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# Identification of Students' Misconceptions Using a Four-Tier Multiple Choice Diagnostic Test on Colligative Properties of Solutions

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**Abstract:** Misconception is an event of a wrong concept received by students after following a learning process, the concept received is not in accordance with existing scientific studies. This study aims to identify students' misconceptions on the colligative properties of the solution and the factors that cause misconceptions. This type of research is descriptive quantitative. The instrument used is a four-tier multiple choice diagnostic test. This study involved 34 students of class XII MIA at MA Khulafaur Rasyidin Sungai Raya. The results showed that the level of misconceptions of students had an average percentage of 34% with a moderate misconception category, where a total of 65% students experienced misconceptions in the sub-topic of vapor pressure depression, 26,30% students experienced misconceptions in the sub-topic of freezing point depression, 33,30% students experienced misconceptions in the sub-topic of boiling point elevation, and 26% students experienced misconceptions in the sub-topic of osmotic pressure. Based on the results of the interview, the factors causing misconceptions in this study consist of internal and external factors. Internal factors come from students, that are students provide concept ideas spontaneously based on their understanding without being investigated first, students provide incorrect reasoning, students are confused in connecting one concept with another, lack of interest and ability of students in learning chemistry. External factors come from the context and teaching methods, where one of the learners' discussion partners has misconceptions, the teacher is more dominant in providing chemical explanations in mathematical form, and limited experiments. Those misconceptions can be reduced by presenting the topic in an interesting way, using an experiment, or using multiple representations approach.

**Keywords:** Colligative Properties of Solutions; Diagnostic Tests; Four-Tier Multiple Choice; Misconceptions

## Introduction

The teaching and learning process is a crucial series of activities that include preparation, implementation, and evaluation of learning. These three components cannot be separated as they form a cohesive unit. In the learning process, one of the things that is highly emphasized is the understanding of a concept so that students' knowledge of a subject matter does not experience errors. Chemistry is one of the subject families in the field of mathematics and natural sciences. Chemistry emphasizes mastery of concepts, chemical concepts are formed in students gradually through their experiences and interactions with the surrounding nature. Low mastery of concepts is one of the obstacles in the teaching and learning process and can result in low learning outcomes (Elisa et al., 2017).

According to Suparno (2013), misconceptions are students' conceptions that do not match the conceptions of scientists. If no improvement is made, these

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misconceptions can affect students' understanding of the next material because the concepts in chemistry are mostly interrelated with one another. Chemistry lessons are abstract and hierarchical in which chemical concepts start from the easiest to the most difficult, so that students' understanding of the material becomes continuous and requires a good understanding of concepts (Malikha & Amir, 2018). Learners' alternative conceptions tend to be very different from abstract scientific conceptions (Asghar et al., 2019). In other words, individual experiences can influence the interpretation of knowledge. Therefore, the understanding of the knowledge that learners have just learned can be a different concept or a misunderstanding of the material taught by the teacher (Yeo et al., 2022).

The problem found is that students often experience conceptual errors or misconceptions in the learning process, even if the learning has been delivered by the teacher. Learners' knowledge is usually incomplete, because chemistry consists of concepts and principles that are very abstract and complex (Arifin, 2017). This causes learners to develop misconceptions and have difficulty in constructing new concepts during the learning process (Woldeamanuel et al., 2014). Because of these difficulties, many students do not understand or experience misunderstandings in learning chemistry (Üce & Ceyhan, 2019). These misconceptions hinder the process of receiving and assimilating knowledge, thus preventing success in the further learning process (Coley & Tanner, 2012; Verkade et al., 2017; Antika & Ibana, 2018; Hala et al., 2018; Wulandari et al., 2021).

One way to find out misconceptions in students is with diagnostic tests. Using diagnostic tests can help teachers determine the misconceptions of students (Syahrianto et al., 2014; Nurulwati & Rahmadani, 2020). To improve the learning process, assessment must be diagnostic, meaning that the assessment can be used to determine the weaknesses of students, so that based on these weaknesses, appropriate treatment can be provided. Diagnostic tests are very useful for finding out the learning difficulties faced by students, including concept understanding errors. Diagnostic tests have two main functions, namely identifying problems or difficulties experienced by students and planning follow-up in the form of solution efforts according to the problems or difficulties that have been identified. Identification of misconceptions in students is a very important first step to find out the understanding of students' concepts in learning (Gurel et al., 2015).

Diagnostic tests are a widely developed way to identify misconceptions with description and multiple-choice questions. Diagnostic tests can accurately describe the way learners think in answering the questions given and the misconceptions they have (Queloz et al., 2017). Diagnostic tests that have been developed to detect misconceptions include: One-Tier, Two-Tier, Three-Tier, and Four-Tier (Vellayati et al., 2020). The four-tier multiple choice diagnostic test is a modified diagnostic test from the three-tier multiple choice diagnostic test. Modifications were made because the three-tier multiple choice diagnostic test was still not fully able to distinguish between answers on Tier-1 and reasons on Tier-2 and the four-tier multiple choice diagnostic test was used because it was felt to be more accurate in diagnosing students' initial conceptions (Cahyani et al., 2019). The development is in the addition of the level of confidence of students in choosing answers and reasons. The advantages of a four-level multiple-choice diagnostic test are that teachers can: 1) distinguish the level of confidence in the answers and the level of confidence in the reasons chosen by students so that they can dig deeper into students' misconceptions, 2) make a deeper diagnosis of the misconceptions faced by students, 3) identify parts of the material that require more attention, 4) plan more effective learning to overcome students' misconceptions (Sheftyawan et al., 2018). Kaltakci (2017) added that by using a four-tier multiple choice diagnostic test, researchers can assess and categorize the nature and causes of misconceptions easily. The four-tier multiple choice diagnostic test is feasible and able to detect students' misconceptions (Kiray & Simsek, 2021).

Louga et al., (2013) in their research said that misconceptions that occur in students in several concepts, namely in the material of colligative properties of solutions, especially the concept of boiling point elevation and freezing point depression. In addition, the results of research by Sumiasih et al., (2022) showed that the misconceptions of students in the material of colligative properties of solutions had a percentage of 66,3% which was included in the high misconception category. In addition, several studies also confirmed that the four-tier multiple choice diagnostic test is very suitable in indicating the occurrence of misconceptions in students (Pujayanto et al., 2018; Negoro & Karina, 2019; Rawh et al., 2020).

Based on the results of an interview on September 10, 2022 with a Chemistry teacher at MA Khulafaur Rasyidin Sungai Raya, the teacher said that to find out misconceptions in chemistry learning on the topic of the colligative properties of the solution is still felt quite difficult, the material of the colligative properties of the solution is considered not a prerequisite concept, so misconception identification is rarely done. Teachers only focus on basic topic and do not focus on complex topic. Teachers use Learner Worksheets (LKPD) and other references for student tests, but have never made diagnostic tests to find out students' misconceptions. The teacher also mentioned that during the Midterm

Test (UTS) there were 24 out of 34 students in class XII MIA who did not complete the topic on the colligative properties of the solution.

Although many studies have examined the misconceptions of students on the colligative properties of solutions and the factors that cause misconceptions, no one has examined the misconceptions of students using a four-tier multiple choice diagnostic test on this topic. This research intends to investigate misconceptions and their causative factors, especially at MA Khulafaur Rasyidin Sungai Raya. Through this research, it is hoped that the four-tier multiple choice diagnostic test can identify students' misconceptions in the material of the colligative properties of solutions so that it makes it easier for teachers to determine the right actions to overcome these misconceptions.

## Method

This research uses descriptive method with quantitative approach. The subjects of this study were XII MIA class students totaling 34 students at MA Khulafaur Rasyidin Sungai Raya. Data collection techniques in this study through several methods, namely test and interview methods. The test used to identify misconceptions is a four-tier multiple choice diagnostic test instrument. The type of interview used was an unstructured interview consisting of general questions to reveal the causes of students' misconceptions on each item. The diagnostic test questions in this study are about the topic of the colligative properties of the solution which includes a vapor pressure depression, a freezing point depression, boiling point elevation and osmotic pressure. In this study, the four-tier multiple choice diagnostic test was tested for validity and reliability. The validity test was carried out by three validators, namely lecturers of Chemistry Education FKIP Tanjungpura University. The reliability test was tested on XII MIA class students totaling 34 students at MA Khulafaur Rasyidin Sungai Raya.

The data analysis carried out in this study is to first group the test results of students into several categories, namely understanding the concept, partially understanding, misconceptions, and not understanding the concept according to the criteria contained in Table 1.

**Table 1.** Four-Tier Diagnostic Test Answer Combinations

| Category | Answer | Confidence Level | Reason | Answer Combination Confidence Level |
|---|---|---|---|---|
| Concept Understanding | Correct | Sure | Correct | Sure |
| Partial Understanding | Correct | Sure | Correct | Not Sure |
| | Correct | Not Sure | Correct | Sure |
| | Correct | Not Sure | Correct | Not Sure |
| | Correct | Sure | Incorrect | Sure |
| | Correct | Sure | Incorrect | Not Sure |
| | Correct | Not Sure | Incorrect | Sure |
| | Correct | Not Sure | Incorrect | Not Sure |
| | Incorrect | Sure | Correct | Sure |
| | Incorrect | Sure | Correct | Not Sure |
| | Incorrect | Not Sure | Correct | Sure |
| | Incorrect | Not Sure | Correct | Not Sure |
| Misconceptions | Incorrect | Sure | Incorrect | Sure |
| Not Understanding the Concept | Incorrect | Sure | Incorrect | Not Sure |
| | Incorrect | Not Sure | Incorrect | Sure |
| | Incorrect | Not Sure | Incorrect | Not Sure |
| Not Understanding the Concept | | | If not filled in one, two, three, or all of them | |

(Sholahuddin et al., 2019)

Furthermore, calculating the percentage value of students in the misconceptions category, understand the concept, partially understand, and do not understand the concept using the Equation 1 proposed by Arikunto (2005). The results of the percentage calculation are then described in the table. Then identify students' answers to each item and concepts that has misconceptions. Then group the level of misconceptions of students according to the percentage in Table 2.

$$P = \frac{f}{\mathrm{N}} x\ 100\% \quad (1)$$

Descriptions :
P : Percentage of the number of students in each category
$f$ : Number of students in each category
N : Total number of students

**Table 2.** Category Percentage Level of Misconceptions

| Percentage of Misconceptions (%) | Category |
|---|---|
| 61-100 | High |
| 31-60 | Medium |
| 0-30 | Low |

(Handayani et al., 2018)

The results of the interviews to identify the factors that cause students' misconceptions were reviewed using the factors that cause misconceptions proposed by (Suparno, 2013).

## Result and Discussion

The data obtained and described in this study are the results of students' misconception test answers and interview results. These results were analyzed through several predetermined steps. Data from the four-tier multiple choice diagnostic test results of class XII MIA students at MA Khulafaur Rasyidin Sungai Raya are grouped into four categories of understanding, namely misconceptions (M), understand the concept (UTC), partially understand (PU), and do not understand the concept (DNUTC), so that the results are obtained according to Table 3.

**Table 3**. Percentage of Diagnostic Test Results

| Topic | Number | M (%) | UTC (%) | PU (%) | DNUTC (%) |
|---|---|---|---|---|---|
| Vapor Pressure Depression | 1 | 65 | 9 | 15 | 12 |
| Freezing Point Depression | 2 | 6 | 38 | 35 | 21 |
| | 3 | 26 | 9 | 43 | 18 |
| | 8 | 47 | 12 | 29 | 12 |
| Boiling Point Elevation | 4 | 53 | 24 | 21 | 3 |
| | 5 | 9 | 26 | 56 | 9 |
| | 6 | 38 | 9 | 35 | 18 |
| Osmotic Pressure | 7 | 26 | 12 | 32 | 29 |
| Average | | 34 | 17 | 34 | 15 |

Table 3 shows that of the 34 students studied, the percentage of understanding levels varied and all questions tested had misconceptions. The average percentage of misconceptions of students in class XII MIA MA Khulafaur Rasyidin Sungai Raya is 34% which if categorized is included in the moderate misconception category. The highest percentage of misconceptions was identified in question number 1 at 65% because students predominantly gave the idea of the concept of vapor pressure depression spontaneously based on their understanding without first investigating the data from the vapor pressure depression experiment on the question item. The lowest percentage of misconceptions identified in question number 2 was 6% because in the learning process the teacher was more dominant in providing chemical explanations in mathematical form. Based on further data analysis of students' answers, the average percentage of students who experience misconceptions on each topic is shown in Figure 1.

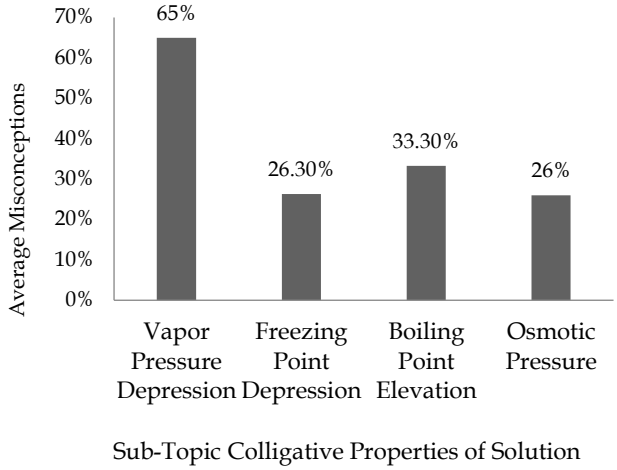



**Figure 1.** Average Percentage of Students' Misconceptions

Based on Figure 1, the average percentage of students who experience misconceptions in the vapor pressure depression topic is 65% with a high misconception category, in the freezing point depression topic is 26,30% with a low misconception category, in the boiling point elevation topic is 33,30% with a medium misconception category, and in the osmotic pressure topic is 26% with a low misconception category. The diagram also shows that most students experience misconceptions on the concept of colligative properties of solutions. Based on the research results in Table 4, the following will discuss the misconceptions of students in each topic of the colligative properties of the solution.

*Vapor Pressure Depression*

In the vapor pressure depression topic, the percentage of misconceptions is 65% in the indicator of analyzing the results of experimental data on vapor pressure depression. In Figure 2, students experienced misconceptions in the indicator of analyzing the results of experimental data on vapor pressure depression. The misconceptions of students found that as many as 18% of students think that the depression in saturated vapor pressure is determined by the saturated vapor pressure of the solution. As many as 24% of students think that the depression in saturated vapor pressure is determined by the type of solute. This is in accordance with the misconceptions investigated by Auliyani et al. (2018) that students assume the vapor pressure depression is determined by the saturated vapor pressure of the solution and the type of solute. Based on the results of the interview, students gave the concept

idea spontaneously based on their understanding without first investigating the data from the vapor pressure depression experiment on the question item. The correct concept according to Syukri (1999) is that the vapor pressure depression is determined by the mole fraction of solute because the vapor pressure depression is directly proportional to the mole fraction of solute.

1.1 Consider the data from the vapor pressure depression experiment below!

| Dissolved Substances | Mole Fraction of Dissolved Substance | Saturated Vapor Pressure of Solution | Saturated Vapor Pressure Depression |
|---|---|---|---|
| Pure Water | - | 17,54 mmHg | - |
| Glycol | 0,01 | 17,36 mmHg | 0,18 mmHg |
| Glycol | 0,02 | 17,18 mmHg | 0,36 mmHg |
| Urea | 0,01 | 17,36 mmHg | 0,18 mmHg |
| Urea | 0,02 | 17,18 mmHg | 0,36 mmHg |

From the data above, the decrease in saturated vapor pressure is determined by...

A. Type of solute
B. Solvent type
C. Mole fraction of solute
D. Saturated vapor pressure of solution

1.2 Level of confidence in the answer

A. Sure
B. Not Sure

1.3 Reasons for choosing an answer:

A. The stronger the force of attraction between the solute molecules, the easier the liquid will evaporate.
B. The decrease in saturated vapor pressure is directly proportional to the mole fraction of the solute so that the greater the value of the mole fraction of the solute, the lower the vapor pressure of the solution.
C. Solute particles will block the motion of solvent molecules to change from liquid to vapor from so that the saturated vapor pressure of the solution becomes higher than the saturated vapor pressure of the pure solution.
D. The more difficult the solvent to evaporate, the greater the saturation vapor pressure.

1.4 Level of confidence in reason

A. Sure
B. Not Sure

**Figure 2.** Example of misconception on vapor pressure depression

*Freezing Point Depression*

In the freezing point depression topic, the highest percentage of misconceptions is in indicator 8, which is analyzing experimental data to compare the colligative properties of electrolyte and non-electrolyte solutions. In Figure 4, students experienced misconceptions in the indicator of analyzing experimental data to compare the colligative properties of electrolyte and non-electrolyte solutions. The misconceptions found were that as many as 12% of students thought that the depression in vapor pressure of electrolyte solutions was higher than non-electrolyte solutions. As many as 15% of students think that the osmotic pressure of electrolyte solution is lower than non-electrolyte solution because the more solute, the more particles that block the solvent (water) to evaporate so that the number of molecules that evaporate becomes more, and the vapor pressure becomes greater. Based on the interview results, students provide incorrect reasoning and are fooled in connecting one concept with another. The correct conception is that the freezing point of electrolyte solutions is lower than non-electrolyte solutions because the presence of solutes will prevent water from freezing at its freezing point, so that electrolyte solutions require a lower freezing point than the freezing point of water (Sitanggang, 2019).

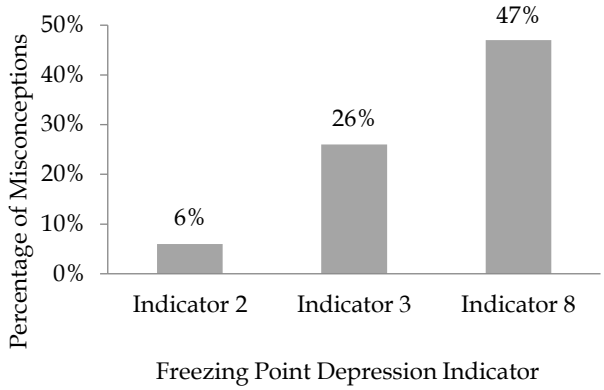



**Figure 3.** Percentage of students' misconceptions on freezing point depression

Description:
Indicator 2: Calculate the freezing point depression of electrolyte solution
Indicator 3: Analyse the data from the freezing point depression experiment on electrolyte and non-electrolyte solutions
Indicator 8: Analyse experimental data to compare the colligative properties of electrolyte and non-electrolyte solutions

8.1 Consider the following experimental data!!

| Solution | Concentration (molal) | Boiling Point (°C) | Freezing Point (°C) | Saturated Vapor Pressure (mmHg) | Osmosis Pressure (atm) |
|---|---|---|---|---|---|
| $C_{12}H_{22}O_{11\,(aq)}$ | 1 | 100,52 | -0,520 | 0,1679 | 0,244 |
| $KCl_{\,(aq)}$ | 1 | 101,04 | -0,104 | 0,1557 | 0,370 |
| $Al_2(SO_4)_{3\,(aq)}$ | 1 | 102,60 | -0,260 | 0,1598 | 0,381 |

The correct statement regarding the colligative properties of electrolyte an non-electrolyte solutions with the same molality is ...

A. The boiling point of electrolyte solutions is lower than that of non-electrolyte solutions.
B. The freezing point of electrolyte solutions is lower than that of non-electrolyte solutions.
C. The vapor pressure depression of electrolyte solutions is higher than that of non-electrolyte solutions.
D. The osmosis pressure of electrolyte solutions is lower than that of non-electrolyte solutions.

8.2 Level of confidence in the answer

A. Sure
B. Not Sure

8.3 Reasons for choosing an answer:

A. The presence of solutes will prevent the solvent (water) from boiling at its boiling point, so an electrolyte solution requires a boiling point lower than the boiling point of water.
B. The more solute, the more particles that block the solvent (water) from evaporating. As a result, the number of molecules vaporized becomes more, and the vapor pressure becomes greater.
C. The presence of solutes will prevent water from freezing at its freezing point, so an electrolyte solution requires a lower freezing point than the freezing point of water.
D. The more solute, the less water molecules move through the semipermeable membrane. As a result, at osmosis pressure becomes lower.

8.4 Level of confidence in reason

A. Sure
B. Not Sure

**Figure 4.** Example of misconception in indicator 8

*Boiling Point Elevation*

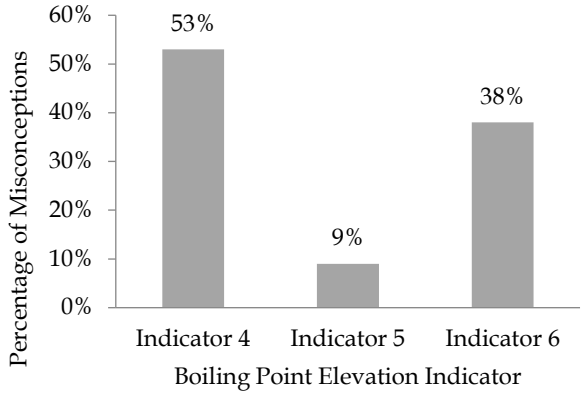
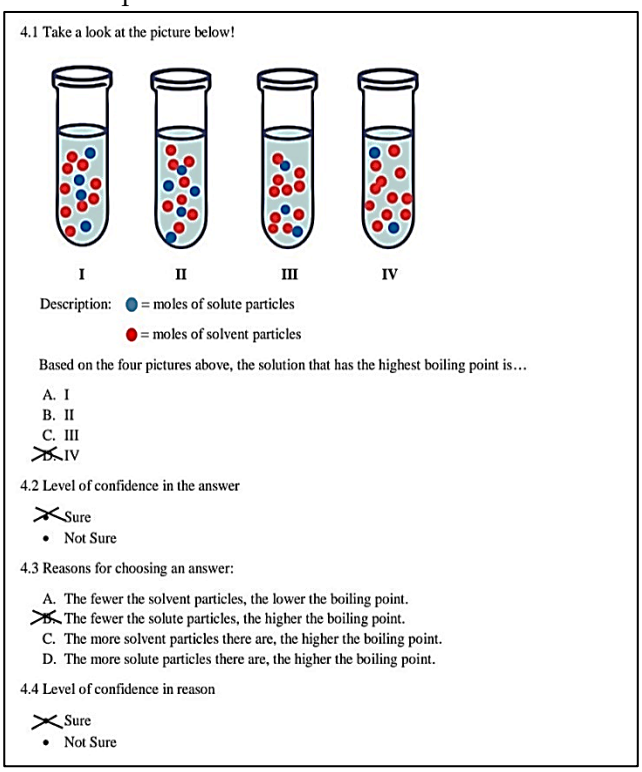



**Figure 5.** Percentage of students' misconceptions on boiling point elevation

Description:

| | |
|---|---|
| Indicator 4: | Analyse the boiling point of a solution based on the boiling point of number of particles of electrolyte solution solute and and solvent |
| Indicator 5 | Calculate the elevation in boiling point of electrolyte solution |
| Indicator 6: | Analyse experimental data on the result of boiling point elevation in electrolyte and non-electrolyte solutions |

In the boiling point elevation topic, the highest percentage of misconceptions is in indicator 4, which is analyzing the boiling point of the solution based on the number of particles of solute and solvent.


4.1 Take a look at the picture below!

I II III IV

Description: = moles of solute particles

= moles of solvent particles

Based on the four pictures above, the solution that has the highest boiling point is…

A. I
B. II
C. III
~~D.~~ IV

4.2 Level of confidence in the answer

~~•~~ Sure
• Not Sure

4.3 Reasons for choosing an answer:

A. The fewer the solvent particles, the lower the boiling point.
~~B.~~ The fewer the solute particles, the higher the boiling point.
C. The more solvent particles there are, the higher the boiling point.
D. The more solute particles there are, the higher the boiling point.

4.4 Level of confidence in reason

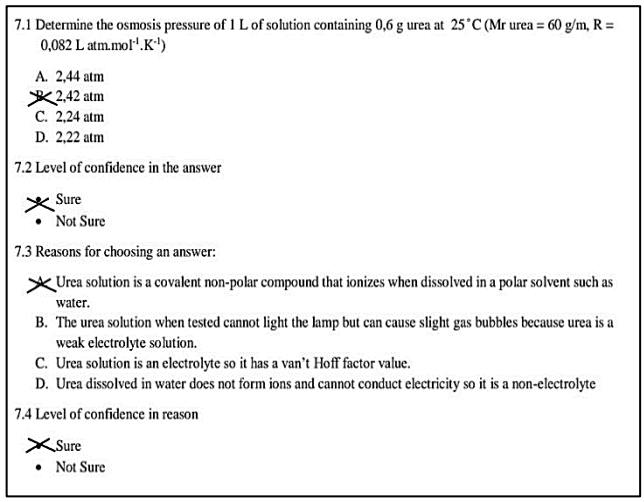
~~•~~ Sure
• Not Sure

**Figure 6**. Example of misconception in indicator 4

In Figure 6, students experienced misconceptions in the indicator of analyzing the boiling point of a solution based on the number of particles of solute and solvent. The misconceptions found that as many as 32% of students think that the solution that has the highest boiling point is solution IV because the fewer solute particles, the higher the boiling point. As many as 15% of students think that the solution that has the highest boiling point is solution IV because the more solvent particles, the higher the boiling point. Based on the results of the interview, students provide concept ideas spontaneously based on their understanding without first investigating the picture and description of the picture on the question item. Students are fooled in connecting one concept with another. The correct concept is that the solution that has the highest boiling point is picture II because the more solute particles that are dissolved, the higher the boiling point will be (Sudarmo, 2013).

*Osmotic Pressure*

In the osmotic pressure topic, the percentage of misconceptions is 26% in the indicator of calculating the osmotic pressure of non-electrolyte solutions.


7.1 Determine the osmosis pressure of 1 L of solution containing 0,6 g urea at 25°C (Mr urea = 60 g/m, R = 0,082 L atm.mol$^{-1}$.K$^{-1}$)

A. 2,44 atm
~~B.~~ 2,42 atm
C. 2,24 atm
D. 2,22 atm

7.2 Level of confidence in the answer

~~•~~ Sure
• Not Sure

7.3 Reasons for choosing an answer:

~~A.~~ Urea solution is a covalent non-polar compound that ionizes when dissolved in a polar solvent such as water.
B. The urea solution when tested cannot light the lamp but can cause slight gas bubbles because urea is a weak electrolyte solution.
C. Urea solution is an electrolyte so it has a van't Hoff factor value.
D. Urea dissolved in water does not form ions and cannot conduct electricity so it is a non-electrolyte

7.4 Level of confidence in reason

~~•~~ Sure
• Not Sure

**Figure 7**. Example of misconception on osmotic pressure

In Figure 7, students experienced misconceptions in the indicator of calculating the osmotic pressure of non-electrolyte solutions. The misconceptions found were that as many as 9% of students thought that the calculation of the osmotic pressure of urea solution was 2,24 atm and the urea solution when tested could not light the lamp but could cause a few gas bubbles because urea was a weak electrolyte solution. As many as 6% of learners think that the osmotic pressure of urea solution is 2,42 atm and urea solution is a covalent nonpolar compound that ionizes when dissolved in a polar

solvent such as water. Based on the interview results, students provide concept ideas spontaneously based on their understanding without first investigating the concept of osmotic pressure. Learners provide incorrect reasoning regarding polarity, electrolyte and non-electrolyte solutions and calculation formulas. The correct conception is the calculation of the osmotic pressure of urea solution of 2,44 atm and urea dissolved in water does not form ions and cannot conduct electric current so it is a non-electrolyte solution (Pandia at al., 2021).

Based on further data analysis of students, interviews were conducted. This interview aims to explore information on the causes of students' misconceptions from the results of the four-tier multiple choice diagnostic test. The results of students' interviews on the factors causing misconceptions are shown in Table 5.

Table 5 shows that there are 3 factors and 7 indicators that cause students to experience misconceptions. Internal factors that cause students' misconceptions mostly come from students. Students provide concept ideas spontaneously based on their intuition/understanding without investigating first, for example on the question items of the topic of vapor pressure depression, boiling point elevation and osmotic pressure, learners do not first investigate the data from the experiment on vapor pressure depression, the description of the picture on the boiling point elevation, and the concept of osmotic pressure. Students provide incorrect reasoning, for example in the osmotic pressure question item, students assume that urea solution is a nonpolar covalent compound that ionizes when dissolved in a polar solvent such as water, while urea is a non-electrolyte covalent compound that is polar. Students are fooled in connecting one concept with another, for example in question indicator 8, students are confused when investigating one item that involves all the concepts of the topic of the colligative properties of the solution, so that students assume that the vapor pressure depression of the electrolyte solution is higher than that of the non-electrolyte solution, while the correct concept of the freezing point depression of the electrolyte solution is lower than that of the non-electrolyte solution. The lack of interest and ability of students to learn chemistry due to the basic concepts of chemistry that are interconnected with the concept of colligative properties of solutions, such as the concept of solution concentration.

External factors causing students' misconceptions come from the context and teaching methods. One of the students' discussion friends has misconceptions, students prefer to discuss and ask questions with peers rather than ask directly with the teacher, so that when friends experience misconceptions, students will experience the same thing. Teachers are more dominant in providing chemical explanations in mathematical form, teachers provide material and practice questions to students in the form of calculation concepts without providing an explanation of the concept of the theory of colligative properties of solutions. Teachers never conduct experimental activities because there is no chemistry laboratory and limited chemistry teaching time.

**Table 5.** Causes of Students' Misconceptions on the Topic of Colligative Properties of Solutions

| Respondent Interview Results | Causes of Misconception |
|---|---|
| Students provide concept ideas spontaneously based on their intuition/understanding without investigating first (wrong intuition) | Students |
| Students provide incorrect reasoning | Students |
| Students are fooled in connecting one concept with another | Students |
| Lack of interest and ability of students to learn chemistry | Students |
| One of the discussion partners has a misconception | Context |
| Teachers are more dominant in giving chemical explanations in mathematical form | Teaching method |
| Limited experimentation | Teaching method |

The main causes of students experiencing misconceptions come from students, teachers, textbooks, context and teaching methods (Suparno, 2013). The results of this study are relevant to the research of Auliyani et al., (2018) that students' difficulties in understanding material are caused by students, the influence of friends around and how to teach. Efforts that can be made by teachers to help students understand the topic being taught, teachers must use teaching topics that are in accordance with KI, KD, and indicators (Aisyah et al., 2020; Apriani et al., 2021). A teaching topic will provide a complete understanding if it can present a description of the topic in accordance with what the teacher wants to achieve (Lau et al., 2019). If the topic presented is correct, it can prevent misconceptions from arising. Efforts that can be made to overcome students' misconceptions in learning chemistry, teachers can conduct chemical experiments according to the topic taught and present chemistry material in an interesting way, such as using videos, applications, games or educational games where chemistry must be explained with multiple representations through various technologies (Ulfah & Erlina, 2022). Mukhlis (2017) states, with students understanding / mastering concepts, students can use

their scientific knowledge in solving a problem and are able to think and act based on their scientific skills.

## Conclusion

Based on the results of the research that has been obtained, overall it can be concluded that the level of misconceptions of XII MIA class students at MA Khulafaur Rasyidin Sungai Raya on the topic of the colligative properties of solutions is 34% with a moderate misconception category, where as many as 65% of students experience misconceptions in the vapor pressure depression topic, as many as 26,30% of students experience misconceptions in the freezing point depression topic, as many as 33,30% of students experience misconceptions in the boiling point elevation topic, and as many as 26% of students experience misconceptions in the osmotic pressure topic. Factors causing misconceptions in this study consist of internal and external factors. Internal factors come from students, where students provide concept ideas spontaneously based on their understanding without being investigated first, students provide incorrect reasoning, students are fooled in connecting one concept with another, lack of interest and ability of students in learning chemistry. External factors come from the context and teaching methods, where one of the learners' discussion partners has misconceptions, the teacher is more dominant in providing chemical explanations in mathematical form, and limited experiments. The way that teachers can reduce students' misconceptions is that teachers can use teaching materials that are in accordance with KI, KD and indicators, teachers can conduct chemical experiments and present topics in an interesting way.

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**Author Contributions**

P.: writing-original draft preparation, methodology, result, discussion, conclusion and editing; E. and L.: analysis, writing-review and editing; Rasmawan and Masriani: analysis, review and validation.

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**Conflicts of Interest**

The authors declare no conflict of interest.

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