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ANALYSIS OF STUDENTS' MISCONCEPTIONS IN CLASS XI MIPA 4 OF HIGH SCHOOL 6 MAKASSAR ON BUFFER SOLUTION USING THE THREE-TIER DIAGNOSTIC TEST INSTRUMENT

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ABSTRACT

This study aims to describe students' misconceptions and the causes of class XI MIPA 4 SMA Negeri 6 Makassar in the buffer solution material. The subjects in this study were students of class XI MIPA 4 SMA Negeri 6 Makassar in 2021/2022 academic year which consisted of 27 students and had studied the buffer solution material. The research instrument used in this study is a diagnostic test, namely Three Tier Multiple Choice which is supported by interview data. The results showed that percentage of students' misconceptions in the buffer solution material occurred in: 1) concept's understanding 71.6%; 2) The properties 70.4%; 3) The components 72.2%; 4) The pH Calculating 49.1%; 5) the work principle 50.0%; and 6) the function of our life of 50.6%. Factors that cause misconceptions in students are those that come from the students themselves.

Keywords: Misconceptions, *Three Tier Multiple Choice* Test, buffer solution

INTRODUCTION

Chemistry subject is a branch of natural science subjects that has its characteristics. Some of the characteristics of chemistry mentioned by Kean, E & Middlecamp (1985) include: (1) most of the chemical concepts are abstract, (2) chemical concepts are generally simplifications of the actual situation, and (3) concepts in chemistry is sequential and develops rapidly (4) chemistry is not just solving problems (5) there are a lot of materials/materials studied in chemistry [1].

Based on the characteristics of chemistry that have been disclosed, it can be seen that chemistry lessons contain sequential and tiered concepts and make it difficult for chemical concepts to be understood properly and correctly. Students must have a good and high understanding in order to understand and study chemistry correctly so that it will not lead to a wrong understanding of a concept. If this erroneous understanding occurs continuously and repeatedly, it will lead to an error called a misconception. Yunitasari (2013) reveals that students who have difficulty understanding concepts in chemistry lessons sometimes make their own interpretations of the concepts being studied in an effort to overcome their learning difficulties [2]. However, the results of students' interpretations of concepts are sometimes not in accordance with scientific concepts understood by experts. According to Suparno (2005), a misconception is an error in understanding a concept that is considered correct but is not in accordance with the concept that has been agreed upon by experts [3].

The misconception is a situation where students answer incorrectly with high confidence [4]. Many things can cause misconceptions. One of the students' misconceptions about chemistry concepts occurs because chemistry subjects are full of abstract and challenging concepts that are not easily understood by students unless connected to something from everyday experience [10]. Students misconceptions about chemistry concepts can interfere with further students' knowledge because the concepts in chemistry learning are interconnected and mutually sustainable. This aligns with Ealy (2018), saying that each chemical concept does not stand alone but is interrelated and built hierarchically from the simple to the more complex [5].

Misconceptions can occur due to several factors, such as prior knowledge (Taber, 2015),

lack of information by teachers and limited textbook content [6], and the abstract and symbolic nature of chemical concepts [7]. Suparno (2005) in his book describes the misconception factors in students that can occur because of the students themselves, teachers, textbooks, context, and learning methods [3].

Many researchers have found misconceptions about chemistry concepts, including the buffer solution material. This can be seen from several studies which reveal students' misconceptions about buffer solution material. Research conducted by Luh Mentari, I Nyoman Suardana, and I Wayan (2014) shows that the distribution of misconceptions among class XI IA students of SMA Negeri 1 Sukasada regarding the matter of buffer solutions is: {a} the concept of 52.44% buffer solution, {b} the concept of acid buffer 24.50%, {c} concept of base buffer 18.62% and {d} concept of pH of buffer solution 23.10% [19]. Furthermore, in research conducted by Al-Qadri (2019) on the buffer solution material, it was shown that students who experienced misconceptions about the buffer solution material were 67.86%, students who understood the concept were 0%, and those who did not understand the concept were 32.14% [8].

Based on observations made by researchers, students in class XI MIPA 4 SMAN 6 Makassar have a low mastery score in the buffer solution material where the learning outcomes obtained in the buffer material are still below the 75 mastery standard, approximately 40% of students complete and 60% pass. not finished. Therefore, it can be assumed that students did not understand the concept or may experience misconceptions.

Misconceptions experienced by students should not be allowed to continue. If this happens continuously, other concepts that have not been studied will likely be affected by misconceptions. Given that the concepts in chemistry are interconnected and interrelated with one another. Therefore, it is necessary to identify students' misconceptions so that teachers can follow up on the misconceptions experienced by students and these misconceptions can be resolved immediately.

A diagnostic test can analyze misconceptions that occur in students [22]. According to Mehrens and Lehman (Suwarto, 2012), a good diagnostic test can accurately picture students' misconceptions based on their mistakes [9]. One misconception detection test that can be used is a three-tier multiple-choice diagnostic test. According to Gurel (2015), the three-tier multiple-choice instrument consists of 3 levels, the first level consists of standard multiple-choice tests, and the second level is the reason that refers to the first part [23]. The third level asked students' beliefs in answering the two previous sections. This type of test is considered capable of diagnosing students' conceptions/misconceptions well because there is a second level of the test that asks the reasons for respondents' answers at the first level. Furthermore, the third level asks how confident the respondent is with his answer [22].

Three-tier multiple choice is a valid test that can be used efficiently with large samples of students. It helps researchers to understand students' reasoning in their answers, distinguish misunderstanding from lack of knowledge, and estimate the percentage of positive and negative errors [11]. This instrument has been widely used by several researchers, such as Jusniar et al. (2020) on chemical equilibrium material, Qadri et al. (2019) on buffer solution material [8], and Arslan et al. (2012) in the field of physics [8], [12].

Based on this background, the formulation of the problem in this study is what are the misconceptions experienced by students in class XI MIPA 4 SMAN 6 Makassar regarding the buffer solution material, what are the factors that cause students in class XI MIPA 4 SMAN 6 Makassar to experience misconceptions about the material buffer solution?

The purpose of this study was to find out what misconceptions were experienced by class XI MIPA 4 students at SMAN 6 Makassar regarding the buffer solution material, to find out the factors that caused XI MIPA 4 students at SMAN 6 Makassar to experience misconceptions about the buffer solution material.

RESEARCH METHOD

This research is descriptive. Descriptive research aims to describe a symptom or event or events that occur in the present (Sudjana, 2005). This study describes the misconceptions experienced by class XI MIPA 4 students at SMAN 6 Makassar regarding the buffer solution material and determines the factors that cause these misconceptions.

The subjects of this study were students in class XI MIPA 4 at SMAN 6 Makassar for the

2020/2021 academic year who had studied the material for buffer solutions. The research subjects consisted of 1 class, namely class XI MIPA 4, with 27 students. The research instrument used in this study was a Three Tier Multiple Choice (3TMC) diagnostic test instrument and an interview guide to reveal the causes of misconceptions.

Three Tier Test diagnostic tests

The type of diagnostic test used in this study is three-tier multiple choice which consists of three levels, namely the first level is multiple choice with five answer choices (A, B, C, D, and E) regarding the concept of buffer solution, the second level is the reason The answers from the first level consist of five choices of answer reasons (1,2,3,4 and 5). The third level is a question of confidence in the previous answer, consisting of two choices: "Sure" and "Not sure." From this test, it can be seen where students' misconceptions lie.

Expert lecturers have validated all test items and then tested on class XII MIPA 3 students at SMA Negeri 6 Makassar to validate the items. The answers from class XI MIPA 3 students at SMA Negeri 6 Makassar were then analyzed for item validation. Item validation includes determining the difficulty index, discriminatory power, validity, and reliability. From the difficulty index, 1 question is obtained in the easy category, 21 in the medium category, and 3 in the difficult category. As for discriminating power, eight questions were obtained in the good category, ten in the good category, and six in the wrong category. Based on the results of item validation, there were two questions in the invalid category and 23 in the correct category. The reliability for the 25-item questions is 0.74, which is classified in the high category.

Data obtained from the Three Tier Multiple Choice (3TMC) diagnostic test were analyzed based on the answers chosen by the students when answering the test questions. There are three categories of students' level of understanding: students who understand, students who experience misconceptions, and students who do not understand the concept. The interpretation of the responses from the Three Tier Diagnostic Test given by respondents according to Arslan et al. (2012) is described in Table 1 [22].

Table 1. Possible patterns of student answers

First Level	Second Level	Third Level	Category
Correct	Correct	Certain	Get the concept
Correct	Wrong	Certain	Misconceptions (False Positive)
Wrong	Correct	Certain	Misconception (False Negative)
Wrong	Wrong	Certain	Misconceptions
Correct	Correct	Not Sure	Lucky guessm lack of confidence
Correct	Wrong	Not Sure	Lack of understanding of concepts
Wrong	Correct	Note Sure	Lack of understanding of concepts
Wrong	Wrong	Note Sur	Lack of understanding of concepts

The equation for finding the percentage of students who experience misconceptions uses the following formula [21]:

$$P = \frac{F}{N} \times 100\%$$

Information:

P = Percentage of students who experience misconceptions

F = Number of students who experience misconceptions

N = Total number of students

To analyze students' misconceptions according to the categories suggested by Al-Balushi et al (2012) that misconceptions are considered as general misconceptions if 20% or more of the sample believes in them [13].

RESULTS AND DISCUSSION

A. RESULTS

1. The percentage of student test results using a three-tier multiple-choice diagnostic test

Based on the overall results of the student's test answers shows the level of understanding. The results of categorizing students' understanding are divided into three categories:

understanding concepts, misconceptions, and not understanding concepts.

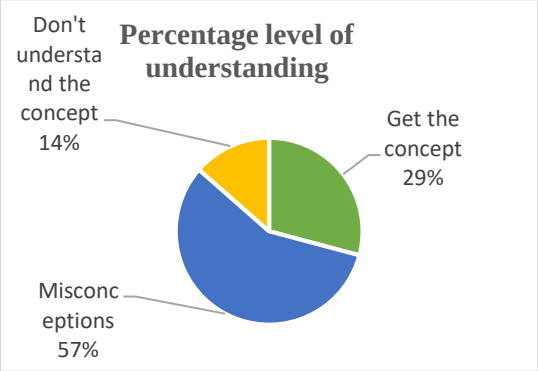

Fig 1 the percentage of students' understanding of the buffer solution

The percentage of misconceptions is the highest, namely 57% in the medium category. The percentage of understanding the concept is 29% in the low category, and the percentage that does not understand the concept is 14% in the low category.

2. The percentage of students' answers on the buffer solution material

A total of 27 students in class XI MIPA 4 at SMAN 6 Makassar were given a Three Tier Multiple Choice test regarding the buffer solution material, totaling 23 items. The following are the results of the answers from students which are summarized in table 2.

Table 2 Percentage of Student Answers for Each Concept

Concept	Percentage %					Total % Misconception (M)
	P	T	M	M(+)	M(-)	
Definition of bufferr solution	11,1	17,3	40,7	22,2	8,6	71,6
Properties of the buffer solution	14,8	14,8	48,1	22,2	0,0	70,4
Components of the buffer solution	15,7	12,0	34,3	15,7	22,2	72,2
pH of buffer solution	37,5	13,4	31,0	7,4	10,6	49,1
Working principle of buffer solution	32,4	17,6	28,7	13,9	7,4	50,0
Function of buffer solutions in life	43,2	6,2	28,4	17,3	4,9	50,6

Information:
P = Understand
T = Don't understand the concept
M (+) = Misconseption (*False Positive*)
M = Pure Misconseption
M (-) = Misconseption (*False negative*)

B. DISCUSSION

1. Students' misconceptions about buffer solution material

Analysis of students' misconceptions about the buffer solution material can be observed by looking at the results of the three-tier multiple-choice test. Based on the test results in table 1 shows that the percentage of misconceptions is the highest percentage of understanding concepts and not understanding concepts. Misconceptions can be divided into pure misconceptions, false positive misconceptions, and false negative misconceptions.

a. Definition of buffer solution

The percentage of misconceptions about this concept is 71.6%, with the following descriptions: 40.7% pure misconception, 22.2% false positive misconceptions, and 8.6 false negative misconceptions. Students assume that a buffer solution can maintain its pH because there is a conjugate base that is very stable towards H+ ions and OH- ions so that it can maintain pH in all circumstances. This shows that students experience misconceptions because students experience conceptual errors in explaining the reasons why buffer solutions can maintain pH when a little acid, a little base, and dilution are added. According to Chang (2004) that a buffer solution is able to resist changes in pH when a small amount of acid or base is added [14].

b. Properties of buffer solutions

The percentage of misconceptions about this concept is 70.4% with the following descriptions: 48.1% pure misconceptions; 22.2% false positive misconceptions; and 0.0% false negative misconceptions. Students experience conceptual errors in explaining the properties of a buffer solution where students assume an acidic buffer will be formed from a mixture of strong acid (HCl) and a strong base (NaOH) and also students assume that a buffer solution will form when the two components have the number of moles the same one. This shows that students experience misconceptions, in understanding the properties of a buffer solution, where students cannot clearly

understand that the pH of the Buffer solution does not change on the addition of a small amount of strong acid or strong base, but the pH will change on the addition of strong acid and strong base in large quantities.

This is in accordance with the concept that a buffer solution must contain a high enough concentration of acid to react with the OH- ions added to it and must contain the same high concentration of base to react with the added H+ ions [14].

c. The components that make up the buffer solution

The percentage of misconceptions about this concept is 72.2% with a description of: 34.3% pure misconception; 15.7% false positive misconceptions; and 22.2% false negative misconceptions. Most students already understand the components of an acid buffer, namely a weak acid and its conjugate base, but are unable to explain correctly how to find out the components of the acid buffer. Students assume that the acid buffer component consists of a weak acid and a base or a strong acid and its salt, this condition indicates a false positive misconception. The results of this study are in line with the findings of Chozim (2018), namely students assume that an acid buffer solution is made from a weak base and its salt or a strong acid and its salt [15]. The correct concept is that a component of an acid buffer solution can be made by mixing a weak acid with its conjugate base or mixing an excess of a weak acid with a limited amount of a strong base [16].

d. Determine the pH of the buffer solution

The percentage of student misconceptions in determining the pH of the buffer solution is 49.1% with a description of: 31.0% pure misconception; 7.4% false positive misconceptions; and 10.6% false negative misconceptions. Misconceptions found in this concept include students not being able to determine the pH of the buffer solution correctly because they assume Ka is the concentration of base equilibrium, so the formula for finding the concentration of base buffer according to students is $[OH^-] =$ Ka $\frac{\text{moles of base}}{\text{mol of salt}}$. this shows that students cannot distinguish between the use of Ka and Kb, causing errors in determining the pH value of the solution. Meanwhile, according to Chang (2004) to determine the concentration of base buffer, the formula $[OH^-] =$ Kb $\frac{\text{Moles of base}}{\text{mol of Salt}}$. is used [14].

e. The working principle of the buffer solution

Based on Table 4.1, the percentage of students' misconceptions in understanding the working principle of a buffer solution is 50.0% with a description of: 28.7% pure misconception; 13.9% false positive misconceptions; and 7.4% false negative misconceptions. In this concept students are correct in determining which solution includes a buffer solution but are wrong in understanding the concept where students assume that a buffer solution is a solution that changes pH when acids, bases and water are added. This shows that students experience misconceptions (false positives). This is similar to Kustiarini's research (2019) that the addition of a little acid, base, and neutralization affects the pH of the buffer solution [17]. The correct concept is that a buffer solution is able to resist changes in pH when a small amount of acid or base is added [14].

f. The function of buffer solutions in life

Based on Table 4.1, the percentage of misconceptions about this concept is 50.6%, with a description of: 28.4% pure misconception, 17.3% false positive misconceptions, and 4.9% false negative misconceptions. Misconceptions found in this concept include students with a buffer in the blood that functions to maintain pH in the blood, which is a carbonate buffer, namely HCO3- – CO32. It can be seen that this statement is not true; according to Keenan (1984), the buffer solutions in the body are carbonate buffer solutions H_2CO_3 – HCO^{3-} and phosphate buffer solutions $H_2PO_4^-$ – HPO_4^{2-} [20]. The carbonate buffer solution is found outsie the cells or, more precisely, in human blood. Phosphate buffer solutions are present in the intracellular fluid.

2. Causes of students' misconceptions about the concept of buffer solutions

According to Suparno (2005), the causes of misconceptions occur, among others, because the students are themselves, the teacher teaching, the teaching method, the context, and the textbooks the students use. In this study, the source of the causes found by the researchers were misconceptions originating from the students themselves [3]. The causes of

misconceptions originating from students found by this study are:

a.The reason is that students whose understanding is not complete with confidence are sure to answer

Wrong reasons or reasoning about a concept can cause students to experience misconceptions. Incomplete reasoning or reasons because the information obtained is incomplete, so students are wrong in concluding, which results in misconceptions (Suparno, 2005) [3]). The following are excerpts from interviews with researchers (P) conducted with students (PS) regarding the concept of understanding buffer solutions:

P : What is meant by buffer solution ?
PS1 : Solutions containing a mixture of weak acids
PS5 : A buffer solution is a mixture of weak acid and its conjugate base
PS6 : Solutions that keep the pH fairly constant have the ability to resist changes in pH upon dilution or addition of a small amount of acid or a small amount of base
PS9 : maintain pH
Based on the interview results above, it can be seen that students consider the buffer solution to be a solution that contains a mixture of weak acids. Students also consider a buffer solution as a solution that can maintain pH. Students do not provide complete reasons regarding the meaning of buffer solution. The correct concept is that a buffer solution is a solution that has the ability to maintain pH changes when a little acid or base is added to the solution [18].

CONCLUSION

Based on the results of the research that has been done, several conclusions can be drawn, namely:
Based on the results of the three-tier multiple choice test given to XI MIPA 4 students at SMAN 6 Makassar on the buffer solution material, it can be seen that misconceptions occur in all buffer solution concepts, namely: (a) The definition of a buffer solution with a percentage of 71.6%, (b)) Properties of the buffer solution with a percentage of 70.4%, (c) Components of the buffer solution with a percentage of 72.2%, (d) Determination of the pH of the buffer solution with a percentage of 49.1%, (e) Working principle of a buffer solution with a percentage of 50.0 %, (e) The function of the buffer solution in everyday life with a percentage of 50.6%. (two item later, there are not in “results and discussion”) The factors that cause misconceptions experienced by students in class XI MIPA 4 SMAN 6 Makassar on the buffer solution material come from students.

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