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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 because most of the material in chemistry lessons is abstract (Viyandari et al., 2012; Yunitasari et al., 2013; Rahayu and Nasrudin, 2014). Chemistry has three levels, namely macroscopic, submicroscopic and symbolic (Brandriet and Bretz, 2014; Naah and Sanger, 2012). According to Rahayu and Nasrudin, (2014) level macroscopic obtained from direct observations. Examples of chemicals that can be seen directly are solids of sugar, salt, iron rust and paper burning. Whereas submicroscopic level is chemical level which cannot be observed directly. An example is a chemical reaction (Kusumaningrum et al., 2018; Setyoko et al., 2017). The symbolic level is a qualitative and quantitative representation in the form of Rahayu and Nasrudin's (2014) formulas, pictures and diagrams.

Chemical equilibrium is a topic in the upper middle school which specifically addresses equilibrium reactions in reversible reactions (Kolobe and Hobden, 2019). This topic is a basis for students to understand other chemical topics such as acid-base, oxidation and reduction reactions, and solubility (Begquist and Heikkinen, 1990). Thus, students who understand well the chemical equilibrium will support understanding other chemical concepts. Therefore, it is important for teachers to diagnose whether students have misconceptions or not before learning.

Based on the results of a preliminary study conducted by interviewing Miss Triatun, S.Pd as a chemistry teacher at SMAN 2 Wonosari. Students tended to experience misconceptions and lack understanding about using the K_c and K_p formulas in chemical equilibrium material. One of the factors causing misconception is preconception given by the teacher, students feel that chemistry is a difficult subject and students do not have a strong foundation before studying chemical equilibrium material.

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 Wonosari 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 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 (Kaltakçi 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.

Table 2. Percentage of Student Misconceptions

No	Sub-topic	Misconceptions		Misconceptions Positive		Misconceptions Negative		Guess or Lack Confidence		Number of Questions
		F	Percentage	F	Percentage	F	Percentage	F	Percentage	
1	Detemination of the formula K_c	7	23.33	1	3.33	-		1	3.33	4
2	Detemination of the formula K_p	4	13.33	-		-		-		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

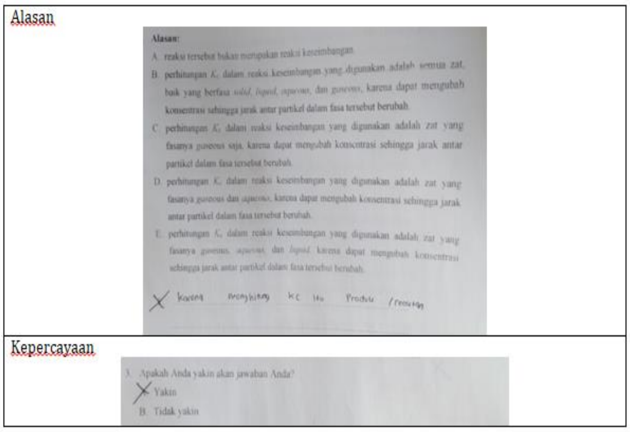


Figure 1. Student Work Results

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:

$\frac{1}{2}\, O_2(g) + Sn^{2+}(aq) + 3\, H_2O(l) \rightleftarrows SnO_2(s) + 2\, H_3O^+(aq)$

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

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

$$K'_c = \frac{[SnO_2]\,[H_3O^+]^2}{[O_2]^{1/2}\,[Sn^{2+}]\,[H_2O]^3}$$

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.

$$\frac{[SnO_2]\,[H_3O^+]^2}{[O_2]^{1/2}\,[Sn^{2+}]\,[H_2O]^3} K'_c = K_c = \frac{[H_3O^+]^2}{[O_2]^{1/2}\,[Sn^{2+}]}$$

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

$\frac{[H_3O^+]^2}{[O_2]^{1/2}\,[Sn^{2+}]}$ That value K_c does not depend on the amount $[SnO_2]$ 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

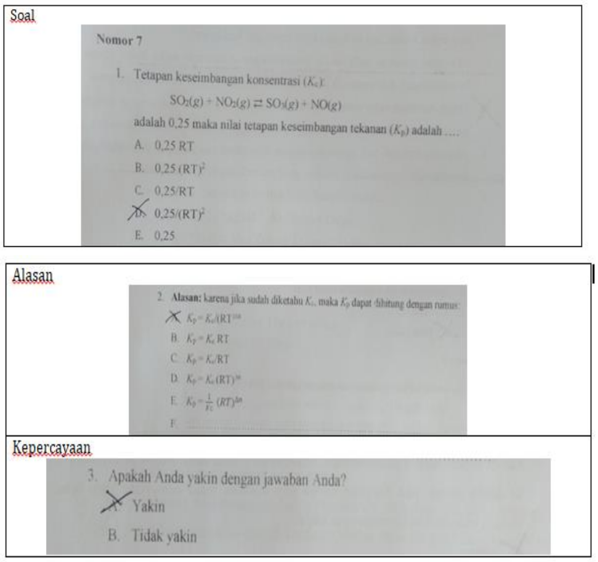
$$K_c = \frac{[H_3O^+]^2}{[O_2]^{1/2}\,[Sn^{2+}]}$$

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:



Soal

Nomor 7

1. Tetapan keseimbangan konsentrasi (K_c):
$SO_2(g) + NO_2(g) \rightleftarrows SO_3(g) + NO(g)$
adalah 0,25 maka nilai tetapan keseimbangan tekanan (K_p) adalah ....
A. 0,25 RT
B. 0,25 $(RT)^2$
C. 0,25/RT
D. 0,25/$(RT)^2$
E. 0,25

Alasan

2. Alasan: karena jika sudah diketahui K_c, maka K_p dapat dihitung dengan rumus:
A. $K_p = K_c/(RT)^{\Delta n}$
B. $K_p = K_c\,RT$
C. $K_p = K_c/RT$
D. $K_p = K_c\,(RT)^{\Delta n}$
E. $K_p = \frac{1}{K_c}\,(RT)^{\Delta n}$
F. ....

Kepercayaan

3. Apakah Anda yakin dengan jawaban Anda?
A. Yakin
B. Tidak yakin

Figure 2. Student Work Results

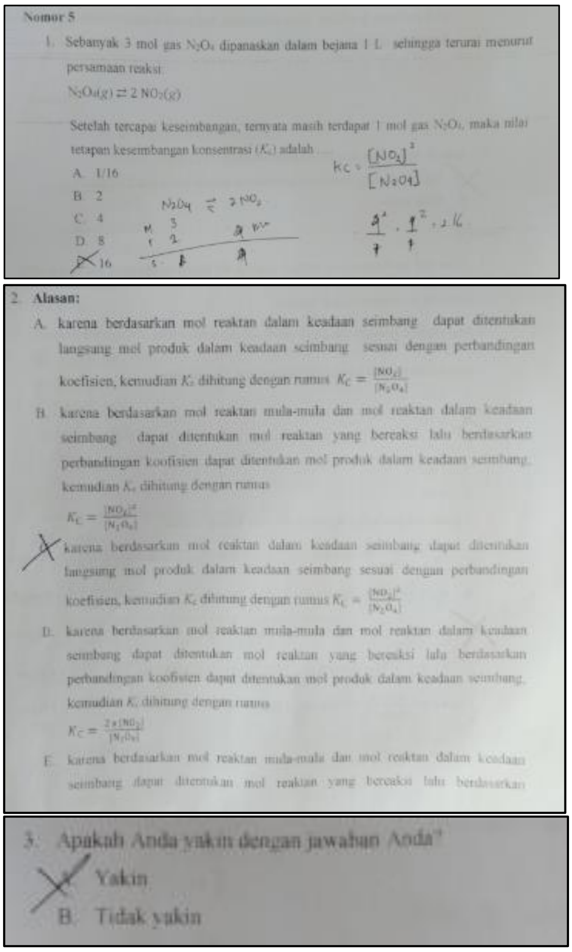
In Figure 2 is an example of the results of student work. They stated that the problem was included in the sub-topic of the direction of shifting and students were confused in working on the problem, especially determining the formula was K_p, so that four students experienced misconceptions.

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 $K_p = K_c\,(RT)^{\Delta n}$. Δn 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 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:



Nomor 5

1. Sebanyak 3 mol gas N_2O_4 dipanaskan dalam bejana 1 L sehingga terurai menurut persamaan reaksi:

   $N_2O_4(g) \rightleftarrows 2\,NO_2(g)$

   Setelah tercapai kesetimbangan, ternyata masih terdapat 1 mol gas N_2O_4, maka nilai tetapan kesetimbangan konsentrasi (K_c) adalah ...

   A. 1/16
   B. 2
   C. 4
   D. 8
   E. 16

2. Alasan:

   A. karena berdasarkan mol reaktan dalam keadaan seimbang dapat ditentukan langsung mol produk dalam keadaan seimbang sesuai dengan perbandingan koefisien, kemudian K_c dihitung dengan rumus $K_c = \frac{[NO_2]}{[N_2O_4]}$

   B. karena berdasarkan mol reaktan mula-mula dan mol reaktan dalam keadaan seimbang dapat ditentukan mol reaktan yang bereaksi lalu berdasarkan perbandingan koefisien dapat ditentukan mol produk dalam keadaan seimbang, kemudian K_c dihitung dengan rumus $K_c = \frac{[NO_2]^2}{[N_2O_4]}$

   C. karena berdasarkan mol reaktan dalam keadaan seimbang dapat ditentukan langsung mol produk dalam keadaan seimbang sesuai dengan perbandingan koefisien, kemudian K_c dihitung dengan rumus $K_c = \frac{[NO_2]^2}{[N_2O_4]}$

   D. karena berdasarkan mol reaktan mula-mula dan mol reaktan dalam keadaan seimbang dapat ditentukan mol reaktan yang bereaksi lalu berdasarkan perbandingan koefisien dapat ditentukan mol produk dalam keadaan seimbang, kemudian K_c dihitung dengan rumus $K_c = \frac{2 \times [NO_2]}{[N_2O_4]}$

   E. karena berdasarkan mol reaktan mula-mula dan mol reaktan dalam keadaan seimbang dapat ditentukan mol reaktan yang bereaksi lalu berdasarkan

3. Apakah Anda yakin dengan jawaban Anda?

   A. Yakin
   B. Tidak yakin

Figure 3. Student Work Results

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 $K_C = \frac{[NO_2]^2}{[N_2O_4]}$. 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

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

sometimes students did not raise it with coefficients.

Correct concept:

$N_2O_4(g) \rightleftarrows 2\,NO_2(g)$

	$N_2O_4(g)$	$2\,NO_2(g)$
Mula2 :	3 mol	
Reaksi :	2 mol	$\frac{2}{1} \times 2$ mol = 4 mol
Setimbang :	1 mol	4 mol

$K_c = \frac{[4]^2}{[1]^1} = 16$

However, some students could answer but did not know the reason, because they can just guessed the answer. The concepts that are often wrong are as follows:

$N_2O_4(g) \rightleftarrows 2\,NO_2(g)$

	$N_2O_4(g)$	$2\,NO_2(g)$
Mula2 :	3 mol	
Reaksi :		
Setimbang :	1 mol	$\frac{2}{1} \times 1$ 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.

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

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%.

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