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Development of Three-Tier Diagnostic Test Instruments to Measure Misconceptions in Atomic Structure

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Abstract: Development of Three-Tier Diagnostic Test Instruments to Measure Misconceptions on Atomic Structure. This study aims to measure misconceptions in atomic structure of tenth grade students at SMA Swasta Nurul Iman Tanjung Morawa. This research was conducted in October 2021-February 2022. The type of research used was Research and Development with the development of ADDIE. Instrument used are tests, questionnaires, interviews and documentation. The diagnostic test developed is a three-tier multiple choice diagnostic test consisting of answer choices, reasons and confidence levels. The results of the validation by the validator show that the instrument developed is valid. The validity of the test developed was 16 valid questions and 4 invalid questions. The results of the reliability test showed a reliability lift of 0.82. The highest percentage of misconceptions is on the concept of electron configuration by 52% and the lowest percentage of misconceptions on the concept of making up atomic particles (protons, electrons, and neutrons) is 21.17%. The percentage of students who understand the concept of atomic structure is 23%. The percentage of categories that do not understand the concept of atomic structure is 32% and the percentage of the category of misconceptions of the concept of atomic structure is 45%.

Keywords: atomic structure, misconception, three-tier multiple choice.

Abstrak: Pengembangan Instrumen Tes Diagnostik Three-Tier Untuk Mengukur Miskonsepsi Pada Materi Struktur Atom. *Penelitian ini bertujuan untuk mengukur dan mendeteksi miskonsepsi siswa yang terjadi pada konsep struktur atom berdasarkan hasil diagnosis siswa kelas X SMA Swasta Nurul Iman Tanjung Morawa. Penelitian ini dilaksanakan pada Oktober 2021- Februari 2022. Jenis penelitian yang digunakan adalah penelitian pengembangan dengan pengembangan ADDIE. Instrumen yang digunakan adalah tes, angket, wawancara dan dokumentasi. Tes diagnostik yang dikembangkan adalah tes diagnostik three tier multiple choice yang terdiri dari pilihan jawaban, alasan dan tingkat keyakinan. Hasil validasi oleh validator menunjukan instrumen yang dikembangan valid. Validitas tes yang dikembangkan sebanyak 16 butir soal valid dan soal yang tidak valid sebanyak 4 butir soal. Hasil uji coba reliabilitas menunjukan angkat reliabilitas sebesar 0,82. Persentase miskonsepsi tertinggi yaitu pada konsep konfigurasi elektron sebesar 52% dan persentase miskonsepsi terendah pada konsep penyusun partikel atom (proton, elektron, dan neutron) sebesar 21,17%. Persentase siswa yang memahami konsep struktur atom yaitu sebesar 23%. Persentase kategori tidak memahami konsep sebesar 32% dan persentase kategori miskonsepsi konsep struktur atom sebesar 45%.*

Kalta Kunci: *struktur atom, miskonsepsi, three-tier multiple choice.*

▪ INTRODUCTION

Chemistry is included in the Natural Sciences family which Study of matter which includes composition, properties, structure, changes and the energy that accompanies these changes. Chemistry as a whole is a complex concept and requires abstract thinking skills. Concepts in Chemistry consist of several interrelated parts and are studied through three levels of representation, namely macroscopic, sub-microscopic, and symbolic. Chemistry is one of the sciences that is not easily understood by students. As a result, students have difficulty understanding concepts in chemistry correctly (A'yun et al, 2018). Learning chemistry in high school still leaves a number of students with misconceptions. Judging from the indicators that are still understood by students' misconceptions, it can be said that these indicators are indicators that require students' thinking skills. From this fact, it is possible that the misconceptions that occur come from students' thinking skills that are not good, or are still relatively low. Therefore, it is necessary to do learning that can train students' thinking skills so that the material being studied can be understood by students as a whole. This statement is as mandated in the Appendix to the Permendiknas No.22 of 2006 concerning Content Standards for High School Chemistry Subjects (Ningrum, 2013).

The results of the data analysis of the 2014/2015 National Examination in Demak Regency showed that there was a difference in the percentage of students' understanding of concepts in each competency being tested. The difference in these understandings, sometimes there are some who experience deviations or discrepancies which are called misconceptions. Misconception is an understanding of concepts that are not in accordance with scientific explanations. The atomic structure is an important basic concept in studying chemistry. The basis of learning chemistry is to make students understand and be able to apply concepts about atoms and molecules. If students experience misconceptions in one of the basic concepts, the possibility of the emergence of misconceptions in more complex concepts will be greater (A'yun et al, 2018). A diagnostic instrument is an assessment instrument that can be used to identify misconceptions in natural student. The three-tier diagnostic instrument can determine the proportion of students who experience misconceptions, by distinguishing between misconceptions and weak conceptual understanding from the third tier. Three-tier diagnostic instrument is an instrument that has three tiers or levels, namely the first level in the form of answer choices. The second level is the choice of reasons for the answers in the first level. The third level is the level of confidence in the answers given at the first and second levels (Wiyono, 2016).

The diagnostic test is intended to determine the learning difficulties experienced by students based on the results of previous formative tests. The diagnosis of student learning difficulties is broader than the implementation of diagnostic tests, so that in carrying out the diagnosis of learning difficulties, in addition to carrying out tests, other activities need to be carried out, namely tracing the types, sources and causes of errors. A good diagnostic test can provide an accurate picture of the misconceptions students have based on the error information they make. Diagnostic tests are used to assess students' conceptual understanding of key concepts on certain topics, specifically for concepts that tend to be misunderstood. Based on this opinion, it can be defined that the characteristics of this diagnostic test have the following abilities: (1) diagnosing the weakness of students' conceptual mastery based on the analysis of students' answers, providing feedback quickly and individually according to the mastery of the concepts

of each item. (3) help help students improve understanding of certain concepts. However, the teacher has not been able to determine the characteristics of the misconceptions experienced by students so that the teacher does not know the concepts of misconceptions experienced by students. This causes teachers to rarely conduct misconceptions diagnostic tests on students (Abbas, 2016). This three-tier diagnostic test is a diagnostic test composed of three levels of questions. The first level (one-tier) is in the form of ordinary multiple choice, the second level (a choice of reasons, and the third level (three-tier) is affirmation questions about beliefs. of the answers that have been selected at levels one and two. While the definition of a diagnostic test is a test that aims to identify students' learning difficulties in terms of understanding key concepts on certain topics. The benefit of the results of this diagnostic test is that it can be used as a reference by educators in determining effective learning patterns in the future (Syahrul, 2015).

▪ METHOD

The type of research that used in this research is research and development with Addie model. The purpose of this research is to develop a three - level multiple choice diagnostic test to identify misconceptions that occur in class X students on atomic structure. This research was carried out at the Nurul Iman Private High School Tanjong Morawa, North Sumatra class X MIA in the odd semester of the 2021/2022 Academic Year. This research was conducted from October 2021 to February 2022 in the odd semester of the 2021/2022 academic year.

The population in this study is 10 classes of class X MIA SMA Nurul Iman Private High School Tanjong Morawa in the odd semester of the 2021/2022. Sampling in this study was taken by purposive sampling technique, namely the technique of determining the sample for certain reasons, namely class X students who excel at the school and halve studied the atomic structure material.

Data Analysis Techniques

The first step in data analysis is that the diagnostic test instrument that has been prepared is tested for feasibility by experts, namely material experts and evaluation experts. After the question was deemed appropriate by teh expert, the diagnostic test instrument was then tested on students to detect students misconceptions about the atomic structure material. Item analysis of three-tier diagnostic test instruments.The questions instrument is in the form of multiple choice questions with a tota of 20 questions with 4 distracting answers. The statistics formula used in this study include:

Validation Test

Item validity is carried out by calculating the correlation between each instrument item score and the tota score, using the "product moment" correlation formula also follows:

$$Rpbs = \frac{Mp - Mt}{St} \int \frac{p}{q}$$

The validity coefficient obtained (r_{pbs}) is compared with the r values of the moment product table with the criteria ; if $r_{pbs} > r_{talble}$, then the item is said to be valid (Silitonga, 2014).

Reliability Test

For reliability caculatons can be determined by looking at the research instruments used. Because the test is used as a research instrument is a multiple choice question the formula used is the formula KR-20 in Silitonga (2014: 155)

$$r11 = \left[\frac{k}{k-1}\right]\left[\frac{S^2 - \sum pq}{S^2}\right]$$

The reliability coefficient (r11 or rxx) is compared to $\mathbf{r_{table}}$ at $\mathbf{r_{product\ moment}}$ with = 0.05; if $\mathbf{r_{count}} > \mathbf{r_{table}}$ then the test is declared reliable (Sugiharti, 2016).

Difficulty Level

The number that shows the level of difficulty of a test item is called the item difficulty index (P) which can be calculated by the formula:

$$P = \frac{B}{T}$$

(Arifin,2017).

Distinguishing Power

Data analysis of discriminatory power of questions for students This data is analyzed to determine the differentiating power seen from the value of the discrimination index for each item, the formula used is:

$$D = \frac{BA}{JA} - \frac{BB}{JB} = PA - PB$$

(Rahayu & Azizah, 2012).

Distractors

According to Arikunto (2012:233), the distractor is considered bad if the distractor is not chosen at all by the testee because the distractor looks too misleading. On the other hand, a well-functioning distractor is a distractor or distractor that is chosen by at least 5%. If it is chosen evenly, it is said to be very good. However, if the upper group chooses more or not, then the distractor is not a good test follower.

Test Scoring

Guidelines for scoring the three-tier multiple choice diagnostic test were used as a guideline to determine the results of the tests used. According to Arikunto (2013), the formula used for student scoring can be seen in Equation:

$$S = R$$

Description:

- S: score obtained
- R: correct answer or reason

Answers and reasons are given a score of 1 and if the answers to suggestions and reasons are wrong or do not provide answers, they are not given a score.

Interpretation of Three-Tier Multiple Choice Diagnostic Test

Choice diagnostic test is divided into three categories, namely understanding, not understanding, and misconceptions (Pesman, 2010).

Table 1. Interpretation of Results Three-Tier Multiple Choice Diagnostic Test

No	Category	Type				
		Answer	Score	Reason	Score	Confidence
1	Uderstanding	True	1	True	1	High
2	Not Understanding	True	1	True	1	Low
		True	1	False	0	Low
		False	0	True	1	Low
		False	0	False	0	Low
3	Misconception	True	1	False	0	High
		False	0	True	1	High
		False	0	False	0	High

To calculate the percentage of students who experience misconceptions based on the measurement of diagnostic test instruments, the formula:

$$\% \text{ MK} = \frac{MK}{N} \text{ X } 100\%$$
$$\% \text{ TMK} = \frac{TMK}{N} \text{ X } 100\%$$
$$\% \text{ MK} = \frac{MK}{N} \text{ X } 100\%$$

Description:
MK = Group of students who understand the concept
TMK = Group of students who don't understand the concept
MK = Group of students who show misconceptions
N = Number of students

▪ RESULT AND DISCUSSION

Data Collection and Literature Study

It starts from collecting several references related to research. Then an analysis was carried out on some of these references so that it was obtained that to determine students' knowledge in understanding the concept of atomic structure, it can be seen from the sources of errors that allow students' misconceptions so that students have difficulty understanding the concept of atomic structure. At this stage, also analyzes curriculum, student and topic.

Product Description and Design

At this stage the researcher designs diagnostic test questions that are used to identify students' misconceptions about the atomic structure. Problems are designed based on the materia that has been analyzed based on indicators of the concept of atomic structure. Researchers designed questions that represented each sub-topic on the atomic structure. The questions developed by the researcher were 30 questions which

were validated to the expert validator and corrected according to the advice of the expert validator, then tested on a small group of 15 students, after that the researcher made a revision before being tested on a large-scale trial. A large-scale tria walls conducted on 34 students with 20 questions. Students are asked to provide an assessment of student response questionnaires on small-scale trials and large-scale trials. The products produced in this study are a grid of test questions, three-level multiple choice diagnostic tests, answer keys, scoring guidelines, and results interpretation guidelines.

Product Validation

Multiple choice diagnostic test instruments three levels before being given to students are validated first to the Expert Review (assessment of experts). Instrument validation is done by providing a question validation sheet containing the validator's assessment of three aspects, namely: material, construction and language. The purpose of validating expert validators is to find out the validity of the test questions that halve been developed, with proven validity, the questions are eligible to be used. The validator in this study consisted of 1 chemistry lecturer Untimed and two chemistry teacher's at SMA Nurul Iman Tanjong Morawa.

Small-Scale Trial

The step taken after revising the validation results by the expert is to conduct a small-scale trial. The purpose of the small-scale tria in this study walls to determine the estimated time and to see how far the students' ability to work on the three-level multiple-choice diagnostic test questions. This tria walls carried out alt the Nurul Iman Private High School Tanjong Morawa which 15 students who held studied atomic structure. The number of items tested alt this stage is 30 questions.

After working on a three-level multiple-choice diagnostic test, students were asked to give an assessment of the student's response questionnaire on a small-scale trial. In the aspect of assessment, student responses are given scores ranging from a score range of one to five. All score of five is given if the aspect is very good, a score of four is given if the aspect is good, a score of three is given if the aspect is quite good, a score of two is given if the aspect is not good, a score of one is given if the aspect is not good.

Product Analysis and Revision

Based on the deta obtaned in the smal-scale tria asessment, it is necessay to revise the time used when conducting the test. The following ae the results of the questionnare aalsis of student asessment of the three-level dianostic test tha has been tested:

Tale 1. Results of the Student Response Questionnaire Analysis of the Three-Level Diagnostic Test in the Small-Scale Trial

No	Aspek	Results (%)	Criteria
1.	The material contained in the test question you have learned	80	Good
2.	Sentences in the test question can be read clearly	67	Enough
3.	Sentences in test questions are easy to understand	60	Enough
4.	You understand what you are doing.	53	Enough
5.	Images, symbols, and formulas on the problem are clearly readable	73	Good
6.	The number of questions given is quite adequate	53	Enough
7.	You need an understanding of the concept of atomic structure to answer test questions	53	Enough
8.	You need an understanding of the concept of atomic structure to answer test questions	60	Enough
9.	The three-level multiple choice diagnostic test you've been working on helps you to find parts of the material you don't already understand.	60	Enough
10.	You are more motivated to better understand the concepts that exist in chemical equilibrium materials after doing the test	53	Enough
11.	The need for the use of three-level multiple-choice diagnostic tests on materials other than Chemical Equilibrium	67	Enough
Average		62	Enough

The average result of student assessment of the response questionnaire is 62%, which means that the three-level diagnostic test instrument is included in the good enough category so that the instrument calm already be used in large-scale trials. Before being tested on a large-scale trial, revisions were made to the previous processing time with 30 questions given 60 minutes to make improvements by adding time to the process. But there is something that must be corrected in severa aspects based on the results of student assessment questionnaires, namely:

1. Socialization on how to understand questions is needed because previously students halve never used a three-level diagnostic test alt the learning stage.
2. The need to consider the number of questions with the processing time to maximize the process of applying the three-level diagnostic test.

Large Scale Implementation

Tria The large-scale tria in this study was used to identify students' misconceptions and determine the validity, reliability, level of difficulty, discriminatory power, and distractors of the three-level diagnostic test. The following are the results of the analysis after a large-scale trial:

Validity of the Three-Level Diagnostic

Validity test of the three-level diagnostic test walls 20 questions which were carried out based on the results of a large-scale tria on tenth grade students of Small Swasta Nurul Iman Tanjong Morawa with 34 students. The results obtained are 15 valid questions and 5 invalid questions.

Table 2. The results of the analysis of the validity of the three-level Diagnostic Test

Item	Questions	Total
Vallid	1,3,4,5,7,8,9,10 , 12,13,14,15,16, 1 7,18,20	16
Invallid	2, 6,11,19	4

Reliability of Three-Level Diagnostic Test

Based on the results of a wide-scale trial, it can be calculated reliability with *Microsoft Excel* using the KR-20 formula, the reliability is 0.82. The three-level diagnostic test is reliable so that it can be used in identifying the level of understanding of the concept of atomic structure.

Three-Level Diagnostic Test Difficulty Level

Table 3. Results of the Three-Level Diagnostic Test Difficulty Analysis

No.	Chategory Difficulty Level	Number	Total
1	Medium	1,2,3,4,5,6,7,9,10,11,12 ,13,14,14,17,18,19,20	18
2	Easy	8,16	2

Based on the analysis of the difficulty level of the three-level diagnostic test items, it shows that from 20 questions, 2 items are classified as easy with a percentage of 10%, 18 items are classified as medium with a percentage of 90%. The percentage of the difficulty level of the test is dominated by the moderate category, this shows that the test used is good. Kuncoro (2012:63) the best test is a test that consists of questions that have a moderate level and a easy difficulty distribution range.

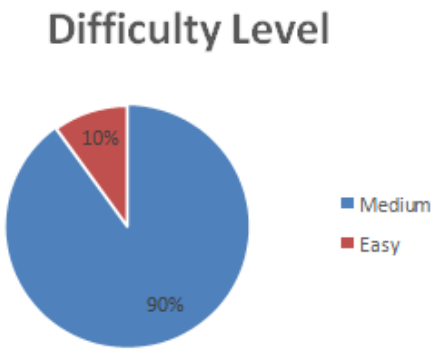

Figure 1. Analysis of the Difficulty Level of the Three Level Diagnostic Test

Distinguishing Test

Table 4. Results of the Analysis of the Differentiating Power of the Three Level Diagnostic Test

No	Chategory	Number	Total	Persentage
1.	Very Good	1,20	2	10%
2.	Good	3,8,9,10,14,15, 16,17,18	9	45%
3.	Enough	4,5,6,12,13,19	7	35%
4.	Bad	2	1	5%
5.	Very Bad	11	1	5%

Based on the table above, it can be seen that the differentiating power of the three-level diagnostic test items is 2 items or 10% of the questions have very good discriminating power, 9 items or 45% of the questions have good discriminating power, 7 items or 35% of the questions have quite good discriminating power, 1 item or 5% of the questions have poor discriminatory power and 1 item or 5% of the questions have very good discriminating power.

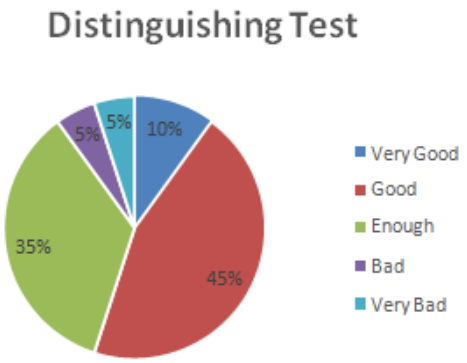

Figure 2. Distinguishing Power Analysis

Distractors

The purpose of the distractors in the three-level diagnostic test that has been tested on a large scale is to deceive those who are less capable or who do not know into distinguishing them from students who are able to answer the questions. Every distractor chosen by students is less than 5%, then the distractor is considered not functioning. Distractors are made to test students' accuracy in answering correct answers. The instrument that was tested on a broad scale consisted of 20 questions and each of them contained 5 options consisting of 1 answer option and 4 distractor options. Then there are 80 distracting options on the test instrument.

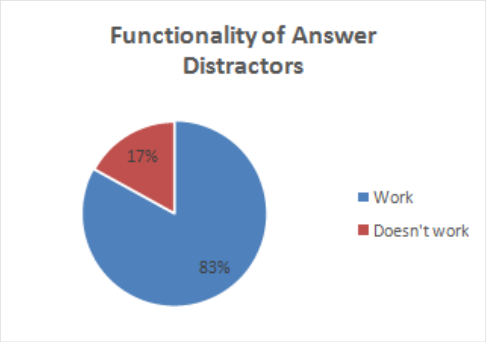

Figure 3. Percentage of Functionality of Answer Distractors

From the picture above shows that distractors in the answers that can be used or function well are 78 (78%) and distractors that cannot be used or do not function properly are 22 (22%).

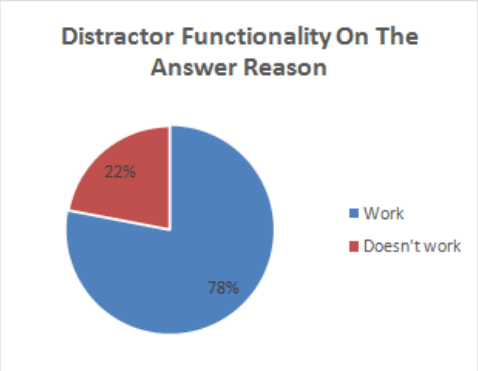

Figure 4. Percentage of Functionality of Distractor Reasons for Answers

From the picture above shows that distractors for answer reasons that can be used or function well are 83% and distractors that cannot be used or do not function properly are 17%.

Analysis of Teacher Interview Results

There are 10 questions in the interview guide to teachers consisting of 7 aspects of assessment. The results of interviews conducted with chemistry teachers alt Nurul Iman Private High School Tanjong Morawa showed a positive response to the three-level multiple choice diagnostic test, because the diagnostic test can identify the level of

knowledge of students who understand, do not understand and halve misconceptions about the concept of chemica equilibrium.

Analysis of Student Responses

After conducting a broad-scale tria of the three-level diagnostic test, a response questionnaire walls given to students on the tests that held been done. There are eleven aspects of the questions in the student response questionnaire sheet. For each aspect of the question there are five choices of student response levels, namely: a score of 1 indicates that students do not agree with the aspects of the questions given, a score of 2 indicates that they do not agree, a score of 3 indicates quite agree, a score of 4 indicates agree and a score of 5 indicates strongly agree. Following are the results of the student assessment questionnaire on the third-level diagnostic test.

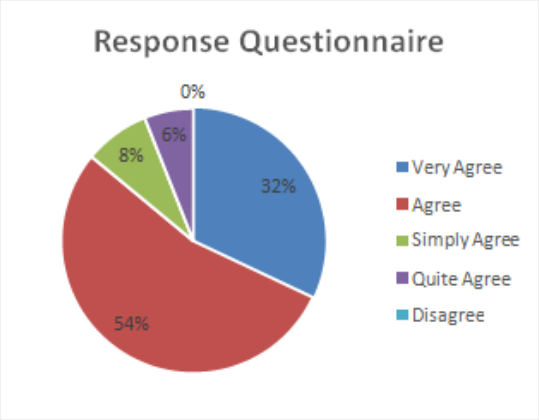

Figure 5. Results of Questionnaire Analysis of Student Assessment of Three-Level Diagnostic Tests on Wide-Scale Trials

Based on the picture above, it can be seen that the response questionnaires given during large-scale trials halve changed manly aspects of students' answers.

Interpretation of Three-Level Diagnostic Test Results

Analysis of three-level diagnostic test questions by giving a score of 1 on the correct answer and correct reason, a score of 0 on the wrong answer or wrong reason. The level of confidence is in the high category if students halve a scale of 4,5,6 and the level of confidence is in the low category if students halve a scale of 1,2,3. The results obtained are then interpreted into the categories of understanding, not understanding and misconceptions. Overall, the percentage of each category of student understanding walls obtained, namely understanding, not understanding, and misconceptions which include the concept of atomic structure.

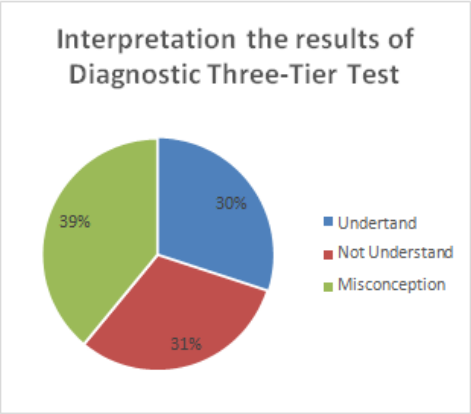

Figure 6. Interpretation of Three-Level Diagnostic Test Results

Figure 6 shows a graph of the percentage of students in understanding concepts, not understanding concepts and misconceptions on all items. Based on the graph above, it can be seen that the category of misconceptions occupies the highest percentage, which is 39%. The percentage of categories that do not understand the concept of atomic structure is 31% and the percentage of categories that understand the concept of atomic structure is 30.

Table 5. Percentage of Each Category Level of Students' Understanding of the concept of atomic structure

Items	Concept of Atomic Structure	Percentage of Categories (%)		
		Understand	Not Understanding	Misconceptions
3,11	Development of Dalton's Atomic Theory and Model	7,5%	47%	45,5%
4	Development of Thomson's Atomic Theory and Model	29%	35%	35%
12,13	Development of Rutherford's Atomic Theory and Model	17,5%	35%	47%
2,5,6,15,16,17	Constituents of atomic particles(protons,electrons and neutrons)	48%	30,2%	21,17%
10,19	Determine atomic number and mass number	23,5%	27,5%	48,5%
8, 18,20	Electron configuration	25,67%	22,7%	52 %
1,7,9,14	Quantum numbers	27%	27,8%	45%

In table 6 it can be seen that the highest percentage of misconceptions is on the concept of electron configuration by 52% and the lowest percentage on the concept of constituent of atomic particles (protons, electrons and neutrons) of 21.17% In the category of understanding the concept the highest percentage is in understanding the concept of constituent atomic particles (protons, electrons and neutrons) of 48.7% and the percentage lowest in understanding the concept of electron configuration by 12%. In the category of not understanding the concept, the highest percentage walls in the concept of the Development of Dalton's Atomic Theory and Model alt 47% and the lowest percentage walls in the concept of Determining the atomic number and malls number of 27.5%. Based on the table above, the percentage of students who understand the concept is 23%, the percentage of students who do not understand the concept is 32% and the percentage of students who halve misconceptions is 45%.

The test results show that *Three-tier* can identify the level of students' conceptual knowledge. This can be seen from the identification of students who experience misconceptions, do not understand concepts, and understand concepts so that from the results of applying diagnostic tests it can be seen which indicators students experience the most misconceptions. Identification using third there-tier diagnostic test instrument is can not only used the level of understanding of students, but can also see students' misconceptions and can see students who don't understand the concept. This misconception can appear in students from daily experiences when interacting with the natura surroundings. According to YuYu (2005) errors in identification will cause errors in how to correctly, which can be used at any time in the teaching and learning process. According to Hammer (1996) & YuYu (2005) Misconceptions can be seen as a conception or cognitive structure that is firmly and stable attached to the minds of students which actually deviates from the conceptions put forward by experts, which can mislead students in understanding natura phenomena and doing explanations scientific (Ramani, 2017).

▪ CONCLUSION

Based on the results of research regarding the Development of Three-Tier to Measure Misconceptions of Class X Students on the Atomic Structure Material, it can be concluded that diagnostic test instrument Three-Tier Multiple Choice developed halls the characteristics of the instrument substance to measure misconceptions in the atomic structure material. double three levels also manly also 20 questions. The test instrument developed for the material atomic structure halls met the qualifications well with the assessment of three expert validators. The validity of the developed test obtained 16 valid questions and 4 invalid questions. The results of the reliability test showed al reliability rating of 0.82. Al reliable three-level diagnostic test walls used to identify the level of understanding of the concept of atomic structure. Based on the test results, the percentage of students who understand the concept is 24.86%. The percentage of the category of not understanding the concept is 32% and the percentage of the misconception category of the chemical equilibrium concept is 43.11% Overall, the results of the analysis of students gave al positive response to the Three-Tier developed with an average positive response is 85%.

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