CHEMISTRY EDUCATION PRACTICE

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# IDENTIFICATION OF STUDENT MISCONCEPTIONS USING A THREE-TIER TEST ON THE CONCEPT OF ATOMS, IONS, AND MOLECULES

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**Abstract**

This research aims to identify misconceptions of the grade ninth students at MTs Al-Ishlahuddiny Putra Kediri Lombok using a three-tier test on the concept of atoms, ions, and molecules. This type of research is descriptive qualitative. The population in this study was class IX students at MTs Al-Ishlahuddiny Putra Kediri, consisting of 216 students. Sampling was carried out using a random sampling technique using the Slovin formula, and a sample of 68 students was obtained. The instrument used in this research is the three-tier test instrument by Riana Dewi Astari and has been validated using product moment correlation. The research results showed that the average percentage of students who experienced misconceptions was 23%, classified as low. Most students need clarification regarding the connection between the concept of compound molecules and elements and the concept of ions that release and receive electrons. Factors that cause misconceptions among students are the gap between preconceptions and concept assimilation, the objects being studied being abstract or difficult for students to understand, and the incompleteness of the information students receive during learning.

**Keywords**: misconceptions, three-tier test, atomic, ion, and molecular concepts

## INTRODUCTION

The science subjects taught at the junior high school level contain chemistry topics. One of the goals of science lessons in junior high schools is for students to have the ability to understand various natural phenomena, concepts, and principles of science (Suryawati & Osman, 2017). Students can apply these abilities in everyday life so that science knowledge, concepts, and skills increase as a basis for continuing to further education. Assessment and learning of chemistry, especially at the junior high school level, must pay attention to students' mastery of concepts because, at this level, students begin to recognize abstract concepts (BSNP, 2006).

The concept of chemistry, an abstract concept, requires good student understanding in learning (Ardiansyah, 2014). One of the basic concepts of abstract chemistry is atoms, ions, and molecules, which cannot be seen directly in everyday life, both in structure and in the form of reactions. The concepts of atoms, ions, and molecules emphasize defined concepts and include microscopic ones. Therefore, some students need help building their understanding, resulting in errors in students' understanding of concepts (Wisudawati, 2015).

Understanding concepts aims to see someone's thinking, seeing what is known and how to think about information that is built, organized, stored, retrieved, and manipulated. In this way, students can be said to understand or comprehend when the construction or development of their thoughts is by concepts in scientific science. Understanding can cause students to have meaningful learning about a concept; with meaningful learning, students can choose new knowledge following experts' concepts. Meaningful learning is obtained by students in several stages (Jonassen et al., 1998).

The first stage comes from student knowledge, knowledge obtained from the process of assimilation (seeing, hearing, and feeling), and accommodation as a combination of several pieces of information obtained regarding a concept. After knowledge has been formed, students initially understand a concept before formal learning occurs, which is called preconceptions. However, perceptions often originating from initial knowledge are not by scientific theory, resulting in an imbalance that can cause misconceptions (Jufri, 2017).

According to Suparno (2005), misconceptions are concepts that do not follow scientific understanding or understanding accepted by scientists in the relevant field, so misconceptions in one material can also cause misconceptions in subsequent material. There are five causes of misconceptions: students, teachers, textbooks, context, and teaching methods. Research by Kusumawati et al. (2014) also found the causes of misconceptions in students: associative thinking, wrong initial preconceptions, wrong intuition, and students' abilities. Misconceptions can also be defined as misunderstandings or in the form of alternative concepts. The source of alternative concepts is the same as misconceptions: they can come from students, society, reading sources, and teachers. Alternative concepts can be an important inhibiting factor for students and teacher references in science learning and teaching (Osborne & Freyberg, 1985).

Misconceptions experienced by students are very difficult to change because the knowledge students have built is the same as their experience. Once students' knowledge has been built, it is not easy to be told that something needs to be fixed if only told to change the misconception that occurs. Students' misconceptions can be changed by constructing new concepts that are more appropriate to explain (Bodner, 1986). In line with this, Suparno (2005) said that symptoms of misconception, according to constructivism, are a normal thing in the process of formation by someone in learning. However, handling student misconceptions must be addressed so they avoid spreading errors in subsequent material. Students construct knowledge by connecting knowledge gained from school and everyday life. The formation of incomplete student knowledge can occur during the construction process because the student's abilities are limited, or the knowledge gained has been mixed with other ideas that have happened to be experienced. Construction of understanding carried out by students can train students to build a correct understanding of concepts. The problem of misconceptions is more serious than students who do not understand the concept. If students do not understand the concept, it will be easy to form concepts in the student's cognitive structure. Students who experience misconceptions can be said to have the wrong path to the actual concept, so more effort is needed to straighten out the wrong understanding of the concept.

Identifying misconceptions can be done in various ways, including interviews, concept maps, essay tests, multiple-choice tests with reasons, in-class discussions, and practicums accompanied by questions and answers. The three-tier test instrument can be used as a tool to identify students' understanding of concepts in the form of multiple choice questions with three levels: the first level is material questions, the second level questions about the reasons for answers from the first level, and the third level questions about students' confidence in answering (Suparno, 2005). The three-tier test instrument has the advantage that it can identify students' understanding of concepts easily and does not require a lot of time, and it can also determine the possibility of students who answer incorrectly because they have misconceptions (Daud et al., 2014). Pesman (2010) said that the three-tier test is a test instrument that is valid, reliable, and capable of identifying student misconceptions, so it can be said that the use of the three-tier test instrument is more effective for identifying misconceptions than ordinary multiple-choice tests.

Hamdil and Mukhlisin (2011) stated that there are misconceptions regarding atoms, ions, and molecules. One of the misconceptions that often occurs is defining the concepts of atoms, ions, and molecules. The concepts of atoms, ions, and molecules are crucial for students to understand because they are the basis for studying further chemistry material. Chemical material related to the concepts of atoms, ions, and molecules, namely element symbols, reaction equations, electrolyte and non-electrolyte solutions, simple compound nomenclature, stoichiometry, thermochemistry, and chemical bonds. If there are misconceptions about basic concepts, these misconceptions will hinder the relevant chemistry learning process (Anggraeni, 2018). The material on the concept of atoms, ions, and molecules is included in the science subjects taught to middle school class IX students

(Content Standards, Minister of Education and Culture of the Republic of Indonesia Regulation Number 22, 2016). The existence of atoms and molecules that cannot be seen directly in everyday life causes students to experience difficulties in building an understanding of concepts, especially as junior high school/MTs students are starting to be introduced to abstract concepts. The basic concepts that junior high school students understand are very important because they will be continued at a higher level of education where, at the next level, students must know these basic concepts.

## METHOD

This research was conducted in March 2023 at MTs Al-Ishlahuddiny Putra Kediri. This research uses a qualitative research approach with a descriptive type. Descriptive research is a research method that attempts to describe and interpret objects according to what they are (Sukardi, 2007).

The population in this study was all class IX students at MTs Al-Ishlahuddiny Putra Kediri, totaling 216 people. The technique used in sampling is random sampling. So, from 216 students, a sample of 68 people was obtained.

Instrument in this research uses a three-tier test instrument, which is a reference from Riana Dewi Astari in her thesis entitled "Development of the Three Tier Test as an Instrument in Identifying Misconceptions of the Concept of Atoms, Ions and Molecules" from UIN Sunan Kalijaga Yogyakarta in 2012. This test's validity and reliability were tested by validators, five peer reviewers, two expert lecturers from UIN Sunan Kalijaga and Yogyakarta State University, and five junior high school science teachers in Yogyakarta as reviewers. The quality of this three-tier test instrument as a tool for identifying student misconceptions regarding the concepts of atoms, ions, and molecules, which Riana Dewi Astari has developed, is based on the reviewer's assessment, namely Good with a score of 61.4 out of a maximum score of 75 so that the test can be used as a detector of understanding—students' concepts in this research.

The data collection technique in this research was carried out using two events, namely giving tests and interviews. Interviews were conducted to determine the level of understanding of students' concepts and determine the causes of misconceptions that occur in students. A test is a data collection instrument that is a series of questions or exercises used to measure knowledge skills, intelligence, abilities, or talents individuals or groups possess. In general, a test can be interpreted as a tool used to measure knowledge or assign measuring objects to a certain set of materials (Sudaryono et al., 2013).

The data analysis technique obtained from this research used descriptive data analysis. Based on the problem formulation that has been put forward, the data analyzed is student test result data—analyzing test results from students by checking the answers to the results of the three-tier tests carried out by students and adjusting them to the provisions to identify students' understanding of concepts.

The assessment and grouping of the three-tier instrument test results data was then analyzed and divided into two categories: quantitative and qualitative. In descriptive research, quantitative data is data in the form of numbers, and qualitative data is data in the form of words or symbols. The scoring guidelines for the three-tier test instrument are used to provide scores for either the first-level answer, reasons at the second level, or whether you are sure or not at the third level. Each correct answer at levels one and two is given a value of 1, while an incorrect answer is 0. At the third level, sure students are given a value of 1, and those who are unsure are given 0. The scoring criteria for the three-tier test instrument are in Table 1.

**Table 1**. Three-tier test instrument scoring criteria

| First Level | Second Level | Third Level |
|---|---|---|
| Correct (1) | Correct (1) | Sure (1) |
| Correct (1) | Correct (1) | Not Sure (0) |
| Correct (1) | False (0) | Sure (1) |
| Correct (1) | False (0) | Not Sure (0) |
| False (0) | Correct (1) | Sure (1) |
| False (0) | Correct (1) | Not Sure (0) |
| False (0) | False (0) | Sure (1) |
| False (0) | False (0) | Not Sure (0) |

(Astari et al., 2012)

Based on the data obtained for each student, the data was then analyzed based on Table 1 so that it could be see the percentage of students who understood the concept, understand the concept but not sure, had misconceptions, did not understand the concept, and guessed.

## RESULTS AND DISCUSSION

This research identifies misconceptions of class IX junior high school students about atoms, ions, and molecules using a three-tier test as the main instrument. The three-tier test was carried out in class IX of MTs Al-Ishlahuddiny Putra Kediri. The test was carried out in 2 classes taught by the same science teacher. Based on interviews with previous science teachers, the two classes have almost the same cognitive abilities. The choice of the ninth-grade junior high school as the research object was because the students in that class had good enthusiasm, so the science teacher recommended conducting research in that class.

Revalidation testing on the three-tier test instrument was carried out before the research was carried out. The validation used was product moment by testing the three-tier test instrument created by Riana Dewi Astari on 30 class XII students at MA Al-Ishlahuddiny Putra Kediri to determine the number of valid questions. Riana Dewi Astari's three-tier test instrument consists of 24 questions, then the appropriate questions are selected to become 16 questions, and after that, they are re-validated to obtain 14 questions. Data processing and validation test results were carried out statistically using Microsoft Excel 2013 software using the Product Moment Correlation (ri) formula so that 14 questions were declared valid. Based on the calculations, the value of rcount > rtable is obtained at a significance level of 5% with an rtable of 0.361 for the number (N) of 30 students. From the results of the indicator analysis, the concepts of atoms, ions, and molecules have been represented in valid questions so that invalid questions were not used in the research, so the number of questions tested in the research was 14 questions.

The results of research using the three-tier test instrument on class IX students at MTs Al-Ishlahuddiny Putra Kediri showed that the average percentage of students' understanding per question item was divided into five categories of degree of understanding, namely the category of understanding the concept (UC), understanding the concept, but not sure (NS), misconceptions (M), error or guessing (ER), and not understanding the concept (NUC) are shown in the percentage table of students' degree of understanding per question item in Table 2.

**Table 2**. Percentage of students' degree of understanding per question item (%)

| No. | Comprehension Category | | | | |
|---|---|---|---|---|---|
| | **UC** | **NS** | **M** | **ER** | **NUC** |
| 1. | 67 | 7 | 16 | 8 | 0 |
| 2. | 61 | 8 | 16 | 11 | 0 |
| 3. | 60 | 4 | 20 | 15 | 0 |
| 4. | 47 | 10 | 23 | 16 | 1 |
| 5. | 55 | 7 | 18 | 19 | 0 |
| 6. | 50 | 7 | 27 | 13 | 1 |
| 7. | 52 | 10 | 22 | 13 | 0 |
| 8. | 51 | 10 | 29 | 9 | 0 |
| 9. | 58 | 5 | 20 | 13 | 0 |
| 10. | 54 | 9 | 18 | 19 | 0 |
| 11. | 50 | 9 | 32 | 4 | 0 |
| 12. | 55 | 10 | 15 | 18 | 1 |
| 13. | 45 | 7 | 26 | 18 | 3 |
| 14. | 44 | 12 | 37 | 7 | 0 |
| Average | 54% | 8% | 23% | 13% | 0% |

Table 2 shows the average percentage of understanding misconceptions is 23%. This percentage figure is classified as low compared to the average percentage in the concept understanding category, namely 54%, which is classified as high. Other categories of not understanding the concept obtained an average percentage of 8%, the guessing category was 13%, and the category of not understanding the concept was 0%. The average percentage of concept understanding results is quite good, which means that most of the concepts have been understood by students. However, there are still things that need to be clarified among some students and some concepts from the concept of atoms, ions, and molecules. The percentage of 23% was then analyzed further to find out where the misconceptions that occurred among students were used as evaluation material for the students themselves or subject teachers so that in the future, the percentage of students who experience misconceptions can be reduced both for the concept of atoms, ions and molecules or materials. which will be discussed next.

The next research was carried out by taking three students as samples to analyze the misconceptions experienced by each student by interviewing them based on the test answers they had taken. Interviews with students were conducted to find out the

misconceptions that occurred in students after taking the tests given to find out the causes of the misconceptions experienced by these students. The category of understanding the misconceptions of the three students is based on the test results, namely students with the percentage of the misconception category with the lowest score, namely 0%, which is classified as low; the percentage of the middle score is 28%, and the highest percentage of misconceptions is 57%.

Based on the interviews with three selected students, it can be concluded that students experience misconceptions in determining atomic mass, distinguishing between elemental molecules and compounds, and the concept of ions that release and receive electrons. Factors that need help understanding the material include the abstract nature of the material, so students do not know its true form. Each student has their way of overcoming the difficulties they face based on the student's abilities.

Data obtained from the three-tier test, student interviews, and previous research results became a reference to determine the causes of misconceptions experienced by students in this research. As Suwarto (2013) argued, students who experience misconceptions tend to embed wrong concepts about a theory in their cognitive knowledge, so further investigation is needed regarding the causes of misconceptions in students. In line with this, Hairy (2018) stated that errors in understanding concepts, such as misconceptions, are a big problem in education that must be resolved. Meanwhile, according to Chaniarosi (2014), misconceptions originating from textbooks are very dangerous because apart from teachers making mistakes in understanding a concept, students can also experience errors in understanding the same concept. Even though the percentage of student misconceptions is only 23%, the causes of student misconceptions need to be known to be used as evaluation material for teachers or students in subsequent learning, and students who still have errors in understanding concepts can have some concepts corrected. Apart from that, by knowing the causes of students' misconceptions, the success of learning, which was previously successful, will be further improved with an average percentage of the concept understanding category of 54% with a high classification.

The success factor in learning the concept of atoms, ions, and molecules must be separated from the role of science subject teachers who are able to implement the learning system well to reduce the possibility of students needing help understanding the concepts. Meanwhile, there are several factors causing students' misconceptions, namely, the objects being studied are abstract, objects that are difficult for students to observe and see directly, such as atomic mass material and the concept of positively and negatively charged ions. Abstract and microscopic objects are difficult for students to observe directly, so students only look at illustrations from books and imagine the illustrations using different students' imagination abilities. This difficulty factor was also included in Ayu Mutmainnah Halim's research, with research results showing that as many as 49 students of class X MIA 4 SMAN 1 Pinrang experienced difficulty in understanding concepts that were abstract and far from everyday experience.

Tresnasih, et al. (2013) stated that several factors cause misconceptions, namely student factors and teacher factors. Other factors are students' prior knowledge (students' preconceptions), misconceptions caused by the school system (school-made misconceptions), students' images and scientific language (students' concepts and scientific language), as well as effective strategies for teaching and learning. The next factor causing misconceptions needs to be completed information about a concept in the learning process. Because each child's ability is different in processing information, during the learning process, some students still need help to assimilate information regarding the concept of learning material completely as desired by the teacher. As a result, misconceptions can occur because students are wrong or incomplete when understanding a concept in learning. For example, in the statement of one of the students who experienced a misconception in question number 13, the student needed to complete compiling information regarding the concept of ions, which experience the release and acceptance of electrons. There are other cases when students have understood the concept correctly, but when the theory is explained in the question, the student needs help to answer it correctly. These two problems follow Gabel's (1993) theory, which states that misconceptions that occur in students can be caused by (1) the results of observations on natural phenomena around students, feelings that

can deceive students in understanding these concepts, and the concepts taught cannot be reached by students' mental development. So, misconceptions can occur due to students' mistakes in conceptual knowledge built based on the surrounding environment or accepted theories. Therefore, misconceptions caused during learning can occur due to errors in assimilated concepts that are something new for students.

## CONCLUSION

Based on the results of research using a three-tier test instrument to identify misconceptions of class IX students at MTs Al-Ishlahuddiny Putra Kediri on the concept of atoms, ions, and molecules, some students experienced misconceptions with a percentage of 23% with a low classification. Most students need clarification regarding the connection between the concept of compound molecules and elements and the concept of ions that release and receive electrons.

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