

## Analysis of Understanding Chemical Bond Concepts in Students with *Three-Tier Multiple Choice*

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### Abstract

One type of diagnostic test is a three-tier multiple choice, which is a test question in the form of choices consisting of three questions, the first part is about the concept of the topic, the second part is the reason refers to the first question, and the third part is the level of confidence in the two previous questions. Students' understanding of chemical bonding. The method used is descriptive with the research subject of 93 students of chemistry education. Data collection with 14 three-tier multiple choice test questions and analysis of students' level of understanding using the Certainty of Responses Index (CRI) technique. The results showed that the understanding of the concept of chemical bonds was very low at 29.50% and misconceptions at 62.77% in the high category. With high student misconceptions, it means that the concept of chemical bonds that they have is still not in accordance with the truth. Based on these findings, for teachers there needs to be special preparations and strategies to improve students' understanding of concepts, for example carrying out learning using methods that are in accordance with the characteristics of the material presented or by using appropriate learning media.

Keywords: CRI; chemical bond; three-tier multiple-choice; understanding concept

### Abstrak

Salah satu jenis tes diagnostik adalah three tier multiple choice yaitu soal tes berupa pilihan yang terdiri atas tiga bagian pertanyaan, bagian pertama tentang konsep materi, bagian kedua alasan merujuk pada pertanyaan pertama, dan bagian ketiga tingkat keyakinan terhadap dua pertanyaan sebelumnya. Penelitian ini bertujuan menganalisis tingkat pemahaman mahasiswa terhadap materi ikatan kimia. Metode yang digunakan adalah deskriptif dengan subjek penelitian mahasiswa pendidikan kimia berjumlah 93 orang. Pengumpulan data dengan 14 soal tes three tier multiple choice dan analisis tingkat pemahaman siswa menggunakan teknik Certainty of Responses Index (CRI). Hasil penelitian menunjukkan pemahaman konsep ikatan kimia sangat rendah yaitu 29,50% dan miskonsepsi 62,77% kategori tinggi. Dengan tingginya miskonsepsi mahasiswa berarti konsep ikatan kimia yang dimiliki masih tidak sesuai dengan sebenarnya. Penggunaan three tier multiple choice dengan teknik CRI mampu mengklasifikasi pemahaman konsep mahasiswa. Berdasarkan temuan ini, untuk pengajar perlu ada persiapan dan strategi khusus untuk meningkatkan pemahaman konsep mahasiswa, misalnya melaksanakan pembelajaran menggunakan metode yang sesuai dengan karakteristik materi yang disampaikan atau dengan menggunakan media pembelajaran yang sesuai.

Kata kunci: CRI; ikatan kimia; pemahaman konsep; three tier multiple choice

## Introduction

A person's understanding of a problem depends on the individual's thinking (Radiusman, 2020). Chemistry is a part of science that emphasizes understanding concepts. Conceptual understanding can be obtained from learning experiences during the learning process (Alighiri, Drastisianti & Susilaningsih, 2018; Novita, Mellyzar & Herizal, 2021). Students can be said to have understood the concept if they can explain the material that has been or is being studied using their language well. However, in the learning process, especially chemistry, many students do not understand the basic concepts. This is very influential on the continuation of the learning that will be followed. Errors that occur continuously on chemical concepts, make students experience conceptual errors or misconceptions (Febriani, Marfu'ah & Joharmawan, 2018).

The introductory study of chemistry is the study of the properties and structure of matter. The basic concept that students need in terms of studying the structure of a material is chemical bonds. Errors in chemical bonding material that are the roots of chemistry need to be analyzed, and find solutions to these problems, especially in terms of the lack of understanding of students' concepts (misconceptions). In addition, another factor that influences solving a problem is an experience (Herizal, 2020; Mellyzar, 2021). Students' mistakes in chemical bonding material are students do not understand how the stability of the electron configuration in an element; the bond mechanism; the polarity of compounds that are influenced by geometric shapes; the electronegativity value; the dipole moment resultant; how to write Lewis dot formulas for polyatomic molecules and ions, and how to determine the formal charge of each atom in the molecule and describe the structure of the Lewis resonance (Mellyzar & Muliaman, 2020).

Conceptual errors experienced by students are a serious concern for a lecturer who must have professional competence,

pedagogic competence, social competence, and personality competence (Ginting et al., 2020). More than 50% of students experiencing misconceptions about chemical bonding material (Fadillah & Salirawati, 2018). Misconceptions have been recognized as the main factor influencing understanding of the material, and teachers also have misconceptions about certain concepts (Utomo et al., 2018). Misconception can affect learning effectiveness and significantly impact learning achievement (Chen et al., 2020).

Chemical bonds are the basis for other advanced chemical sciences such as inorganic chemistry, organic chemistry, and physical chemistry (Gudyanga & Madambi, 2014). The solution that can be done to determine concept understanding is with a diagnostic test (Widiyatmoko & Shimizu, 2018).

A practical test instrument needs to be developed as an instrument for identifying errors in chemical concepts. One instrument that can be developed is a diagnostic test. The diagnostic test aims to determine student weaknesses and can be used as a basis for following up with appropriate treatment (Mutmainna, Mania & Sriyanti, 2018). 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 questions about the material concept, the second part contains reasons referring to the first question, and the third part is the level of student confidence in the two parts previous question (Adriani, Selaras & Yogica, 2019). The three-tier multiple-choice test instrument is very well used for analyzing the level of student understanding (Savira et al., 2019). Some of the advantages of the three-tier multiple-choice diagnostic test include diagnosing misconceptions in-depth experienced by students, knowing the material that needs in-depth explanation during learning, planning better learning in the future, and helping reduce student misconceptions (Mubarak, 2016). The three-tier multiple-choice diagnostic test and

providing information to lecturers regarding understanding student concepts can also determine the level of student confidence in the questions answered.

Technology as a learning media has been known for a long time. The use of technology as a medium for evaluating learning outcomes is still rarely done by educators. Nowadays, technology is very efficient to use, both for direct learning or distance learning. Diagnostic tests can be combined with computer, laptop or smartphone media that can be accessed anywhere. Online evaluation is also more efficient than the use of paper and pen. In addition to the online test, the process of checking answers is also faster than in writing (Halim et al., 2018). The platform that can be used to conduct online tests is Google Form. The use of this platform is easy to do and effective (Rahardja, Lutfiani & Alpansuri, 2018).

This study aims to identify students' conceptual understanding in mastering chemical bonding material by using an instrument in three-tier multiple-choice diagnostic test questions based on Google Form.

**Table 1**  
*Expert Validator Assessment Criteria*

Percentage Range	Criteria
81.25% < score = 100%	Very good
62.50% < score = 81.25%	Good
43.75% < score = 62.50%	Fair
25.00% < score = 43.75%	Poor

(Sudijono, 2018)

To classify students into understanding concepts, not understanding concepts and misconceptions, it employed the technique for measuring student confidence in answering each question using CRI (Certainty of Responses Index). The level of student confidence was reflected in the scale given for each question (A'yun, Harjito & Nuswowati, 2018). The level of confidence using CRI can be seen in Table 2.

Provisions on the possibility of students answering multiple-choice questions were with open reasons using the

## Research Method

This research was conducted at the Chemistry Education Study Program, Malikussaleh University. The research subjects were 93 students consisting of 4 classes, namely A1, A2, A3 and A4. The research method used was a qualitative description by describing the research data obtained.

The instrument used was a three-tier multiple-choice test for chemical bonding based on Google Forms, and the questions can be accessed at <http://bit.ly/jualfinalikatankimia>. Good questions were validated before being used (Utomo, 2019). The questions were developed by researchers and validated by five expert lecturers. The validators were the lecturers who teach Basic Chemistry, Chemical Bonds and Inorganic Chemistry courses. The test questions that were compiled consisted of 14 questions that were developed from chemical bond indicators. The criteria for assessing the item instruments by expert validators can be seen in Table 1.

CRI modification technique. Students who answered correctly and were sure of their answers on the three-tier test indicate that they understand a specific concept. The students who believed in the answer even though the answer is wrong indicates that they have misconceptions. In contrast, the students who answered incorrectly and were unsure of the answer do not mean that they experience misconceptions but a lack of knowledge (Nurhayati, Al Sagaf & Wahyudi, 2019). The assessment criteria using the CRI technique can be seen in Table 3.

**Table 2**  
*Confidence Level Scale with CRI Technique*

Index	Explanation
0	<i>Almost guess</i> (if in answering the question, the percentage of guessing is between 75-99%)
1	<i>Not sure</i> (If 50%-74% of students answer the question by guessing)
2	<i>Sure</i> (if 25%-49% of students answer the question by guessing)
3	<i>Almost certain</i> (if 1%-24% answered the question by guessing)
4	<i>Certain</i> (if 0% of students answer the question by guessing)
5	<i>Total guess the answer</i> (if 100% guessing)

**Table 3**  
*Assement Criteria with CRI Modification Technique*

Answer Criteria	Reason	CRI Index	Explanation
Correct	Correct	$\geq 2.5$	Understand the concept
Correct	Correct	$\leq 2.5$	Understand the concept Less sure
Correct	Incorrect	$\geq 2.5$	Misconception
Incorrect	Correct	$\geq 2.5$	Misconception
Incorrect	Incorrect	$\geq 2.5$	Misconception
Correct	Incorrect	$\leq 2.5$	Do not understand the concept
Incorrect	Correct	$\leq 2.5$	Do not understand the concept
Incorrect	Incorrect	$\leq 2.5$	Do not understand the concept

The stages of data analysis technique used include: (1) analyzing students' answers between the results of multiple-choice, reasons, and the level of confidence in the answers according to the category of understanding level in the three-tier multiple choice (2) classifying the categories of answers into understand, do not understand, and misconceptions, (3) calculate the percentage of misconceptions experienced in each item, (4) draw conclusions from the data obtained in the form of a profile of misconceptions and the percentage of misconceptions. The category of level of misconception (percentage) 0-30 (low), 31-60 (moderate), 61-100 (high) ( Halim et al., 2017). According to Sudijono, the average percentage of students' understanding levels were analyzed by categorizing them into five categories, namely 30-45 (fail), 46-55 (poor), 56-65 (fair), 66-79 (good), 80-100 (very good) (Vellayati et al., 2020).

## Results and Discussion

The questions that researchers have developed were based on the indicators in the chemical bond course. The questions were arranged according to the three-tier multiple-choice diagnostic test criteria based on Google Form. The results of expert validation of the test items can be seen in Figure 1.

Based on the results of expert validation, the questions are included in the very good criteria and can be used for research. Analysis of students' conceptual understanding was carried out with a description for each indicator and item. The level of conceptual understanding is categorized into understanding the concept (PK), understanding the concept but not sure (PKKY), misconception (M) and not understanding the concept (TPK).

**Figure 1**

Chart of Item Validation Results

**Table 4**

Level of Concept Understanding of Student on Indicator 1

Indicator 1: The Role of Electrons in Bond Formation				
Class	Percentage of Concept Understanding Level			
	PK	PK	PK	PK
A1	15.15	15.15	15.15	15.15
A2	50.00	50.00	50.00	50.00
A3	36.84	36.84	36.84	36.84
A4	90.48	90.48	90.48	90.48
Average	48.11	48.11	48.11	48.11

The questions for this indicator are: *In the Lewis structure  $H_2SO_4$ ,  $NH_3$ ,  $PCl_5$ , how many electrons are involved in a row? The answer to this question is 32, 8, 40.* The correct answer is that *the primary electrons that play a role in chemical bonds are electrons in the outer shell* (Petrucci & Suminar, 1999). The percentages of the four classes for indicator 1, namely the role of electrons in forming chemical bonds, can be seen in Table 1. Analysis of student answers

with an overall percentage of 48.11% understanding the concept, 0.76% understanding the concept but not sure, 42.54% misconception, and 8.59% do not understand the concept. Based on the percentage analysis of the answers to indicator 1, the student's level of understanding of the concept of the role of electrons in the formation of chemical bonds is in the moderate category, and the criteria for the misconception is moderate.

**Table 5**

Level of Concept Understanding of Student on Indicator 2

Indicator 2: Ionic Bond Formation				
Class	Percentage of Concept Understanding Level			
	PK	PKKY	M	TPK
A1	15.15	6.06	72.72	6.06
A2	25.00	0.00	67.50	7.50
A3	13.16	2.63	81.58	2.63
A4	15.11	2.17	78.67	4.05
Average	17.10	2.72	75.12	5.06

The questions for indicator two consists of two questions. The first question is: *forming ionic bonds between Mg and Cl, the number of released and accepted electrons and the charge that each ion can form is (Atom No Mg = 12; Cl = 17)*. The answer to this problem is that *Mg loses 2 electrons to form a +2 ion, and Cl gains 1 electron to form a -1 ion*. The right reason for this answer is that *the bond formation between Mg and Cl occurs because it only transfers electrons, thus encouraging positive ions and negative ions* (Yustin & Wiyarsi, 2019). The second question is: *Among the following groups of compounds, there are ionic and covalent bonds in one compound at the same time...* The answer to this question is *NH<sub>4</sub>Cl, CaC<sub>2</sub>, Na<sub>2</sub>O<sub>2</sub>*. This answer is that *ionic bonds occur due to the transfer of electrons while covalent bonds occur because of the sharing of electrons* (Syukri, 1999).

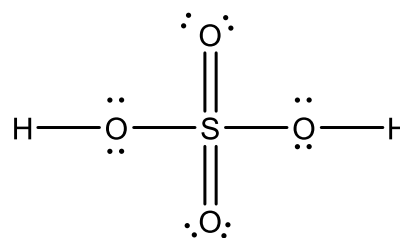
Based on table 5, the overall percentage is 17.10% understand the concept, 2.72% understand the concept but

are not sure, 75.12% have misconceptions, and 5.06% do not understand the concept. Based on this percentage, the level of understanding of students regarding the formation of ionic bonds is very low (failure), and the level of misconception is in the high category. Based on the analysis of students' answers regarding the formation of ionic bonds, they still assume that ionic bonds only occur between metal atoms and non-metal atoms. In the NH<sub>4</sub>Cl molecule with non-metallic constituent atoms, they assume that the molecule is only covalently bonded. Students fail to understand ionic bonds, which only assume that the bond consists of metal with a non-metal, even though there are exceptions to the concept of ionic bond formation, where not all ionic bonds are formed from metals and non-metals such as BeCl<sub>2</sub>, compounds, where Be is metal and Cl is a non-metal, but the type of bond in this molecule is covalent (Prodjosantoso, Hertina & Irwanto, 2019)

**Table 6**  
*Level of Concept Understanding of Student on Indicator 3*

Indicator 3: Formation of Covalent Bonds				
Class	Percentage of Concept Understanding Level			
	PK	PKKY	M	TPK
A1	24.24	3.03	66.67	6.06
A2	55.00	0.00	40.00	5.00
A3	21.05	0.00	68.42	10.53
A4	4.76	0.00	95.24	0.00
Average	26.26	0.76	67.58	5.40

The understanding of concepts in indicator three with an average percentage of 26.26%, is included in the very low category (failure). Students' misconceptions are high, with a percentage of 67.58%. *The question of indicator 3 is Consider the following H<sub>2</sub>SO<sub>4</sub> structure:*



*The bond that occurs between atoms in the above structure is. The answer to this question is covalent bonds because of the electron sharing among atoms* (Nordholm & Bacskay, 2020). The high level of

misconceptions is caused by students not distinguishing between bonds between atoms and bonds between molecules. From the structure of  $\text{H}_2\text{SO}_4$ , there is a bond between H and O atoms. Most students think that the structure is a hydrogen bond. They

already know the mechanism of the formation of covalent bonds, namely the sharing of electrons between atoms. In comparison, hydrogen bonds occur among molecules (Vinsiah & Fadhillah, 2018).

**Table 7**  
*Level of Concept Understanding of Student on Indicator 4*

Indicator 4: Metal Bond				
Class	Percentage of Concept Understanding Level			
	PK	PK	PK	PK
A1	24.24	24.24	24.24	24.24
A2	15.00	15.00	15.00	15.00
A3	10.53	10.53	10.53	10.53
A4	9.52	9.52	9.52	9.52
Average	14.82	14.82	14.82	14.82

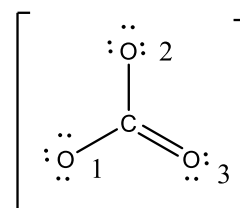
Overall, the percentage of understanding of the concept of indicator 4, which is 14.82%, means that students' understanding is very low (failed). The level of misconception is high, with a percentage of 78.04%. The question of indicator 4 is *Some metals are presented, including Aluminum (Al), Sodium (Na) and Magnesium (Mg). The order of metals from the highest boiling point is.* The correct answer is *Al, Mg, Na*. The answer is the number of valence

electrons that affect the strength of metal bonds. The more electrons a metal can release, the higher the density of the electron cloud/sea and the stronger the metallic bond. From the students' answers, most answered the order of metals based on boiling point elevation but could not relate to the type of bond among atoms. Metallic bonding occurs due to electrostatic forces between metal cations and delocalized electrons (Cheng & Oon, 2016).

**Table 8**  
*Level of Concept Understanding of Student on Indicator 5*

Indicator 5: Formal Charge				
Class	Percentage of Concept Understanding Level			
	PK	PK	PK	PK
A1	27.27	27.27	27.27	27.27
A2	22.50	22.50	22.50	22.50
A3	5.26	5.26	5.26	5.26
A4	7.14	7.14	7.14	7.14
Average	15.54	15.54	15.54	15.54

The percentage of student's level of understanding of the concept of formal content indicators is very low, i.e. 15.54% and students' misconceptions with high criteria, i.e. 75.80%. The question of indicator5: *Consider the Lewis structure of the following carbonate ion:*



The formal charge of each constituent atom is... The correct answer is  $C = 0$ ;  $O(1) = -1$ ;  $O(2) = -1$ ;  $O(3) = 0$ . The answer is that the formal charge is the charge that will appear on the atoms in the Lewis structure, which is used to determine the most reasonable bond arrangement (Petrucci et al., 2011). Next question: *The most plausible Lewis structure of NOCl is... (Atomic No = 8; Cl = 17; N = 7).*

The correct answer is  $\ddot{O}=\ddot{N}-\ddot{Cl}:$  that the correct NOCl structure with the formal charge of each atom equals zero (Petrucci & Suminar, 1999). The formal charge can also be defined as the charge on an atom in a molecule or ion, assuming that the electrons in all chemical bonds are shared equally between the atoms (Welsh & Allison, 2019).

**Table 9**  
*Level of Concept Understanding of Student on Indicator 6*

Indicator 6: Compound Polarity				
Class	Percentage of Concept Understanding Level			
	PK	PKKY	M	TPK
A1	15.15	9.09	60.61	15.15
A2	5.00	5.00	80.00	10.00
A3	36.84	5.26	53.63	5.26
A4	80.95	0.00	19.05	0.00
Average	34.48	4.84	53.07	7.60

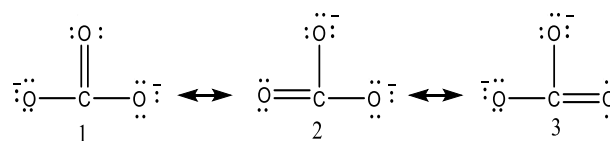
For the indicator of compound polarity, the percentage of students who understand the concept is 34.48%, with the category of very poor (fail) and 53.07% (moderate) misconceptions. The question for this indicator is to *identify the most polar bond*. The correct answer is *the difference in electronegativity of two different atoms*

*forming a bond. The electron pair is pulled towards the atom with a higher electronegativity to form partly negative and partly positive* (Brady, 1999). The concepts of electronegativity and polarity go hand in hand (Danckwardt-Lillieström, Andrée & Enghag, 2020)

**Table 10**  
*Level of Concept Understanding of Student on Indicator 7*

Indicator 7: Resonance				
Class	Percentage of Concept Understanding Level			
	PK	PKKY	M	TPK
A1	66.67	6.06	24,4	3.03
A2	35.00	0.00	55.00	10.00
A3	36.84	5.26	47.37	10.53
A4	85.71	0.00	14.29	0.00
Average	56.06	2.83	35.22	5.89

The question of indicator 6 is:  
*Pay attention to this structure:*



*The correct Lewis Structure of  $CO_3^{2-}$  is. The answer to this question is numbers 1, 2, and*



3. The reason is that the structure is resonance; it can describe more than one Lewis structure (Chang, 2004). The percentage of students' conceptual understanding of the concept for the resonance indicator is in the sufficient category with a percentage of 56.06%, while the misconception is 35.22% in the

moderate category. Resonance is one of the difficult materials for students to understand. This material is the basis because it affects the structure, reactivity, and physical properties of organic compounds (Betancourt-Pérez, Olivera, L. J., & Rodríguez, 2012).

**Table 11**

*Level of Concept Understanding of Student on Indicator 8*

Class	Indicator 8: Bentuk Molekul			
	Percentage of Concept Understanding Level			
	PK	PKKY	M	TPK
A1	37.88	3.03	56.06	3.03
A2	35.00	10.00	55.00	0.00
A3	21.05	2.63	73.68	2.63
A4	42.86	0.00	57.14	0.00
Average	34.20	3.91	60.47	1.42

The questions for this indicator are: *Among the following ions that have a trigonal planar shape are. (A)  $SO_3^{2-}$  (B)  $PO_4^{3-}$  (C)  $PF_6^-$  (D)  $CO_3^{2-}$  (E)  $NO_2$ .* The answer to this question is  $CO_3^{2-}$ . The answer is that it occurs in a structure with three bonding electron domains and no free electron domain on the central atom (Petrucci et al., 2011). The student's misconception for this problem is to look only at the number of terminal atoms bonded to the central atom. Some students answered  $SO_3^{2-}$  without paying attention to (remembering) the VSEPR theory that there are lone pairs of electrons in the structure of the ion. Then, the next question is what *the molecular shape for  $XeF_4$  and  $CCl_4$  is.* The answer to this question is *a flat quadrilateral and a tetrahedral.* This answer in  $XeF_4$  is that

*there are four pairs of bonding electrons and two pairs of lone electrons, while in  $CCl_4$ , there are four pairs of bonding electrons.* Students were a mistake on the  $CCl_4$  and  $XeF_4$  molecules with the assumption that they have the same structure.

Analysis of student answers to the questions for indicator eight resulted from the overall percentage of 34.20% understood the concept, 3.91% understood the concept but was not sure, 60.47% had misconceptions, and 1.42% did not understand the concept. From this percentage, the level of understanding of the concept of form owned by students is included in the sufficient category, and the criteria for misconceptions is moderate.

**Table 12**

*Level of Concept Understanding of Student on Indicator 9*

Class	Indicator 9: Hybridization			
	Percentage of Concept Understanding Level sep			
	PK	PKKY	M	TPK
A1	19.70	4.55	74.24	1.52
A2	27.50	5.00	67.50	0.00
A3	18.42	5.26	73.68	2.63

A4	16.67	0.00	83.33	0.00
Average	20.57	3.70	74.69	1.04

The percentage level of understanding of the concept of hybridization is 20.57%, with a very low category (fail) and high misconception criteria is 74.69%. The questions for this indicator are: *The hybrid orbitals for PCl<sub>3</sub> and PCl<sub>5</sub> are. The correct answer is that sp<sup>3</sup> and sp<sup>3</sup>d because the number of orbitals containing electron pairs*

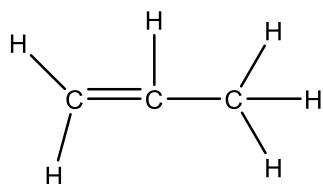
*for PCl<sub>3</sub> is smaller than for PCl<sub>5</sub>. The next question is what Molecules with sp<sup>3</sup> hybrid orbitals are. The answer is NH<sub>3</sub> because one s orbital and three p orbitals combine to produce a new set of hybrid orbitals consisting of four hydride orbitals. In NH<sub>3</sub>, there are only p orbitals involved in hybridization (de Farias, 2017).*

**Table 13**

*Level of Concept Understanding of Student on Indicator 10*

Class	Indicator 9: Pi Bonds and Sigma Bonds			
	Percentage of Concept Understanding Level			
	PK	PKKY	M	TPK
A1	15.15	3.03	81.82	0.00
A2	15.00	15.00	70.00	0.00
A3	5.26	10.53	84.21	0.00
A4	76.19	0.00	23.81	0.00
Average	27.90	7.14	64.96	0.00

The percentage level of understanding of the concept of sigma ( $\delta$ ) and pi bond ( $\pi$ ) is 27.90% (fail), and the high category of misconceptions is 64.96%. The question for this indicator is: *Consider the following structure of propene:*



*The number of sigma bonds ( $\delta$ ) and pi bonds ( $\pi$ ) of the above structure is. The answer to this question is eight sigma bonds ( $\delta$ ) and one pi bond ( $\pi$ ) because overlapping orbitals (ends) result in sigma bonds while overlapping (sides) of two parallel orbitals results in pi bonds.*

**Table 14**

*Students' Understanding Level for All Indicators*

Class	Percentage of Concept Understanding Level			
	PK	PKKY	M	TPK
A1	26.06	4.70	63.03	6.21
A2	28.50	3.50	60.75	7.25
A3	20.52	3.16	70.89	5.53
A4	42.94	0.22	56.44	0.41
Average	29.50	2.89	62.77	4.84

The concept of bonds among atoms or molecules is quite abstract and far from everyday experience, so that it becomes difficult for students. However, as much as possible, this basic concept must be remembered to make it easier to master other chemistry materials (Pérez et al., 2017). Based on the calculation results of ten indicators, the test was able to classify the level of understanding of chemical bonding material, which was only 29.50% of students who understand chemical bond concepts and 62.77% experience misconceptions. This research is also able to explore the weaknesses of students in understanding the concept. The three-tier multiple-choice diagnostic test is an instrument to determine the level of conceptual understanding and identify misconceptions (Desfandi et al., 2020).

### Conclusion

The level of understanding of students' concepts on chemical bonding material is still very low, with a percentage of 29.50%, and a high percentage of misconceptions reached 62.77%. With high student misconceptions, it means that the concept of chemical bonds they have is still not in accordance with the truth. Based on these findings, both teachers and lecturers need to have special preparation and strategies to improve students' conceptual understanding, for example, carrying out learning using methods that are in accordance with the characteristics of the material presented or by using appropriate learning media.

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