Analysis of student difficulties based on respondents ability test on the topic of geometry molecules

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Abstract. In this research, the comprehension levels and students difficulties on the subject of molecular geometry were determined via respondents ability test. This test consist of five items designed specifically to detect what the students think. One problem has several options, each of which has an indicator of learning difficulty so that when the student selects one of these options, the researcher can immediately detect the difficulties that the student has. The students answer comes with a reason to avoid guess answers. The test was applied on 52 students of grade X. Analysis of test results using descriptive qualitative analysis. According to the findings obtained from the test, the students had numerous difficulties. It was found there are 7 kinds difficulties in geometry molecules material. The top three difficulties experienced by students are (1) 71% of students do not understand the meaning of the symbol of lewis where students describe in the form of covalent bonds; (2) 65% of students do not understand the influence of free electron pairs at geometry molecules; 31% of students do not understand the various types of geometry molecules when given the problem of placing between the name and geometry of the molecules. These results shown that students still do not understand the basic concept of geometry molecules, so that it is required further investigation to find out how to overcome student learning difficulties on the topic of geometry molecules.

1. Introduction
Chemistry is a field of science that emphasizes the mastery of concepts. In the learning process, concepts are things that need to be understood, studied and mastered by students. Chemical concepts form within students gradually through their experiences and interactions with the natural surroundings [1]. Chemistry is the study of the structure of matter, the properties of matter, the transformation of matter into other matter, and the energy that accompanies the change of matter [2]. Chemistry is classified as a difficult subject. Kean and Middlecamp say that one of the characteristics of chemistry is abstract, sequential and tiered. This means that understanding more complex chemical concepts requires a correct understanding of the underlying concepts. If students have difficulty on one of the basic concepts, then there is the possibility of students having difficulty with more complex concepts. Understanding improper concepts can lead to students’ misconceptions [3].

In chemistry, research on student understanding and misconceptions has been conducted in several conceptual areas [4, 5] Recent studies have been carried out about misconceptions of covalent bonding and structure [6, 7]. Research has shown that some alternative conceptions are resistant to instruction, even when teaching is aimed explicitly to produce conceptual changes [8]. These require more intense study to take into account not only the students' previous ideas and knowledge of the topic but also the ways of reasoning they use to form their constructions [9]. In chemistry teaching the difficulties of
learning should be clarified in order to extend the meaning of these not only to conceptual obstacles but also to reasoning difficulties that are based on a "common sense methodology [10. 11]. knowing students' learning difficulties in a material, teachers can design an innovative learning to overcome student learning difficulties and improve learning quality.

Geometry molecular is an important subject in comprehending the substance correctly since it has a significant role in the determination of the physical and chemical properties of a molecule [12. 13]. Based on the results of interview with chemistry teacher of one high school in Bandung found that one of the chemical topics that are considered difficult is geometry molecules. Geometry molecules is an essential material because based on the analysis of the last 5 years final exam from 2012-2016, the question of this topic always appears. Students still memorize in the process of learning geometry molecules. Students are required to memorize molecular types to determine the shape of the molecule. For example if the molecular type is AX2E, then the molecular form is trigonal pyramid. This tends to make the students only memorize without understanding why the molecular shape of the trigonal pyramid and what is the effect of the electron pair on the molecular shape. Difficulties can occur due to teachers tend to encourage students to memorize the concept with the pattern of learning in the form of delivery of knowledge from teacher to student.

Research about geometry molecules has been done by many researchers. The results of research conducted by Furio [14] showed that the majority of the misconceptions occurring can be explained by the difficulties of three-dimensional visualization and, in particular by methodological obstacles as supposed in the main hypothesis. So some perceptive difficulties are those in which the students confuse the arrangement of electron pairs and molecular shape. Another procedural difficulty is the functional fixedness of Lewis structure by which the students suppose that the molecular shape is the same as the Lewis structure. Polarity is a much more difficult concept for students to apply than molecular shape. Some of the misconceptions about the polarity of the molecule are based on ways of common sense reasonings, such as functional reduction. Students exhibiting this have identified bond polarity as a variable but have not considered the influence of molecular shape. Or students have only considered the molecular shape without taking into account the nature of attached atoms. The purpose of this research is to obtain information about student's difficulties and level of students' understanding on the topic of geometry molecules.

2. Methods
The research was conducted at one of the high schools in Bandung, Indonesia. The subject is 52 students of grade X MIPA. The subject selection is based on input from the chemistry teacher. This study uses a test method that is pencil based test to determine the difficulties of students in learning the geometry molecules. Test that will be used is a test of the ability of the respondent. The test is an objective problem consists of five specially designed to detect what students think. So the results of the test can identify barriers to student learning. One question has several options (not have to be 4 or 5 options), which each of these options has an indicator of learning barriers so that when students choose one of these options, researchers can directly detect obstacles belonging to students. Answer students come with a reason to avoid the guessing answer. Data analysis of research result is done by descriptive qualitative. Qualitative analysis is done to know the students understanding about geometry molecules.

3. Result and Discussion
Based on the results of the analysis of student answers on the question number one, it is known that students have obstacles in understanding the meaning of the structure of lewis. This is because students have not understood the meaning of the symbol or the correct structure of lewis. According to Petrucci, the lewis symbol expresses the valence electrons of an atom using dots placed around a chemical symbol. The lewis structure is a combination of the lewis symbols used to express chemical binding [15]. Of the seven obstacle indicators in determining the structure of lewis, found the three difficulties most experienced by students. First, students describe the structure of lewis in the form of covalent bonds. Second, there are students who experience obstacles in determining valence electrons in atoms. The students suppose that the molecular shape is the same as lewis structure. Finally, there are students
who describe the structure of lewis in the form of its molecular geometry. The following is a sequential snippet of answers to students who experienced these three difficulties.

Students describe the structure of lewis in the form of covalent bonds

Students describe the structure of lewis in its molecular geometry

The Lewis structure selected by the students lacks valence electrons in central atoms

**Figure 1.** Sample student answers to question number one.

On the question number two, students are asked to pair between names and molecular geometry. In this case, the researcher gives more than one correct answer. Almost all students can pair it, most students correctly answer the geometry of the octahedral molecule. There are some errors when students do not select the molecular shape of tetrahedral and trigonal pyramids as shown in Figure 2. This can be due to the students' lack of careful reading of the questions or, they do not understand the shape of tetrahedral and trigonal pyramids.

**Figure 2.** Sample student answers to question number two.
Furthermore, question number three students are asked to determine the angle of the given geometry molecules name. In this case the students not only determine the angle but also must be able to determine the molecular geometry of the given name. Here’s a snippet of student answers (Figure 3).

![Figure 3. Sample student answers to question number three.](image)

There are seven out of 26 students who experience obstacles, it can be said that more than half of students are able to determine the angle of molecular geometry. Difficulties arise because students cannot visualize the angle formed from the given geometry. Students who study chemistry seem to experience difficulties visualizing the structure of matter in terms of a particulate model [16]. The difficulties are due to the abstract, unobservable, particulate basis of chemistry and the need for rapid transfer among the three levels of thought—the macroscopic, submicroscopic and symbolic[17, 18].

At number four students are asked to pair between the hybridization and the molecular form of the CH₄ compound. It is expected that students are able to use hybridization theory to determine the shape of the molecule. There were 10 students who experienced resistance to determining the molecular shape based on the hybridization theory. At the time of the hybridization determination process, they find sp³, but they give trigonal planar names because they think there are three bonded atoms. This is because students have not understood how to determine the name of geometry molecules based on the hybridization theory. Here is a snippet of student answers on question number four (Figure 4).

![Figure 4. Sample student answers to question number four.](image)

Next on the number five that aims to see the student's resistance in the influence of free electron pairs on the shape and angle of the molecule. Here the researchers present two compounds that share three bonded atoms, but have different central valence electrons, BF₃ and NH₃. Many students experience obstacles to this problem. They assume because there are three bonded atoms, the two compounds have the same angular and molecular shape (Figure 5). This is because, students do not understand the effect of free electron pair repulsion is greater than the pair of electron binding. So that will change the shape of the molecule and will reduce the angle of a molecular geometry.

![Figure 5. Sample student answers to question number five.](image)
The test was applied on 52 students of grade X. Here is the result of the percentage of students' obstacles in solving TKR problems.

**Table 1.** Percentage of students that experience difficulties.

| Question Number | Indicator of student difficulty                                                                 | Percentage of students (n = 52) |
|-----------------|-----------------------------------------------------------------------------------------------|-------------------------------|
| 1               | Students do not understand the meaning of the symbol of lewis students describe in the form of covalent bonds | 71.2 %                        |
| 1               | Students do not understand the meaning of the symbol of lewis students describe in the form of molecular geometry | 5.8 %                         |
| 1               | Students do not understand the precise formation of valence electrons to illustrate the structure of lewis | 7.7 %                         |
| 1               | Students do not understand the various types of molecular forms                                  | 31.0 %                        |
| 2               | Students do not understand to determines the proper angle of molecular geometry                  | 15.0 %                        |
| 3               | Students do not understand in determining the shape of molecules based on hybridization theory   | 27.0 %                        |
| 5               | Students do not understand the effect of free electron pairs on the angle and shape of the molecule | 65.0 %                        |

**4. Conclusion**

Based on the results of the study it can be concluded that students are still experiencing difficulties in the basic concept of determining the shape of molecules. This will discourage students from understanding the concept of molecular form and hampering students to solve more complex problems. The most common obstacles are (1) 71% of students do not understand the meaning of the symbol of lewis where students describe in the form of covalent bonds; (2) 65% of students do not understand the influence of free electron pairs at geometry molecules; 31% of students do not understand the various types of geometry molecules when given the problem of placing between the name and geometry of the molecules.

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