Validity of student’s misconceptions diagnosis on chapter Kinetic Theory of Gases using three-tier diagnostic test

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Abstract. In the learning process, students still have misconceptions although the concept has been taught by the teacher. One of the causes of misconceptions comes from the students themselves. The teacher often does not know that students have misconceptions because the assessment that has been given does not review the cause of misconception that occurs in students. Students have misconception especially in abstract concept like in chapter Kinetic Theory of Gases. Because of that, this study made three tier diagnostic instrument test to diagnose student’s misconception in chapter Kinetic Theory of Gases. Moreover, it is also done an analysis in order to know the quality of instrument that has been made. According to the trials, the percentage of average internal validity is about 84.6% which means it is in proper to use and the reliability of instrument is 0.752, meaning reliable to use. This instrument used to diagnose the students’ misconceptions on chapter Kinetic Theory of Gases.

1. Introduction
Students learn about the world around them through formal education at school and day-to-day experiences. Student usually begin developing their knowledge based on experiences they posses. Hence, there are different initial concept in the class and we do not know the conformity of the initial concept with the scientific concept. Osman and Sukor [1] said, “Theoretically, student conceptions are built from their interaction with other people or learning mediums.” So that, the student initial concepts could not be guaranteed its suitability towards the scientific concept. Because of that, several studies have been conducted to depict student’s understanding. The different forms of student understandings have been called by a number of different terms such ‘misconceptions’ [2-5], ‘alternative conceptions’ [6-10], ‘children ideas’ [11], ‘mental models’ [12-13], and so forth.

Early concepts or conceptions that are inconsistent with scientific concepts called misconceptions. In the present study, the term ‘misconception’ is going to be used for those conceptions that contradict the scientifically accepted theories because of its common usage in the literature [14]. ”Misconception” is used as a label for synthetic concepts that do not match to the accepted view and that form as students attempt to integrate existing knowledge with the new information, before deeper conceptual change occurs [15].

The cause of misconception can come from various sources, including textbooks, teachers, and students themselves. In Physics subjects, students often have misconceptions on abstract material. Teachers will have more difficulty in explaining abstract concepts because there are no real examples in the daily life of the students. One example of the abstract material in Physics is the Gas Kinetic
Theory. Based on the questionnaire given to the students of Driyorejo Senior High School, there are still many students who do not understand about the material about gas kinetic theory even though the material has been taught. This is corroborated by student test results on the gas kinetic theory material showing more than 40% of students have values below minimum standards. According to one teacher at Driyorejo Senior High School, students are more focused on memorizing the formula so that students are less understanding of the concepts in the chapter gas kinetic theory. This leads to misconceptions in students.

It cannot be denied that students build their own knowledge while learning. But, because students do not have a scientific frame of mind that fits to serve as a benchmark, so that students are having errors in constructing their knowledge. This causes student’s misconceptions. Suparno [16] states some of the things that are causing the misconceptions originating in students, among others (1) preconceptions or early concepts of students, (2) student associative thinking, (3) humanistic thinking, (4) reasoning, (5) false intuition, (6) the stage of cognitive development of students, (7) student’s abilities, and (8) interest in student learning.

Misconceptions can be identified by providing diagnostic tests to students. Diagnostic tests are assessment tools which are concerned with the persistent or recurring learning difficulties that are left unresolved and are the causes of learning difficulties [17]. These diagnostic test instruments bring to light the disparity between what we want our students know or learn and what they really know or learn. There are many kinds of methods to identify the student’s misconceptions such as interviews, open ended tests, multiple-choice tests, multiple-tier test [14]. The multiple-tier test consists of two-tier, three-tier, and four-tier form of diagnostic test. The three-tier diagnostic test is a diagnostic test items consisting of three levels of questions, the first level contains the usual multiple-choice questions, the second level contains the choice of reason, and the third level contains questions relating to the belief in the answer chosen in two the previous level [18-19]. Compared to the two-tier diagnostic test, this three-tier diagnostic test is more effective to distinguish between nonconformist students and students who are misconception with the added question of belief in choosing the answer [19]. Using three-tier diagnostic test, it can be known the students who understand the concept, students who have experience misconception, and students who do not understand the concept.

Based on the adoption and adaptation of Kutluay [20] research, obtained a table on the analysis of the combination of student answers on three-tier according to the answer categories, showed by Table 1. Based on Table-1, there are three types of answers for the misconception category. These three types of answers indicate the student is confident about the answer he or she chooses but no student answers are equally true between the first and second levels. The advantages of using a three-tier diagnostic test are knowable and differentiated between students who actually suffer from misconceptions with students who do not understand about certain concepts seen from the combination of student answers [18]. By using this three-tier diagnostic test instrument, teachers can find out the location of student misconceptions, and can overcome the weaknesses of student learning in the future and improve the learning process in accordance with the needs of students.

Some of the three-tier diagnostic test instruments developed by Kirbulut and Geban [19] as well as by Peşman and Eryılmaz [18]. Kirbulut and Geban using SDMT (The State Matter Diagnostic Test) to examine student misconceptions on the material properties of the gas. SDMT developed in the form of three-tier diagnostic test. The results of Kirbulut and Geban showed that the use of three-tier diagnostic tests was more effective in identifying student misconceptions than using two-tier and one-tier instruments. The existence of a sure or unsure question in the three-tier diagnostic test shows a more accurate result to distinguish between students who actually suffered misconceptions with students who did not experience misconceptions. Based on Kirbulut and Geban research data, the percentage of false negative is 3.8%, false positive is 8.9%, and the lack of knowledge is 25.2%.

Peşman and Eryılmaz [18] developed the SECDT (Simple Electric Current Diagnostic Test) instrument to identify student misconceptions about simple electrical circuits. Based on the SECDT trial conducted, It can be concluded that valid instruments are used to identify student misconceptions. Using SECDT instruments in tests, a lack of knowledge was found to be 36% indicating the ineffectiveness of teachers in teaching simple electrical circuitry [18].
Table 1. Combination of three-tier test answers [20].

| Problem Level Analysis                        | Category                        | Answer Type       | Code |
|-----------------------------------------------|---------------------------------|-------------------|------|
| Understand the Concept                        | First-tier                      | True              | UC   |
|                                               | Second-tier                     | True              |      |
|                                               | Third-tier                      | Sure              |      |
|                                               | First-tier                      | True              |      |
| Less Understand the Concept                  | Second-tier                     | True              | LUC  |
|                                               | Third-tier                      | Not Sure          |      |
|                                               | First-tier                      | False             |      |
| Do Not Understand the Concept                | Second-tier                     | False             | NUC  |
|                                               | Third-tier                      | Not Sure          |      |
| Three-tier                                   | First-tier                      | True              | G    |
|                                               | Second-tier                     | False             |      |
|                                               | Third-tier                      | Not Sure          |      |
|                                               | First-tier                      | True              |      |
|                                               | Second-tier                     | False             |      |
|                                               | Third-tier                      | True              |      |
|                                               | First-tier                      | False             |      |
|                                               | Second-tier                     | False             |      |
|                                               | Third-tier                      | True              |      |
|                                               | First-tier                      | False             |      |
|                                               | Second-tier                     | False             |      |
|                                               | Third-tier                      | Sure              | M    |
|                                               | First-tier                      | False             |      |
|                                               | Second-tier                     | False             |      |
|                                               | Third-tier                      | Sure              |      |
|                                               | First-tier                      | True              |      |

2. Research Method

This research was a qualitative descriptive research. Data figures contained in this study was the implementation of qualitative data obtained from the research results. The figures obtained describe the quality of the instrument of three-tier diagnostic test developed as well as the misconception profiles of students on chapter gas kinetic theory. The developed three-tier diagnostic test instrument was tested to 60 students to determine the quality of instrument. The instrument quality test is performed through internal validity, external validity, and reliability test. After that, the instrument was used to identify misconceptions in 34 students of Senior High School 1 Driyorejo.

The flow chart of this research shown in figure 1. The following explanation for each step in this research. The study of literature done by studying research that has been doing related to diagnostic tests of student misconception. Field studies conducted through interviews with Physics teachers at Driyorejo Senior High School. The interviews discussed about students' understanding of the kinetic gas theory materials. In addition, given a questionnaire to students who have obtained materials kinetic gas theory to know student difficulty on the material.

The study of materials of kinetic gas theory through the understanding of the material on the books and research journals. The compiled instruments are adapted from theses, international journals, books, and experimental videos related to gas kinetic theory.

Arrange the instrument diagnostic test item grille, diagnostic test item along with the identification sheet. First, a one-tier item test instrument was developed in January 2016. Then in February 2016, a test conducted for Physics students of second year by asking the test participants to include the reasons. This is done to establish the reasons so that the the one-tier instrument become two-tier form. After the two-tier instrument is formed, the instrument is added with a choice of belief so that the test instrument becomes a three-tier form.
The compiled instrument validated by the validator. The selected expert validator is a Physics lecturer who has a course in relation to the gas kinetic theory. Validation performed includes the validity of the constructs of the instruments that have been prepared. Instruments revised according to the suggestions of expert validators in terms of sentences, drawings, and material concepts on each test item.

Test I conducted to determine the quality of diagnostic questions that have been prepared. The experiment conducted on 60 students of Driyorejo Senior High School who have received material on gas kinetic theory.

The tested instrument analyzed to determine the quality of the instrument. The quality of the instruments is tested using validity and reliability tests. Instrument validity is obtained through internal validity and external validity. Internal validity performed by the expert as described before. While external validity obtained from the analysis of items test results by calculating the item test validity of the content and item test validity of constructs. Based on instrument quality analysis, there are some invalid test items. The invalid test item is not used in test II.

Test II conducted to 34 students of Driyorejo Senior High School to identify student misconception on the material of Gas Kinetic Theory. The results of this misconception identification were then analyzed to obtain a student misconception profile on the material of Gas Kinetic Theory.

After test II using three-tier diagnostic test instrument, students' answers grouped into five categories: Understand the Concept (UC), Less Understand the Concept (LUC), Do Not Understand the Concept (NUC), Guessing (G), and Misconception (M) in accordance with Table 1. Based on choice of reasons and choice of student beliefs, analyzed the causes of misconceptions experienced by students. In the end step, report of student misconception diagnosis on the material of Gas Kinetic Theory.

![Figure 1. Stages of research activities.](image)

The instruments used in this research are three-tier diagnostic test instrument and instrument validation sheet. The developed three-tier diagnostic test refers to the dimensions of cognitive thinking according to Bloom's taxonomy before it is revised. While the instrument validation sheet is an assessment sheet covering material, construction, and language aspects.
3. Result and Discussion
Based on a literature study on the diagnosis of student misconceptions, it found that three-tier diagnostic tests more effectively used to identify misconceptions than other diagnostic instruments because the use of the three-tier diagnostic test distinguishes between students who are completely misconceptible with students who simply lack conceptualism [18, 21]. The identification of misconceptions using appropriate diagnostic instruments is necessary considering the results of field studies indicating that 40% of students in one class at Driyorejo Senior High School are rated below minimum standards. The process of arranging the instrument done in accordance with the stages of the research activities shown by Figure 1.

The internal validation of three-tier diagnostic test instrument was included instrument assessment of three aspects those are material used, instrument construction, and language. Validation results by two validator showed on Table 2.

Table 2. Internal validation results of the three-tier diagnostic test instrument.

| Validity | Description                                                                 | Validator 1 | Validator 2 |
|----------|-----------------------------------------------------------------------------|-------------|-------------|
| Material | The test items correspond to the gas kinetic theory chapter                  | 3           | 3           |
|         | Items according to indicator                                                | 3           | 3           |
|         | Each test items was ordered according to material                           | 3           | 4           |
|         | Limitation of questions, answers, and expected reasoning were clear         | 3           | 3           |
|         | Direction of diagnostic test about Kinetic Theory of Gases was clear.       | 4           | 4           |
|         | Suitability criteria of test items with Bloom’s taxonomy                    | 4           | 4           |
| Construct| Each of diagnostic test items can identify students misconception.          | 3           | 3           |
|         | Optional reasons that presented can reveal the cause of students misconception.| 3           | 3           |
|         | Deception in optional reasons was rational and homogen with the answer at first level. | 3           | 3           |
|         | Table, graph, figure, and the other kind corolated with presented problems.  | 3           | 4           |
|         | The sentences of item test use good and right language.                    | 3           | 4           |
| Language | Various sentences or statements do not lead to multiple interpretations     | 4           | 3           |
|         | The statement of each test item is clearly stated and communicative.        | 4           | 4           |

Based on data of validation score each category, average validity from both validator can calculated. It have scored 3.3, means the instrument that established is very good categorized. While the percentage of instrument properness is 84.6%, it means the instrument that established is proper to used.

Analysis of external validity done by analyzing content validity and construct validity of three-tier diagnostic test instrument. Content validity is contain the percentage of false negative and false positive from each test item. False positive (FP) is occur when students chooses the right answer at first level but he/she chooses the wrong reason at second level surely. False negative (FN) is occur when students chooses the wrong answer at first level but he/she chooses the right answer at second level [19]. Data of FP and FN showed on Table 3.
Table 3. Total FP and FN each test items.

| Quest. Number | FP | FN | Answer Pattern |
|---------------|----|----|----------------|
| 1             | 6  | 2  | 60             |
| 2             | 0  | 4  | 60             |
| 3             | 11 | 9  | 60             |
| 4             | 6  | 2  | 60             |
| 5             | 6  | 12 | 60             |
| 6             | 7  | 1  | 60             |
| 7             | 5  | 8  | 60             |
| 8             | 2  | 1  | 60             |
| 9             | 3  | 11 | 60             |
| 10            | 7  | 7  | 60             |
| 11            | 4  | 6  | 60             |
| 12            | 3  | 2  | 60             |
| 13            | 11 | 0  | 60             |
| 14            | 12 | 2  | 60             |
| 15            | 4  | 3  | 60             |
| 16            | 2  | 8  | 60             |
| 17            | 1  | 5  | 60             |
| 18            | 2  | 7  | 60             |
| 19            | 5  | 10 | 60             |
| 20            | 11 | 5  | 60             |
| 21            | 3  | 0  | 60             |
| 22            | 3  | 3  | 60             |
| 23            | 7  | 0  | 60             |
| 24            | 6  | 3  | 60             |
| 25            | 4  | 3  | 60             |
| Total         | 131| 114| 1500          |
| Percentage    | 8.73% | 7.6% |

Based on percentage of FP and FN, it can be known that FP and FN below 10%. Corresponding to requirement of FP and FN that must be below 10% according Hestenes and Halloun in Kirbulut and Geban [19], so the developed of three-tier diagnostic test instrument was fulfilled content validity aspect.

Analysis of construct validity calculated to identify students who have understanding concepts and who have not understanding concepts by calculating correlation using Pearson product moment (r). The value of rtable with 60 students in total respondent and 5% of significance level is 0.254. The requirement of test item was stated valid if \( r_{\text{count}} > r_{\text{table}} \). Based on calculation result, 14 questions are valid and 11 questions are invalid from total 25 questions were developed. The valid questions was used to identify students misconception in Kinetic Theory of Gases material.

Besides analysis of validity, reliability also tested in three-tier diagnostic test instrument by calculating r using Alpha Cronbach. Based on calculation, the value of \( r_{\text{count}} \) is 0.752 while \( r_{\text{table}} \) with 60 in total respondent is 0.254. It is showed that \( r_{\text{count}} \) bigger that \( r_{\text{table}} \). It can concluded that the developed of three-tier diagnostic test instrument is reliable.

After three-tier diagnostic test instrument was quality tested and stated that was proper to used (valid and reliable), that instrument used to diagnose students’ misconception (second trial stage). Diagnosis of misconception trial conducted for 34 students. Students answer analyzed based on answer combination and the group of students who have misconception was determined by using criteria on Table 1. Table 4 is tabulation of students who have a high total misconception to less total misconception.
Table 4. Tabulation of student misconception.

| Student Code | Number of misconception items | Student Code | Number of misconception items |
|--------------|-------------------------------|--------------|-------------------------------|
| Student 1    | 1,2,3,4,6,7,8,9,10,11,12,13,14| Student 24   | 1,3,4,9,12                   |
| Student 31   | 1,2,4,5,6,7,8,9,10,11,12,13,14| Student 28   | 3,4,6,12,14                  |
| Student 13   | 2,3,4,5,6,7,8,9,10,11,13,14  | Student 33   | 3,8,9,11,13                  |
| Student 16   | 2,3,4,5,6,7,8,9,10,11,13,14  | Student 29   | 3,4,6,14                     |
| Student 3    | 1,2,4,7,8,9,11,12,14          | Student 32   | 3,4,5,8                      |
| Student 5    | 4,7,8,9,10,11,12,13,14        | Student 7    | 9,12,14                      |
| Student 22   | 2,3,4,5,6,10,12,13,14         | Student 14   | 1,8,11                       |
| Student 12   | 3,4,6,7,10,11,12,13           | Student 15   | 3,4,6                        |
| Student 18   | 4,5,6,9,10,12,13,14           | Student 27   | 10,13,14                     |
| Student 19   | 4,5,6,9,10,12,13,14           | Student 30   | 4,11,13                      |
| Student 20   | 1,3,6,10,11,12,13,14          | Student 2    | 1,9                          |
| Student 34   | 4,6,7,9,11,12,13,14           | Student 21   | 9,14                         |
| Student 4    | 1,2,4,8,10,12,13              | Student 6    | 2                             |
| Student 10   | 2,4,9,10,12,13,14             | Student 23   | 10                            |
| Student 17   | 3,5,6,8,9,11,14               | Student 25   | 9                             |
| Student 9    | 1,2,6,8,9,11                  | Student 26   | 6                             |
| Student 8    | 1,4,9,11,14                   | Student 11   | -                             |

Based on Table 4, student 1 have misconception in almost all questions. In this article, student 1 misconception profile will revealed. The cause of misconception for student 1 showed on table 5.

| Number of item test | Cause of misconception |
|---------------------|------------------------|
| 1                   | Reasoning              |
| 2                   | Humanistic thinking    |
| 3                   | False negative         |
| 4                   | Intuition              |
| 6                   | Reasoning              |
| 7                   | False Negative         |
| 8                   | Preconception          |
| 9                   | Reasoning              |
| 10                  | Associative thinking   |
| 11                  | Associative thinking   |
| 12                  | Reasoning              |
| 13                  | Intuition              |
| 14                  | Reasoning              |

Student 1 have misconception on question item number 1 because the student have less reasoning in concept of the properties of ideal gas. Thompson explain the relationship between interpretation and inference on a variety of reasoning tasks [22]. Based on Thompson [22] study, Student 1 have interpretation and deductive inference to the given condition on question item number 1. Student 1 made interpretation about the movement of ideal gas particles, he/she concluded that the particle collided have different speed with the initial speed of particle. Based on characteristics of ideal gas, the particle was collided perfectly with wall so that particle speed do not change. Since the Student 1 reasoning is wrong because he/she gives a wrong conclusion about the movement of ideal gas particles. In this situation, teachers suggest to teach with more detailed explained especially on characteristics of ideal gas. It is a good way if teacher was included video animation that can help students to understand characteristics of ideal gas.
Humanists believe that the use of reason – to form and assess our ideas – is also crucial when approaching moral questions, even some aesthetic questions, and that reason must lie behind any real understanding of life. In question item number 2, Student 1 assumed collision between gas particles producing opposite direction. It comes from daily life when two objects collide each other with high velocity can causing the objects tends to be in opposite direction. Because of that, Student 1 assumed when gas particles were collided that direction must be in opposite from earlier condition, Student 1 assumed that gas particles behaviour tend to be same with daily life. In this situation, teachers suggest to teach with more detail explained especially on characteristics of ideal gas. It is a good way if teacher was included video animation about collision that can help students to understand the material.

"False negative (FN) is occur when students chooses the wrong answer at first level but he/she chooses the right answer at second level" [19]. In question item number 3, Student 1 did not make a relation between the scope of ideal gas and the behavior of ideal gas. Student 1 understand that when gases placed in a closed container was pressed so the scope of gases will narrower, but Student 1 did not make relation between the scope of gases and the behavior of gases so that Student 1 was chose a wrong answer at first level. In this situation, teachers suggest to teach using a video that explaining the ideal condition in a closed container.

"Intuition refers to the domain specific capability to reach an appropriate decision without deliberately analyzing various data” [23-24]. "The intuitive bases-making refer to information processing that is not based on data” [25]. For the question number 4, Student 1 experience misconception in this condition because of her/his intuition. Intuition of student 1 assume that reducing the volume of the ping pong ball will also reducing the pressure, so it can made a ping pong ball back to the actual shape. This question is Charles Law application about the pressure inside ping pong ball is constant. Temperature and volume can make a ping pong ball back to its actual shape, the higher of gases temperature, the higher of gases volume. To reduce the misconception of Student 1, teachers suggest to teach with more detail explained and included experiment video related to ideal gas law that can help students to understand about the ideal gas law.

Student 1 did not experience misconception in question number 5. In question number 6, given figure about gases molecules in closed container. Gases molecules when in a closed container will not escapes from it even temperatures raised as long as the container is still closed. Figure in question item number 6 is clear enough. A tube with gases inside is closed. Student 1 have misconception because his/her less understanding on the concept of gases equation so the reasoning went wrong and gives wrong conclusion that gases can escape from its container if temperature raised event in a closed container. Redish [26] describes a model for the use of mathematics in sciences: "The first step comes, i.e. he maps the physical structure into a mathematical model. Secondly, in the process step, to transform the initial description he is involved in some mathematical manipulations. In the third, he interprets his results in terms of physical terms again and finally evaluates whether the results fit to the physical system chosen at the beginning”. The students believe that physics is merely the totality of various abstract equations and formulae. As Redish put it straightforwardly, physics is not just mathematics and has a specific semantics contrary to mathematics. That is why so many students, despite successful performance in mathematics, fail in physics classes and get disappointed [27]. In this case, teachers suggest to teach includes video that explain about the condition of ideal gas in closed container that can help students to understand about the condition of gases in closed container.

In question item number 7, student 1 understand a concept that the higher temperature of gases, the motion of gases particles get faster. But, student 1 can not make a relation that if the motion of gases particles get faster so its kinetic energy also get bigger. So, Student 1 experience misconception in this condition because of false negative. In this condition, teachers suggest to teach includes a video that explain about kinetic energy of gases that can help students to understand about the concept of kinetic energy of gases.

"The students' conceptions can be considered as the "precursors" of the to-be-acquired concepts” [28]. In this study, this conceptions called preconception. In question item number 8, the initial concept or preconception that student 1 have about the particles motion was wrong. If gases in closed container is heating up it can cause the gases particles move faster, not shrink. This condition might happen, when teacher was explained about this material, student 1 is put less attention so he/she have a wrong initial
concept about the particles motion when it is heating up. In this case, teachers suggest to teach includes video that explain about kinetic energy of gases that help students to understand the concept of kinetic energy of gases easily.

Student 1 reasoning on question item number 9 is wrong. Student 1 assume that pressure inside the balloon when in injection tube little more than outside pressure the injection tube, this is causing misconception. When the pump is pull up it cause tube pressure reducing so the pressure inside the balloon bigger than the pressure of injection tube, so the balloon is expanding. In this case, teachers suggest to teach with more detail explanation and includes experiment video that relating to ideal gas law so it can help student to understand about the gas ideal laws easily.

Associative thinking enables people to reflect on a situation from a new perspective, by considering information (that is not directly) related to that situation [29]. In question item number 10, Student 1 was mis-associating the concept about pressure. Student 1 assume that because the candle was closed by the glass, so nothing happens to the candle. This is cause misconception. When the candle closed by the glass, it can make candle being extinguished because it have less oxygen for combustion. When the candle was extinguished, water inside the glass will raised up because pressure inside the glass is smaller than the pressure outside the glass, so that water pushed enter the glass. Students also assume that because the candle was closed, so the pressure inside the glass higher than outside the glass. In this case, teachers suggest teach with more detail explained and includes experiment video that relating with gas ideal law so it can help students to understand gas ideal laws sub material easily.

In question item number 11, dry ice makes pressure inside the bottle raising, not reducing. Student 1 have misconception because have mis-associative thinking. Associative thinking is the mental process of making associations between a given subject and all pertinent present factors without drawing on past experience. In this question item number, Student 1 did not making association. Mis-associative at Student 1 caused by daily mind of student that be assumed the function of dry ice is to reduce of pressure. In this case, teacher suggest to teach with more detail explained and includes experiment video that relating to ideal gas law especially effect of pressure, temperature, and volume of gases in closed container so it helps students to understand about gas ideal laws sub material easily.

Given the figure of balloons with different temperature. Shape of balloon in question item number 12 effected by surrounding temperature. When the temperature is raising up, the volume of balloon is also get bigger. Student 1 was assumed that the temperature do not have an effect in shape of balloon so balloon didn’t change. It is showed that student 1 have a wrong reasoning. In this case, teachers suggest to teach in more detail explanation and includes experiment video that relating to gas ideal law especially effect of pressure, temperature, and also volume of gases in closed container so it helps students understand about gas ideal laws easily.

Student 1 have a wrong intuition in question item number 13. When inside the freezer, gas particles were not in rest, but reducing in velocity so it will move little bit slower than before because kinetic energy of gases get smaller. Student 1 was assumed that kinetic energy of gas would increase if gases inside the freezer. In this case, we suggested the teachers to include animation while teaching to explain about concept kinetic energy of gases so it can help students understand about concept kinetic energy of gases easily.

In question item number 14, energy of gases dependent to kind of gas and temperature of gas. Student 1 have misconception to this item because a wrong reasoning. Student 1 was assumed that each of tube have a same energy, independent to temperature and volume of gases. In this case, teacher was suggested to give an explanation in detail about energy of gases while teaching so it can help students to understand about it easily.

Students’ misconception identification and cause of misconception conducted for 34 students with analyzing cause of misconception with the same way as student 1 analysis. The cause of misconception percentage shows in Table 6. Study profil for each topic of Kinetic Theory of Gases will discuss later on the next paper.
Table 6. Cause of Misconception Percentage.

| Item number | Cause of Misconception (%) |
|-------------|-----------------------------|
|             | Pr  | AT  | R   | HT  | I   | FN  |
| 1           | 33.33 | 16.67 | 25  | 0   | 0   | 25  |
| 2           | 8.333 | 16.67 | 25  | 0   | 0   | 25  |
| 3           | 13.33 | 0   | 20  | 0   | 0   | 16.67 |
| 4           | 13.64 | 4.55 | 4.55 | 54.55 | 16.67 |
| 5           | 8.333 | 0   | 3.33 | 25  | 0   | 16.67 |
| 6           | 5.26 | 36.84 | 10.53 | 15.79 | 15.79 |
| 7           | 0   | 0   | 16.67 | 66.67 | 0   |
| 8           | 38.46 | 15.38 | 7.69 | 7.69 | 23.08 | 7.69 |
| 9           | 25  | 25  | 25  | 25  | 25  | 0   |
| 10          | 18.75 | 18.75 | 6.25 | 12.5 | 12.5 | 12.5 |
| 11          | 11.76 | 23.53 | 23.53 | 0   | 29.41 | 11.76 |
| 12          | 27.78 | 16.67 | 27.78 | 0   | 11.11 | 16.67 |
| 13          | 29.41 | 5.882 | 11.76 | 23.53 | 23.53 | 5.88 |
| 14          | 23.81 | 19.05 | 14.29 | 14.29 | 19.05 | 9.52 |

Pr=Praconception, AT=Associative thinking, R=Reasoning, HT=Humanistic Thinking, I=Intuitive, FN=False Negative

Based on Table 6, there are variations of causes of misconception from students' answers. Causes of misconceptions are pre-conception, associative thinking, reasoning, humanistic thinking, intuition, and false negative. Among the causes of student misconception that exist through this test, humanistic thinking have the highest percentage (66.7%) that are responsible to students misconception in Kinetic Theory of Gases material. The highest percentage of causes of misconception, which is humanistic thinking is on question item number 7 about kinetic energy of gases. In this item, students were trained to analyze the effect of temperature change due to gas particles motion in closed container. Students were used humanistic thinking to analyze the condition that given by linking the daily phenomenon which is the gas condition was in open space. Dissonance between given condition and students’ humanistic thinking lead to students’ misconception.

4. Conclusion

Based on this research, it can be concluded that the three-tier diagnostic test was valid to be used. Developed instrument quality have percentage of internal validity is 85.6%. This result of validity for FP is 8.73% and FN is 7.6% were fulfilled the requirement of FP and FN which is not below than 10%. Result of construct validity stated that 14 questions is valid an 11 questions is invalid. Reliability 0.752 showed that the instrument is reliable. Student misconception diagnose showed that student have misconception in almost all of the test items.

Acknowledgement

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Appendix

The sample of test item of GKT three-tier diagnostic test instrument:

An ideal gas-filled tube. The following true statement is...

a. When the gas particles hit the tube wall, the particles lose energy.

b. When the gas particles hit the tube wall, the particles lose their momentum.

c. The gas particles will lose speed (still) after colliding with the wall.

d. Gas particles will experience a change in speed after a collision with the wall.

e. Gas particles experience a change in direction of momentum when collided with a tube wall.

Supportive reasons:

i. Particle energy moves on the tube wall.

ii. When mashing the wall, the particle's momentum is equal to zero so that the particle has no speed.

iii. Particles that pound the dense walls will lose speed because the walls have a larger inert force.

iv. When pounding the particles wall changes the direction of the velocity so that the particle also changes the direction of momentum.

v. Particles of gas suffer a partial collision with walls so that particle speed changes.

vi. When pounding the wall of particle energy out of the particle itself the particles lose energy.

vii. ............................................................

Are you sure about your answer?

a. Sure  b. Not sure

Each tube in the image has the same number of gas molecules. Each tube heated to reach the temperature as shown. If sorted, the tubes that have the greatest pressure to the smallest are...

a. Tube 4 < Tube 3 < Tube 2 < Tube 1

b. Tube 1 > Tube 2 > Tube 3 > Tube 4

c. Tube 4 > Tube 3 > Tube 2 > Tube 1

d. All tubes have the same pressure

e. Tube 1 > Tube 3 > Tube 2 > Tube 4

Supportive reasons:

i. The greater the temperature, the faster the molecular movement increases the pressure.

ii. As long as the container covered the gas pressure is the same.

iii. Warming does not affect pressure.

iv. The gas pressure is inversely proportional to the temperature.

v. The greater the gas temperature undergoes expansion resulting in reduced pressure.

vi. The hotter the gas molecule container exits the more so that the pressure decreases.

vii. ............................................................

Are you sure about your answer?

a. Sure  b. Not sure