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THE ANALYSIS OF STUDENT MISCONCEPTIONS ON ESSAY QUESTIONS BASED CHEMICAL EQUILIBRIUM LESSON WITH IN DEPTH INTERVIEW

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Abstract

Lack of students' understanding of the concept of chemical equilibrium causes many misconceptions to occur. Chemical equilibrium is one of the topics in chemistry that consists of various concepts that are interconnected, sequential, and organized, so it is often considered complex and causes misconceptions. This study aims to analyze students' misconceptions on the topic of chemical equilibrium and determine its percentage. This study used a mixed method with an explanatory sequential design. The subjects of the study involved 30 students of class XI Tahfiz SMA IT Fadhilah Pekanbaru. The data collection instrument was in the form of essay questions with a reliability coefficient of 0.814 and empirical validity showed 10 valid questions and 3 invalid questions. Data analysis techniques were carried out after collecting test results, including data processing and interpretation to identify misconceptions. The results showed that 17% of students from the total sample had misconceptions. The lowest misconception occurred in indicator (10), namely determining the direction of equilibrium shifts influenced by temperature, with a percentage of 3.33%. Meanwhile, the highest misconception was found in indicator (8), namely determining the direction of equilibrium shift influenced by concentration, with a percentage of 46.67%. Based on these results, it is concluded that the misconceptions that occurred in the sample were in the low category. This shows that the learning method used is quite effective in improving conceptual understanding.
Key words: misconceptions, essay question, chemical equilibrium

INTRODUCTION

Chemistry learning is very important to form a generation that not only understands scientific ideas but is also able to use them in everyday life. A scientific approach involving observation, experimentation, data analysis, and problem solving is highly recommended to build a deeper understanding. In chemistry learning, students are required to understand various concepts that have been previously learned and relate them to the material currently being studied, so that they can gain a comprehensive understanding [1].

However, the characteristics of chemistry learning that include memorization, calculations, and deep understanding of complex concepts are often challenging for students. In addition, chemical materials that are interrelated with each other can cause difficulties in understanding one concept, which in turn can affect understanding of other materials and potentially cause misconceptions [2].

Misconception is a form of mistaken understanding experienced by students, where the scientific concept understood does not correspond to scientific facts. In chemical equilibrium material, the possibility of misconception is quite high because the concept of equilibrium is abstract and complex. In addition, the lack of practical experiments and effective visual modeling in learning can also increase the risk of misconceptions on this topic [3]. This is also often influenced by students' personal experiences, erroneous initial understandings, or ineffective learning approaches. Teachers have an important role in recognizing and addressing misconceptions to ensure correct understanding in students.

One of the concepts in chemistry that is often a source of misconception is chemical equilibrium. One of the concepts in chemistry that is often a source of misconception is chemical equilibrium. Research conducted by Akbar on grade XI MIA students at SMA Negeri 2 Pekanbaru found misconceptions in all concepts in the chemical equilibrium material. This chemical equilibrium concept covers various sub-materials, such as acids-bases, oxidation-reduction reactions, solution equilibrium, and reaction rates, which are often considered complex by students [4].

Previous research shows that students' misconceptions occur in various aspects of chemical equilibrium, such as partial pressure, equilibrium constant, and the effect of volume on equilibrium shifts [5]. For example, many students make mistakes in calculating partial pressure in gas reactions; they assume that partial pressure can be calculated by multiplying the number of moles of a substance by the total pressure, when in fact they should use the mole fraction of the substance multiplied by the total pressure. In addition, misconceptions are also found in understanding the effect of volume changes on the direction of equilibrium shifts [6]. Similar errors often occur in the basic concepts of chemical equilibrium, the calculation of equilibrium constants, and the application of Le Châtelier's principle [7].

Misconceptions can be influenced by various factors, such as student characteristics, teacher roles, textbook quality, and teaching methods applied. Misconceptions can be caused by incorrect initial understanding, individual developmental stages, or low student interest in the subject matter [8]. On the other hand, teachers who do not understand the material or do not use the right learning approach can also be a contributing factor. In addition, textbooks with inaccurate explanations and teaching approaches that tend to be one-dimensional can worsen student misunderstandings. Misconceptions on the topic of chemical equilibrium are caused by incorrect preconceptions, inappropriate teacher explanations, and abstract and difficult-to-understand material. The use of incorrect analogies and outdated textbooks also worsen students' conceptual errors [9].

Misconceptions can have a big impact because they can hinder students' ability to integrate new knowledgem[10]. Misunderstanding of initial concepts can create obstacles in understanding subsequent concepts, thus affecting overall learning success [11]. The correct delivery of chemical material must be based on the correct concept and supported by quality learning, so that the process of transferring knowledge from teacher to student can take place effectively [12]. Therefore, it is important for teachers to actively evaluate students' understanding and use diagnostic tools to identify misconceptions [13]. Essay-based diagnostic tests are considered effective because they can explore students' understanding in depth and minimize the possibility of students giving the correct answer simply by guessing.

An evaluation method that combines essay tests and in-depth interviews is able to provide a more comprehensive picture of student understanding. Essay tests allow students to explain their ideas in detail, while in-depth interviews can dig deeper into the reasons behind their understanding [14].

The results of preliminary interviews at SMA IT Fadhilah Pekanbaru showed that many students had misconceptions on the topic of chemical equilibrium. This indicates the need for research to identify and further understand the misconceptions that occur. For this reason, an essay-based diagnostic instrument was chosen because it has advantages over a tier diagnostic test. Through essays, students' conceptual understanding can be explored more deeply, because students are given the opportunity to explain their reasons and thought processes in detail. Thus, researchers can identify the sources and forms of misconceptions more accurately.

Therefore, this study aims to analyze students' misconceptions about chemical equilibrium material based on essay tests and in-depth interviews. The results of this study are expected to provide practical solutions for

teachers in recognizing and overcoming students' misconceptions, so that chemistry learning becomes more effective and meaningful.

METHOD

This study uses mixed methods with an Explanatory Sequential Design, which combines quantitative and qualitative approaches to explore and analyze data [15]. The initial stage of the research involved collecting quantitative data through essay tests, followed by in-depth interviews to explore findings related to students' misconceptions on chemical equilibrium material. The study was conducted at SMA IT Fadhilah Pekanbaru between November 2023 and May 2024, with a population of grade XI students from two classes, namely bilingual and tahfiz classes. The research subjects consisted of 30 students selected by purposive sampling based on their involvement in learning the material.

The instrument in the form of 19 descriptive questions was validated by lecturers and chemistry teachers, then selected into 13 questions for empirical testing. The results showed that 10 questions were declared valid and 3 were invalid, with a reliability coefficient of 0.814 indicating a high level of reliability. This test was used to collect quantitative data on student understanding, while semi-structured interviews were used to obtain qualitative data related to misconceptions.

RESULTS AND DISCUSSION

Research Result

Overall Student Understanding

The researcher evaluated the students' overall understanding based on three main categories, namely understanding the concept, not understanding, and experiencing misconceptions. The results of the analysis of students' understanding related to the concept of chemical equilibrium, obtained through essay questions, can be seen in Figure 1 below:

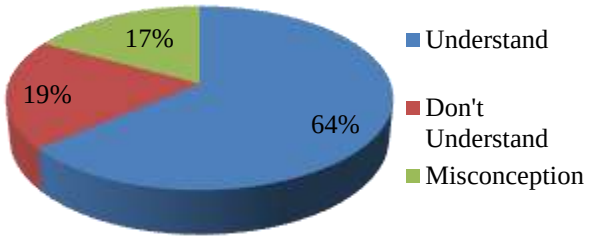

Figure 1. Percentage of Students' Concept Understanding

The results of the essay test of class XI students of SMA IT Fadhilah Pekanbaru showed an average understanding of the concept of 64%, not understanding the concept of 19%, and misconceptions of 17%. Thus, students' misconceptions in the material of chemical equilibrium are classified as low.

Table 1. Misconception Criteria

Percentage of Misconceptions	Misconception Criteria
0-30%	Low
31-60%	Currently
61-100%	Tall

(Islami et al., 2018)

Student Understanding Based on Question Indicators

Students showed misconceptions on almost all indicators in the chemical equilibrium material. The percentage of student understanding is presented in Figure 2 below:

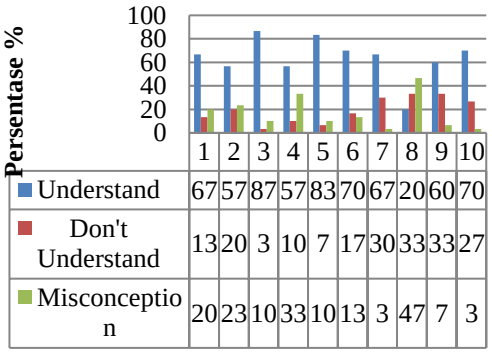

Figure 2. Percentage of Student Understanding Based on Indicators

Based on Figure 2, it shows that the highest percentage of misconceptions is in the concept of the direction of equilibrium shift due to concentration (question indicator number 8)

reaching 47%, while the lowest is in the concept of the relationship between Kc and Kp (question indicator number 7) and the effect of temperature of (question indicator number 10) 3%.

The highest conceptual understanding was found in determining Kc from heterogeneous reactions (question indicator number 3) at 87%, while the lowest was in the direction of equilibrium shift due to concentration (question indicator number 8) at 20%. The highest lack of understanding was in the concept of the direction of equilibrium shift due to concentration and volume (question indicators number 8 and 9) at 33.33%, while the lowest was in determining the Kc formula from heterogeneous reactions (question indicator number 3) at 3.33%.

Discussion

This study aims to detect students' misconceptions on chemical equilibrium material at SMA IT Fadhilah Pekanbaru. The research process involved analysis of essay questions and student interviews based on 10 indicators of chemical equilibrium concepts. The results of the analysis showed that the level of misconceptions varied from low to moderate, with the misconception category being partial understanding accompanied by conceptual errors.

In the dynamic equilibrium concept indicator, 66.67% of students showed good understanding, 13.33% did not understand the concept correctly, and 20% had misconceptions. The main error occurred because of students' misunderstanding of changes in product and reactant concentrations in an equilibrium system. This finding is in line with the results of Monita's study which states that when equilibrium conditions are reached, the total mass of reactants is equal to the total mass of products [16].

In the concept of irreversible and reversible reactions, 56.67% of students understand, 20% do not understand, and 23.33% have misconceptions, which are influenced by the assumption that all chemical reactions cannot return to the initial reactants. Similar misconceptions were also found in Permatasari's study, where students mistakenly understood that the reverse reaction would not occur if all products had not been formed [7].

In the indicator of determining the equilibrium constant (Kc) for heterogeneous reactions, 86.67% of students understand the concept well, 3.33% do not understand, and 10% have misconceptions. This misconception is mainly caused by errors in including liquid-phase compounds in the Kc calculation. This finding is in line with Monita's study which found that heterogeneous equilibrium involves different phases and can include more than two phases at once [16].

The indicator of determining Kp in heterogeneous reactions shows that 56.67% of students understand, 10% do not understand, and 33.33% have misconceptions. Student errors include incorrect application of formulas, including the addition of incorrect plus signs. Similar misconceptions were also found in a study conducted by Pujianto, where students assumed that the calculation of the pressure equilibrium constant (Kp) was the same as the calculation of the concentration equilibrium constant (Kc), with the only difference being in the phase of the reacting substance, which only involves the gas phase [17].

In the Kc value calculation indicator, 83.33% of students showed good understanding, 6.67% did not understand, and 10% had misconceptions. The students' errors were in the placement of compounds that did not match the correct formula. Similar misconceptions were also found in Pujianto's research, where students tended to only memorize the formulas in books or those given by teachers, resulting in errors [17].

In the indicator of calculating the Kp value, 70% of students understand the concept, while 13.33% experience misconceptions, with the error being the assumption that the remaining moles are the result of multiplying the equilibrium moles and the total pressure. This result is in line with Mayasri's research, which found that students mistakenly think that partial pressure can be calculated directly by multiplying the moles of a substance by the total pressure [6].

In the concept of the relationship between Kc and Kp, although 66.67% of students understand, 33.33% experience misconceptions, especially errors in understanding the value of Δn which causes a wrong understanding of the relationship between Kc and Kp. Research conducted by Pujianto also found similar misconceptions, where students tend to rely on memorizing formulas in books or taught by teachers, without really understanding the concept, resulting in errors in application [17].

In the indicator regarding the direction of equilibrium shift due to changes in concentration, only 20% of students showed correct understanding. Meanwhile, 46.67% of students had misconceptions, especially in stating the direction of the shift to the left when the product concentration was added. This finding is in line with the results of Monita's research which showed that some students assume that increasing concentration will always cause an equilibrium shift to the right, so that the number of first reactant ions increases, while the second reactant ions decrease [16].

Indicators related to the direction of equilibrium shift due to pressure, showed 60% who understood the concept and 6.67% who had misconceptions. The main error lies in students' wrong understanding of the direction of equilibrium shift due to pressure. This finding is supported by Mayasri who stated that students believe that increasing pressure shifts the equilibrium towards a larger number of coefficients [6].

The indicator of the direction of the equilibrium shift affected by temperature shows that 70% of students understand the concept and 3.33% have misconceptions. Misconceptions occur due to errors in existing concepts. Mayasri found students' misconceptions that the reaction reaches optimum results if the temperature or pressure is reduced [6].

Overall, the misconceptions experienced by students are mostly caused by incorrect initial understanding and the tendency to use memorization methods without in-depth understanding. Based on the results of the interview, it was revealed that most students rely solely on memory in answering questions related to chemical equilibrium, without understanding the basic concepts underlying it. In addition, the minimal application of learning methods involving experiments and discussions also strengthens the occurrence of misconceptions on this topic.

This study has important significance because it reveals students' misconceptions about chemical equilibrium material, and shows that essay tests are effective in identifying the level of conceptual understanding. These findings emphasize the need for the implementation of concept-based learning and the use of active methods to improve the quality of student understanding.

Misconceptions that arise generally come from errors in understanding fundamental concepts. To overcome this, a learning strategy is needed that is able to trigger cognitive conflict, thus encouraging the process of assimilation and accommodation in students' cognitive schemes. In order to achieve a state of equilibration (cognitive balance), teachers need to provide guiding questions or connecting narratives that reinforce correct conceptions. In addition, the use of appropriate analogies can help students reconstruct their understanding and replace erroneous concepts with more accurate understandings.

CONCLUSION

Based on the existing discussion, it can be concluded that students of class XI Tahfiz SMA IT Fadhilah Pekanbaru showed misconceptions in understanding the concept of chemical equilibrium. Of the total 30 students studied, 17% had misconceptions. The concept with the highest level of misconception is the direction of equilibrium shift influenced by concentration, with a percentage of 46.67%.

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