

Analysis of Students Misconception using Two-Tier Multiple Choice Diagnostic Test on Electrolyte and Nonelectrolyte Topic in SMAN 2 Padang

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Abstract—This research aims to (1) knowing whether there are misconceptions of 10th grade students at SMAN 2 Padang on the topic electrolyte and nonelectrolyte solutions and (2) the percentage of 10th grade students at SMAN 2 Padang who have misconceptions about the topic electrolyte and nonelectrolyte solutions. This research uses a two-tier multiple choice diagnostic test instrument consisting of 14 item questions. The method used in this research is a quantitative descriptive approach. The sampling technique was taken using a simple random sampling technique. Data collection techniques were carried out through tests given to students of class X MIPA 6 which were attended by 40 people. In this research, the population was all of 10th grade students at SMAN 2 Padang, while the sample was students of class X MIPA 6. The results of data processing in this research indicate that in general students of class X MIPA 6 have misconceptions with an average percentage of misconceptions of 36.94%. Students experience misconceptions on the sub-concept of the properties of the electrolyte solution by 22.5%, the sub-concept of chemical bonds and electrolyte properties of 43.75%, and the sub-concept of the electrical conductivity of the solution has the highest percentage of misconceptions, which is 44.58%.

Keywords— Electrolyte and Nonelectrolyte Solution, Misconception, Two-Tier Multiple Choice Diagnostic Test

I. INTRODUCTION

Understanding the concept is one of the most important things in the learning process. Concept is a collection of thoughts from a group of facts or ideas that are related formally and informally. Students must be taught to understand concepts, because concepts help in organizing thinking [1]. Therefore, learning is a process that occurs continuously and never ends. And because of this, the concepts taught to students must be well understood so that there is no wrong understanding of the concept and is believed to be true by students or better known as misconceptions.

Misconception is a condition in which a person has a conception of a concept that is different from that which has been agreed upon by experts. Misconceptions occur because the person concerned has a different perception of the observed facts. In accordance with Treagust's (2013) statement which states that misconceptions are a person's mistake in understanding a concept. Misconceptions occur because the person concerned has a different perception of the observed facts [2]. Misconceptions can also come from interactions with learning resources such as books, teachers or friends who have experienced misconceptions. A person who experiences common misconceptions is resistant. The owner of the misconception is very sure that his conception is correct [3]. Misconceptions in the learning process will affect the effectiveness of the next learning process. If students continue to remember and believe in incorrect concepts, problems will arise in receiving learning in the future. As a result, it will disrupt the process of accepting new concepts that are still related to old concepts in the future. Science is one example of a field of science whose material concepts are interrelated with one another.

According to Indrawati [4] IPA (Natural Science) is a collection of concepts, principles, laws and theories that are formed through a creative and systematic process through inquiry followed by a continuous (empirical) observation process. This observation is a human effort that includes mental operations, skills, and strategies for manipulating and calculating, which can be re-examined based on an attitude of curiosity, determination (courage), persistence which is done by individuals to uncover the universe. In general, science is divided into three scientific fields, namely biology, physics and chemistry. Chemistry is one of the branches of science that is included in the science group, therefore chemistry has characteristics similar to science, which contains theoretical concepts. The chemical concepts that are usually taught do not stand alone, meaning that one chemical concept with another chemical concept is related and interconnected. So every chemical concept taught must be understood and understood well by students before studying other chemical concepts.

Chemistry is one of the compulsory subjects that must be studied by students, especially the science majors in high school. Chemistry is a branch of Natural Sciences (IPA) that specifically studies the structure, composition, properties and changes of matter, and the energy that accompanies changes in matter. Chemistry consists of various concepts, laws and principles from the simple to the complex [5]. The concepts in chemistry lessons are generally taught in a hierarchical manner, meaning from simple concepts to complex concepts. So that if the concept is simple, students have experienced misconceptions, it will continue to understand more complex concepts, students will have difficulty understanding the concept, as a result there will be errors in understanding the concept on an ongoing basis. Misconceptions are very disturbing in the learning process if they are not followed up because they will disrupt the process of understanding concepts in the cognitive structure of students.

Electrolyte and nonelectrolyte solutions are one of the chemistry learning materials that are studied in class X SMA in the even semester. Suyanti (2012) states that the material for electrolyte and nonelectrolyte solutions is a material that is classified as difficult by students because the concepts are abstract (submicroscopic) [6]. This abstract chemical concept is difficult to observe directly because it is related to submicroscopic molecules. Therefore, every chemical concept studied must be understood and understood well by students. In addition, research conducted by Orgill and Sutherland (2008) revealed that teachers tend to focus students on the computational aspect rather than conceptually when explaining the material, this also causes students to experience misconceptions [7].

To find out the existence of misconceptions in students, one way that can be done is by means of a diagnostic test. Misconceptions cannot be generalized directly because the misconceptions that occur can be different or the same, so an instrument is needed that can identify misconceptions (Astari, 2012). According to Suwanto [8] explained that the diagnostic test is a test used to find out weaknesses or misconceptions on certain topics in learning so that from the test results input is obtained about student responses to improve their weaknesses. Diagnostic tests are a series of tests used to determine the weaknesses of students so that these results can be used as a basis for providing follow-up in the form of appropriate treatment and in accordance with the weaknesses of the students.

One form of diagnostic test that can be used is a two-tier multiple choice diagnostic test instrument. According to (Bayrak, 2013) Two-tier consists of two parts, the first part consists of a diagnostic test similar to several questions. This section consists of question items or premises, one of which is the correct answer and the rest are bullies. To distinguish diagnostic tests from multiple choice tests is the second part. In this section, students are asked to state the reasons why they choose certain options [10]. According to Tuysuz (2009) who said that there are several advantages to this diagnostic test, namely this test can be used repeatedly and does not take a long time to implement. In addition, this diagnostic test can also reduce the possibility of respondents guessing the answer [11]. However, Griffard and Wandersee in Pesman (2005) revealed that the weakness of this diagnostic test is that it cannot distinguish between students who have misconceptions and those who do not understand the concept [12]. According to Pesman and Eryilmaz (2010), it is necessary to distinguish between students who experience misconceptions and those who do not understand the concept because overcoming misconceptions is more difficult than not understanding the concept [13].

Based on information from chemistry teachers who teach at SMAN 2 Padang that there has never been a test related to the misconceptions experienced by students in learning chemistry at SMAN 2 Padang, the teacher only evaluates to find out students' understanding of the chemistry learning material that has been taught in the classroom. classes such as exams and practice questions. However, from the learning outcomes data on the electrolyte and nonelectrolyte solution material, it was found that 66.78% of class X MIPA at SMAN 2 Padang had not reached the specified Minimum Completeness Criteria (KKM). While the class criteria are

considered successful in achieving learning if there are 85% of students above the KKM. This shows that students' understanding of electrolyte and nonelectrolyte solutions is still low.

Thus, the researcher wants to analyze whether there are misconceptions that occur in students regarding the electrolyte and nonelectrolyte solution material at SMAN 2 Padang using a two-tier multiple choice diagnostic test.

II. METHOD

The time for conducting this research is from May to June in the even semester of the 2020/2021 academic year. This research was conducted at SMA Negeri 2 Padang which is located at Jalan Musi no. 2 Rimbo Kaluang, West Padang, Padang.

This research uses a two-tier multiple choice diagnostic test instrument using a quantitative descriptive approach. In this study, researchers collected data on students' misconceptions about the concept of electrolyte and nonelectrolyte solutions at SMA Negeri 2 Padang.

In this research, the population was all students of class X MIPA at SMA Negeri 2 Padang. The sampling technique used in this study is a simple random sampling technique, in this technique the sampling of members of the population is carried out randomly without regard to the strata in the population [14]. The sample in this study were students of class X MIPA 6 SMA Negeri 2 Padang.

The instrument used in this research is a two-tier multiple choice diagnostic test developed by Rafsanjani Supardi [15]. Meanwhile, the data collection technique used in this study was carried out through the administration of tests.

The data analysis that will be carried out on the results of the two-tier multiple choice test is as follows:

- a. Determine the criteria for student answers.
- b. The data from the answers are grouped based on the criteria for the level of understanding of the students.

According to Salirawati, 2011 [16], students' answers are classified as follows:

Table 1. Classification of Student Answers

No	Pola Jawaban Peserta Didik	Kategori Tingkat Pemahaman
1.	Jawaban inti tes benar-alasan benar	Memahami (M)
2.	Jawaban inti tes benar-alasan salah	Miskonsepsi (Mi)
3.	Jawaban inti tes salah-alasan benar	
4.	Jawaban inti tes salah-alasan salah	Tidak memahami (TP)

- c. The percentage level of understanding of students is grouped into 3 categories, namely understanding, not understanding and misconceptions, can be calculated using the formula:

$$P = \frac{n}{N} \times 100\%$$

Information:

P = Percentage number (per group)

n = The number of students in each group from each question

N = Number of students used as research subjects

d. Calculating the percentage of the number of students based on the concept of electrolyte and nonelectrolyte solution material

e. Grouping percentages based on the concept of electrolyte and nonelectrolyte solution material based on the percentage of students.

According to (Siwi, 2013:45): the results of the percentage calculation can be grouped into:

Tabel 2. Misconception Criteria

Kriteria	Persentase
Tinggi	61-100%
Sedang	31-60%
Rendah	0-30%

f. Summarizing data

III. RESULT AND DISCUSSION

Result

The research conducted to analyze the students' misconceptions on the electrolyte and nonelectrolyte solution material was carried out using a written test. The research results obtained are displayed in the form of tables and graphs. The written test was conducted using a two-tier multiple choice instrument. The number of questions tested were 14 questions which included 3 sub-concepts, namely the nature of the electrolyte solution, the electrical conductivity of the solution, as well as chemical bonds and electrolyte properties.

Research that has been carried out with a two-tier multiple choice instrument, students' answers are grouped into several categories of levels of understanding based on the pattern of answers, namely understanding concepts, misconceptions and not understanding the concept of the 14 items tested. After processing the data from the test results, the test results were obtained based on the answer categories shown in the table below.

Table 3. Category of Student Answers per Concept

No	Concept	Category of Answer (%)		
		Understand (B ; B)	Misconception (B ; S, S ; B)	Not Understand (S ; S)
1	Sifat larutan elektrolit	70	22,5	7,5
2	Hantaran listrik larutan	47,91	44,58	7,4
3	Ikatan kimia dan sifat	40,83	43,75	14,16

	keelektrolit annya			
Total		158,74	110,83	29,16
Average		52,91	36,94	9,72

Table 1 shows the results of the two-tier multiple choice test of students as a whole. Based on table 6, the understanding of students' concepts in the electrolyte and nonelectrolyte solution material with the three concepts tested was 52.91%, while for the misconception category it was 36.94%, and the category did not understand was 9.72%. The test results obtained are in accordance with the acquisition of learning outcomes of students who both show numbers that are still low in the category of understanding the electrolyte and nonelectrolyte solution material.

In the concept understanding category, the largest percentage on the concept of electrolyte solution properties is 70%, while for the smallest percentage on the concept of chemical bonds and electrolytes it is 40.83%. In the category of misconceptions, the largest percentage in the concept of electrical conductivity of the solution is 44.58%, while the smallest percentage is in the concept of the nature of the electrolyte solution of 22.5%. In the last category, namely the category of not understanding the concept, the largest percentage is in the concept of chemical bonds and electrolytes, which is 14.16%, while the smallest percentage is in the concept of electrical conductivity of the solution, which is 7.4%.

There are two sub-concepts of electrolyte and nonelectrolyte solutions which have a percentage below the average total understanding of the concept. The concepts of electrolyte and nonelectrolyte solutions are the electrical conductivity of the solution as well as chemical bonds and their electrolyte properties. Meanwhile, in the category of misconceptions, the two sub-concepts (electrical conductivity of solutions and chemical bonds and their electrolyte properties) have a higher percentage than the average percentage of the total misconception category. In the category of not understanding the concept, there is one sub-concept that has a percentage above the total category average, namely the sub-concept of chemical bonds and their electrolyte properties.

Based on the category data of students' answers for each sub-concept, a comparison of each category as a whole in the material of electrolyte and nonelectrolyte solutions is obtained, which can be seen in the following figure.

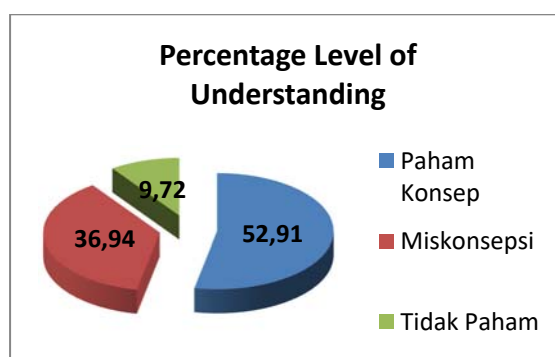


Fig 1. Percentage of Students' Overall Level of Understanding on the Concept of Electrolyte and Nonelectrolyte Solutions

Discussion

A more detailed description of understanding concepts, misconceptions and not understanding the concepts experienced by students per each sub-concept can be seen in the following discussion.

1. Properties of Electrolyte Solutions

In the sub-concept, the nature of the electrolyte solution has the largest percentage of dominance in the concept understanding category, which is 70%. This indicates that more than some students have understood the sub-concept of the nature of electrolyte solutions. In another category, namely the category of misconceptions in this sub-concept, the percentage of students experiencing misconceptions is 22.5%, while for the category of not understanding the concept the percentage is 7.5%.

1. NaCl padat tidak dapat menghantarkan arus listrik, sedangkan larutan NaCl dapat menghantarkan arus listrik. Berdasarkan fakta tersebut dapat disimpulkan bahwa...
- A. Larutan NaCl merupakan larutan elektrolit
 - B. NaCl padat merupakan larutan elektrolit
 - C. NaCl padat merupakan larutan non elektrolit
 - D. Larutan NaCl merupakan larutan non elektrolit
 - E. Larutan NaCl dan NaCl padat merupakan senyawa elektrolit
- Alasannya :
- A. Adanya air mengubah NaCl yang semula berikatan kovalen menjadi ikatan ion
 - B. NaCl padat bila dilarutkan dalam air akan terionisasi sempurna dan membentuk ion-ion yang dapat menghantarkan arus listrik**
 - C. NaCl padat berikatan kovalen tetapi larutan NaCl merupakan senyawa yang berikatan ion
 - D. Air menimbulkan perubahan pada kekuatan arus listrik
 - E. Arus listrik akan mengalir bila ada air sebagai mediumnya

Fig 2. Question 1

The percentage for question number 1 about the characteristics of ionic compounds in solids and solutions obtained the results of students' answers in the category of understanding concepts as much as 67.5%, the category of misconceptions 22.5%, while for the category of not understanding concepts as much as 10%. In question number 1, the category with a high percentage is in the concept understanding category. It can be said that in general students can understand this concept. However, there are still 9 students who experience misconceptions. The misconception in this problem occurs because students only know that NaCl solution can conduct electricity and NaCl solids cannot conduct electricity, but do not know the reason why NaCl in solution can conduct electric current, while in solid NaCl cannot conduct electric current. In the category of not understanding there are 4 people who do not understand this concept. This is because students have not been able to understand the difference between solids and solutions in conducting electric current.

2. Larutan yang menyebabkan lampu tidak menyala dan tidak muncul gelembung gas di sekitar elektroda saat dilakukan uji dengan alat uji elektrolit adalah
- A. NaOH
 - B. H_2SO_4
 - C. H_2S
 - D. $\text{C}_2\text{H}_5\text{OH}$**
 - E. HNO_3
- Alasannya :
- A. Tidak terionisasi**
 - B. Terionisasi sempurna
 - C. Terionisasi sebagian
 - D. Memiliki jumlah ion yang banyak
 - E. Merupakan senyawa kovalen

Fig 3. Question 2

In question number 2, it is about determining which solution is a nonelectrolyte based on the illustration given. The percentage of understanding the concept is quite high, namely 72.5%, the percentage of misconceptions obtained is 22.5%, while the category of not understanding the concept is only 5%. It can be concluded that most students understand this concept better, because it only determines which solution is a nonelectrolyte and the reason is because the solution is not ionized.

2. Solution's electrical conductivity

In the sub-concept of electrical conductivity, the percentage in the concept understanding category is 47.91%, while for the misconception category it is slightly lower than the concept understanding, which is 44.58 %. In the category of not understanding the concept of 7.5%. This means that in this concept the understanding of students is still low because students who experience misconceptions and do not understand are more numerous than those who understand the concept.

6. Dalam sebuah percobaan daya hantar listrik, diperoleh data percobaan seperti gambar dibawah ini:



Berdasarkan hasil uji coba di atas, jenis larutan yang paling sesuai untuk gelas kimia nomor 1 dan 5 berturut-turut adalah...

- A. NaCl dan CH_3COOH
- B. CH_3COOH dan NaCl
- C. H_2SO_4 dan $\text{C}_6\text{H}_{12}\text{O}_6$
- D. $\text{C}_2\text{H}_5\text{OH}$ dan NaOH
- E. NH_3 dan H_2SO_4

Alasannya :

- A. Larutan CH_3COOH dan NaCl merupakan larutan elektrolit kuat yang dapat mengalami ionisasi sempurna dan dapat menghasilkan gelembung gas
- B. CH_3COOH dan NaCl adalah senyawa yang mengalami ionisasi sebagian sehingga bersifat sebagai elektrolit lemah namun dapat menghasilkan gas dan nyala lampu
- C. Larutan NaCl mengalami ionisasi sempurna (elektrolit kuat) dan CH_3COOH hanya mengalami ionisasi sebagian (elektrolit lemah)
- D. Larutan NH_3 mengalami ionisasi sebagian (elektrolit lemah) dan NaOH mengalami ionisasi sempurna (elektrolit lemah)
- E. H_2SO_4 dan $\text{C}_6\text{H}_{12}\text{O}_6$ sama – sama mengalami ionisasi ketika dilarutkan ke dalam air sehingga dapat menghasilkan gelembung gas dan nyala lampu

Fig 4. Question 6

In question number 6 about determining the type of solution that best fits the picture of the experimental results, in this question the percentage for the concept understanding category is 30%, for the misconception category the percentage is 62.5%, and the category does not understand the concept is 7.5%. The category that has the highest percentage is in the category of misconceptions. In the questions asked to determine the type of solution suitable for beakers 1 and 5, respectively. Beaker 1 has lots of bubbles and the lamp can light up brightly, which is a characteristic of a strong electrolyte solution, for beaker 5 there are few bubbles and the lamp does not light up which is a characteristic of a weak electrolyte solution. As a result of not knowing the concept, students experience misconceptions.

8. Perhatikan tabel!

Sampel/larutan	Nyala bola lampu	Pengamatan pada elektrode
I	Menyala redup	Tidak ada gelembung
II	Menyala terang	Banyak gelembung
III	Menyala redup	Sedikit gelembung
IV	Tidak Menyala	Tidak ada gelembung

Yang merupakan ciri-ciri dari larutan Na_2SO_4 dan H_2S adalah...

- A. II dan IV

B. II dan III

- C. I dan II

- D. II

- E. III

Alasannya :

- A. Na_2SO_4 merupakan elektrolit kuat dan H_2S merupakan larutan nonelektrolit.
- B. Na_2SO_4 dan H_2S merupakan larutan elektrolit lemah.
- C. Na_2SO_4 dan H_2S merupakan larutan elektrolit kuat.
- D. Na_2SO_4 merupakan elektrolit kuat dan H_2S merupakan larutan elektrolit lemah.
- E. Na_2SO_4 merupakan elektrolit lemah dan H_2S merupakan larutan elektrolit kuat

Fig 5. Question 8

In question number 8 about determining the characteristics of Na_2SO_4 and H_2S solutions based on the flame and bubbles of an unknown sample, in this question the percentage for the concept understanding category is 37.5%, for the misconception category the percentage is 50%, and the category is not. understand the concept of 12.5%. The category that has a high percentage in this question is also the category of misconceptions. This is because students do not understand that Na_2SO_4 is an example of a strong electrolyte solution and H_2S is an example of a weak electrolyte solution, so there are still many students who experience errors in choosing answers and reasons for this question.

3. Chemical bonds and their electrolytic properties

The sub-concept of chemical bonds and their electrolyte properties has a high percentage in the category of misconceptions, which is 43.75%. This indicates that many students have misconceptions about the sub-concept of chemical bonds and their electrolyte properties. In another category, namely the category of understanding the concept of this sub-concept, the percentage of students who already understand the concept is 40.83%, while for the category that does not understand the concept the percentage is 14.16%. To reveal the existence of misconceptions and do not understand the concept of students, the following is an example of questions in this sub-concept that has the highest percentage of misconceptions, namely items number 13 and 14.

13. Dibawah ini merupakan beberapa contoh larutan elektrolit.

Larutan elektrolit	Konsentrasi
HCl	0,1 M
NaOH	0,7 M
H ₂ SO ₄	0,3 M
Na ₂ SO ₄	0,5 M
Al ₂ (SO ₄) ₃	0,2 M

Berdasarkan tabel diatas, larutan yang lebih baik dalam menghantarkan arus listrik adalah...

- A. Na₂SO₄
 B. NaOH
 C. Al₂(SO₄)₃
 D. H₂SO₄
 E. HCl
 Alasannya :
 A. Memiliki konsentrasi larutan paling besar
 B. **Memiliki konsentrasi ion terbesar**
 C. Memiliki konsentrasi larutan yang paling kecil
 D. Merupakan asam kuat
 E. Memiliki jumlah ion paling besar

Fig 6. Question 13

In question number 13 about determining a better solution to conduct electric current, the percentage for the category of understanding the concept is 37.5%, for the category of misconceptions the percentage is 60%, and the category of not understanding the concept is only 2.5%. The category that has a high percentage of this question is also in the category of misconceptions. The misconceptions experienced by students in this problem occur because students only see from the highest number in the concentration table presented without seeing the solution paired with a known concentration, but students already understand well that the solution has the largest ion concentration. is the best solution for conducting electric current.

14. Perhatikan beberapa contoh senyawa beserta sifat hantar listriknya dibawah ini!

No	Contoh senyawa	Daya Hantar Listrik			jenis senyawa
		Padatan	Lelehan	Larutan (dalam Pelarut Air)	
I	NaOH	Dapat menghantarkan	Dapat menghantarkan	Dapat menghantarkan	Senyawa ionik
II	C ₆ H ₁₂ O ₆	Tidak menghantarkan	Tidak menghantarkan	Dapat menghantarkan	Senyawa kovalen nonpolar
III	NaCl	Tidak dapat menghantarkan	Dapat menghantarkan	Dapat menghantarkan	Senyawa ionik
IV	H ₂ CO ₃	Tidak menghantarkan	Tidak menghantarkan	Dapat menghantarkan	Senyawa kovalen polar

Berdasarkan data di atas, contoh senyawa yang benar dengan sifat daya hantar listrik dan jenis senyawanya yaitu...

- A. I dan II
 B. **III dan IV**
 C. I dan III
 D. II dan III
 E. II dan IV
 Alasannya :
 A. Senyawa ionik dan senyawa kovalen polar dapat menantarkan listrik dalam semua jenis wujudnya
 B. Semua jenis senyawa kovalen polar dan senyawa ionik dapat menghantarkan arus listrik pada wujud lelehan dan larutannya
 C. Senyawa ionik dapat menghantarkan arus listrik pada semua wujudnya sedangkan pada senyawa kovalen hanya pada wujud larutan dan lelehan
 D. Senyawa ionik bersifat elektrolit kuat dan senyawa kovalen polar bersifat elektrolit lemah pada wujud lelehannya
 E. **Ion pada senyawa ionik dalam bentuk lelehan dapat bergerak bebas dan menghantarkan arus listrik namun tidak pada senyawa kovalen polar**

Fig 7. Question 16

In question number 16 concerning determining compounds according to their electrical conductivity and types of compounds, the percentage for the concept understanding category is 25%, for the misconception category the percentage is 22.5%, and the category does not understand the concept is only 52.5%. . The category that has a high percentage in this question is in the category of not understanding the concept. This indicates that there are still many students who do not understand the relationship between the conductivity of compounds and the types of compounds, and also because students do not understand the types of compounds from the examples of compounds in the table presented.

IV. CONCLUSION

This study aims to determine whether there are students' misconceptions about electrolyte and nonelectrolyte solutions using a two-tier multiple choice diagnostic test instrument and see misconceptions based on the percentage of students' ability levels. Based on the results of the research that has been done, it can be concluded that in general the students of class X MIPA 7 at SMAN 2 Padang have misconceptions with an average percentage of misconceptions of 36.94%. Students experience misconceptions on the sub-concept of the properties of the electrolyte solution by 22.5%, the sub-concept of chemical bonds and their electrolyte properties by 43.75%, and the sub-concept of the electrical conductivity of the solution has the highest percentage of misconceptions, which is 44.58%.

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