Analysis of Students Misconception in Chemical Equilibrium Material Using Three Tier Test

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ABSTRACT

This study aimed to analyze students misconception seen from the relationship between the results of the three tier test and interviews about chemical equilibrium material on the concept of determining the formula \( K_c \), \( K_p \), and the concept of \( K_c \) calculation. The research method was descriptive qualitative method. The data collection technique in this study was a test. The research instrument was in the form of three tier test questions consisted of four concepts. The misconceptions were analyzed based on the result of tests given to 30 students were further clarified by interviewing as matching answers. The study was conducted at SMA Negeri 2 Wonosari in Gunungkidul Regency with five interviewed research subjects. The result showed that students experienced misconceptions about the concept of determining the \( K_c \) formula by 23.33%, determining the \( K_p \) formula by 13.33%, and concept of \( K_c \) calculation by 16.67%.

Keywords: misconception, three tier test, chemical equilibrium

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1. INTRODUCTION

The learning process in the education is arranged in a curriculum that experiences changes and development, until finally the curriculum used is the 2013 revised 2017 curriculum. Changes in the curriculum are intended to make changes in the learning process to get better results, so that variations in learning models and their supporters are needed (Kemendikbud, 2014). The Ministry of Education and Culture (Kemendikbud) formulates that the 21st century learning paradigm emphasizes the ability of students to find out from various sources, formulate problems, think analytically, and work together to solve problems. The learning process that has been going on is considered less making students actively involved. So the knowledge gained is not deep enough and can lead to misconceptions.

Chemistry is one of the mandatory lessons that must be followed by high school students who majored in natural sciences. Chemistry is a scary subject for students (Şendur et al., 2011; Muchtar and Harizal, 2012). This can happen
Analysis of Students Misconception in Chemical Equilibrium Material Using Three Tier Test

Furthermore, Louisa et al. (1989); Şen and Yilmaz (2013) claims that the cause of students' misconceptions is that teachers do learning using multi-interpreted words, so students experience confusion in understanding a concept. In fact, misconceptions can be caused by information from the internet that is received by students but is not able to be absorbed to the maximum (Sesen and Ince, 2010). As a result, misconceptions cause students to have difficulty in solving problems (Cohen et al., 1983), and negatively impact students' chemical achievement.

Misconception analysis can be done using two-tier tests or three-tier tests (Wijayanti et al., 2015). Three-tiered tests are three-level tests where one-tier is a multiple-choice question, while two-tier is a reason with multiple-choice form, and three-tier is a statement of students who are included in the test problem. The use of conventional multiple choice tests was not used too often to determine students' misconceptions, because the results are less accurate. Three-tier test is the most appropriate solution to analyze students 'misconceptions or students' lack of understanding concept (Şen and Yilmaz, 2017).

2. RESEARCH METHOD

This study used a qualitative design using a descriptive approach. The study was conducted at SMAN 2 Wonomosari in September 2019 and the research subjects were 30 students who were in class XII MIPA 1 with the criteria that students had studied chemical equilibrium material. The instrument was a three tier test item totaling 15 questions that had three levels. The first level consisted of multiple choice questions, the second level contained the reasons from the first level, and the last level was students' confidence in understanding concept (Şen and Yilmaz, 2017).
answering the first and second level. The question indicators that were used as follows determination the formula $K_c$ an equilibrium reaction, determination the formula $K_p$ an equilibrium reaction and use the $K_c$ formula to solve the equilibrium problem.

The three tier question was used as the basis for conducting interviews in accordance with the misconceptions experienced by each student. There were only five students who were interviewed. Selection of five students to be interviewed using purposive sampling technique, with the criteria of the first student correct answer + wrong reason + sure, second student wrong answer + correct reason + sure, third student correct answer + right reason + not sure, fourth student wrong answer + true reason + not sure and fifth student wrong answer + wrong reason + sure. The selection was to clarify whether students got misconceptions, do not understand or just guess based on the results of the analysis of answers to the three tier questions that have been categorized.

Table 1. Diagnosis of Misconception

| Code | Category                                      | Answer type                                 |
|------|-----------------------------------------------|---------------------------------------------|
| SK   | Scientific Knowledge (Understand the concept) | Correct answer + true reason + sure         |
| LG   | Lucky Guess (guessing)                       | Correct answer + true reason + not sure     |
| YOU  | Less Understanding (Lack of Concept Understanding) | Incorrect answer + true reason + not sure   |
|      |                                               | Right answer + wrong reason + not sure      |
| LK   | Lack of Knowledge (Don't Understand the Concept) | Incorrect answer + wrong reason + not sure  |
| M-   | Misconception false negative (Misconception) | Wrong answer + correct reason + sure        |
| M+   | Misconception false positive (Misconception) | Right answer + wrong reason + sure          |
| M    | Misconception (misconception)                | Incorrect answer + wrong reason + sure      |

The category of misconception can be seen in Table 1. The category was taken from (Kaltakçı and Didi, 2007; Drastisianti et al., 2018; Arslan et al., 2012). The result of the interviews that had been obtained will then be matched with the answers of three-tier students' questions. The correct interview answers will invalidate misconceptions, whereas the wrong answers will reinforce misconceptions. Clarification results made a list of misconceptions experienced by students. Furthermore, a descriptive analysis was conducted for each research data obtained in drawing conclusions in the form of student misconceptions on equilibrium material containing 2 sub concepts, namely the determination of the formula $K_c$, $K_p$, and $K_c$ calculations.

3. RESULT AND DISCUSSION

Three tier tests are used as a learning evaluation tool, while the misconception profile is used to analyze the misconceptions that occur in students.

3.1. Determination of The Formula $K_c$

Based on Table 2 students experienced misconceptions 23.33%, positive misconceptions 3.33% and students lack of confidence by 3.33%. Based on Table 3 students who experienced misconceptions were represented by S4 and S5, while negative misconceptions were represented by masters and students who experienced lack of confidence were represented by S1.

As for one of the questions given to students regarding the determination of the $K_c$ formula, it was presented in Figure 1.
**Analysis of Students Misconception in Chemical Equilibrium Material Using Three Tier Test**

Table 2. Percentage of Student Misconceptions

| No | Sub-topic                                      | Missconceptions Positive | Missconceptions Negative | Guess or Lack Confidence | Number of Questions |
|----|-----------------------------------------------|--------------------------|--------------------------|--------------------------|---------------------|
|    |                                               | F | Percentage | F | Percentage | F | Percentage | F | Percentage | F | Percentage |
| 1  | Determination of the formula $K_c$            |  7 | 23.33     |  1 | 3.33       | - |           |  1 | 3.33       |  4 |           |
| 2  | Determination of the formula $K_p$            |  4 | 13.33     | - |           | - |           |  2 | 6.67       |  4 |           |
| 3  | The calculation concept $K_c$                 |  5 | 16.67     |  7 | 23.33     |  3 | 10         |  2 | 6.67       |  7 |           |

Note: $F =$The number of students; total students = 30 people

Table 3. Categories of Student Misconceptions

| Subject | First Tier | Second Tier | Third Tier | Categories                                      |
|---------|------------|-------------|------------|-------------------------------------------------|
| S1      | Correct    | Correct     | Uncertain  | Guess the answer or lack of confidence           |
| S2      | Correct    | Incorrect   | Certain    | Positive misconception                           |
| S3      | Incorrect   | Correct     | Certain    | Negative misconception                          |
| S4      | Incorrect   | Incorrect   | Certain    | Misconception                                   |
| S5      | Incorrect   | Incorrect   | Certain    | Misconception                                   |

The formula $K_c = \frac{[\text{Product}]^{\text{coefficient}}}{[\text{reactant}]^{\text{coefficient}}}$

One solid, two gases, one liquid, and one solution, this forms four separate phases. On balance, the equilibrium constant can be written as follows.

$$K'_c = \frac{[\text{SnO}_2][\text{H}_3\text{O}^+]^2}{[\text{O}_2]^{1/2}[\text{Sn}^{2+}][\text{H}_2\text{O}]^3}$$

However, the "concentration" of a solid, like its density, is intensive and does not depend on the amount of substances present. [note that a concentration (mole per liter) can be converted to a unit of density (grams per cm$^3$) and vice versa.] Based on this reason, a term [SnO$_2$] is itself a constant so that it can be combined with equilibrium constant. Will be simplified by the equilibrium equation as follows.

$$\frac{[\text{SnO}_2][\text{H}_3\text{O}^+]^2}{[\text{O}_2]^{1/2}[\text{Sn}^{2+}][\text{H}_2\text{O}]^3} \times K_c = K'_c$$

Where $K_c$ the “new” equilibrium constant, is now easily expressed in one concentration, i.e.

Figure 1. Student Work Results

In Figure 1 is an example of the results of student work. They stated that the problem is about the factor of chemical equilibrium influence and does not remember $K_c$ formula well, but the concept that must be used is the determination of the formula $K_c$ and $K_p$ with the indicator problem determining the formula $K_c$ of an equilibrium reaction.

Though the correct concept is as follows:

$$\frac{1}{2} \text{O}_2(g) + \text{Sn}^{2+}(aq) + 3 \text{H}_2\text{O}(l) \rightleftharpoons \text{SnO}_2(s) + 2 \text{H}_3\text{O}^+(aq)$$

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That value $K_c$ does not depend on the amount $[\text{SnO}_2]$ that exists, as long as there is little of each of them in a state of balance.

Alternatively, equilibrium constant can be stated as follows.

$$K_p = P[O_2]^{1/2}$$

The equilibrium constant in this case has the same numerical value as the $[O_2]^{1/2}$ gas pressure, a quantity that is easily measured. Based on the explanation or information above that the solid also applies to liquids. So, if the reactant or product is a liquid, it can treat its concentration as a constant and can eliminate it from the equilibrium constant equation. It is more concise that the formula $K_c$ because of concentration is used as the aqueous phase or solution and gas. Whereas $K_p$ pressure is only a gas phase (Chang and Overby, 2011).

So, the correct answer is

$$K_c = \frac{[\text{H}_3\text{O}^+]^2}{[O_2]^{1/2}[\text{Sn}^{2+}]}$$

The answer options are level 1: D, level 2: D and level 3: sure.

### 3.2. The Formula $K_p$

Based on Table 2 students had misconceptions 13.33%, positive misconceptions did not exist and students lacking confidence did not exist. Based on Table 3 students who experienced misconceptions are already represented by S4 and S5.

As for one of the questions given to students regarding the determination of the $K_p$ formula, it was presented in Figure 2 as follows:

![Student Work Results](image)

In Figure 2 is an example of the results of student work. They stated that the problem was included in the sub-topic of the direction of shifting and students were confused in working on the problem, especially determining the formula was $K_p$, so that four students experienced misconceptions.

Even though the problem was about the quantitative relationship between the components and the equilibrium reaction with the indicator problem calculating the price of $K_p$ based on the relationship with $K_c$. The answer was correct because if the reaction which has the gas phase, the product coefficient and reactants are the same then $K_p$ can be said to be the same as $K_c$, because the formula is $K_p = K_c (RT)^{\Delta n}$. $\Delta n$ is the difference from the product and reactant coefficients. Therefore, if the coefficients are equal then $K_p = K_c$. Applies to the gas phase only because the formula above is based on the ideal gas law (Chang and Overby, 2011). The correct answer should be E which is 0.25 and the reason is D.

### 3.3. The Calculation Concept $K_c$

Based on Table 2 students experienced 16.67% misconceptions, 23.33% positive misconceptions, 10% negative misconceptions.
Analysis of Students Misconception in Chemical Equilibrium Material Using Three Tier Test

and 6.67% less confident students. Based on Table 3 students who experience misconceptions are already represented by S4 and S5.

As for one of the questions given to students regarding the concept of calculating $K_c$ is presented in Figure 3 as follows:

![Figure 3. Student Work Results](image)

In Figure 3 is an example of the results of student work. The correct answer should be E which is 16, the reason is because based on the initial reactant mole, and reactant mole in a balanced state, it can be determined mole of reactant that reacts then based on the coefficient ratio can be determined the product mole is in a balanced state, then $K_c$ calculated by formula $K_c = \frac{[\text{product}]^{\text{coefficient}}}{[\text{reactant}]^{\text{coefficient}}}$. Misconception often occured is students did not understand the basic laws of chemistry such as the comparison of coefficients to get a balanced mole and a mole that reacts from a product. That the product mole in a balanced state cannot be directly obtained from the ratio of the reactant mole coefficients in a balanced state, but must first find the product mole that reacts with the coefficient ratio. In addition, misconceptions occured from the inverse formula $K_c$

$$K_c = \frac{[\text{reactant}]^{\text{coefficient}}}{[\text{product}]^{\text{coefficient}}}$$

sometimes students did not raise it with coefficients.

Correct concept:

$$\text{NO}_2(g) = 2 \text{NO}_3(g)$$

| Mula2 | Reaksi | Seimbang |
|-------|--------|----------|
| 3 mol | $\frac{2}{1}$ | $\frac{2}{1}$ |
| 1 mol | 4 mol | 4 mol |

So the answer is wrong: $K_c = \frac{[2]^2}{[1]^1} = 4 \text{ mol}$

$\text{NO}_2(g) = 2 \text{NO}_3(g)$

| Mula2 | Reaksi | Seimbang |
|-------|--------|----------|
| 3 mol | $\frac{2}{1}$ | $\frac{2}{1}$ |
| 1 mol | 4 mol | 2 mol |

Students did not look for moles that react from reactants to get reaction moles from products because they thought that a balanced mole is the same as a balanced mole of reactants with a coefficient ratio.
Based on the results of the above explanation, students had misconceptions about determining the formula $K_c$, $K_p$ and calculate $K_c$ because students did not understand the basic laws of chemistry, did not remember well the formulas $K_c$ and $K_p$. This is in line with the results of research conducted by Conpolat et al. (2006); Ozmen (2008) that students were confused in determining the formula and its relationship. As for the equilibrium constants $K_c$ and $K_p$ will increase with increasing temperature in the exothermic reaction, but there were students who are still confused about it, so students experience misconceptions. This is supported based on the results of research conducted by Ozmen (2007); Voska and Heikkinen (2000).

4. CONCLUSION

Based on the results of the test and interviews, students experienced misconceptions about the concept of determining the formula $K_c$ of 23.33%, the formula $K_p$ of 13.33%, and the concept of calculating $K_c$ of 16.67%.
Analysis of Students Misconception in Chemical Equilibrium Material Using Three Tier Test

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Analysis of Students Misconception in Chemical Equilibrium Material Using Three Tier Test

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