



## Identification of Misconceptions in Chemical Bonding Materials Using Three Tier Diagnostic Test

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### ABSTRACT

Chemistry learning focuses on understanding concepts, thus students who get difficulty understanding the concepts of chemistry learning will experience conceptual mistakes, especially abstract concepts such as chemical bonds. Students' difficulty understanding the material of chemical bonds can occur due to misconceptions. The misconceptions will hinder the construction and assimilation of new knowledge in students and thus students will experience difficulties in learning chemistry. To address such issue, an instrument for detecting misconceptions in chemistry is necessary to find out the misconceptions that occur among learners. The identification of such emerging misconceptions in understanding the subject matter can be analyzed using a three-tier multiple-choice diagnostic test. The present study was carried out to determine the presence or absence, and the percentage of misconceptions regarding chemical bonding material using the Three Tier Test diagnostic test. Conducted through purposive sampling technique, this research-based paper is a type of qualitative research with a descriptive approach. The research instrument uses a three-tier test objective test. The data obtained was analyzed descriptively for each student's response by using students' level of understanding list. In general, the results obtained in this line of research showed that; (1) Indicator 1, student misconceptions were 91.17% (2) Indicator 2, student misconceptions were 64.14%, (3) Indicator 3, student misconceptions were 67.64%, (4) Indicator 4, student misconceptions were 76.47%. (5) Indicator 5, students' misconceptions were 63.23%. By way of conclusion, the present project argues that there were misconceptions that occurred in students of SMA Negeri 1 Class X Teluk Kuantan on the chemical bonding material, with the percentage 72.53% students experiencing misconceptions, 14, 98% students do not understand the concept, and the rest 12.48% students understand the concept of chemical bonding.

**Keywords:** misconception, diagnostic test, three tier test.

### INTRODUCTION

Learning materials related to chemistry, students are required to understand concepts. This is because chemistry learning focuses on understanding concepts. Students' difficulty in understanding the concepts of chemistry learning allows students to experience conceptual errors. According to Suparno (2005), conceptual errors experienced by students occur when students provide wrong answers to different questions, yet the conceptual basis is just similar. Such obvious error is also formed from the nature of chemistry learning material because chemistry is a concept that is always abstract (Middlecamp & Kean. 1985). One chemical material that is abstract and difficult for students to understand is chemical bonding material. Tan & Treagust (1999) stated that students still often have difficulty learning and understanding chemical bonds. This is because the nature of the material is abstract material and is far from students' daily life experiences.

On account of such obvious matters, difficulties in understanding the material of chemical bonds have been expressed by several studies, including; (1) Butts & Smith (1987), using an interview technique, reported that most grade 12 students do not understand the material of ionic bonds. One example is that students assume that electrons transfer from sodium chloride. They also do not understand the three-dimensional nature of ionic bonds for solid sodium chloride, (2) Peterson et al. reported that students had difficulty understanding some chemical bonding materials, including intermolecular forces, octet rules, molecular shape, and polarity (Tan & Treagust. 1999), (3) Nicoll (2001) reported that students had difficulty understanding the material of chemical bonds, namely why and how bonds occur (Uzuntiryaki, 2003), (4) Ardiansyah (2002) reported that grade 1 students at MAN I Malang had considerable difficulty understanding the material of chemical bonds. , namely: related to electron configuration 33.2%, Lewis structure 52.0%, ionic bonds 43.5%, covalent bonds 42.1%, coordination covalent bonds 59.4%, and the polarity of covalent compounds is 59.1%, (5) Rusdiana (2010) reported that students of SMA Negeri 6 Malang still have difficulty understanding the stability of elements (41.8%), Lewis structures (43.8%), the polarity of some compounds and its relationship to electronegativity (56.7%), metallic bonds and their relationship to physical properties of metals (43.9%), ionic bonds (63.7%), covalent bonds (68.7%), coordination covalent bonds (70.9 %). From the achievement data of the research, it can be concluded that students find it challenging to understand chemical bonding material, both configuring electrons, Lewis symbols, ionic bonds, covalent bonds, the polarity of covalent and covalent coordination compounds, (6) Divine (2011) Students' difficulties in understanding bonding materials chemistry also occur in SMA Laboratorium UM. The difficulty of these students can be seen from the class average and the percentage of students' test scores that do not meet the standard value of completeness for the chemical bonding material. The standard value of completeness for each subject is 75. There is a low-grade average in the subject of chemical bonds and is still below the standard value of completeness.

The difficulties that students understand the chemical bonds material can affect misconceptions students. The negative influence is the occurrence of misconceptions or misunderstandings. In the English-Indonesian dictionary, the misconception is a translation of Misconceptions which means misunderstanding. According to Suparno (2005), five things can cause misconceptions, namely students, teachers, textbooks, context, and teaching methods. The misconceptions that occur to students will hinder the construction and assimilation of new knowledge in students so that students will experience difficulties in learning chemistry. To find out the misconceptions that occur in students, an instrument for detecting misconceptions in chemistry is needed to distinguish between students who understand the concept, experience misconceptions, or do not understand the concept. Taufik (2012) also states that diagnostic tests can be used to find out the misconceptions that occur in students. The identification of misconceptions that occur in students in understanding the subject matter can be analyzed using a three-tier multiple-choice diagnostic test. Ayla Cetin and Omer Geban argue that the three-tier test is the most valid, reliable, and accurate test instrument to identify students' misconceptions (Dindar & Geban, 2011).

The present study was conducted to determine the misconceptions that occur or do not occur in students about chemical bonding material, using a diagnostic test technique, known as the three-tier test. The test technique used differs from previous research in obtaining and knowing the misconceptions in students about chemical bonding material.

Based on such description, it is necessary to conduct research that aims to identify misconceptions in students regarding chemical bonding material using a three-tier diagnostic test.

## METHODOLOGY

This is a type of qualitative research with a descriptive approach. Descriptive research is used to explain the misconceptions that occur in students. Conducted through purposive sampling technique, the population in this study were all students of class X IPA SMAN 1 Teluk Kuantan. Purposive sampling is a technique with specific considerations (Sugiyono, 2014). The consideration in this study is that the researcher chose students of class X IPA 2 totaling 34 students who had just finished studying chemical bonding material, to avoid students who forgot the chemical bond material. The data collection technique used in this research is measurement. The instrument used is a test item in the form of a multiple-choice test (objective test three-tier test) developed by Mutiara Ismet (2015) on the chemical bonding material of class X SMA. These questions have been tested for validity and reliability, distinguishability, and difficulty and have been tested for validity and reliability, tested on class X students who have experienced chemical bonding.

The data obtained were analyzed descriptively for each student's response using the following categories of students' levels of understanding:

**Table 1. Categories of students' understanding levels based on three-tier test answer**

First Stage	Second Stage	Third Stage	Category
True	True	Sure	Understand
True	True	Unsure	Less Understand
True	False	Sure	Misconception
True	False	Unsure	Less Understand
False	True	Sure	Misconception
False	True	Unsure	Less Understand
False	False	Sure	Misconception
False	False	Unsure	Less Understand

According to Nuraini (2011), the percentage of students' misconceptions was calculated using the following equation:

$$NP = \frac{PR}{n} \times 100\%$$

Description:

NP = the percentage of the number of students who understand / misconceptions / less understand

PR = the number of students who understand / misconceptions / less understand

n = total number of students

## RESULT AND DISCUSSION

### Description of Student Concept Understanding

The results of students' answers are based on the subject matter, choice of reasons, and the level of confidence in each item and are categorized. The categories of students' level of understanding obtained by each question indicator are presented in the following table:

**Table 2. Results of descriptive analysis of students' understanding of class X MIA 2 at SMA Negeri 1 Teluk Kuantan**

No		Understand (%)	Less understand (%)	Misconception (%)
1	Describes the tendency of an element to achieve stability by bonding with other elements	0.00	8.82	91.17
2	Estimate the formula of the compound. the type of bond formed. and the particles that make up the compound	21.24	14.62	64.14
3	Comparing ionic bonds and covalent bonds based on the difference in electronegativity	1.47	30.88	67.64
4	Give examples of materials that have metallic bonds	8.82	14.71	76.47
5	Explain the relationship between metallic bonds and the physical properties of metals	30.88	5.88	63.23
<b>Average</b>		<b>12.48</b>	<b>14.98</b>	<b>72.53</b>

Misconceptions about chemical bonds are also described in each sub-topic of the material. Misconceptions about the sub-concept of atomic stability can be caught in the following table:

**Table 3. Misconceptions about the sub-concept of atomic stability**

Question Number	Misconceptions	Correct
1	Atoms that gain electrons form cations (positive ions)	Atoms that gain electrons form anions (negative ions)
	The hydrogen atom is stable if it follows the octet rule	The hydrogen atom will be stable if it follows the duplet rule
10	Compounds deviate from the octet rule if the central atom has eight valence electrons after forming bonds. BF <sub>3</sub> deviates from the octet rule because its central atom has an odd number of valence electrons after bonding.	Compounds deviate from the octet rule if the central atom does not have eight valence electrons after forming bonds.

Misconceptions on the sub-concept of metallic bonds can be seen in the following table:

**Table 4. Misconceptions on metal bond sub-concepts**

Question number	Misconceptions	Correct
11. 12	Metallic bonds are only found in a mixture of metal and metal (alloy).	Metallic bonds exist in metals and their alloys.
	Metallic bonds exist in metals	
	Metallic bonds are formed due to the presence of non-metal atoms	
13. 14	Metallic bonds are formed due to a mixture of metal and metal	Metallic bonds are formed because of positive ions and a sea of attracting electrons.
	The physical properties of metal-bonded materials are due to the presence of positively charged electrons	

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The physical properties of metal-bonded materials are due to the presence of neutrally charged electrons in the material

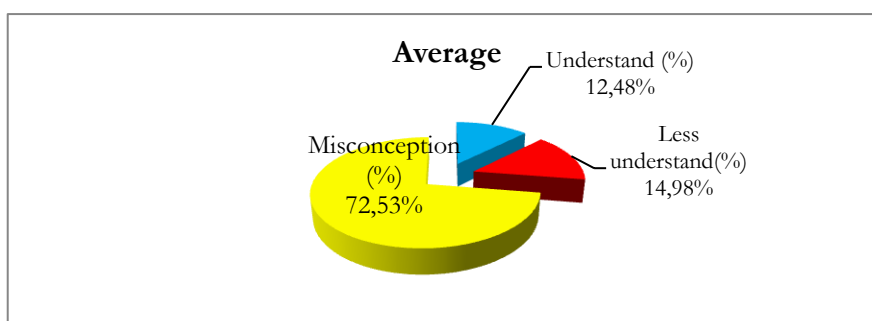
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The physical properties of a metal-bonded material are due to the electrons released by the material

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The results of the descriptive analysis of the level of student understanding based on students' answers to multiple-choice, choice of reasons, and the level of confidence obtained by students can be seen from the graphic images for each indicator so that the percentages of students who get students who understand, lack understanding and misconceptions. Categories of students who understand the concept of lack of understanding and misconceptions are categorized based on the answers given by students at three levels (multiple-choice, choice of reasons, and level of confidence) for each item and analyzed based on table III.4. In this case, students categorized as understanding are students who choose the correct answer choice on multiple-choice reasons and believe in their level of confidence. Students who do not understand are students who choose not to believe in the level of confidence. Finally, students categorized as misconceptions are students who answered incorrectly on multiple-choice or reason or wrong on both levels but chose to believe in the level of belief.

The following is a graphic description of the results of the average percentage of all indicators obtained by students both in the level of understanding, lack of understanding, or the presence or absence of misconceptions that occur in students of SMA Negeri 1 Teluk Kuantan class X IPA 2, as follows;



**Figure 1. Average Percentage**

The results of the descriptive analysis are in Figure 4.1, shows that the average percentage of students who understand the concept of chemical bonds is 12.48%. The low percentage of students who understand this concept shows that students do not fully understand the concept of chemical bonding. Students are said to have understood the concept if they know a concept and can see it from various aspects. In addition, according to Abraham et al., students who understand the concept will give the correct explanation of the answer. The low average percentage indicates that students' conceptual understanding is still low and is dominated by misconceptions and lack of conceptual understanding. Based on the levels of intellectual development Piaget is divided into sensorimotor (0 – 2 years), pre-operational (2-7 years), concrete operational (7 – 11 years), and formal operational (11 – above).

Students who are at the high school level of class X aged between 15 and 16 years, their thinking ability is at the level of formal thinking. However, students' low level of understanding to understand chemical bonding material whose material is abstract is not by the stage of intellectual development.

The results of the descriptive analysis in Figure 1. show that the average percentage of students who do not understand the chemical bonding material is 14.98%. Students who do not understand the concept are unsure about the answers given at the first and second levels. Students who choose the unsure option show low student confidence in their understanding of the material being tested. So the answer given is based on guesswork. The guessing process plays an essential role in determining the answer. Regardless of whether the answer is right or wrong. students' uncertainty in answering indicates an element of guesswork. which indirectly reflects ignorance or lack of understanding of the concepts that are the basis for students in determining answers.

The average percentage of students who have misconceptions about chemical bonds is 72.53%. The high percentage of misconceptions that exceeds 50% indicates that the students' conceptual understanding is inconsistent with generally accepted concept understanding. Students who experience misconceptions have a high level of confidence in the given answers. Thus, the misconceptions are difficult to change because everyone constructs knowledge according to their own experiences.

The level of understanding and misconceptions students have on each indicator tested can be seen in the discussion below.

1. Indicator One (Indicator 1)

Indicator 1 explains the tendency of an element to achieve stability by binding to other elements. and questions consisted of indicator 1. namely questions at numbers 1 and 10. The average percentage of students for the indicators for question 1 is as follows;

a. Understand

This indicator is 0%. which means that out of 34 students. none of the students understand the subject matter with the indicators contained in questions number 1 and 10.

b. Less understand

In this indicator. students who experience a lack of understanding of the concept are 8.82%. which means that out of 34 students in question the concept.

c. Misconception

In this indicator. students who experience misconceptions reach 91.17% and are the highest percentage of misconceptions. Wherefrom the number of students. 34 people in question number 1 who experienced misconceptions amounted to 34 people. which means that all students experienced misconceptions in that question. While in question number 10. out of 34 students. 28 students experienced misconceptions. So for this indicator. there are many misconceptions about students' understanding of concepts.

The following is a description of the level of understanding, lack of understanding and misconceptions that occur in students for indicator 1;

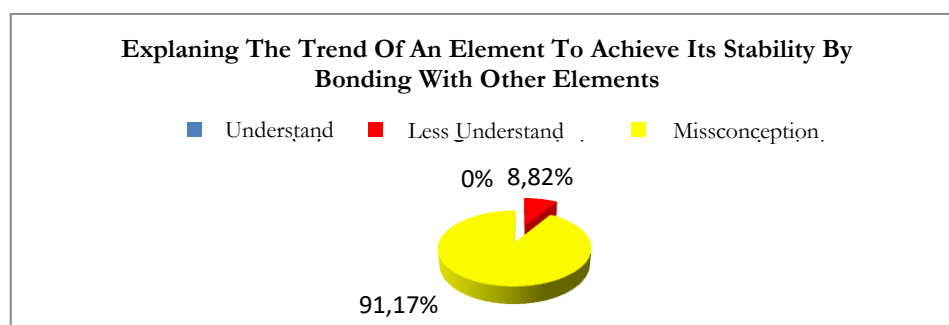


Figure 2. Percentage indicator 1

2. Indicator Two (Indicator 2)

Indicator 2 estimates the formula of the compound, the type of bond formed, and the particles that make up the compound. The questions that are indicator 2 are numbers 2, 3, 4, 5, 8, and 9. The average percentage of students who occur in indicator 2 is as follows:

a. Understand

In this indicator, the percentage of students who understand is 21.24%. From this percentage, it is obtained that based on the number of students who understand this indicator with question number 2 totaling 22 people, question number 3 totaling 27, questions number 4, 5, and 9 totaling 0 which means that questions number 4, 5 and 9 there are none of the students understood, question number 8 totaled 13 students.

b. Less understand

In this indicator, the percentage of students who do not understand is 14.62%. Based on these percentages, it was obtained that from 34 students, the number of students who answered question number 2 amounted to 2 people, question number 3 amounted to 0, which means that none of the students did understand the question number 3, question number 4 amounted to 12 students who did not understand, Question number 5 has ten students, question number 8 has three students, and question number 9 has three students who do not understand.

c. Misconception

In indicator 2, there is a misconception that students are 64.14%. To identify students' misconceptions on this indicator, students are asked to answer questions number 2, 3, 4, 5, 8, and 9. Of the 34 students who answered the questions that were indicator two and the occurrence of misconceptions, namely; Question number 2 had ten students, question number 3 had seven students, question number 4 had 22 students, question number 5 had 24 students, question number 8 has 18 students, and question number 9 has 31 students who have misconceptions.

The following is a description of the level of understanding, lack of understanding, and misconceptions that occur in students for indicator 2;

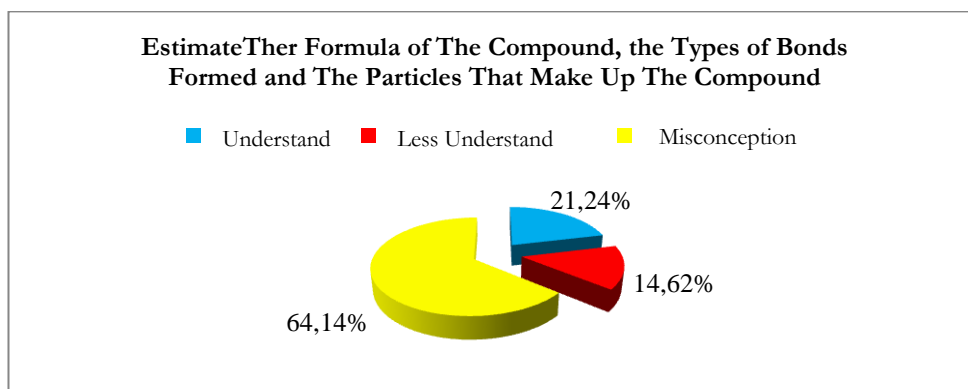


Figure 3. Percentage indicator 2

3. Indicator Three (Indicator 3)

Indicator 3 compares ionic bonds and covalent bonds based on differences in electronegativity. The questions, which are indicators, consist of questions 6 and 7. The average percentage of students who occur in indicator 3 is as follows;

a. Understand

In the third indicator, students who understand the concept are 1.47%. This percentage explains that out of 34 students. In question number 6, there is only one

student provided correct and confident answer. And in question number 7, none of the students provided correct answer.

b. Less understand

In the indicator, three students who do not understand the concept are 30.88%. From this percentage, it can be explained that from 34 students with the indicators contained in question number 6, students who do not understand are 12 students. And in question number 7, nine students do not understand the concept.

c. Misconception

In indicator 3, the percentage of students who experience misconceptions is 67.64%. Where, from the total number of 34 students. The number of students who answered questions related to indicator 3 with the criteria for question number 6 who experienced misconceptions were 21 students. In question number 7, there were 25 students.

The following is a description of the level of understanding, lack of understanding, and misconceptions that occur in students for indicator 3;

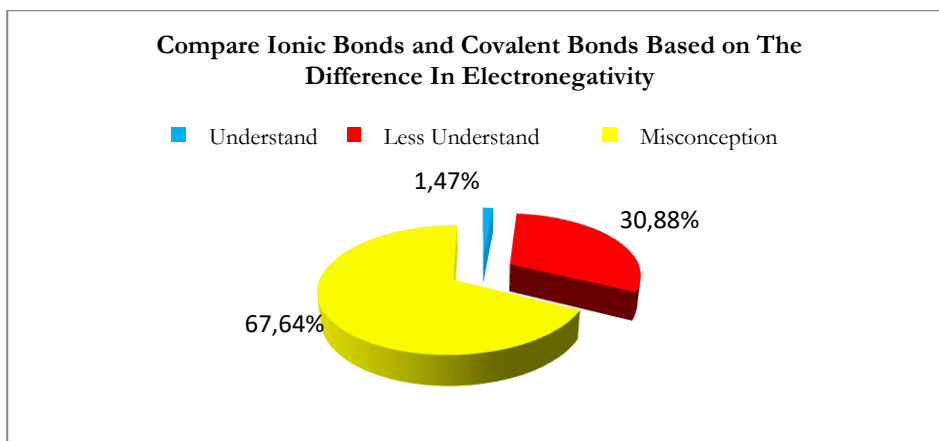


Figure 4. Percentage indicator 3

4. Indicator Four (Indicator 4)

Indicator 4 describes examples of materials that have metallic bonds. The following consist of questions 11 and 12. The average percentage of students who occur in indicator 4 is described as follows;

a. Understand

In Indicator 4, students who understand the concept are 8.82%. This percentage can explain that from 34 students, the number of students who understand the concept for question number 11 are two students. And in question number 12, there are four students.

b. Less understand

In Indicator 4, the percentage of students who do not understand this concept is 14.71%. This percentage can explain that from the total number of 34 students, the number of students who do not understand the concept for question number 11 are eight students. And in question number 12, there are only two students.

c. Misconception

In Indicator 4, the percentage of students with misconceptions reaches 76.47%. This percentage can explain that from 34 students who possessed misconceptions about the concept for question number 11 were 24 students. And in question number 12, there were 28 students.



The following is a description of the level of understanding, lack of understanding, and misconceptions that occur in students for indicator 4;

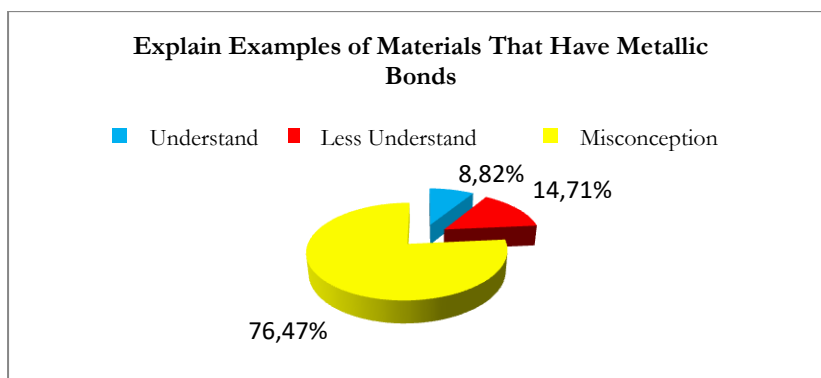


Figure 5. Percentage indicator 4

5. Indicator Five (Indicator 5)

Indicator 5 relates the relationship between metallic bonds and the physical properties of metals. The questions that are indicators of this consist of question Number 13 and 14. The average percentage of students who occur in indicator 5 is described as follows;

a. Understand

In Indicator 4, students who understand this concept are 30.88%. This percentage can explain that from 34 students, there are five students who understand the concept for question number 13. And in question number 14, there are 16 students.

b. Less understand

In Indicator 4, the percentage of students who do not understand this concept is 5.88%. This percentage can explain that of the 34 students, there are two students who do not understand the concept for question number 13. And in question number 14, there are two students.

c. Misconception

In Indicator 5, the percentage of students with misconceptions reaches 63.23%. This percentage can explain that of the 34 students, there are 27 students who have misconceptions about the concept for question number 13. And in question number 14, there are 16 students.

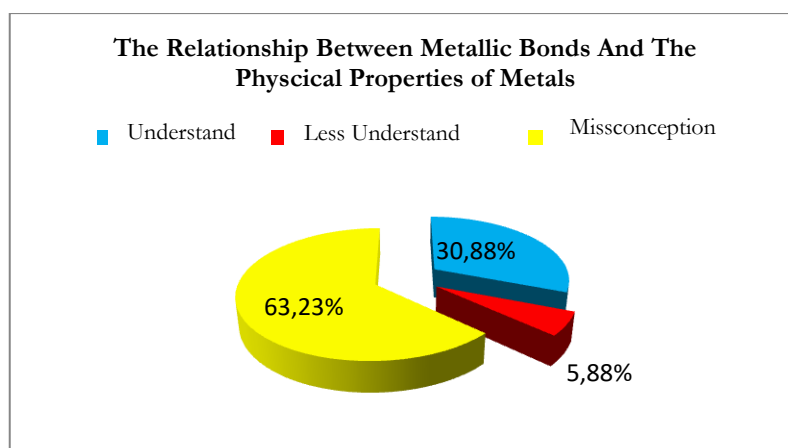


Figure 6. Percentage indicator 5

Based on the results of the descriptive analysis above for each indicator, it can be concluded that there are misconceptions in students' understanding of chemical bonding material. This formulated concept only applies to essential competencies 3.5 comparing the process of forming ionic bonds, covalent bonds, coordinating covalent bonds and metallic bonds and interactions between particles (atoms, ions, molecules) of matter and their relationship to the physical properties of matter. Therefore, in these essential competencies, the giving of this test is also limited to the question indicators in the fifth indicator which explains the relationship between metallic bonds and the physical properties of metals.

The misconceptions that occur in these students can be identified using a diagnostic test. And one of the diagnostic tests that can be used is a three-tier test type diagnostic test. Knowing the location of students' misconceptions will make it easier for teachers to carry out remediation learning (remediation), and errors that occur in students can be immediately identified. In addition, misconceptions that occur in students will impact students' understanding of the following material. Puspitasari (2009) states that misconceptions in one material will impact learning difficulties in other materials. This is because the concepts in chemistry are interrelated with one another to form a concept hierarchy.

Students who have misconceptions and do not understand the concept are students who have difficulty studying chemical bonds. So that teachers should organize remedially or repair learning programs. So that students who have misconceptions and do not understand the concept can understand the material as a whole. The analysis results can show the distribution of misconceptions that occur in each of the questions given. The number of students, the level of students' understanding of the chemical bond material are presented in the following table:

**Table 5. Number of students at the level of understanding of class XI MIA 2 SMA Negeri 1 Teluk Kuantan on chemical bonding materials**

Number	Number of Students		
	Understand	Less Understand	Misconception
1	0	0	34
2	22	2	10
3	27	0	7
4	0	12	22
5	0	10	24
6	1	12	21
7	0	9	25
8	13	3	18
9	0	3	31
10	0	6	28
11	2	8	24
12	4	2	28
13	5	2	27
14	16	2	16

The following is an illustration of a bar graph to illustrate and show each difference in the number of percentages obtained by students in the category of the level of understanding, lack of understanding, and misconceptions that occur in students of SMA Negeri 1 Taluk Kuantan on chemical bonding material given to class X IPA 2 students which amounted to 34 students can be seen in the following graph;

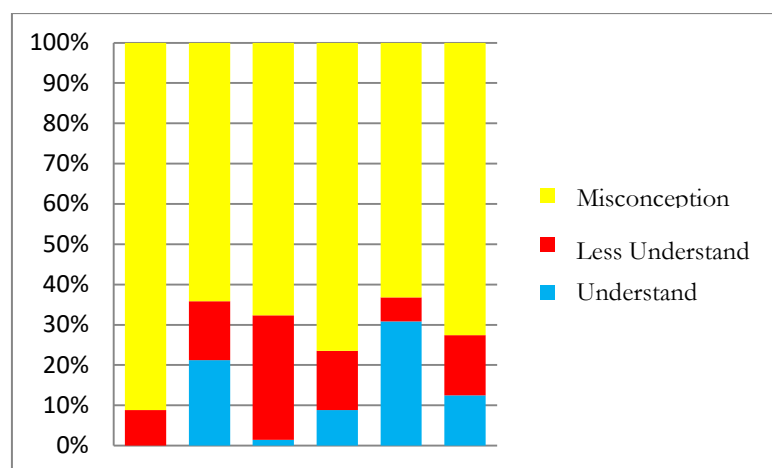


Figure 7. Average percentage of indicator

Based on the description of the graph results, there are still many students who experience misconceptions about the material of chemical bonds. The high level of misconceptions in students is caused by several factors, including students, teachers, or supporting books used during the learning process. In addition, misconceptions in students will affect achievement and learning outcomes in the future. Thus, it is necessary to make improvements made by the teacher to avoid and correct the misconceptions in students. According to Suparno (2013), the causes of misconceptions in students are students themselves, teachers, textbooks, contexts, and learning methods.

Based on the data on student misconceptions that occur, students' misconceptions may be caused by the teacher. This is in line with Piaget's statement (Effendy, 2002), which states that the learning climate developed by teachers has a considerable influence on learning success. Suparno's (2013) statement states that the cause of teacher misconceptions when teaching occurs in two ways: the teacher does not master the correct concepts, and the teacher explains incorrectly even though the concepts taught are correct. Suparno (2005) stated that the main factor that students experience misconceptions mostly comes from the students themselves. This follows the opinion of experts who state that most misconceptions come from students. Research by Setiawati (2011) also reveals that students are the most significant factor that causes misconceptions. Some of the factors that cause misconceptions that come from students are how students learn to memorize more than understand concepts.

The findings on the pattern of student answers indicate that students only memorize the material without understanding it. In addition, students cannot apply the concepts they have learned in solving a problem and linking them to one another. Therefore, learning outcomes obtained by simply memorizing without understanding are temporary and can impact mastery of less than optimal concepts. This can lead to misunderstandings in developing the basic concepts they master to solve problems and solve various kinds of problem development and lead to misconceptions in students. (Marsita, Priatmoko and Kusuma 2010).

Unexpected findings were also obtained based on the level of cognitive development. The level of thinking aged 11 years and over is an elevated level of thinking. However, the reality is that grade I high school students aged 15-17 years of thinking level are still not at the formal level. This is indicated by the magnitude of the misconceptions in students on abstract chemical bonding material. According to Fadlan (2011), students whose thinking level is at the concrete operational stage will find it difficult to understand and often misunderstand something abstract. Other findings were also obtained that the questions were easy, which should be easy for students to answer correctly, but there were still students who had misconceptions. Vice versa, challenging questions for some students have no misconceptions because students can answer correctly.

To overcome the limitations imposed on misconceptions, further research is needed on the background to the occurrence of misconceptions, such as the teacher's teaching on the chemical bonding material and how to overcome the misconceptions that occur, one of which is by applying appropriate strategies with the material.

## CONCLUSION

Based on results obtained in this line of research, it was concluded that there were misconceptions that occurred in students of SMA Negeri 1 Class X Teluk Kuantan on chemical bonding material. The percentage of research results that occurred in students of SMA Negeri 1 Teluk Kuantan on chemical bonding material was 72.53% students have misconceptions. 14.98% students do not understand the concept, and 12.48% students understand the concept of chemical bonding material.

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