

D. Erkekler kadınlardan daha iyi buluşlar yapabilirler; çünkü erkekler mühendislik ve mekanik
alanlarında kadınlardan daha başarılıdır.

Kadın ve erkek bilim insanlarının yaptıkları keşifler arasında *fark yoktur*;

E. Çünkü; kadın ve erkek bilim insanları aynı eğitimi alır. Fakat kadınlara geçmişten günümüze kadar,
yeterli olanakların verilmemesi, onların bu alandaki yeteneklerinin ortaya çıkışına engel olmuştur.

F. Kadın ve erkek eşit derecede zekidir. Bilimde keşfetmek istedikleri konular açısından kadın ve erkek aynıdır.

G. Buluşları arasındaki herhangi bir fark, aralarındaki bireysel farktan dolayıdır. Bu tür farklar kadın ya da erkek olmakla ilgili değildir.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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10. Bilim insanları, araştırmalarına bazı kurumlardan maddi destek almak ve buluşu yapan ilk kişi olmak için yarışırlar. Bazen bu acımasız yarış, bilim insanlarının gizlilik içinde davranmasına, başka bilim insanlarının fikirlerini çalmalarına ve para için kulis yapmalarına yol açar. Diğer bir deyişle, bazen bilim insanları (paylaşma, dürüstlük, bağımsızlık gibi) bilimin kurallarını çiğnerler.

(Lütfen A'dan E'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

Bazen bilim insanları, bilimin kurallarını çiğnerler;

A. Çünkü rekabet ve başarı isteği bilim insanlarını daha sıkı çalışmaya iter.

B. Çünkü kişisel ve parasal ödüllere ulaşmak için her şeyi yapabilirler.

C. Çünkü; onlar için sonuca nasıl ulaşıldığı değil, sonuç önemlidir.

D. Bilim diğer mesleklerden farklı değildir. Bazen bilim insanları da bilimin kurallarını **duruma bağlı olarak çiğnerler**.

E. Birçok bilim insanı birbiriyle iş birliği yapar, **yarışmaz** .

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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11. Bilim insanı tenis oynayabilir, partilere gidebilir ya da konferansa katılabilir. Bu *sosyal ilişkiler*, bilim insanının çalışmasını etkileyeceği için bu buluşların içeriğini de etkileyebilir. *(Lütfen A'dan E'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).*

<u>Sosyal ilişkiler buluşun içeriğini etkileyebilir;</u>

A. Çünkü bilim insanları etkileşim içinde oldukları insanların fikirlerinden, deneyimlerinden yararlanır.

B. Çünkü bu ilişkiler, dinçleştirici özelliğiyle bilim insanını canlı tutar.

C. Çünkü bu ilişkiler, bilim insanlarını toplumun ihtiyaçlarıyla ilgili araştırmalar yapmaya teşvik eder.

D. Çünkü bilim insanları bu ilişkilerle, insan davranışlarını ve bilimsel olayları gözleyebilir.

E. Sosyal ilişkiler buluşun içeriğini etkilemez; çünkü sosyalleşmeyle bilim insanının çalışması arasında herhangi bir ilişki yoktur.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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12. Farklı teorilere inanan başarılı bilim insanlarının yaptıkları gözlemler de *farklı* olacaktır.

(Lütfen A'dan E'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

A. Evet, çünkü bilim insanları farklı yöntemler kullanarak yaptıkları deneylerde farklı şeylere dikkat edeceklerdir.

B. Evet, çünkü bilim insanları birbirlerinden farklı düşündükleri için gözlemleri de farklı olacaktır.

C. Başarılı bilim insanları farklı teorilere inansalar da bilimsel gözlemleri çok fazla değişmez.

D. Hayır, çünkü bilim kesin olan gözlemlerle gelişir.

E. Hayır, gözlemler gördüklerimizden başka bir şey değildir ve gerçektir.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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13. Araştırma laboratuvarlarında kullanılan birçok bilimsel model (örneğin DNA modeli ve atom modeli) gerçeğin kopyasıdır.

(Lütfen A'dan G'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

Bilimsel modeller gerçeğin kopyasıdır.

A. Çünkü bilim insanları böyle söyler.

B. Çünkü birçok bilimsel kanıt onların **gerçek** olduğunu kanıtlamıştır.

C. Çünkü onlar **hayatın gerçekleridir**. Amaçları bize gerçekleri göstermektir.

D. Çünkü onlar bilimsel gözlem ve araştırmalara dayanır.

Bilimsel modeller gerçeğin kopyaları değildir.

E. Çünkü sadece kendi sınırları içinde öğrenme ve açıklamaya yardım ederler.

F. Çünkü onlar da teoriler gibi, zamana ve bilgimizin durumuna göre değişir.

G. Çünkü onlar düşünce ya da tahminlerden oluşur.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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14. Bilim insanları sınıflandırmayı (örneğin türlerine göre bitkileri, periyodik tabloya göre bir elementi vb.) doğaya uygun olarak yaparlar. Bundan *başka bir yol yanlış* olurdu.

(Lütfen A'dan F'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

A. Çünkü; bilim insanları sınıflandırmaların **doğadaki gerçeklerle birebir uyumlu olduğunu** kanıtlamışlardır.

B. Bilim insanları, sınıflandırma yaparken gözlenebilir özellikleri kullandıkları için**, doğadaki gerçek şekle birebir uyar.**

C. Bilim insanları, doğayı en basit ve mantıklı bir şekilde sınıflandırırlar, ama bunun için kullandıkları yol her zaman tek yol değildir.

D. Doğayı sınıflandırmanın birçok yolu vardır, ama bir **evrensel sistem** üzerinde anlaşmak bilim insanlarının çalışmalarındaki karışıklıkları önler.

E. Doğayı sınıflandırmanın başka doğru yolları da olabilir. Çünkü bilim, değişikliklere uğrar.

F. Hiç kimse doğanın gerçek şeklini bilemez. Bilim insanları, doğayı, algılamalarına göre veya teorilere göre sınıflandırırlar.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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15. Bilim insanları tarafından yapılan araştırmalar doğru olarak yapılsa bile, araştırma sonunda vardıkları bulgular gelecekte *değişebilir.*

(Lütfen A'dan E'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

A. Bilimsel bilgi değişir; çünkü, bilim insanları yeni teknikleri ve geliştirilmiş araçları kullanarak, kendilerinden önceki bilim insanlarının teorilerini ya da buluşlarını çürütebilirler.

B. Bilimsel bilgi değişir; çünkü eski bilgiler yeni buluşların ışığında yeniden yorumlanır. Bilimsel gerçekler değişebilir.

C. Bilimsel bilgi değişir gibi görünür ama doğru şekilde yapılan deneyler **değişmez gerçeklere** yol açar.

D. Eski bilgilere yeni bilgiler eklendiği için **bilimsel bilgi değişir gibi görünür.**

E. Bilgiler zamanla değişebilir, ama bilimsel bilgi **kesindir, değişmez.**

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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16. Bilimsel düşünceler, hipotezlerden teorilere doğru gelişir; ve sonuçta yeterince güçlülerse, ***bilimsel*** olurlar.

(Lütfen A'dan D'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

A. Hipotez teoriye, teori kanuna dönüşebilir; çünkü bir hipotez deneylerle test edilir, eğer doğruluğu **kanıtlanırsa** teori olur. Teori uzun zamanda birçok kez farklı insanlar tarafından test edilip **kanıtlanırsa** kanun olur.

B. Hipotez teoriye, teori kanuna dönüşebilir; çünkü bilimsel düşüncenin gelişmesi için bu mantıklı bir yoldur.

C. Teoriler kanun olamaz; çünkü bunlar farklı türdeki düşüncelerdir. Teoriler, kesinliğinden tam olarak emin olunamayan bilimsel düşüncelere dayanır ve doğrulukları kanıtlanamaz. Ancak kanunlar sadece gerçeklere dayanır ve %100 kesindir.

D. Teoriler kanun olamaz; çünkü bunlar farklı türdeki düşüncelerdir. Kanunlar olguları genel olarak **tanımlar**. Teoriler ise bu kanunları **açıklar**. Ancak destekleyici kanıtlarla, hipotezler teorilere veya kanunlara dönüşebilirler.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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17. Bilim insanlarının, yeni teorileri ya da kanunları geliştirirken, doğa hakkında bazı tahminler yapmaları gereklidir (örneğin: maddeler atomlardan oluşur). Bilimin düzenli bir şekilde gelişmesi için bu tahminler doğru olmak zorundadır.

(Lütfen A'dan F'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

<u>***Bilimin gelişmesi için bu tahminler doğru olmalıdır;***</u>

A. Çünkü doğru teori ve kanunlar için doğru tahminler gereklidir. Aksi halde çok fazla zaman ve çaba boşa harcanabilir.

B. Aksi halde toplum, yetersiz teknoloji ve tehlikeli kimyasal maddeler gibi ciddi problemlerle karşı karşıya kalır.

C. Çünkü bilim insanları çalışmalarını ilerletmeden önce, tahminlerinin doğru olduğunu kanıtlamak için araştırma yaparlar.

D. Bilimin gelişmesi için tahminlerin doğru olması gerekir düşüncesi duruma göre değişir. Tarihin, bir teorinin **çürütülmesi** veya onun **yanlış tahminlerinin** öğrenilmesi ile büyük buluşların oluştuğunu gösterdiği olmuştur.

E. Bilimin gelişmesi için tahminlerin doğru olup olmaması sorun değildir. Bilim insanları, projelerine başlamak için doğru ya da yanlış tahminler yapmak zorundadırlar.

F. Bilim insanları varsayımlarda **bulunmazlar.** Onlar, bir fikrin doğru olup olmadığını öğrenmek için araştırırlar.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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18. İyi bilimsel teoriler, gözlemleri iyi bir şekilde açıklar. Aynı zamanda iyi teoriler, karmaşık değil basit olurlar.

(Lütfen A'dan F'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

A. İyi teoriler **basit** olurlar. Bilimde kullanılacak en iyi **dil** basit ve kısa olandır.

B. Bu ne derecede **derin** açıklamalar yapmak istediğinize bağlıdır. İyi bir teori, bir şeyi hem basit hem de karmaşık bir yolla açıklayabilir.

C. Bu, **teoriye** bağlıdır. Bazı iyi teoriler basit, bazıları ise karmaşık olabilir.

D. İyi teoriler karmaşık olabilir, ama kullanılacaklarsa **basit ve anlaşılabilir** olmalıdır.

E. Teoriler genellikle **karmaşıktır**. Bazı şeyler, eğer birçok ayrıntı içeriyorsa basitleştirilemez.

F. İyi teorilerin çoğu **karmaşıktır**. Eğer dünya daha basit olsaydı, teoriler de daha basit olabilirdi.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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19. En iyi bilim insanları bilimsel yöntem basamaklarını izleyenlerdir.

(Lütfen A'dan E'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

A. Çoğu bilim insanı, geçerli, açık, mantıklı ve kesin sonuçlar sağlaması nedeniyle ***bilimsel yöntemi*** izler.

B. Okulda öğrendiğimize göre, bilimsel yöntem birçok bilim insanı için uygun olandır (problemi tespit etmek, veri toplamak, hipotez kurmak, kontrollü deney yapmak vs.).

C. En iyi bilim insanları bilimsel yöntemin yanında özgünlük ve yaratıcılığı da kullanacaklardır.

D. En iyi bilim insanları hayal gücü ve yaratıcılığı içeren, ***herhangi bir yöntemle*** sonuca ulaşabilirler.

E. Birçok bilimsel keşif, bilimsel yönteme bağlı kalmadan ***tesadüfen*** keşfedilmiştir.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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20. Bilim insanları çalışmalarında hata yapmamalıdır, çünkü bu hatalar bilimin ilerlemesini *yavaşlatır.*

(Lütfen A'dan E'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

A. **Hatalar bilimin ilerlemesini yavaşlatır**. Eğer bilim insanları sonuçlarındaki hataları anında düzeltmezlerse bilim ilerlemez.

B. **Hatalar bilimin ilerlemesini yavaşlatır**. Yeni teknoloji ve araçlar, doğruluğu artırarak hataları azaltır ve böylece bilim daha hızlı gelişir.

C. **Hatalardan kaçınılamaz;** bu nedenle bilim insanları birbirlerini kontrol ederek hataları azaltırlar.

D. Bazı hatalar bilimin ilerlemesini yavaşlatabilir, ama bazı hatalar yeni veya büyük bir buluşa neden olabilir.

E. Hatalar genellikle bilimin ilerlemesine **yardım** eder. Bilim, geçmişin hatalarını tespit edip düzelterek ilerler.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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21.* Bilim insanları ve mühendisler, bize, doğru bilgilere dayanarak varsayımlar yaparken bile, sadece neyin muhtemel olabileceğini söyleyebilirler. Kesin olarak ne olacağını *söyleyemezler.

(Lütfen A'dan E'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

<u>Varsayımlar asla kesin değildir; çünkü,</u>

A. Sonucu etkileyecek, önceden tahmin edilemeyen olaylar ve hata olasılığı her zaman vardır. **Hiç kimse geleceği kesin olarak tahmin edemez.**

B. Yeni buluşlar yapıldıkça, doğru bilgi ve varsayımlar daima değişir.

C. Varsayımlar iyi yapılmış tahminlerdir.

D. Bilim insanları asla tüm gerçeklere sahip değildirler. Bazı bilgiler daima eksiktir.

E. Duruma bağlıdır. Varsayımlar ancak doğru ve yeterli bilginin olması halinde kesindir.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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22. Bir sanatçı bir heykeli **"icat ederken"**, bir altın madencisinin de altın **"keşfettiğini"** farzedelim. Bazı insanlar bilim insanlarının bilimsel ***KANUNLARI "keşfettiğini",*** bazıları ise ***"icat ettiklerini"*** düşünürler. Siz ne dersiniz?

(Lütfen A'dan E'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

<u>Bilim insanları bilimsel kanunları keşfederler;</u>

A. Çünkü kanunlar her zaman doğada açığa çıkartılmayı bekler.

B. Çünkü kanunlar deneysel **gerçeklere** dayanır.

C. Aynı zamanda bu kanunları bulmak için de **yöntemler** yaratırlar.

D. Bazı bilim insanları, bir kanunu şans eseri bulur. Ancak diğer bilim insanlarıda kanunları önceden bildikleri gerçeklere dayanarak icat ederler.

E. Bilim insanları bilimsel kanunları icat ederler; çünkü onlar doğanın yaptıklarını değil, doğanın yaptıklarını **tanımlayan** kanunları icat ederler.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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23. Bir sanatçı bir heykeli **"icat ederken"**, bir altın madencisinin de altın **"keşfettiğini"** farzedelim. Bazı insanlar bilim insanlarının bilimsel ***HİPOTEZLERİ "keşfettiğini"***, bazıları ise ***"icat ettiklerini"*** düşünürler. Siz ne dersiniz?

(Lütfen A'dan F'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

Bilim insanları bir hipotezi keşfederler;

A. Çünkü fikir her zaman doğada, açığa çıkartılmayı bekler.

B. Çünkü hipotez deneysel **gerçeklere** dayanır.

C. Aynı zamanda bir hipotezi bulmak için **yöntemler** yaratırlar.

D. Bazı bilim insanları, bir **hipotezi şans eseri bulur.** Ancak diğer bilim insanlarıda hipotezi önceden bildikleri gerçeklere dayanarak icat ederler.

Bilim insanları bir hipotezi icat ederler;

E. Çünkü bir hipotez, bilim insanlarının keşfetmiş olduğu deneysel gerçeklerin yorumlanmasıdır.

F. Çünkü hipotezler zihinden gelir, onları biz oluştururuz.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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24. Bir sanatçı bir heykeli **"icat ederken"**, bir altın madencisinin de altın **"keşfettiğini"** farzedelim. Bazı insanlar bilim insanlarının bilimsel ***TEORİLERİ "keşfettiklerini"***, bazıları ise ***"icat ettiklerini"*** düşünürler. Siz ne dersiniz?

(Lütfen A'dan F'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

Bilim insanları bir teoriyi keşfederler;

A. Çünkü fikir her zaman doğada açığa çıkartılmayı bekler.

B. Çünkü bir teori deneysel **gerçeklere** dayanır.

C. Aynı zamanda bu teorileri bulmak için **yöntemleri** yaratırlar.

D. Bazı bilim insanları, bir teoriyi şans eseri bulur. Ancak diğer bilim insanları da teoriyi önceden bildikleri gerçeklere dayanarak icat ederler.

Bilim insanları bir teoriyi icat ederler;

E. Çünkü bir teori, bilim insanlarının keşfetmiş olduğu deneysel gerçeklerin yorumlanmasıdır.

F. Çünkü teoriler zihinden gelir, onları biz oluştururuz.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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25. Farklı alanlardaki bilim insanları, aynı şeye çok farklı açılardan bakarlar (örneğin, H + kimyagerlerin asit oranını, fizikçilerin protonları düşünmelerine sebep olur). Bu, farklı alanlarda çalışan bilim insanlarının birbirlerinin çalışmalarını anlamalarını *zorlaştırır.*

(Lütfen A'dan E'ye kadar okuyunuz ve sizin görüşünüze uygun olan bir seçeneği işaretleyiniz).

Farklı alanlardaki bilim insanlarının birbirlerini anlamaları zordur;

A. Çünkü bilimsel düşünceler, bilim insanlarının **bakış açısına** veya onların alışkanlıklarına bağlıdır.

B. Çünkü bilim insanları farklı alanlarda farklı dil kullanırlar.

Farklı alanlardaki bilim insanlarının birbirlerini anlamaları oldukça kolaydır;

C. Çünkü bilim insanları zekidir, diğer alanların dillerini öğrenmenin yollarını bulabilirler.

D. Çünkü bilim insanları aynı anda değişik alanlarda çalışmış olabilirler.

E. Çünkü farklı alanlardaki bilimsel düşünceler kesişir. Gerçekler bilimsel alan ne olursa olsun gerçektir.

Yukarıda size uygun bir seçenek yoksa, lütfen bu konudaki görüşlerinizi aşağıdaki boşluğa yazınız.

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APPENDIX G

OBSERVATION CHECKLIST

	Evet	Hayır	Kısmen
1. Öğretmen öğrencilerin konu hakkında ne bildiklerini fark etmelerini sağlayacak ortamlar oluşturdu mu?			
2. Öğretmen öğrencilerin konu hakkındaki ön bilgilerini açıklamalarına fırsat verdi mi?			
3. Öğretmen öğrencilerin konuya farkı yaklaşımlarını tartıştırarak bu kavramların yetersizliğini/yanlışlığını fark etmelerini sağladı mı?			
4. Öğrenciler konuyu öğrenmek için ihtiyaç hissetmeye başladılar mı?			
5. Öğretmen öğrencilere konuyla ilgili günlük hayattan örnekler verdi mi?			
6. Öğretmen öğrencilere düşündürücü sorular sordu mu?			
7. Öğrenciler aktif olarak derse katıldılar mı?			
8. Konu ile ilgili sayısal problemler çözüldü mü?			
9. Öğretmen bilgisayar animasyonlarını etkili bir şekilde kullandı mı?			
10. Öğrenciler öğrendikleri konuyu yeni bir durum içerisinde uygulama fırsatı buldu mu?			
11. Öğretmen etkinlikler sırasında konuyu açıkladı mı?			
12. Etkinliklerden sonra sınıfta tartışma ortamı oldu mu?			
13. Öğretmen kavramları açıklarken öğrencilerin önbilgilerini göz önünde bulundurdu mu?			
14. Sınıfın fiziksel ortamı (sıcaklık, aydınlatma, oturma düzeni, vb.) dersin planlandığı gibi işlenmesine uygun mu?			
15. Öğrenciler dersin işlenişinden hoşlandılar mı?			

APPENDIX H

A SAMPLE LESSON PLAN BASED ON CONCEPTUAL CHANGE METHOD ABOUT PRESSURE TEMPERATURE RELATIONSHIP

Introduction

The teacher will begin the lesson with the discussion of previous lesson.
Teacher: What did you learn in the previous lesson?

Some of the students will probably answer this question as the relationship between volume and temperature. Than the teacher will ask what the relationship between volume and temperature is, what the reason of this relationship is by creating a discussion environment. After taking students responses the teacher summarized the concept.

Teacher: The law that explains the relationship between the volume and temperature is called Charles' Law. As you remember from the animation that we watched last week if we increase the temperature of a gas system, the particles of gas starts to move faster and collide with each other and wall of the container more frequently. If the gas is not in a closed container than the volume of it starts to increase. Similarly if we decrease the temperature, the kinetic energies of the particles decrease, they start to move slower. Then they collide with each other and wall of the container less frequently, and the volume of the gas decreases.

After this summary the teacher will ask students the Charles' Law equation. (The expected equation is $V_1/T_1=V_2/T_2$). After taking students responses she will again ask them the reason of inverse proportion between temperature and volume. Then teacher will inform students about the day's topic

Teacher: Today you will learn about the relationship between pressure and temperature.

Dissatisfaction

Teacher will ask students that if we increase the temperature of a gas in a closed container what would happen. The aim of this question is to create a discussion environment in order to reveal students' previous knowledge about the concept. Students may hold some misconception about the concept such as the volume of a gas increase. If students will give such an answer the teacher will remind them it is a closed container and the volume is fixed.

Some of the students may think that if we increase the temperature than the particles of the gas expands. Then the teacher will ask;

Teacher: If the particles expand, what would happen to distance between particles?

Students most probably answer this question as the distance between particles decrease. Then the teacher will elaborate this discussion by asking that if you are correct, when we increase temperature so much, the distance between particles gets very small and may be they are stick together. However, as you remember from kinetic theory that the gases composed of particles whose size is negligible compared with the average distance between them. If you were correct a gas can goes to liquid or solid state by heating. But you know that it is impossible.

Moreover the teacher can explain that if the size of the particles of a substance change with temperature, all of the objects around us including people would get bigger or smaller with the temperature change. However, we do not get bigger in the summer. This discussion will continue until students realize that the particles of a substance do not change with the effect of pressure, temperature etc.

Also students might answer that if we increase the temperature the gas particles accumulate at the top of the container. If there are students holding this misconception, the teacher will repeat them gas particles distribute the entire container homogenously. Also the teacher will give the following daily life example.

Teacher: As you know we need to take breathe to live. This room is full of air. If your argument were correct, in summer the air in this room collect at the ceiling and then we can not take a breath. However we can breathe even in the summer.
In addition the teacher can remind students the first animation about the properties of solids, liquids and gases. She will emphasize gas particles distribute homogenously.

If students will not give any answers to the question, the teacher might ask prompting questions such as does the size of the particles change, does volume of the gas change, or does the distribution of the particles change?

These discussions will continue until students realize that the pressure of the system change. If students can not find it, the teacher will guide the discussion.
Teacher: Ok. Which properties of the gas do stay constant?
Students will probably say that the size, shape, and distribution of the particles, volume of gas, the amount of gas.
Teacher: What about pressure of the gas?
Then the teacher will start to explain the relationship between temperature and pressure.

Intelligibility

Teacher: The law that explains the relationship between the pressure and temperature is called as Gay Lussac Law. According to this law in a closed container and fix amount of gas there is a direct proportion between pressure and temperature. To explore this relationship let's watch the animation.

The teacher will show the corresponding animation here. To prevent any misconception she reminds students that actually we can not see the particles of gases with any magnifier and the particles are colorless. In the animation it is seen that a closed container filled with gas. At constant volume, temperature of the system can be increased with the help of heater. When the temperature increased, students see that the particles of the gas start to move faster collide with each other and hit wall of the container more frequently. So the increase in the pressure of the gas can be seen from the cursor.

Teacher: In the kinetic theory of gases, you have learned that gas particles move in all direction with different speeds. So each particle has different kinetic energies because of collisions. The average kinetic energy of particles is the temperature of that gas. Thus, increasing temperature also increases the average kinetic energy of the particles. As you can see from the animation, as the temperature increase the particles start to move faster, they collide with each other and the wall of the container more frequently. As you know these collisions cause gas pressure. If the frequency of collision increases, pressure of the gas also increases. Decreasing the temperature has the inverse effect that as the temperature decreases, the pressure of the gas also decreases.

After this explanation teacher will want students to write the equation of relationship between pressure and temperature. The expected relationship is as follows:

$P_1/T_1=P_2/T_2$

If students have a difficulty in establishing the relationship equation, the teacher may help them by reminding the Charles' equation.

The teacher will solve a number of quantitative questions about Gay Lussac Law and want students to solve other questions written on the board. When students solve the question the teacher will ask of them to solve it on the board.

Plausibility

To enhance students' understanding of the pressure temperature relationship the teacher will present a new situation or daily life examples.

Teacher: Basketballs jump less in cold weathers could you state the reason of this situation?

The teacher will give opportunity to students think about the situation and take their thoughts. She will guide the discussion until the students find the logical explanation.

Also the teacher will give additional daily life examples to advance students' understanding of the concept.

Teacher: Can you explain why deodorant containers should not be left under the direct sunlight?

By this way students got an opportunity to test the plausibility of the new concept.

Fruitfulness

At the end of the lesson the teacher will assign quantitative questions which require the application of Gay- Lussac Law from the textbook. Also she might give conceptual homework involving the application of new conceptions to the new situation.

Teacher: You will find an example about pressure temperature relationships that is encountered in our daily lives. This is your homework. We will discuss your answers next week.

APPENDIX I

PROPERTIES OF SOLIDS- LIQUIDS- GASES

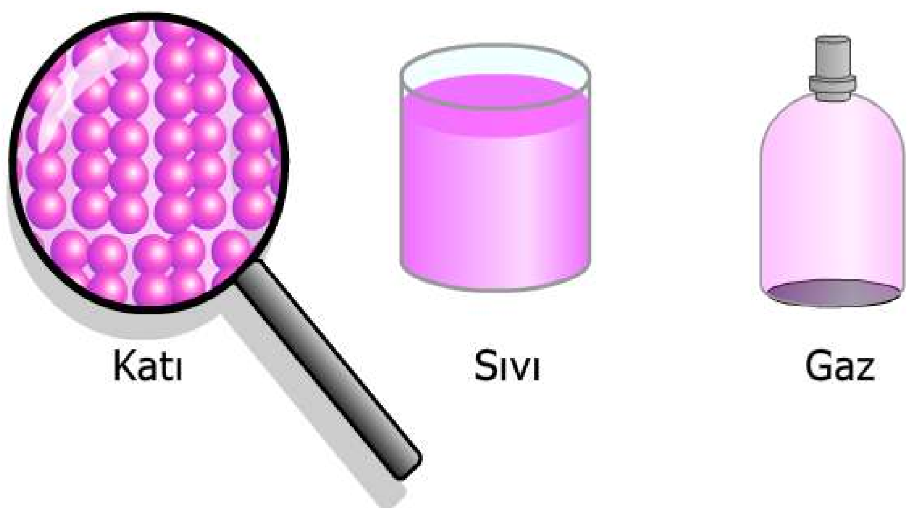


Figure I.1 Particles of Solid

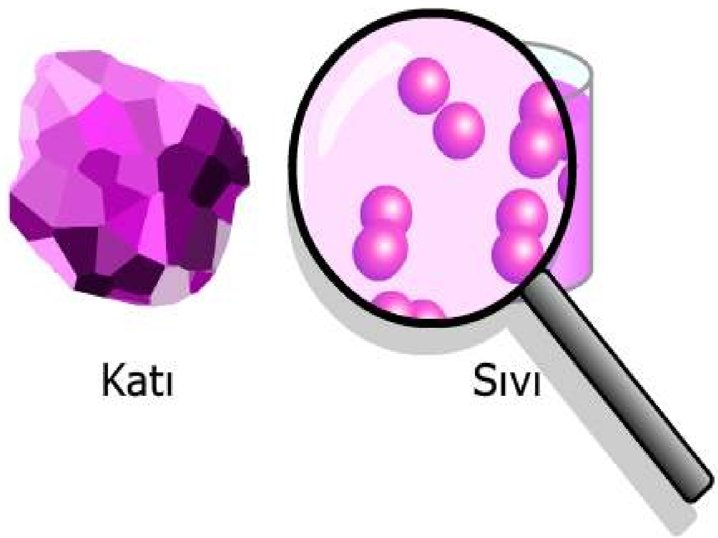


Figure I.2 Particles of Liquid

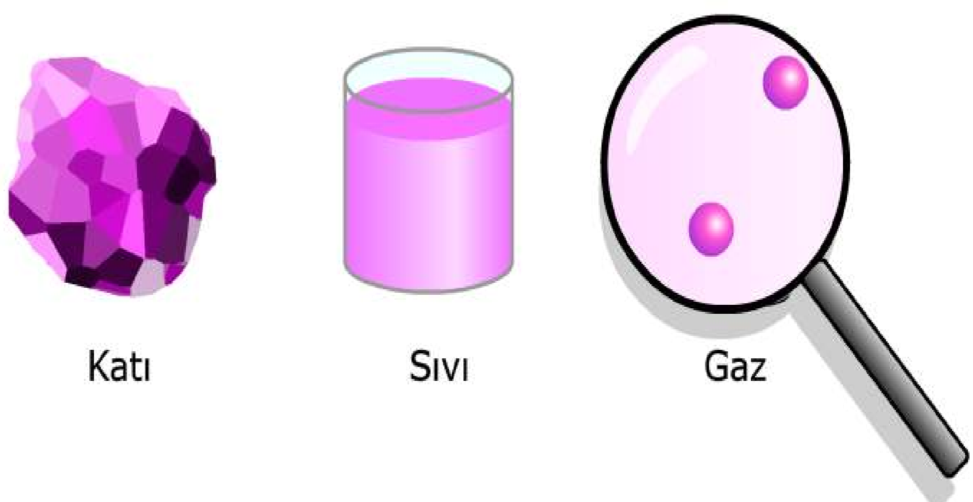
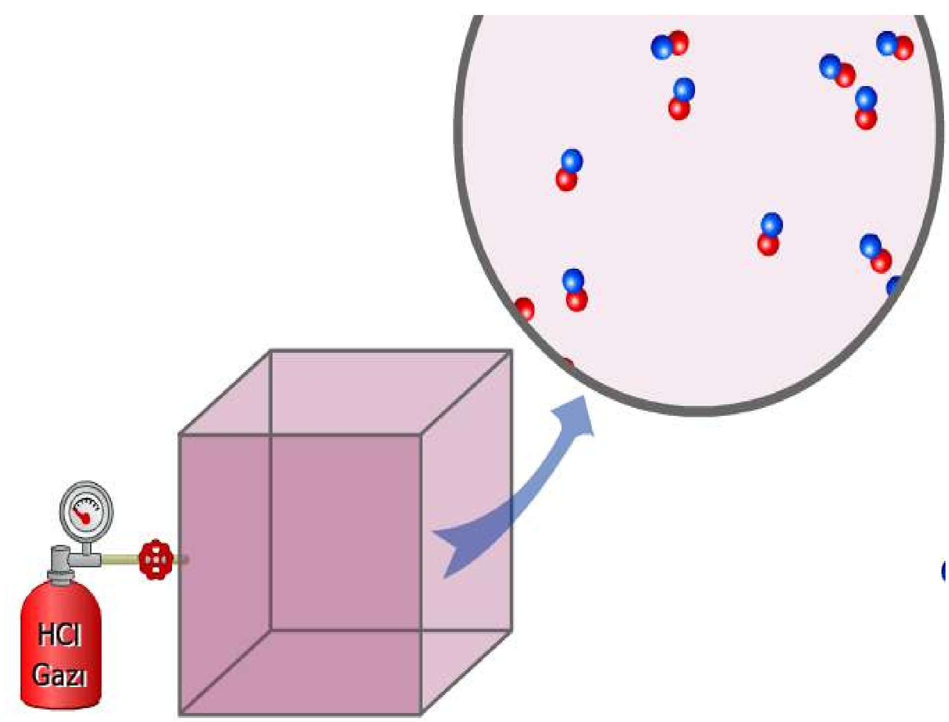


Figure I.3 Particles of Gases

APPENDIX J

KINETIC THEORY OF GASES



APPENDIX K

VOLUME OF GASES AND PARTIAL PRESSURES OF GASES

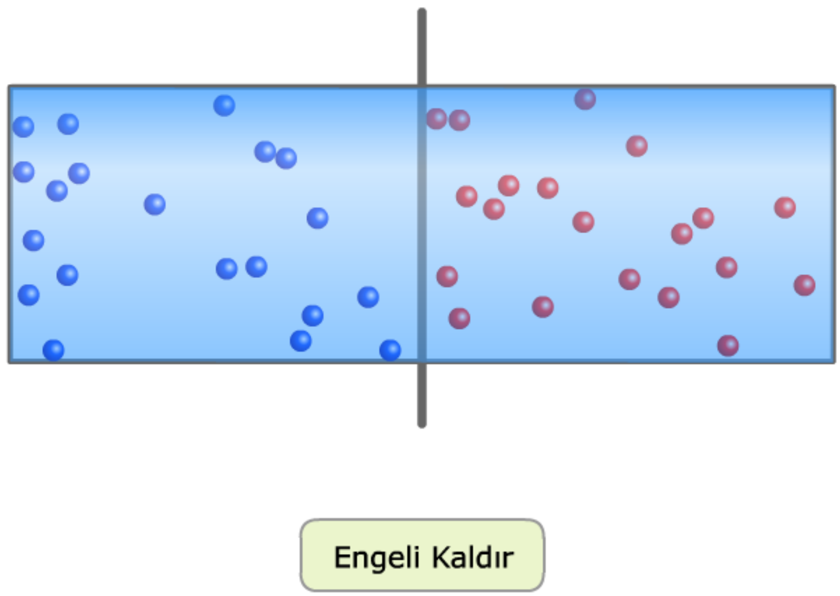


Figure K.1 Distribution of gases before the barrier is removed

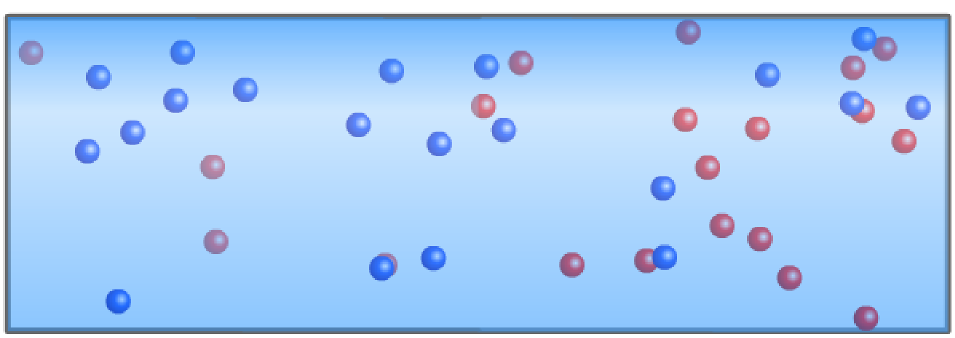


Figure K.2 Distribution of gases after the barrier is removed

APPENDIX L

DIFFUSION OF GASES

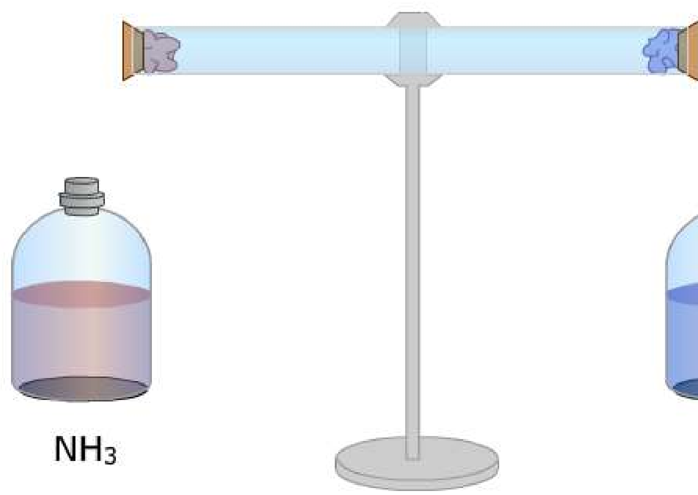


Figure L.1 NH_3 and HCl gases

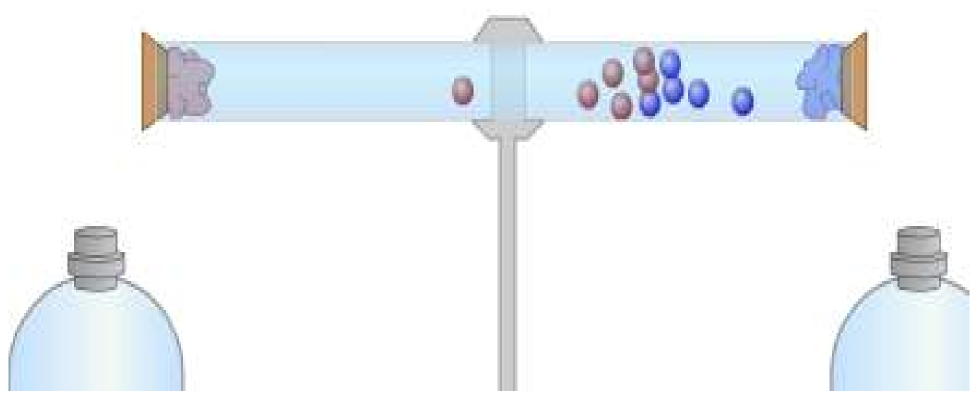
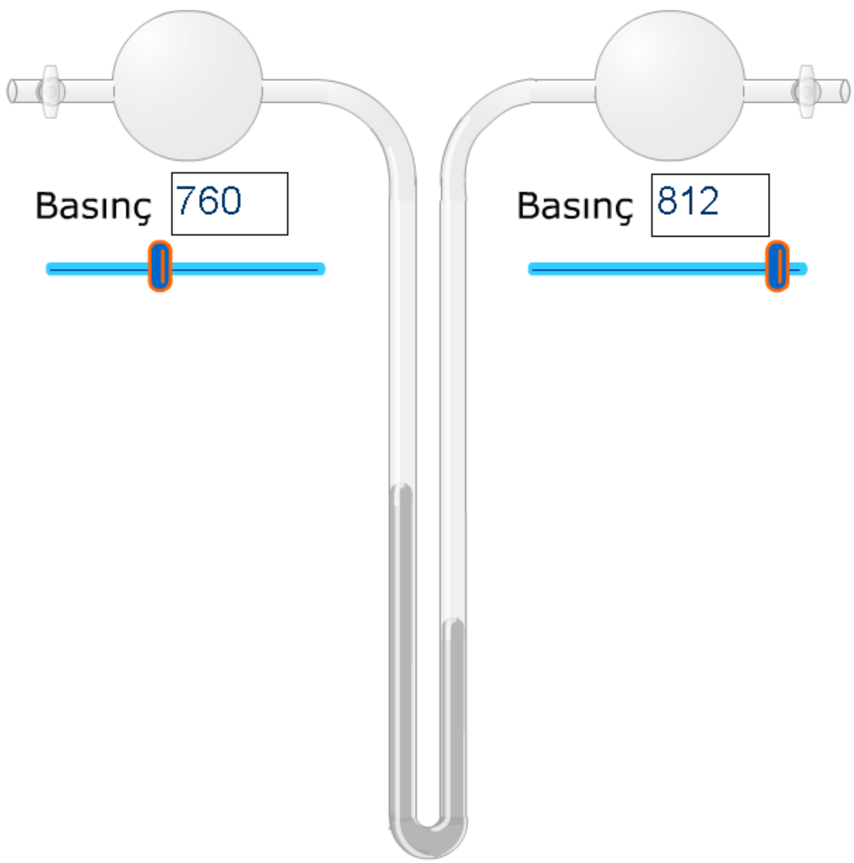


Figure L.2 Diffusion of gases

APPENDIX M

PRESSURES OF GASES



APPENDIX N

BOYLE'S LAW

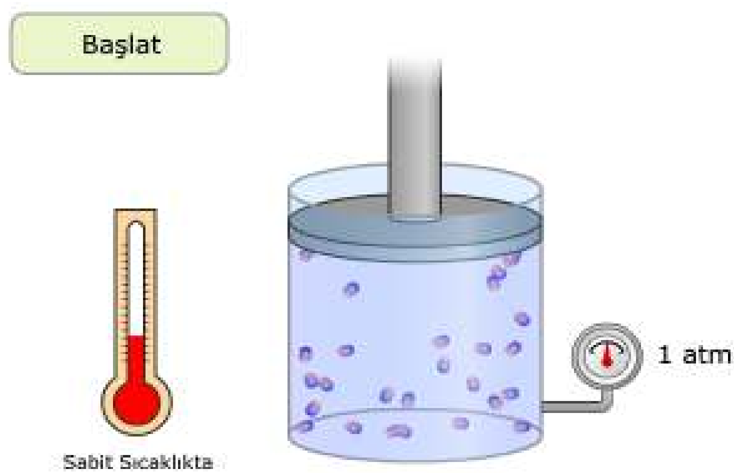


Figure N.1 Volume of a gas at constant temperature and 1 atm pressure

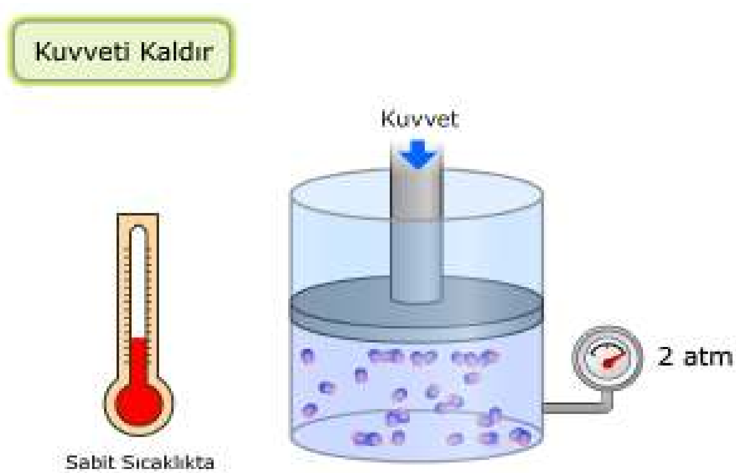


Figure N.1 Volume of a gas at constant temperature and 2 atm pressure

APPENDIX O

CHARLE’S LAW

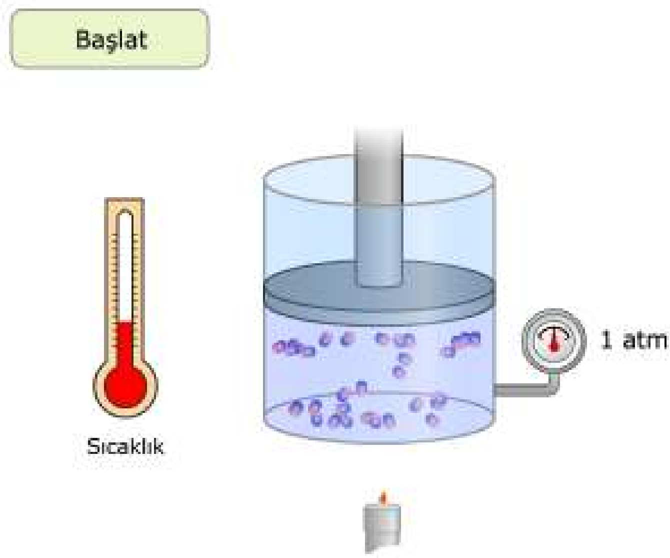


Figure O.1 Volume of a gas at 1 atm pressure and low temperature

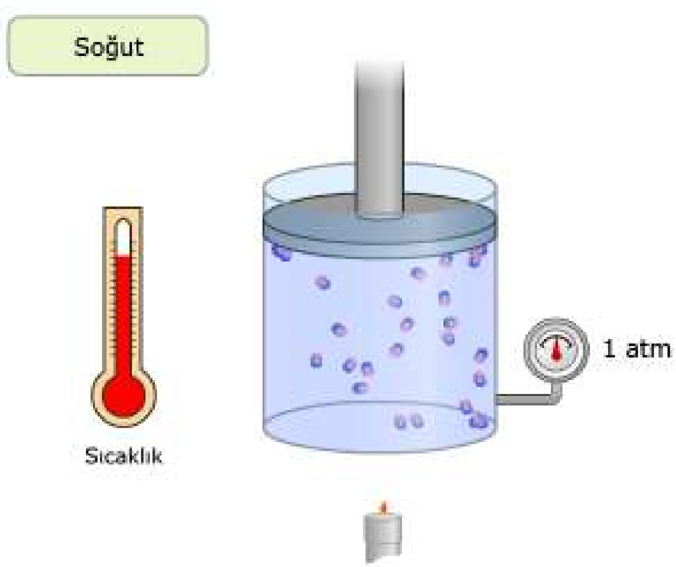


Figure O.2 Volume of a gas at 1 atm pressure and high temperature

APPENDIX P

GAY- LUSSAC'S LAW

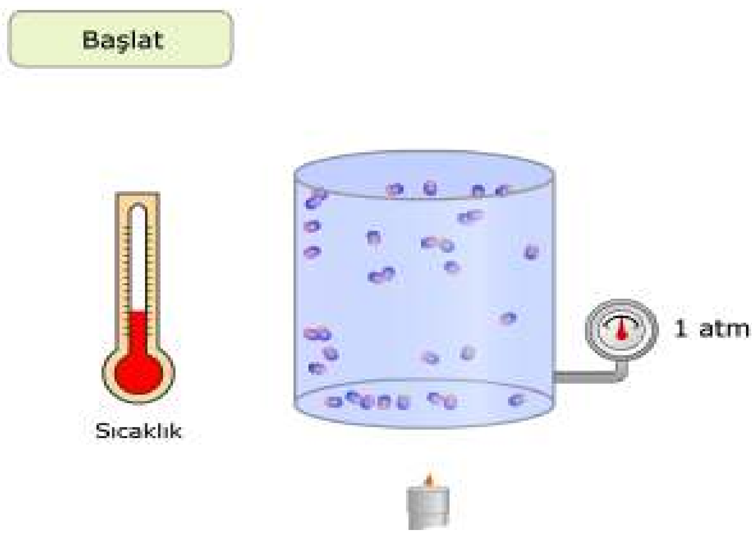


Figure P.1 Pressure of gases at fixed volume and low temperature

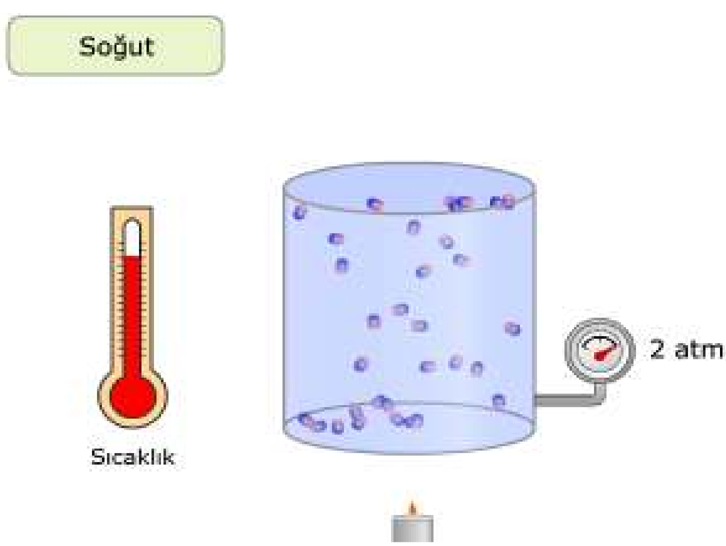


Figure P.2 Pressure of gases at fixed volume and high temperature

APPENDIX R

AVOGADRO’S PRINCIPLE

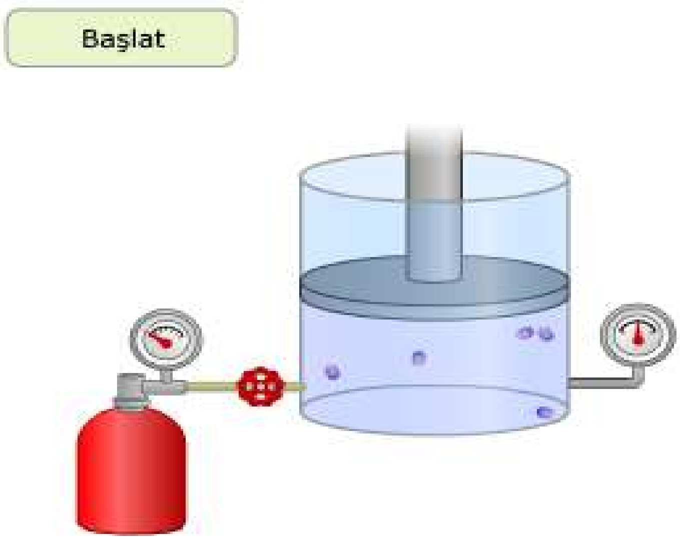


Figure R.1 Volume of 1 mol of gas at constant pressure

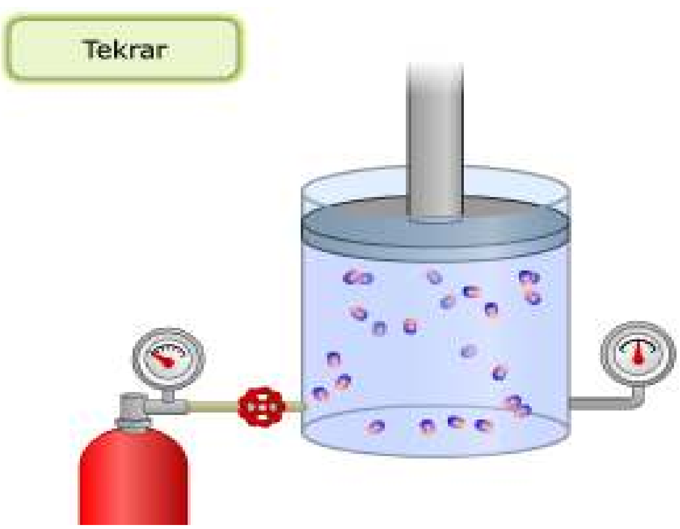


Figure R.2 Volume of 3 mol of gas at constant pressure

APPENDIX S

RELATIONSHIP BETWEEN MOLES OF GAS AND ITS PRESSURE

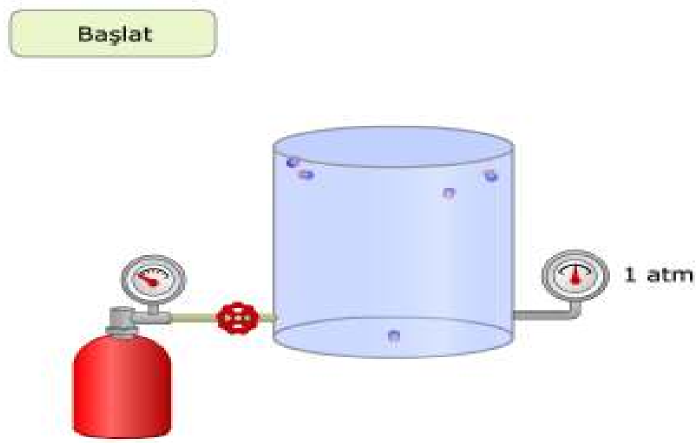


Figure S.1 Pressure of 1 mol of gas at fixed volume

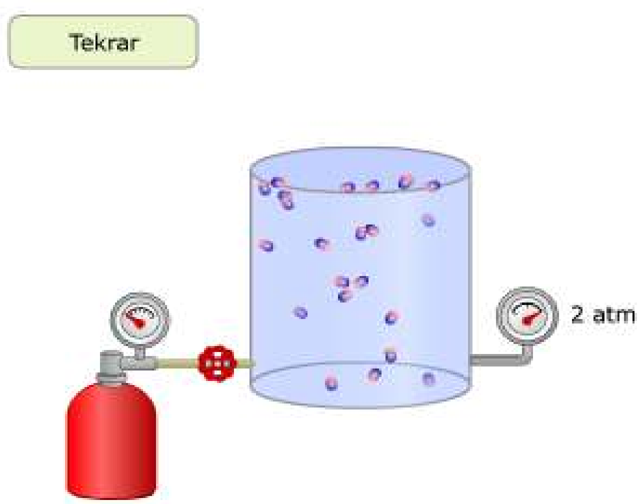


Figure S.2 Pressure of 3 mol of gas at fixed volume

CURRICULUM VITAE

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