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by Masrid Pikoli

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Analysis of Students' Misconceptions Using Three-Tier Multiple Choice Diagnostic Tests in Colligative Properties of Solutions

N A Djafar ^{a)}, M Pikoli ^{b)} and A L Kilo ^{c)}

Chemical Education Study Program, Faculty of Mathematics and Natural Sciences, Universitas Negeri Gorontalo, Prof. Dr. Bacharuddin Jusuf Habibie street, Bone Bolango, 96119, Gorontalo-Indonesia

^{b)} Corresponding author: pikolimasrid@ung.ac.id

^{a)} nuraprilianidjafar18@gmail.com

^{c)} akram@ung.ac.id

Abstract. Misconception is an error in connecting one concept to another which causes the formation of a wrong concept and contradicts the conception of experts. This study aims to analyze the misconceptions of class XII science students in MAN 1 Gorontalo City and MAN 1 Gorontalo Regency on the colligative properties of solutions. This research is a qualitative descriptive study with a sample of 231 students of MAN 1 Gorontalo City and 65 students of MAN 1 Gorontalo Regency. Data collection using a three-level multiple choice diagnostic test instrument. The test instrument used has been declared valid by 3 experts, and the reliability is 0.8. Based on the analysis of misconception data, it can be concluded that students who experience misconceptions at MAN 1 Gorontalo City are 53%, and at MAN 1 Gorontalo Regency it is 50%. Some of the misconceptions found in students' answers in this study: (1) the more solute, the greater the vapor pressure that occurs, (2) the less solute, the greater the increase in boiling point, (3) the more solute, the higher the boiling point, the greater the freezing point that occurs, and (4) the greater the concentration, the greater the osmotic pressure of the electrolyte solution.

INTRODUCTION

Preconceptions are facts, ideas or concepts that students have before learning a new concept. Conception is the ability to understand concepts, whether obtained through interaction with the environment or concepts obtained from formal education, one's conception is different from the conception of others [1]. Misconceptions are the result of a lack of critical observation, follow-up discussions, and unfinished instructions by parents, teachers or peers [2]. The existence of misconceptions can affect the learning process in a broader sense and only produce explanations for questions. When faced with new conceptions that conflict with the concepts they have, students will find it difficult to understand or receive information [3].

Many studies in the field of chemistry have experienced misunderstandings in understanding chemical concepts, including research conducted [4, 5, 6] several studies found that misconceptions that occur in concepts include acid-base [7], colligative properties [8], buffer solution [9], and chemical bonding [10].

One of the first steps that can be taken to overcome the low understanding ability is to identify the descriptions of understanding along with the errors of understanding that occur in a certain concept through diagnostic tests. The test results obtained are then followed up through an appropriate remedial learning process [11]. Three-tier diagnostic test is an instrument that can measure and distinguish students who understand the concept, do not understand the concept, and misconceptions on the material that has been studied [12]. Three-tier multiple choice consists of three levels, the first level is a question about the concept of a material, the second level is the reason for choosing the answer at the first level, and the third level is confidence in the answers given. Three levels are more

effective than two levels because they can distinguish between misconceptions of concepts and lack of knowledge, namely by increasing the level of confidence in the answers chosen by students [13].

Chemistry is the study of matter and the changes experienced by material substances [14]. One of the materials studied is the colligative properties of solutions. Colligative properties of solutions are properties of solutions that do not depend on the type of solute, but only on the concentration of the solute particles. There are two types of colligative properties, namely colligative properties of electrolyte solutions and colligative properties of non-electrolyte solutions.

Based on previous research, misconceptions about the colligative properties of solutions are caused by conventional teaching methods applied in the learning process to understand a concept or calculation that makes it difficult for students to applied [15]. The results of observations at the MAN Gorontalo school showed that students had difficulty in answering questions, this is in accordance with the results of interviews with teachers that when given questions students only focus on the sentence questions such as when the question is about glucose students can answer it but when glucose is broken down into $C_6H_{12}O_6$ students are confused to do. In addition, because of online learning, when students are given assignments, students look for answers on google so that there are several formulas only for non-electrolyte solutions but are used in problems with electrolyte solutions.

The analysis of misconceptions using a three-level diagnostic test on the colligative properties of solutions is an important thing to be studied further, especially for MAN Gorontalo students, the analysis is needed to evaluate students' conceptual understanding in providing feedback on progress and motivation to learn in chemistry lessons, especially learning that related to concepts and calculations.

MATERIALS AND METHOD

This research is included in the type of descriptive qualitative research where through this research obtained the misconceptions experienced by MAN students on the colligative properties of solutions in Gorontalo City and Gorontalo Regency. The population in this study were all students of MAN 1 Gorontalo City and MAN 1 Gorontalo Regency with a total of 296 respondents. The samples of this study were students of MAN 1 Gorontalo City consisting of Class XII IPA Excellent 1, XII IPA Excellent 2, XII IPA 1 to XII IPA 5; and students of MAN 1 Gorontalo Regency consist of class XII IPA 1 to class XII IPA 3.

The analysis of student misconceptions was carried out by examining student answers on the three-level multiple choice test found on the google form. The test given has been tested for validity which has been declared valid by 3 experts and the test reliability test is 0.8. The instrument used in this study was a three-level multiple choice containing knowledge (first level), reasoning (second level) [16] and confidence in answering the first and second levels (third level). Data were obtained from the results of students' answers who answered right, wrong, sure, unsure of the answers given, and students' answers were categorized as in Table 1 [17].

TABLE 1. The category of the level of students' misconceptions is based on the answers to the three-tier multiple choice test

First tier	Second tier	Third tier	Categories
Correct	Correct	Certain	Scientific knowledge
Correct	Incorrect	Certain	Misconception 1
Incorrect	Correct	Certain	Misconception 2
Incorrect	Incorrect	Certain	Misconception 3
Correct	Correct	Uncertain	Lucky guess, lack of confidence
Correct	Incorrect	Uncertain	Lack of knowledge
Incorrect	Correct	Uncertain	Lack of knowledge
Incorrect	Incorrect	Uncertain	Lack of knowledge

The test used to find out the misconceptions experienced by students consists of 10 indicators. Every 1 question there is 1 indicator of the concept of colligative properties of the solution. The 10 indicators are listed in Table 2.

TABLE 2. Indicators of Colligative Properties of Solutions

Indicator	Question Number
1. The cause of the decrease in the vapor pressure of non-electrolyte solutions	1
2. The cause of the increase in the boiling point of non-electrolyte solutions	2

Indicator	Question Number
3. Designing experiments on the effect of solutes on the freezing point of non-electrolyte solutions	3
4. The cause of the decrease in the freezing point of non-electrolyte solutions	4
5. P-T diagram showing vapor pressure drop, boiling point elevation, and freezing point depression due to the presence of a solute	5
6. Non-electrolyte solution osmotic pressure in daily life	6
7. Benefits of colligative properties of non-electrolyte solutions in everyday life	7
8. The cause of the colligative properties of electrolyte solutions is greater than the colligative properties of non-electrolyte solutions for solutions of the same concentration	8
9. Determine the freezing point depression of an electrolyte solution	9
10. Electrolyte solution osmotic pressure	10

Data analysis techniques were used to find the percentage of students who were categorized as understanding concepts, not understanding concepts, and misconceptions. The data that has been obtained is then analyzed by means of; 1) Provide a raw score for each student's answer on a three-level multiple choice written test. 2) Calculate the total score of multiple choice tests per item indicator level. 3) Calculate the percentage of each indicator per question item which is categorized as understanding concepts, misconceptions and not understanding concepts. The percentage value can be calculated using the following formula:

$$P_{(1,2,3)} = \frac{S_{(1,2,3)}}{JS} \times 100\% \quad (1)$$

Where:

P1 = percentage of the number of students who understand the concept

P2 = percentage of students who have misconceptions

P3 = percentage of the number of students who do not understand the concept

S1 = the number of students who understand the concept

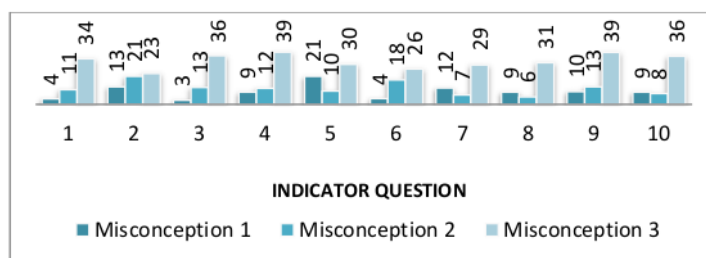
S2 = the number of students who have misconceptions

S3 = the number of students who do not understand the concept

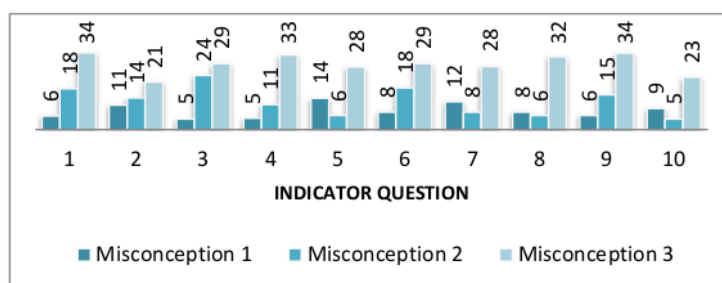
JS = total number of students taking the test

RESULTS AND DISCUSSION

The result of this research is the percentage of students' misconceptions in solving problems related to the concept of colligative properties of solutions. The material tested related to the concept of colligative properties of the solution consisted of (1) the cause of a decrease in the vapor pressure of a non-electrolyte solution, (2) the cause of an increase in the boiling point of a non-electrolyte solution, (3) designing experiments on the effect of solutes on the freezing point of non-electrolyte solutions, (4) causes of a decrease in the freezing point of a non-electrolyte solution, (5) a PT diagram showing a decrease in vapor pressure, an increase in boiling point, and a decrease in freezing point due to the presence of solutes, (6) the osmotic pressure of a non-electrolyte solution in daily life, (7) the benefits of colligative properties of non-electrolyte solutions in everyday life, (8) the cause of colligative properties of electrolyte solutions is greater than the colligative properties of non-electrolyte solutions for solutions of the same concentration, (9) determining the freezing point pressure drop of electrolyte solutions, (10) the osmotic pressure of the electrolyte solution. Based on the results of the research conducted, data on the percentage of misconceptions experienced by students on each indicator of the concept of material colligative properties of solutions of students in MAN 1 Gorontalo City and MAN 1 Gorontalo Regency were obtained as shown in Figure 1.



(a)



(b)

FIGURE 1. (a) Percentage of misconceptions of students in MAN 1 Gorontalo City, (b) Percentage of misconceptions of students in MAN 1 Gorontalo Regency

Based on Figure 1 in indicator 1, most students experience misconceptions 3 and students assume that the more dissolved substances, the greater the vapor pressure that occurs. In indicator 2, most students experience misconceptions 3 and students assume that the less the amount of solute, the greater the increase in boiling point. In indicator 3, most students experience misconceptions 3 and students think that the smaller the salt concentration, the faster the ice puter will freeze. In indicator 4, most students experience misconceptions 3 and students assume that the more dissolved substances, the greater the freezing point that occurs. In indicator 5, most students experience misconceptions 3 and students assume that on the P-T diagram point M is the boiling point of the solvent, where the boiling point line of the solution is a liquid-gas phase transition. The difficulty of students on the P-T diagram is very high because students misunderstand the concept of the P-T diagram on the colligative properties of non-electrolyte solutions [18].

In indicator 6, most students experience misconceptions 3 and students assume that the use of salt that can kill leeches is an application of the process of decreasing the vapor pressure of non-electrolyte solutions in everyday life, where leeches die due to salt concentration which causes an increase in the boiling point so that the liquid in the leech body is reduced. In indicator 7, most students experience misconceptions 3 and students assume that the use of salt that can melt snow is an application of the process of decreasing vapor pressure, where snow melts is caused by the addition of salt which can lower water vapor pressure and can increase the boiling point of water. In indicator 8, most students experience misconceptions 3 and students assume that the $\text{CO}(\text{NH}_2)_2$ and NaCl solutions are non-electrolyte solutions that have the same large molecules. In indicator 9, most students experience misconceptions 3 and students assume that the higher the concentration, the greater the freezing point that occurs. And on indicator 10, most students experience misconceptions 3 and students assume that the greater the concentration, the greater the osmotic pressure of the electrolyte solution and the hypotonic solution is a solution that has a lower osmotic pressure. Students are confused when finding questions that are only known about the mass of a substance, volume, and osmotic pressure, students assume that what is known about the problem is not related to concentration to determine the molecular mass of a substance [18]. From the 10 test indicators given to students, it can be seen in Figure 1 that the highest percentage of misconceptions is in indicator 9 which proves that most students tend to not understand the indicators determining the freezing point depression of the electrolyte solution.

Based on the analysis above, it can be seen that students do not fully understand in answering questions because they only remember the basic formula so that when they know from different questions, students become confused which causes misconceptions [18] about the effect of solutes on non-electrolyte solutions, the use of formulas in electrolyte solutions, or the difference between electrolyte and non-electrolyte solutions, each question is changed in numbers or changes are made to the formula, so students are confused to answer the question because students only memorize formulas, not understand concepts [18]. This misunderstanding leads to misconceptions..

Misconceptions occur because students store knowledge according to the concepts they know, but the concept violates scientific review [19]. Misconceptions experienced by students can be reduced by diagnosing misconceptions, after the misconceptions are obtained, direct instruction methods are carried out with a hierarchy or use a conflict approach [20] on the colligative properties of the solution.

CONCLUSION

Based on the analysis of misconception data, it can be concluded that students who experience misconceptions at MAN 1 Gorontalo City are 53%, and at MAN 1 Gorontalo Regency it is 50%. The average percentage of misconceptions 1 out of 10 indicators in MAN 1 city students is 9%, misconception 2 is 12%, and misconception 3 is 32% while in MAN 1 district students the average percentage of misconceptions 1 out of 10 indicators is 8%, misconceptions 2 is 13% and misconception 3 is 29%. Some of the misconceptions found in students' answers in this study were: (1) the more solute, the greater the vapor pressure that occurs, (2) the less solute, the greater the increase in boiling point, (3) the more solute, the higher the boiling point. the greater the freezing point that occurs, and (4) the greater the concentration, the greater the osmotic pressure of the electrolyte solution.

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