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Analyzing of Students' Misconceptions About Chemical Equilibrium

Gülten ŞENDUR, Dokuz Eylül University, Department of Secondary Science and Mathematics Education, Izmir, gulten.sendur@deu.edu.tr
Mustafa TOPRAK, Dokuz Eylül University, Department of Secondary Science and Mathematics Education, Izmir, mustafa.toprak@deu.edu.tr
Esin ŞAHİN PEKMEZ, Ege University, Department of Primary Education, Izmir, esin.pekmez@ege.edu.tr

Abstract

Many students have some difficulties in understanding chemistry since many chemical concepts abstract and complex. Consequently, students could construct concepts differ from scientific explanation which is named as misconceptions. Identifying misconceptions is the first step to prevent these misconceptions. In this study, the goal is to describe 11th grade students' misconceptions about chemical equilibrium. The participants of the study consisted of 151 students who studied in 11th grade at three different high schools in Izmir. Chemical equilibrium misconceptions test (KR-20=0,79) was developed to identify students' understanding of chemical equilibrium. The results showed that most of the students had misconceptions in the areas related to approach to equilibrium and changing equilibrium conditions.

Keywords: Chemical Equilibrium, Chemistry Education, Misconception

INTRODUCTION

There have been a lot of studies conducted in chemistry education. Many of these studies were interested in students' understanding concerning phenomena taught in chemistry. These studies' results show that students come to class with their existing knowledge that they construct with their experiences or formal learning (Fetherstonhaugh & Treagust, 1992). Students' this prior knowledge is called as preconceptions. Some of these preconceptions are in conflict with the scientific view. Preconceptions which are in conflict with the scientific view are called as misconceptions.

According to Mulford and Robinson (2002), misconceptions play a larger role in learning chemistry than simply producing inadequate explanations to questions. Students either consciously or subconsciously construct their concepts as explanations for the behavior, properties they experience. They believe most of these explanations are correct because these explanations make sense in terms of their understanding of the behavior of the world around them. Consequently, if students encounter new information that contradicts their alternative conceptions it may be difficult for them to accept the new information because it seems wrong. In this way, students' misconceptions can interfere with learning process. Accordingly, to provide conceptual understanding and conceptual change, students' misconceptions should be considered while teaching and learning (Coştu, Ayas & Niaz, 2010). With this aim, students' misconceptions must be determined in the phase of preventing the misconceptions. To prevent students' misconceptions, firstly, the teachers must learn the students' existing knowledge before teaching. Some of the methods such as concept maps, prediction-observation-explanation, interview about the events and the instances, interview about the concepts, drawings, word assosaciation and diagnostic tests can be used to determine of students' misconceptions (Ayas et all, 2001; Schmidt, 1997). Secondly, teachers should use more effective teaching strategies to prevent misconceptions and promote conceptual change (Özmen, 2008).

Since most of the chemistry concepts are abstract and their daily life terminology and scientific terminology are different, many students at all levels struggle to learn chemistry (Erdemir, Geban & Uzuntiryaki, 2000; Özmen, 2004) It has been determined that the students' misconceptions intensify on the abstract concepts such as mole concept, atom, molecule, chemical equilibrium, chemical bonding, electro-chemistry and phase changes (Bar & Travis, 1991; Griffiths & Preston,

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1992; Novick & Nussbaum, 1981; Wheeler & Kass, 1978). However, students' misconceptions are mostly about chemical equilibrium among these subjects.

Chemical equilibrium is one of the basic subjects in the chemistry as this subject is related to other areas of chemistry like solubility, electro-chemistry, and acid-base. So, if a student has misconceptions about chemical equilibrium, these misconceptions can interfere with subsequent learning. Therefore, it is important that determining of students' misconceptions about chemical equilibrium. Several studies have shown that students have different concepts about chemical equilibrium those held by scientist (Banerjee, 1991; Griffiths, 1994; Quilez & Solaz, 1995; Özmen, 2008). Some of the misconceptions are presented in Table 1.

Table 1. Identified Misconceptions about Chemical Equilibrium

Identified Misconceptions	Revealed by
The rate of the forward reaction is greater than the reverse one at equilibrium. No reaction occurs at equilibrium. A catalyst affects the rates of the forward and reverse reactions differently. Concentration of the products or reactants change with addition of a catalyzer.	Griffiths (1994)
When one of the reactives is added, Equilibrium always shifts to products' side. When a solid substance is added to a heterogeneous equilibrium system, equilibrium is disturbed. If a inert gas is added to equilibrium mixture, equilibrium is never disturbed. Since inert gases do not react.	Quilez and Solaz (1995).
When the pressure is increased, only the rate of favored reaction increases. When the pressure is increased, concentrations of the products or reactants remains the same.	Banerjee (1991)
Le Chatelier's principle can be applied in the initial state Before the reaction has reached equilibrium. When more products are added to an equilibrium system At constant temperature, equilibrium constant will increase. Increasing the amount of a solid ionic substance that is at Equilibrium causes more dissolved ions to be produced	Özmen (2008)

The main aim of this study is to reveal secondary school students' misconceptions about chemical equilibrium.

METHOD

Sample

The sample of this study included 151, 11th grade students who were studied three different high schools in Izmir, Turkey. It was considered to be appropriate to name the high schools with

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codes of letters (such as A, B, C) instead of using their names. Distribution of groups with respect to the schools is presented in Table 2.

Table 2. Distribution of Groups with Respect to Schools

High School	The Number of Participants (N)
A	53
B	38
C	60

Instrument

Chemical Equilibrium Misconceptions Test (CEMT)

In order to diagnose students' misconceptions and the understanding level of students about chemical equilibrium, a 25 multiple choice item test was developed by the researches. During the development stage of the test, first, the instructional objectives of the unit chemical equilibrium were stated. This step was carried out to define the content of the test. Then, students' conceptual difficulties, and misconceptions were identified from previous studies in literature, and the most common misconceptions of light and sound concepts used in the test were stated (see Table 1). Items of the test were constructed with respect to misconceptions obtained from literature . Each item of the test included one correct answer and four distracters. Each item requires students to select definition of scientifically complete response and reason of correct answer. Four different categories which help to classify scientifically acceptable and unacceptable explanations were determined. These categories are below:

Scientifically Correct (SC): Scientifically complete response and correct explanations take part in this category.

Partially Correct (PC): Scientifically complete response and incorrect explanations or scientifically incorrect response and correct explanations match this category.

Specific Misconceptions (SM): This level involves completely scientifically unacceptable response or explanations.

No Response (NR): Students who does not choose any response and make any explanations are put in this category.

An example of question of test item is presented in Table 3.

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Table 3. Sample Question in CEMT

The equilibrium between A gas and B gas is as follows:

$$aA_{(g)} \rightleftharpoons bB_{(g)}$$

When volume of the container was increased at a constant temperature, reaction shifted to reactants' side. According to this, what can we say about equilibrium?

A) a>b because when volume of the container was increased, equilibrium will proceed to make more moles of gases.

B) a>b because when volume of the container was increased, equilibrium will proceed to make fewer moles of gases.

C) b>a because when volume of the container was increased, equilibrium will proceed to make fewer moles of gases..

D) b>a because when volume of the container was increased, equilibrium will proceed to make more moles of gases.

E) It cannot be estimated because moles of gases don't have any influence on equilibrium shift.

A group of expert in chemistry education and also chemistry teachers examined the test for the appropriateness of the items as the extent to which the test measures a representative sample of the domain of tasks with respect to the chemical equilibrium. Reliability coefficient (KR-20) of the test was found to be 0.79 after the item analysis.

Analysis

In analyzing test items, first, students' responses were analyzed with categories presented above. Secondly, frequency and proportion of students' responses were calculated and presented in Tables. Table 4 shows percentage of students' responses.

FINDINGS

Analysis of the results collected with the CEMT show that students did not acquire a satisfactory understanding of the chemical equilibrium concept. Table 4 shows that most of the students gave responses that fell into " PC" and" "NR" categories. As seen in Table 5, the percentages of " SC" category ranged from 13% to 28%. According to Gilbert (1977), Odom and Barrow (1995), if a multiple-choice item has four to five distractors, understanding is considered satisfactory if 75% of the students answer the item correctly. For this reason, it could be said that students did not acquire a satisfactory understanding of the chemical equilibrium concepts. The results indicate that althought there are some similar percentage of "SC" category (such as item 3, 23, 24, 25) between schools, there are also significiant diffrences between them (such as item 1, 4, 6, 8, 9, 10, 11, 14, 15). This diffrence could be explained diffrence in the learning envirovement. Also, fifty misconceptions were indentified through analysis of items on the CEMT. Some of the misconceptions are presented in Table 5.

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Table 4. Percentage of students' responses

Test Item	Categories	A High School	B High School	C High School
Item 1	**SC**	15	16	28
	PC	25	18	20
	SM	13	13	8
	NR	47	53	43
Item 2	**SC**	17	13	17
	PC	23	18	23
	SM	17	11	8
	NR	43	58	52
Item 3	**SC**	17	16	17
	PC	23	18	17
	SM	13	13	6
	NR	47	53	60
Item 4	**SC**	21	18	27
	PC	25	18	17
	SM	13	16	6
	NR	41	48	50
T Item 5	**SC**	21	16	20
	PC	25	18	22
	SM	15	13	8
	NR	39	53	50
T Item 6	**SC**	25	13	22
	PC	26	18	15
	SM	9	13	8
	NR	40	56	55
T Item 7	**SC**	23	16	22
	PC	27	21	18
	SM	11	11	8
	NR	39	52	52
T Item 8	**SC**	18	13	22
	PC	18	16	22
	SM	13	8	8
	NR	51	63	48
T Item 9	**SC**	23	16	27
	PC	26	21	18
	SM	9	13	6
	NR	44	50	49
T Item 10	**SC**	18	13	27
	PC	21	26	22
	SM	11	13	8
	NR	50	48	43
T Item 11	**SC**	15	13	22
	PC	26	24	22
	SM	13	11	8
	NR	46	52	48
T Item 12	**SC**	21	16	23
	PC	34	26	23
	SM	15	16	8
	NR	30	42	46
Item 13	**SC**	21	16	20
	PC	18	21	22
	SM	9	13	10
	NR	52	50	48
Item 14	**SC**	17	18	25
	PC	18	21	23
	SM	11	11	8
	NR	54	50	44
Item 15	**SC**	19	16	27
	PC	30	16	20
	SM	13	13	7
	NR	38	55	46
T Item 16	**SC**	19	21	18
	PC	25	21	23
	SM	9	16	8
	NR	47	42	31
T Item 17	**SC**	15	18	22
	PC	13	18	25
	SM	11	11	8
	NR	61	53	45
T Item 18	**SC**	24	21	25
	PC	26	26	18
	SM	9	13	10
	NR	41	40	47
Item 19	**SC**	15	21	22
	PC	24	21	20
	SM	15	8	10
	NR	46	50	48
T Item 20	**SC**	24	13	23
	PC	24	18	23
	SM	6	11	10
	NR	46	58	44
T Item 21	**SC**	19	18	17
	PC	26	24	22
	SM	11	13	10
	NR	44	45	51
T Item 22	**SC**	26	18	23
	PC	24	29	22
	SM	11	24	10
	NR	39	29	45
T Item 23	**SC**	19	18	20
	PC	24	24	25
	SM	11	13	10
	NR	46	45	45
T Item 24	**SC**	16	13	13
	PC	27	37	22
	SM	11	18	15
	NR	46	32	50
Item 25	**SC**	24	24	22
	PC	19	29	23
	SM	11	16	8
	NR	46	31	47

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Table 5. Percentages of Students' Misconceptions

Misconceptions	% of Students		
	A High School	B High School	C High School
When a solid substance is added to an equilibrium system at constant temperature, K_{eq} increases.	6	5	5
When a solid substance is added to an equilibrium system at constant temperature, K_{eq} decreases.	8	8	3
When system reaches equilibrium, the rate of reverse reaction is greater than the rate of forward reaction.	6	8	5
When more reactants are added to an equilibrium system, K_{eq} increases.	8	5	3
When more reactants are added to an equilibrium system, K_{eq} decreases.	4	5	5

CONCLUSION AND DISCUSSION

This study showed that students have difficulties in understanding chemical equilibrium concept and appliying of Le Chatelier principle. This reveals the need to implement different teaching materials or teaching strategies in order to help students eliminate their misconceptions.

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