Potency to overcome misconceptions by using multiple representations on the concept of chemical equilibrium

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Abstract. This study aims to analyze the potential of some representations in overcoming misconceptions about the concept of chemical equilibrium. In this study using research and information gathering, the first stage conducted is related to articles relating to misconceptions that exist on the concept of chemical equilibrium, obtained in chemical equilibrium, then carried out an analysis of 14 articles, which cite misconceptions on chemical equilibrium, from this article a misconception that is often found is that the rate of the forward reaction is not the same as the rate of back reaction. From this collection of articles, 5 general chemistry textbooks were then reviewed, which presented the concept of chemical equilibrium for multiple representations, to overcome the misconceptions associated with the articles that were analyzed previously. The results obtained from general chemistry textbooks with several representations are able to overcome misconceptions derived from article analysis and can help students visualize the observed concept changes.

1. Introduction

Chemistry is based on concepts, a lot of material is abstract and therefore it is difficult for students to understand and learn it, especially when students are placed in a position to believe something without seeing it. To be able to understand chemistry thoroughly and deeply, students must be able to connect the multiple representation. The multiple representation are the macroscopic level, the submicroscopic level, and the symbolic level [1]. Representation at the macroscopic level is a phenomenon that can be observed in real terms, to explain the macroscopic representation a submicroscopic approach consists of atoms and molecules. Submicroscopic microscopic representations are chemical representations that describe microscopic and submicroscopic levels through equations and graphs [2]

In general, students have difficulty connecting macroscopic and symbolic knowledge with submicroscopic knowledge, so there will be many misconceptions when students convert their knowledge to the submicroscopic level. Some of the causes of misconceptions are due to phenomena that cannot be observed, abstract concepts in chemistry and operating mathematical calculations [3] In studying chemical equilibrium, students use other abstract and special concepts such as chemical reactions, stoichiometry, and kinetics. This is in line with the fact that much literature has written that there are learning difficulties associated with the concept of chemical equilibrium. One of the causes of misconceptions is that the concept of chemical equilibrium is abstract and there are differences between terminology in everyday life and terminology in this material. [4] Many misconceptions in chemistry
are caused by the inability to visualize structures and processes at the submicroscopic or molecular level, whereas a large part of chemistry learning only involves macroscopic and symbolic levels [5].

Many studies have been conducted to study students' understanding of concepts and misconceptions on chemical equilibrium material [10,11,12,13,14,15,16,17,18,19,20,21,22]. Relevant research was conducted [11], expressing students' assumptions of forward and backlash reactions to equilibrium reactions are two separate reactions. The same study also proved that most students failed to understand the concept of dynamic equilibrium. They assume compilation reactions reach equilibrium, so no further reactions occur. Misconceptions that occur in students among others: (1) students consider those related to reactants and related products by simple arithmetic relationships. They assume that the concentration of the product is the same as the concentration of the reactants under equilibrium conditions; (2) students express their beliefs about the compilation of equilibrium then accelerate the forward and reverse reactions will change [11]. The same thing was published in which many students thought that considered increasing the balance when adjusting and fixing the reactants would only change the concentration of the product [20].

The macroscopic level involves observable phenomena, the submicroscopic level involves something very small such as atoms, ions, molecules to explain phenomena, and symbolic levels involve representations of atoms, ions, molecules, and so on. Learning that connects particle properties of matter (submicroscopic level) with other levels (macroscopic and symbolic levels), is effective in helping students make connections between the three levels in chemistry so that their understanding is better. Multiple representations play an important role in the teaching and learning of chemistry. Therefore, to be able to understand the concept of chemistry as a whole, multiple representation must be connected [6,7,8] The relationship between the three levels of representation is known as intertextual [6].

2. Method

In this study using research and information collecting research stages, the first step taken is the analysis of articles. Articles collected by searching through a google scholar search regarding misconceptions contained in the concept of chemical equilibrium obtained 14 articles that examine the misconceptions that occur. From the article analyzed obtained points as the focus of identification namely the forward reaction rate is not the same as the reverse reaction rate. After that, the second stage is reviewing the literature on multiple representations, namely the macroscopic, submicroscopic, and symbolic levels of the concept of chemical equilibrium in the General Chemistry textbook to overcome the misconceptions that occur.

3. Result and Discussion

3.1 Analysis of research journals regarding misconceptions on chemical equilibrium material

In the review article, 14 articles discuss misconceptions, the focus of this article is on the equilibrium system, the rate of forward reaction is not the same as the rate of reverse reaction [3,5,10,11,12,13,14,15,16,17,18,19,20]. This misunderstanding is the focus here because it is found in every 14 journals analyzed. This misconception is a problem for students described in the article where the students' inability to analyze abstract chemical equilibrium concepts. This is in line with what is expressed by Gabel [9] that most of the concepts learned in chemistry are abstract and cannot be explained without certain analogies or modeling, so a high reasoning ability is needed to be able to understand them [11]

3.2 Review the literature on multiple representations of chemical equilibrium material in the General Chemistry textbook

Mastery of concepts is based on students' ability to connect levels of chemical representation both macroscopic, submicroscopic, and symbolic. The survey results using journal analysis showed that fewer students understood the concept of chemical equilibrium, to overcome the misconceptions that occurred in the study of 5 general chemistry books using several representations.
In the concept of chemical equilibrium many students still think that in the equilibrium system, the rate of the forward reaction is not the same as the rate of the reverse reaction. After reviewing several general chemistry books, it is explained that equilibrium occurs when the reverse and forward reaction processes are at the same rate \[21\], equilibrium occurs when the reverse and forward reaction processes are at the same rate: the rate of product formation from reactants is equal to the rate of formation reactants and products \[22\], equilibrium occurs when an alternating reaction, molecularly produces products and reactants at a relatively constant amount \[23\], chemical equilibrium is reached when the rate of reaction back and forth is the same and the concentrations of reactants and products remains constant \[24\], a dynamic state wherein the forward and backward reactions are constantly at the same rate so that there is no net change from reactants to products \[25\].

Basically these chemical concepts will be easily revealed by understanding microscopic representations \[17\]. The use of representation in various ways to represent a phenomenon is called multiple representation. To overcome students’ misconceptions in chemical equilibrium, namely in the equilibrium system, the rate of the forward reaction is not the same as the rate of the reverse reaction. Will be explained based on the phenomenon summarized in the multiple representations below.

In a closed container, H\(_2\) gas and I\(_2\) gas are put into the same container, at a certain temperature. 1 mole of colored H\(_2\) gas reacts with 1 mole of purple I\(_2\) gas. When H\(_2\) gas with Figure 1.a and I\(_2\) gas in Figure 1.b flows to a container that has the same volume and temperature. The origin of the color produced from the gas mixture in the cylinder is purple as shown in Figure 1.c, the purple color produced because this gas mixture contains a complete I\(_2\) gas in purple.

![Figure 1](image1.png)

**Figure 1.** H\(_2\) gas reacted with I\(_2\) gas

Over time, the resulting purple fades. This is because the I\(_2\) gas in the cylinder is reduced. I\(_2\) gas is reduced because it reacts with H\(_2\) gas which forms a colorless HI gas. Microscopically, HI was not formed initially, so that in the tube there were only H\(_2\) gas and I\(_2\) gas as shown in Figure 2.a. Whereas in Figure 2.b, the color intensity of the gas in the tube fades, this is due to the formation of a colorless HI gas.
Figure 2. The reaction that forms on mixing $\text{H}_2$ and $\text{I}_2$ gases

From the above experiment in Figure 2.a is a mixture of $\text{H}_2$ gas and $\text{I}_2$ gas in the initial state, after settling for a while a mixture of gas $\text{I}_2$, $\text{H}_2$ gas and $\text{HI}$ gas produces a faded purple color, the result is purple in a fixed intensity tube (unchanged) as agreed by Figures 2.b and 2.c. This shows that there is still $\text{I}_2$ gas in this cylinder. In other words, the reaction between $\text{H}_2$ and $\text{I}_2$ gases that form $\text{HI}$ gas has increased the equilibrium which is indicated by a fixed color, with the following reaction equation

$$\text{H}_2(\text{g}) + \text{I}_2(\text{g}) \rightleftharpoons 2\text{HI}(\text{g})$$

The state of equilibrium occurs when the formation of $\text{HI}$ gas from $\text{H}_2$ gas and $\text{I}_2$ gas occurs simultaneously with the decomposition of $\text{HI}$ gas to $\text{H}_2$ gas and $\text{I}_2$ gas again. Product substances ($\text{HI}$ gas) and reagents ($\text{H}_2$ gas and $\text{I}_2$ gas) which have reached equilibrium, have a fixed composition, or do not increase with time. This can be seen in the number of gas molecules contained in the tubes of Figure 2.a (b) and Figure 2.a (c) as much. Unchanged concentrations can indicate that in an equilibrium state there is a component of a reagent and also a component of a product substance. That is the reason why the resulting purple color is still observed with a fixed intensity over time.

The above phenomenon is an example of the elaboration of concepts that have been described in the form of macroscopic, submicroscopic, and symbolic based on phenomena that will facilitate students in understanding the concept of chemical equilibrium to overcome misconceptions on chemical equilibrium material.

4. Conclusion

In this article, a misconception that discusses the reaction rate is not the same as the reverse reaction rate, the real concept is chemical equilibrium reached when the rates of the forward and reverse reactions are equal and the concentrations of the reactants and products no longer change with time. This can be proven by a phenomenon based on many representations, where the reaction of $\text{H}_2$ gas and $\text{I}_2$ gas which has reacted to form $\text{HI}$ gas. Product substances ($\text{HI}$ gas) and reagents ($\text{H}_2$ gas and $\text{I}_2$ gas) that have reached equilibrium have fixed or unchanged concentrations over time. This phenomenon is an example of the elaboration of concepts that have been described in the form of multiple representations to overcome misconceptions about chemical equilibrium.
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