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Analysis of Chemistry Problem-Solving Ability in Symbolic Level for Senior High School Students

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Abstract: Analysis of Chemistry Problem-Solving Ability in Symbolic Level for Senior High School Students. Objective: The study aims to analyze the ability to solve symbolic level of chemistry problems on buffer solution. **Methods:** This research used descriptive qualitative method. Population in this study was used as research sample, i.e sixty students from XI MIPA. Data collection was carried out using a three-tier multiple choice diagnostic test and a student response questionnaire. **Findings:** The results showed that the ability to solve symbolic level chemistry problems on buffer solution was still low, with an average percentage of understanding the concept was 9.77%, misconceptions was 57.75%, and not understanding the concept was 32.48%. Students' responses to the use of three-tier multiple-choice questions were positive, with a percentage of 74.30%; students gave good responses to the three-tier test, so this test is categorized as good to identify the level of student understanding in solving symbolic level chemistry problems on buffer solution. **Concusion:** The research findings confirmed that the diagnostic three-tier test is a good diagnostic test to analysis chemistry problem-solving skills.

Keywords: chemistry problem solving ability, symbolic level, three-tier diagnostic test.

Abstrak: Analisis Kemampuan Penyelesaian Masalah Kimia dalam Level Simbolik bagi Siswa SMA. Tujuan: *Penelitian ini bertujuan untuk menganalisis kemampuan menyelesaikan soal kimia tingkat simbolik pada materi larutan penyangga.* ***Metode:*** *Penelitian ini menggunakan metode kualitatif deskriptif. Seluruh populasi dalam penelitian ini dijadikan sampel yaitu seluruh siswa kelas XI MIPA yang berjumlah 60 siswa. Pengumpulan data dilakukan dengan menggunakan tes diagnostik Three Tier Multiple Choice dan angket respon siswa.* ***Hasil:*** *Hasil penelitian menunjukkan bahwa kemampuan menyelesaikan soal kimia tingkat simbolik pada materi larutan penyangga masih rendah, dengan persentase rata-rata paham konsep 9,77%, miskonsepsi 57,75%, dan tidak paham konsep 32,48%. Respon siswa terhadap penggunaan soal three-tier multiple choice adalah positif dengan persentase 74,30%; siswa memberikan respon yang baik pada tes three-tier, sehingga bentuk tes ini dikategorikan baik untuk mengidentifikasi tingkat pemahaman siswa dalam menyelesaikan soal kimia level simbolik pada materi larutan penyangga.* ***Kesimpulan:*** *Temuan penelitian mengkonfirmasi bahwa tes diagnostik three-tier yang dikembangkan merupakan salah satu bentuk tes yang baik untuk mengetahui keterampilan pemecahan masalah kimia siswa.*

Kata kunci: *kemampuan pemecahan masalah kimia, level simbolik, three tier diagnostic test.*

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INTRODUCTION

Chemistry lessons for some students are lessons that are considered difficult to understand, one of which is due to their abstract nature, which results in a lack of student interest and motivation to learn chemistry (Sözbilir, 2004; Schwedler, S., & Kaldewey, 2020). The type of difficulty that often occurs in students is having difficulty connecting between concepts in the material that has been taught. The ability to use mathematical logic in solving problems is needed. According to Sirhan (2007) and Treagust et al. (2000), the causes of learning difficulties in chemistry are that students do not know how to learn, they think chemistry is a relatively new material, the material taught is related to chemical reactions, they lack basic math skills, and they lack problem-solving skills.

Students will more easily understand chemistry if they have good representation skills. Scientists categorize representation into three aspects, namely macroscopic, microscopic, and symbolic (Herga et al., 2016; Syahri et al., 2021). The process of observing something concrete, whether through carried out experiments or events that exist in daily life, is how macroscopic representation is obtained. Microscopy-based representation is the second technique. The microscopic aspect is a particulate study of atoms, ions, molecules, and structures and, at the same time, a conceptual study behind these macroscopic phenomena (Wu, 2003; Jansoon et al., 2009). The third is the symbolic aspect, where this representation takes the form of mathematical calculations, reaction equations, diagrams, images, and both qualitative and quantitative chemical formulas (Yaman, 2020; Luviana et al., 2020).

In the context of chemistry, physical chemistry subjects have many abstract concepts. It involves macroscopic (observable), microscopic (constituent particles), and symbolic (substance) aspects, so that physical chemistry courses are difficult for students to understand. It is said that students do not like chemistry and do not think they will do well in the class. The things that make it hard for students to learn chemistry are problems with terms, problems with understanding chemical ideas, and problems with numbers. These learning difficulties can be overcome through good management of chemistry learning, especially at the planning stage and during the learning process (Taber, 2001; Andayani et al., 2018). Students' ability to solve chemistry problems is still regarded as low. This is because students have difficulty analyzing chemical problems, especially those related to the concept of calculation and chemical reactions, which are symbolic discussions, while in chemistry there are chemical problems that require mathematical skills. Chemistry and chemical symbols have a relationship, so student learning can be seen from the ability to use symbolic language (Dori & Hameiri, 2003; Davidowitz et al., 2010; Bain et al., 2018).

Therefore, the role of the symbolic level is important in the chemistry learning process because students' ability to understand the symbolic level can have an influence on their learning outcomes. The level of student ability to solve symbolic-level chemistry problems can be identified using the Three-Tier Multiple-Choice Diagnostic Test because it is one type of diagnostic test used to distinguish the level of student understanding. One type of diagnostic test is a three-tier multiple-choice test, which is a choice of three questions consisting of three parts. The first part contains a material concept question; the second part contains the rationale for the first question; and the third part is the student's level of confidence in the previous two parts of the question. The three-tier multiple-choice test instrument is very well used to analyze the level of student understanding. The three-tier multiple-choice diagnostic test has a number of benefits, including the ability to identify significant misconceptions that students have, identify content that needs in-depth explanation during learning, plan better learning, and aid in the reduction of misconceptions among students (Mellyzar, 2021). Since the three-level diagnostic test has belief questions, it is thought to be a more accurate way to find out what students don't understand. (Maskuri et al., 2018; Siswaningsih et al., 2019). The three-level multiple-choice diagnostic test provides information to teachers and lecturers about students' understanding of concepts and can also be used to determine the level of student confidence in answering the questions given.

The focus of material studies used to reveal and present the ability to solve symbolic level chemistry problems is the subject matter of buffer solutions because it has complex properties and uses a lot of mathematical calculations included in symbolic topics such as the concept of moles, reaction equations, and pH calculations. Based on interviews with chemistry instructors of class XI SMAN 1 Mawasangka Tengah, it was discovered that students frequently struggle to solve reaction equation problems because they are unfamiliar with the molecular formula of the compound mentioned in the problem. As a result, they make mistakes when equating the reaction, which leads to incorrect calculations of the pH of the buffer solution. Students find it challenging to write reaction equations when acids and bases are added to buffer solutions; they find it difficult to distinguish between strong acids and weak acids related to buffer solutions; and they find it difficult to determine the formula to be used and the mathematical calculations to calculate the pH of buffer solutions.

The same thing was found in several studies: the material of the buffer solution is one of the elements that are difficult to understand. Azizah et al. (2018) said that a buffer solution is a reasonably complicated material that involves equations and needs to be solved accurately. Besides that, Gani et al. (2018) and Yani et al. (2020) wrote that the buffer solution material is a part of the subject that is quite complicated and must involve good reasoning skills. This is because buffer solutions involve concepts and equations that require a fairly complex analysis. Moreover, the study reported that several subject matters involving mathematical concepts and equations were suggested for use with the Tier Multiple Choice Test to test students' conceptual understanding, misconceptions, problem-solving skills, and critical thinking abilities. This is based on the Tier Multiple Choice Test, which is designed to involve many elements and patterns so that it is not monotonous or fixated on one aspect. This is a good reference when conducting a multiple-choice test on buffer solutions where the material involves many equations, formulas, or concepts. In this study, the Tier Multiple Choice Test is presented in the form of multiple choices that are not only in the form of simple questions but involve many elements, for example, concept questions raised in the form of symbolic pictures, series of equations, and more complex molecular bonds, so that students are more experienced and able to practice their abilities in compiling solutions to the problems given.

Based on what has been described in several previous arguments, the researcher is interested in studying the understanding of the symbolic level of science XI students at SMAN 1 Mawasangka Tengah on buffer solution material as seen in the ability of students to solve symbolic chemical problems such as reaction equations and enter numbers into formulas. The goal of this study is to determine the extent of students' ability to solve symbolic level chemistry problems in buffer solution material at SMAN 1 Mawasangka Tengah, so that the analysis can provide useful information and be used as a consideration in efforts to improve the ability of grade XI high school students to solve symbolic level chemistry problems in high school. This study will look at how well people at the SMA level can use buffer solutions to solve symbolic-level chemistry problems. This study is expected to be able to contribute as well as provide information related to the use of the Tier Multiple Choice Test, which can be used as a reference by teaching staff or teachers in preparing learning instruments so that the results obtained are in line with the expected achievements.

METHODS

The quantitative descriptive research method was used in this study. The researcher will discuss how well students in class XI MIPA at SMAN 1 Mawawsangka Tengah can answer symbolic-level chemistry questions. The population in this study was 60 students in MIPA class XI. The research procedure is described in Figure 1.

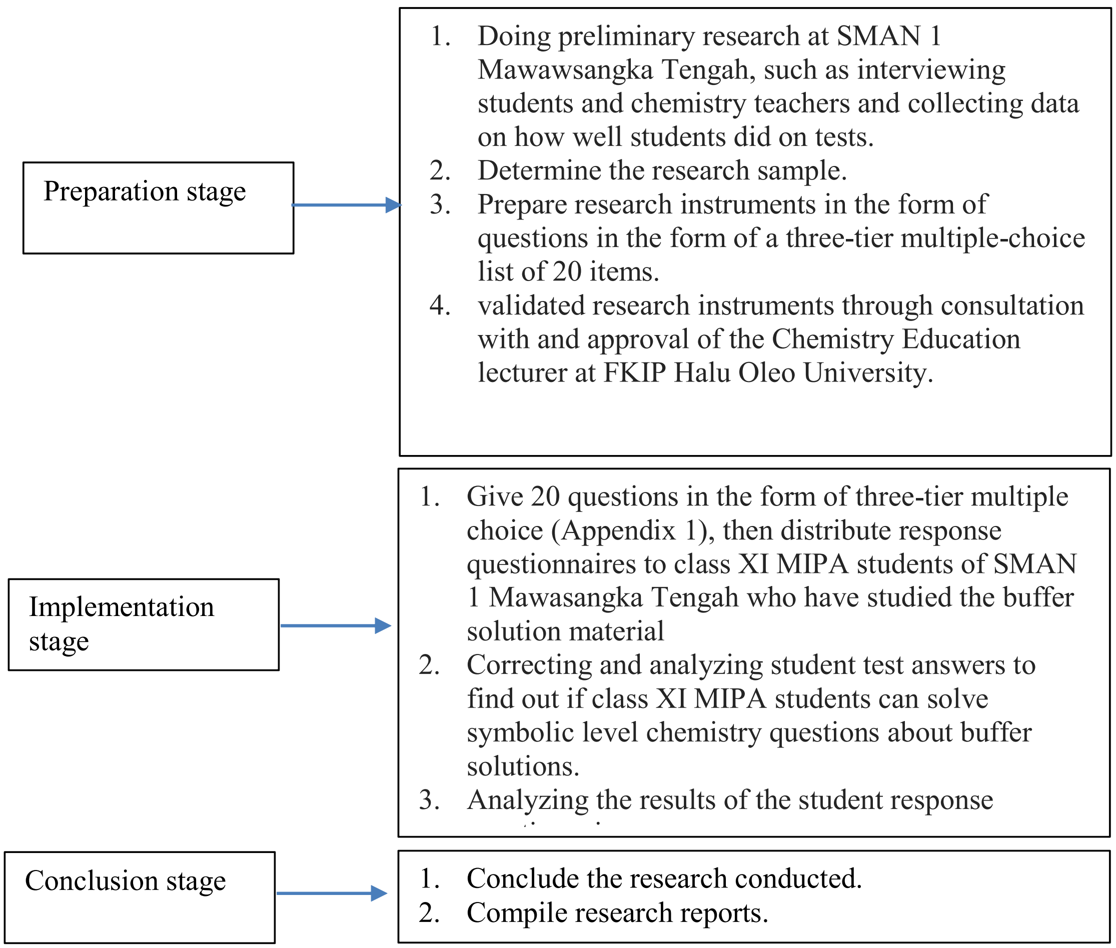

Figure 1. Research procedure

This study uses a sequential explanatory design. The design of this study aims to collect data on the ability to solve chemical problems in a bottle solution topic using a four-tier multiple-choice diagnostic test instrument. The sequential explanatory design has two stages: data collection and analysis of the results. The data collection stage consists of collecting quantitative and qualitative data. Quantitative data were obtained by data collection techniques through tests, while data collection techniques obtained qualitative data through interviews and questionnaires. At the results analysis stage, data analysis of the results of the student diagnostic tests was carried out, and then a questionnaire was given to all students. The results of the study of the two data sets must be mutually sustainable and mutually supportive.

The research instruments consisted of tests and student response questionnaires. Tests used with three-tier diagnostic test instruments The test instrument was given to students who were the research subjects, namely students of class XI MIPA at SMAN 1 Mawasangka Tengah, totaling 60 people. This study used a three-level multiple-choice test. In this test, there are three parts: the first part contains questions that contain various choices of answers; the second part includes the reasons contained in the first part; and the third part includes the level of confidence in choosing solutions and giving reasons. This makes the diagnostic instrument more effective in providing knowledge about the reasons underlying student answers. The test questions were adopted from Ratna (2019) research which three experts had validated. Meanwhile, the questionnaires used in this study were both open and closed. An open questionnaire has a simple form, so people can fill it out as they wish and based on their situations. In terms of the response questionnaire adapted from research conducted by Nurhidayatullah & Prodjosantoso (2018).

Table 1. Categories of student answers based on the dignostic three tier test

First Level	Second level	Third level	Category
True	True	Sure	Understand concept
True	True	Not sure	Not understand concept
True	False	Not sure	Not understand concept
False	True	Not sure	Not understand concept
False	False	Not sure	Not understand concept
False	False	Sure	Misconception
False	True	Sure	Negative misconception
True	False	Sure	Positive misconception

The data analysis technique used is descriptive analysis. Determine the percentage of students who have been grouped into conceptual understanding, misconceptions, and not understanding the concept categories based on the buffer solution topic. Maksimum et al. (2017) wrote that the percentage criteria for understanding concepts were very high (90–100%), high (78–89%), moderate (60–75%), low (50–59%), and very low (0–39%). Meanwhile, Permana (2013) defines high categories (61-100%), medium categories (31-60%), and low categories (0-30%) for the percentage of misconceptions.Then to see the percentage of student response scores adapted from Kartini & Putra's research (2020) with category levels of 81–100 (Very Good), 61–80 (Good), 41–60 (Enough), 21–40 (Not Good), 0–20 (Very Less).

■ RESULTS AND DISCUSSION

Students' problem-solving ability in symbolic level toward chemistry problems

A student's ability to solve a problem with a solution in a chemistry equation with 20 items using three-tier multiple-choice questions on the topic of buffers divides students into three groups: those who understand concepts, those who do not, and those who have misconceptions. From the analysis result toward shown in Table 5.

Table 5. The data of percentage result answer student

Indicator	Number item	Not understand concept		Misconception		Not understand questions	
1	1	22	36.67%	29	48.33%	9	15.00%
	2	7	11.67%	33	55.00%	20	33.33%
	3	3	5.00%	36	60.00%	21	35.00%
	4	12	20.00%	30	50.00%	18	30.00%
	Average		**18.33%**		**53.33%**		**28.33%**
2	5	11	18.33%	36	60.00%	13	21.67%
	6	8	13.33%	34	56.67%	18	30.00%
	7	11	18.33%	33	55.00%	16	26.67%
	8	10	16.67%	30	50.00%	20	33.33%
	Average		**16.67%**		**55.42%**		**27.92%**
3	9	5	8.33%	37	61.67%	18	30.00%
	10	4	6.67%	35	58.33%	21	35.00%
	11	1	1.67%	38	63.33%	21	35.00%
	12	8	13.33%	34	56.67%	18	30.00%
	Average		**7.50%**		**60.00%**		**32.50%**
4	13	2	3.33%	38	63.33%	20	33.33%
	14	3	5.00%	37	61.67%	20	33.33%
	15	1	1.67%	37	61.67%	22	36.67%
	Average		**3.33%**		**62.22%**		**34.44%**
5	16	1	1.67%	32	53.33%	27	45.00%
	17	1	1.67%	40	66.67%	19	31.67%
	18	0	0.00%	34	56.67%	26	43.33%
	Average		**1.11%**		**58.89%**		**40.00%**
6	19	6	10.00%	36	60.00%	18	30.00%
	20	8	13.33%	32	53.33%	20	33.33%
	Average		**11.67%**		**56.67%**		**31.67%**
Overall average			**9.77%**		**57.75%**		**32.48%**

Information:

1. Explanation understand that pH buffer solution remains diluted, a small amount of acid or a sma amount of the base is added
2. Explain the mechanism by which buffer solutions maintain their pH with the addition of sma amounts of acid, base, or dilution.
3. Determine of buffer pH solution
4. Make buffer solution with certain pH
5. Identification buffer pH solution when diluted, added acid small or added base small
6. Explain the role of buffer solution in the body of living organism

Understand the Concept

Based Table 5, the percentage of students who understand is 9.77%. With a concept understanding of 18.33% in indicator 1 and a very high percentage in question 1, ask the student to choose the correct statement about the definition buffer solution and connect the correct reason. Students who correctly answer with the correct reason and belief that the buffer solution can maintain pH when small amounts of acid, base, and dilutions are added choose the correct answer of 36.67%. Explain the mechanism by which the buffer solution maintains pH in the presence of small amounts of added acid, base, and dilutions of 16.67%. When students solve chemistry problems, they have to remember fixed ways of thinking to improve their understanding. This pattern is consistent with other studies showing that most students solve problems by rote without understanding what they are doing or why they are doing it. Assessment questions that let students repeat information make the problem worse because they give the false impression that they understand something when they don't. This makes it harder for them to learn more about chemistry concepts. So, students can move up in school and come up with different ideas about introductory chemistry (Cristian & Talanquer, 2012; Salame et al., 2022).

The item question which student representation have to able correct answer questions in the first level and link with the correct answer in the item question 5 and 7 as mean 18.33%. Students understand the concept in indicator 3 determining the pH of buffer solution as much as 7.50%. In this indicator, students who are able to connect answers with the right reasons are mostly found in questions number 9 (8.33%) and 12 (13.33%). In the problem, the moles of the weak acid or base and the salt are known, so in the solution, students do not need to write the reaction equation first because the problem has given information related to the moles of the salt. In the solution, questions 10 and 11 require students to react weak acids and bases with strong bases and acids to determine the moles of salt. The average student understands the concept in indicator 4 of making buffer solutions with a certain pH obtained a percentage of 3.33%, with the percentage of understanding the concept represented by item number 14, which asks students to determine the buffer solution mass CH_3COOK (Mr = 98) that must is add in 20 mL solutions CH_3COOH 0.002M to obtain buffer solution with dengan pH = 5 (Ka $CH_3COOH = 1 \times 10^{-5}$). This is because the questions presented do not involve many variables, so students feel it needs to be more difficult or apply high-level understanding to solve the equations given. Khun (2007) and Pimta et al. (2009) wrote that students' problem-solving ability depends on the variables involved. This is in line with the report of Utami et al. (2020) and Zbiek et al. (2015), who wrote that the variable element in the equation plays an important role in training students' abilities to think and solve problems.

Furthermore, Student can be able answer is correct in the first and second level and confident about the answer choose as much 5.00%. When diluted and adding small acid or small base, the average of indicator 5 to understand buffer solution pH 1.11%. The items of question numbers 16, 17, and 18 represent the understanding concept. Only one student answered correctly on the second level and confidently on the third level in questions 16 and 17. Meanwhile, in item question number 18, the student answer does not correspond to the correct answer and thus is incorrect. As much as 11.67% of the average understanding concept in 6 indicators explains the role of buffer solution in the organism. The student understands the concept very well and answers question number 20 with 13.33% accuracy. This is in line with what was reported by Drastisianti et al. (2019) said that written responses and student interviews show that the acid-base reactions need to be balanced. Changes occur when the weak acid CH_3COOH is combined with the $NaCH_3COO$ salt and the macroscopic aspect indicator, as indicated by the number 14. Students record their understanding that weak acids and salts form an acid buffer solution. Due to the addition of a soft acid-conjugate base, the pH of the acid buffer solution will be greater than that of the diluted acid buffer solution. These results show students' conceptual understanding.

Misconception

Based on the overall test results in Table 6, a percentage of 57.75% was obtained. In Table 6, it is known that the total average misconception category is 37.36%, positive misconceptions are 11.89%, and negative misconceptions are 8.50%. Some students have more misconceptions than others.

Table 6. Data percentage of student misconception

Indicator	Item Number	Category					
		Misconception		Negative Misconception		Positive Misconception	
1	1	7	11.67%	8	13.33%	14	23.33%
	2	17	28.33%	5	8.33%	11	18.33%
	3	19	31.67%	5	8.33%	12	20.00%
	4	16	26.67%	8	13.33%	6	10.00%
	Average		**24.58%**		**10.83%**		**17.92%**
2	5	29	48.33%	4	6.67%	3	5.00%
	6	23	38.33%	3	5.00%	8	13.33%
	7	15	25.00%	7	11.67%	11	18.33%
	8	17	28.33%	8	13.33%	5	8.33%
	Average		**35.00%**		**9.17%**		**11.25%**
3	9	28	46.67%	4	6.67%	5	8.33%
	10	27	45.00%	7	11.67%	1	1.67%
	11	22	36.67%	1	1.67%	15	25.00%
	12	18	30.00%	5	8.33%	11	18.33%
	Average		**39.58%**		**7.08%**		**13.33%**
4	13	25	41.67%	5	8.33%	8	13.33%
	14	19	31.67%	5	8.33%	13	21.67%
	15	30	50.00%	2	3.33%	5	8.33%
	Average		**41.11%**		**6.67%**		**14.44%**
5	16	24	40.00%	6	10.00%	2	3.33%
	17	31	51.67%	4	6.67%	5	8.33%
	18	18	30.00%	9	15.00%	7	11.67%
	Average		**40.56%**		**10.56%**		**7.78%**

6	19	29	48.33%	3	5.00%	4	6.67%
	20	23	38.33%	5	8.33%	4	6.67%
	Average		**43.33%**		**6.67%**		**6.67%**
Overall Average			**37.36%**		**8.50%**		**11.89%**

Many students in indicator 1 need clarification about the explanation that the pH of the buffer solution remains when diluted, added a little acid, or added a little, as represented by question item number 3 and as much as 31.67% contained in Table 6. Students understand that 100 mL CH3COOH 0.1 M and 100 mL NaOH 0.1 M, as well as a solution of 200 mL NH4OH 0.1 M and 200 mL HCl 0.2 M, can form the buffer solution, which is a reaction between an excess of a weak acid-base and a conjugate base or acid. The answer options chosen by students at the first level are not included in the buffer solution because in the first solution CH_3COOH and NaOH are both absent while in the second solution the excess is HCl. If only the remaining or excess weak acid or base is used in a reaction, the actual concept of a buffer solution can be formed. Buffer Solution is a water-based solvent-based solution that contains a mixture of a weak acid and its conjugate base, or a weak base and its conjugate acid (Pan et al., 2021). Furthermore, the buffer solution in the problem is a solution made up of excess weak acid or base and strong base or acid.

Students make mistakes when they try to solve this problem because they can't figure out how to use the concept of moles to figure out what reactions are happening in buffer solutions and because they can not figure out what strong acid bases are in the problem. This is in accordance with the research of Orgill & Sutherland (2008) and Schmidt-McCormack et al. (2019) which found that most students still have difficulty distinguishing strong acids, weak acids, strong bases, weak bases, and salts, resulting in students not being able to classify solutions as buffers or not. According to Table 6, students' misconceptions on indicator 2 explain the mechanism of buffer solution in maintaining its pH against the addition of a little acid, base, or dilution, as represented by question item number 5 with a percentage of 48%, asking what will happen if 5 mL of distilled water is added into 50 mL of buffer solution with pH 5. The buffer solution will become neutral if water is added, students responded in the choice of reasons. The idea is that because the buffer solution has components that maintain the pH levels of one another, its pH can be relatively maintained with only a small addition of acids, bases, and dilutions. These elements consist of bases that lower pH and acids that raise pH (Nurhujaima et al., 2016).

These students' misconceptions are caused by their emphasis on memorization, which leads them to be misled by the answer options available. This is in accordance with Al-Qadri's research (2019), which shows that misconceptions occur because students only memorize the theory without understanding the concept, so when given a question with the same concept but in a different form, they make mistakes in choosing their answers. Indicator 3, which is about figuring out the pH of buffer solutions, students got things wrong 36.67% of the time, which is shown by question item number 11. Item number 11 calculates the pH of a mixture consisting of 0.3 mol NH4OH and 0.1 mol HCl with a Kb value of 10^{-5}. From the results of the analysis of the answers, most students answered incorrectly at levels one and two but were confident in their answers. Students answer the choice of reason with answer B, where students determine $[OH^-]$ by directly entering the mole value of NH_4OH known in the problem without reacting first. The mole of NH_4OH that should be entered in the formula for determining $[OH^-]$ is the mole value after the reaction with HCl. This occurs because the students' initial concepts regarding their ability to react the compounds that form buffer solutions and the concept of moles following the acid-base reaction are still low. This finding is supported by Suprapto (2020) and Mideama et al. (2022), which state that misconceptions occur because students' initial concepts are wrong due to the incomplete information they previously knew..

Indicator 4 student misconceptions regarding the preparation of buffer solutions with a specific pH are represented by item number 13 with a percentage of 41% of the total 63.33%. Students are asked to determine the mass of NH_4Cl if the NH_3 solution used is 2 liters with a concentration of 0.01 M and a pH of 8 (Kb = 10^{-5}; Ar N = 14; Ar H = 1; Ar Cl = 35.5). In their choice of reason, students misunderstand the formula used and assume that the moles of NH_3 involved in determining the concentration of $[OH^-]$ are the initial moles. The concept is that the moles involved are moles of weak bases and moles of conjugate acids in excess after reaction with strong acids; the cause is the inability of students to apply the understood formula to the problem. Students continue to lack the ability to translate information into mathematical language, causing them to choose the incorrect answer for the wrong reason.

With a percentage of 51.67%, question 17 represents the misconception of indicator 5 identifying the pH of buffer solution when diluted, a little acid or a little base is added. In this question, students must calculate the pH of a mixture of 120 mL of NH_3 0.1 M and 100 mL of $(NH_4)_2SO_4$ 0.08M by adding 10 mL of H_2SO_4 0.2 M solution (Kb NH_3 = 10^{-5}). From the analysis of the answers, students chose answer A in the choice of reasons, namely to determine the pH, they look for $[OH^-]$ by entering the mole value of NH_3 and $(NH_4)_2SO_4$ before the reaction with H_2SO_4. To solve this problem, students should first react NH3 and H_2SO_4 to produce $(NH_4)_2SO_4$ and then determine the remaining moles from the reaction results. Then the moles are entered in the formula for determining $[OH^-]$ to get the pH value. Student errors in this problem are caused by incorrectly determining the moles of the weak base and its salt when added to the acid solution (H_2SO_4). Besides that, students ignore the number of valences of the weak base of the salt, which results in the calculation of pH and the formula chosen in the reasons given to be incorrect. This is because students only memorize the basic formula, so when something is known in a different problem, they choose the wrong answer. According to Izza et al. (2021), learning obtained through memorization without understanding is temporary and can have a negative impact on mastery of concepts, causing misunderstanding in developing the basic concepts they master. Someone who experiences misconceptions is not the same as someone who does not understand the concept. If students do not understand the concept, then after the teacher explains good learning, students will be able to understand the concept. But if students have misconceptions, even though the explanation is good, they will still find it difficult to accept the correct concept (Laeli et al., 2021).

The question item that represents indicator 6, explaining the role of buffer solution in the bodies of living things, is number 19, with a percentage of 48.33%. In this item, students understand that when the blood enters an acidic compound, the H^+ ions from the substance react with H_2CO_3. Actually, because HCO_3- is basic and H_2CO_3 is acidic, H^+ from acidic compounds that enter the blood will react with HCO_3^-. Students' mistakes in answering question number 19 are because they only rely on memorization without understanding the nature of acids and bases, so they are fooled in choosing answers.

Not Understand the Concept

Based on Table 5, the average percentage of people not understanding the concept is 32.48%. In indicator 1, most students answered incorrectly at both levels and were unsure of the choice of reasons as much as 35% of the time in question number 3, which asked students to choose compounds that can form buffer solutions with the concentration and volume known in the question. From the analysis of the answers, the high level of not understanding the concept in question 3 is due to the students' initial knowledge related to the reaction equation and the concept of mole as well as the identification of acidic and basic compounds, which is still low. From the research of Kusumaningrum et al. (2017) and Dean (2002), students cannot determine the mixture that can form a buffer solution because they cannot determine the moles of a substance from the volume and concentration information of the substance. Table 5 shows the percentage of students who do not understand the high concept of indicator 2 in question item number 8, which is 33.33%. Students' confusion with item 8 stems from their inability to identify bases, specifically NH_3, and conjugate acids, specifically NH^{4+}, which causes them to be unable to write the reaction equation when a small amount of base is added to the components, causing them to answer incorrectly at both levels of the question and be unsure of their answer choices.

The question items that represent not understanding the concept in indicator 3, determining the pH of the buffer solution, are questions 10 and 11, which are 35% in Table 5. Student errors in this item are because students have not been able to write the reaction equation, which causes them to be unable to determine the moles used to determine the concentration of $[H^+]$ or $[OH^-]$ to get the pH value of the buffer solution. The percentage of students who do not understand the concept of indicator 4 when making buffer solutions with a specific pH is represented by question item number 15, which asks students to calculate how much sodium acetate salt is added to 1 liter of 0.1 M acetic acid solution whose pH is 3 plus sodium acetate salt so that the pH is twice the original. Students do not understand the concept due to their inability to determine the value of Ka needed to find the concentration of $[H^+]$ to get moles of sodium acetate salt. This indicates that students' mathematical abilities are still weak, making it difficult to translate questions into mathematical formulas.

The most students do not understand the concept in indicator 5 identifying the pH of buffer solutions when diluted, added a little acid or added a little base is in question item number 16 as much as 45% which asks students to calculate the pH of a mixture of solutions from 500 mL of solution consisting of CH3COOH 0.01 M and CH3COONa 0.01 M after adding 1 mL HCl 1 M solution ($Ka = 1.8 \times 10^{-5}$). The students' error lies in their inability to determine the formula to determine the moles of acetic acid (CH_3COOH) with its conjugate base/salt (CH_3COONa) after reacting with HCl, the students do not have the right plan for solving the problem because they have no good understanding of calculating moles, so they are wrong in determining the pH value of the buffer solution. This is supported by the answers to the statements in the response questionnaire that students still find it difficult to solve the problem of calculating the pH of the buffer solution, which causes students to not be able to identify the problems in the problem. This is in accordance with research, which states that the initial ability of the concept of moles determines the reaction of buffer solutions and the calculation of the pH of those solutions (Gultom et al., 2019). The question item that represents not understanding the concept of indicator 6 is question number 20, which is 33.33%. The high percentage of students who do not understand this question item is because students rely on memorization so that they do not properly understand the concept of the role of buffer solutions in everyday life. Dewi and Primaryana (2019) research found that students would forget the subject matter faster if they only memorized.

Another thing that makes students not understand the concept is their lack of interest in learning, especially in chemistry lessons. Asbupel et al. (2020) reported that students' lack of interest and motivation makes them lack understanding of chemistry concepts, and then they have difficulty answering questions about chemistry. Most students think that chemistry is a difficult subject. Poor perception can affect students' interest in chemistry. Sausan et al. (2018) found that students are interested in doing experiments when learning chemistry, but they see chemistry as a hard science lesson with abstract symbols and terms that they have to remember. The teacher's skill in conveying abstract concepts affects students' interest. An unfavorable perception of chemistry makes students uninterested in learning it because they do not feel curious. So, chemistry teachers should try to make a good first impression and get their students interested and motivated to learn.

Results of student responses to the three-tier multiple choice test

The response questionnaire that has been given to 60 students of class XI MIPA has 15 statement items that were completed after completing the three-tier multiple choice diagnostic test questions. The percentage can be found by looking at the answers to the student survey, as shown in Table 7.

Table 7. Students' questionnaire percentage data

No	Statement	Percentage	Criteria
Concept aspect			
1	I like the material of buffer solution	70.00%	Good
2	I mastered all the concepts of buffer solution material	61.33%	Good
3	I do not find it difficult to understand the buffer solution material.	61.67%	Good
4	In the buffer solution material, I am required to memorize not only the material but also at the symbolic level (reaction equations, symbols, and formulas).	80.33%	Good
	Average	68.33%	Good
Language aspect			

Language aspect			
5	The language used in multilevel multiple choice questions is easy to understand	78.67%	Good
6	The sentence in the question does not cause multiple interpretations	70.67%	Good
Respond student aspect			
7	A description type question is appropriate for being asked about buffer solution material	70.33%	Good
8	Multiple-choice questions are the best type of questions for working on buffer solution material	71.33%	Good
9	The type of evaluation in the form of multilevel, multiple choice questions provides an overview of how much I understand the buffer solution material.	83.33%	Very good
10	Multilevel multiple-choice questions are more difficult for me than description-type questions or regular multiple-choice questions.	70.67%	Good
11	I am able to identify the problems in the problem	58.67%	Enough
12	Question texts that contain a lot of information can help me answer questions better	84.67%	Very good
13	The problems I worked on were able to train my symbolic level skills	78.00%	Good
14	The questions I do can test my learning outcomes	84.00%	Very good
15	I am confident in the appropriateness of the answers and reasons I choose	67.67%	Good
	Average	74.30%	Good

According to student responses to the three-tier multiple-choice diagnostic test instrument on the concept aspect, students liked the buffer solution material, with an average percentage of student responses of 70% in the good category, and 61.33% of students mastered all buffer solution material in the good category. However, based on the test results, the percentage of students who understand the concept is only 9.77%. This shows that students feel that they have mastered the concept of buffer solution, but actually they still understand it a little. This is because students only rely on understanding during the learning process at school and do not try to train their understanding again with questions related to buffer solution material after returning home, so they are more likely to experience misconceptions. This can be seen from the high percentage of student misconceptions, which is 57.75%.

The language aspect, represented by statement items 5 and 6, with percentages of 78.67% and 70.67%, respectively, in the good category, demonstrates that the language used in the questions does not cause multiple interpretations, allowing students to understand the language used in the three-tier multiple-choice questions. The questionnaire of students' responses to the use of the Three-Tier Multiple-Choice According to the diagnostic test, this type of evaluation can provide information that helps students answer questions correctly as well as an overview of how well students understand the buffer solution material, with a percentage of 83.33% obtained, placing it in the "very good" category. However, 70.67% of students thought the three-tier multiple-choice questions were more difficult than the description and multiple-choice questions. This is due to the fact that three-tiered multiple-choice questions can delve deeper into students' understanding abilities related to understanding concepts, overcoming misconceptions, and not understanding concepts that students encounter. Gilbert (1997) and Milenkovic et al. (2016) say that students have a satisfactory understanding of concepts when at least 75% of them choose the right answer (for tasks with four options). If the percentage is lower (50–74%), then it can be said that students achieved approximately adequate performance. A percentage of students correctly answering between 25 and 49% indicate poor performance, while a percentage of students correctly.

■ CONCLUSIONS

Based on the results of the analysis of students' ability to solve symbolic level chemical problems on buffer solution material, it can be concluded that: (1) the ability of SMA Negeri 1 Mawasangka Tengah students to solve symbolic level chemical problems on buffer solution material is still low, with 9.77% of students understanding the concept, 57.75% having misconceptions, and 32.48% not understanding the concept; (2) Students' responses to the use of three-tier multiple-choice questions are positive, with a percentage of 74.30% indicating that students give good responses to the three-tier test, so this form of test is categorized as good for identifying students' ability to solve symbolic-level chemistry problems on buffer solution material.

This research has two main effects: (1) it gives teachers information that can help them figure out their students' skill levels, which can then be used to choose learning strategies that make it easier and faster for students to understand what they are learning; and (2) it gives students a way to judge how well they understand concepts, which can be used as a way to improve the quality of education. The drawback of this research is that the research instrument needs to be studied in more depth according to the needs of schools because each school has different needs. The concept of a buffer solution is one of the ones that are quite complicated, so it requires good accuracy in preparing the instrument.

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