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## **Developing a Four-Tier Concept Test on the Topic of Matter for Middle School Students**

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### Abstract

In this study, a four-tier concept test was developed to determine the conceptual understanding and misconceptions of 8th-grade middle school students regarding the topic of matter. The Matter Concept Test (MCT) was prepared with 16 items, each consisting of four steps, and applied to 175 eighth-grade students studying in Eskişehir. SPSS, Excel, and Factor statistical programs were used to analyze the data. According to the results of the exploratory factor analysis, the test's KMO value was found to be .652, exhibiting a four-factor structure with eigenvalues above one and explaining 42.4% of the total variance. All factor loadings were above .30, supporting the construct validity of the items. In the reliability analysis, the KR-20 coefficient for the scientific knowledge score was 0.816, and the KR-20 coefficient for the misconception score was 0.743. Both values being above .70 indicate that the test is reliable. Furthermore, the false positive average was calculated to be 5.2%, and the false negative average was calculated to be 3.7%. Both ratios being below the 10% threshold specified in the literature support the validity of the test. When the item difficulty and discrimination indices were examined, it was seen that the test consisted of items of medium difficulty and high discrimination. The findings showed that students had clear misconceptions about pure matters, atoms, mixtures and the separation of mixtures. This finding supports that the developed test can identify conceptual errors across multiple dimensions, including content knowledge, reasoning and confidence levels. In conclusion, the developed four-tier concept test was evaluated as a measurement tool that reliably and validly reveals both students' scientific knowledge and their misconceptions.

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### Introduction

Conceptual misconceptions in education are a fundamental problem in education and teaching, arising from the negative impact of students'/teachers' scientifically incorrect or incomplete knowledge of a subject on the educational process (Smith et al., 1993; Türkdöğän et al., 2015). Although there is erroneous or incomplete information in misconceptions, not every error or incomplete information encountered is a misconception (Eryılmaz, 2002; Önder Çelikkanlı, 2019). To speak of a misconception, it is necessary that a thought/knowledge possessed on a subject does not correspond with scientific knowledge and that, despite this, the false knowledge/thought is defended and accepted as correct (Eryılmaz & Sürmeli, 2002; Önder Çelikkanlı, 2019). Furthermore, misconceptions can hinder students' ability to make sense of newly acquired knowledge and integrate previously acquired knowledge, thereby affecting their scientific thinking skills and complicating the education, teaching, and learning process (Geçgel & Şekerci, 2018; Vosniadou, 2008). Therefore, for practical education and teaching to occur and to prevent disruptions in educational environments, misconceptions must be identified as early as possible and addressed using appropriate methods.

Since misconceptions significantly impact students' learning processes, researchers have developed various tools to identify and address them effectively. In the literature, one of the most common methods used to identify misconceptions is two-tier tests that include multiple-choice questions along with second-tier justification questions (Avcı et al., 2018; Çil et al., 2025; Pan, 2021; Jung, 2020; Küçükkeskin & Kılıncı, 2024; Sarı & Bayram, 2018). Two-tier tests not only reveal the correct answer but also how students arrived at it. However, two-tier tests do not always provide sufficient opportunity to analyze students' conceptual knowledge in depth. Three-tier tests have been developed to address these limitations and shortcomings. Three-tier tests reveal the conceptual understanding processes with richer data by revealing whether students are confident in their answers as well as justifying their answers (Akbolat et al., 2023; Akdağ Kılıncı, 2019; Çetinkaya & Taş, 2018; Demirtaş, 2023; Elmas & Pamuk, 2021; Haryono et al., 2021; Haryono & Aini, 2020; Ristanto et al., 2023; Suprpto & Abidah, 2020).

However, because the step of certainty included in these tests does not clearly distinguish whether students' answers or their reasoning reflect conceptual misunderstanding, these tests have certain limitations in the process of diagnosing conceptual misunderstanding. Four-tier tests developed based on this approach have gained increasing attention in recent years because they have the potential to analyze students' responses in terms of scientific accuracy, justification, conceptual consistency, and confidence level (Bessas et al., 2024; Çelik, 2024; Hermita et al., 2017; Kaltakçı Gürel et al., 2017; Kartimi et al., 2021; Jumilah & Wasis, 2023; Putica, 2022).

This diversity supports the multidimensional approach to misconception research, analyzing students' knowledge structures and thinking patterns, not just in terms of measurement and evaluation. Although there are an increasing number of application examples for test types in the literature, tests that allow students' misconceptions to be analyzed in terms of both reasoning consistency and confidence level, as well as scientific accuracy level, are still limited (Çelik, 2024; Ma et al., 2025; Jumilah & Wasis, 2023). This situation highlights the need for new studies to further develop existing measurement tools (Desstya et al., 2025; Kaltakçı Gürel & Eryılmaz, 2015; Mert et al., 2023).

As alternatives to these methods used to identify conceptual misconceptions, other methods include open-ended questions (Alın & İzgi, 2017; Çalgıcı et al., 2020; Gökulu, 2017; Kabasakal & Uygur, 2021; Karaer, 2019; Şener Çoruhlu & Terzioğlu, 2024; Önal & Aksu, 2025), multiple-choice tests (Kardaş et al., 2020; Sancar & Koparan, 2019; Uyanık & Serin, 2016), concept cartoons (Estacio et al., 2024; Siong et al., 2023), questionnaire (Kartal, 2017), learning-oriented letter writing (Uzoğlu & Gürbüz, 2013), concept map (Kordaki & Psomos, 2015; Serttaş & Yenilmez Türkoğlu, 2020), word association tests (Kaya et al., 2019) and diagnostic decision trees (Geçgel & Şekerci, 2018; Karaaslan & Turanlı, 2018). In some studies, semi-structured interviews were conducted in conjunction with diagnostic tests to analyze students' conceptual understanding and misconceptions in depth (Kandemir & Apaydın, 2020). In addition, visual interpretation activities and concept inventories, among qualitative data collection tools, are effectively used to reveal students' mental models (Clement, 1993; Lindell et al., 2007). Some studies also included applications aimed at increasing the awareness level of students or teachers regarding misconceptions (Kandemir & Apaydın, 2020).

This study aimed to develop a valid and reliable four-tier concept test to assess students' conceptual understanding of the concept of matter in the 7th-grade middle school science curriculum in a multidimensional manner. A literature review identified that open-ended questions, interviews, multiple-choice tests, concept cartoons, and tiered tests (two-tier and three-tier) are methods commonly used to identify misconceptions and to reveal information about students' thinking structures. However, these instruments often do not allow for the simultaneous evaluation of multiple variables such as the scientific accuracy of students' answers to questions, the content of the reasons for their answers, their conceptual consistency, and their confidence level. Four-tier tests, developed to overcome this limitation, enable simultaneous analysis of students' cognitive and affective responses.

### **Problem Statement**

A comprehensive literature review revealed that there is no four-tier diagnostic test specific to the topic of "Pure Matters and Mixtures" at the middle school level. In addition, the concept of matter is among the topics where students' prior knowledge gained from their daily life experiences often conflicts with scientific concepts and where misconceptions are frequently observed (Clement, 1993). This situation highlights the need for a novel measurement tool to be developed for this area of study. In this context, this study aims not only to develop an assessment tool but also to contribute to a healthier conceptual understanding of the topic of matter.

It is anticipated that this four-tier test will reveal the underlying thought structures and reasoning behind students' responses to the questions, enabling an assessment of their levels of scientific consistency and confidence. Thus, it will be possible for teachers to identify misconceptions in students and restructure the education-learning processes to eliminate these misconceptions. In addition to these aspects, this study aims not only to provide a functional assessment tool for those who will apply to the developed four-tier test but also to make a comprehensive, original, and innovative contribution to the field of measurement and evaluation. In this context, the sub-problems addressed in the study are presented below:

1. Is the four-tier test developed to reveal middle school students' conceptual understanding of matter a valid measurement tool?
2. Is the four-tier test developed to reveal middle school students' misconceptions about matter a suitable measurement tool in terms of reliability?

3. What are the factor-based findings regarding middle school students' scientific knowledge levels, knowledge gaps, and misconceptions about matter?
4. What are the percentages of scientific knowledge that middle school students possess regarding the matter subject?
5. What are the percentages of knowledge gaps that middle school students possess regarding the matter subject?
6. What are the percentages of middle school students' misconceptions about matters?

## Method

### Research Design

This study is a test development study aimed at developing a four-tier concept test called the Matter Concept Test (MCT). In the test development process, the survey model was preferred over quantitative research methods to systematically conduct validity, reliability, and item analyses and to identify students' misconceptions in the developed test. The survey model is a research design that aims to present the current situation as it is and to produce statistically relevant results for the phenomenon in question through quantitative data obtained from large sample groups (Freankel et al., 2012; Büyüköztürk et al., 2019).

### Data Collection

In the study, non-random sampling was preferred among sampling methods, allowing the application process to be planned according to field conditions. This method was preferred because it minimizes the researcher's limitations in terms of time, access, and implementation processes, making the process more feasible; it also aligns with sampling approaches commonly recommended in test development studies (Frankel et al., 2012; Büyüköztürk et al., 2019). In determining the sample size, it was considered that at least five times the number of items in the measurement tool should be included (Tabachnick & Fidell, 2013). In line with this, the targeted sample size was achieved in the study.

For a pilot study, the first version MCT was applied to 200 eighth-grade students attending public middle schools affiliated with the Ministry of National Education in the province of Eskişehir. Data from students who only answered some tiers of the test or left many questions blank were considered incomplete and excluded from the analysis. Data from 175 students who answered all four tiers of the test were included in the analysis. The ages of the students included in the analysis ranged from 12 to 14 years old. After revisions of the pilot version, the final version of the test was administered to 430 eighth-grade students attending public schools affiliated with the Ministry of National Education in Eskişehir to identify misconceptions. The ages of the students participating in the main study ranged from 12 to 14 years old. Detailed demographic characteristics of both the pilot and main study samples are presented in Table 1.

Table 1. Gender distribution

	Gender	Number	Percentage %
Pilot study	Female (F)	93	53.1 %
	Male (M)	82	46.9 %
	Total	175	100 %
Main study	Female (F)	209	48.6 %
	Male (M)	221	51.4 %
	Total	430	100 %

According to the 2018 Science Teaching Program of the Ministry of National Education (MEB), the topic of "matter" is included in the "Pure Matters and Mixtures" unit at the 7th-grade level. In the Turkey Century Education Model Science Curriculum, published in 2024, it is again presented at the 7th-grade level under the heading 'Journey to the Nature of Matter'. However, since the new curriculum was only applied in 5th grade starting in the 2024–2025 education year, the study group consisted of 8th-grade students, considering that they had completed the learning process related to the topic based on the 2018 curriculum.

A comprehensive literature review was conducted before the test development process, and in this context, the distractors in the test were prepared to include misconceptions frequently encountered in the literature (Avcı et al., 2018; Lindell et al., 2007; Özmen & Sever, 2024; Sadler, 1998; Ünal et al., 2010). Following the approach of

Kıray et al. (2015), open-ended questions were prepared to assess students' conceptual understanding of the subject and identify any misconceptions they may have.

Before the pilot study, a preliminary trial process was conducted. The questions were first read to 10 eighth-grade students, who were not part of the main sample, in order to gather feedback on visual appeal, language clarity and comprehensibility. Based on the students' suggestions, necessary revisions were made. Following this tier, the revised items were administered to another group of 100 eighth-grade students in Eskişehir to examine students' response patterns. The researchers analyzed these responses and common misconceptions were identified. The distractors of the test items were then structured to reflect these misconceptions.

Based on these analyses, frequencies were calculated for the responses obtained, and each item was converted into a three-option multiple-choice format (two false and one correct option) based on these frequencies. Subsequently, the question "Why did you select this option?" was added below these multiple-choice items, asking students to write their reasons for choosing their response. The responses obtained were then subjected to frequency analysis, the most frequently given reasons were converted into options, and the rationale for the correct answer to the question was also included among the options. At this point, the test was structured in four steps, allowing students to select either "I am sure" or "I am not sure" after providing their answers and justifications.

The four-tier draft test was first submitted to three subject matter experts for content and face validity review, and necessary adjustments were made based on their feedback. Following these revisions, the draft test was administered to 200 eighth-grade students as a pilot study. After excluding incomplete forms, data from 175 students who completed all four tiers were used to conduct item analyses and finalize the test. After the test development process was completed, the final version of the MCT was administered to larger sample of 430 eighth-grade students during the second semester of the 2024–2025 school year in order to identify students' misconceptions and determine their levels of scientific knowledge, knowledge gaps, and error types. The findings reported in this article are based on this main application.

### Data Analysis

The validity and reliability analyses of the developed MCT were performed using statistical software packages, including SPSS, Excel, and Factor. During the data analysis process, different scoring types were considered in accordance with the four-tier test structure. In this context, separate coding was performed according to categories such as scientific knowledge, conceptual misconceptions, false positives, and false negatives. In the coding, responses given in the first and third tiers were scored as "1" if correct and "0" if false. In the second and fourth tiers, where the confidence level was questioned, the "I am sure" option was coded as '1' and the "I am not sure" option as "0".

Scientific knowledge scores were calculated based on the 1-1-1-1 coding, representing the case where all tiers were answered correctly. In the conceptual misunderstanding scoring, false answers in the first and third tiers and confident answers in the confidence tiers (0-1-0-1) were considered. False positive (correct answer, incorrect reasoning) were coded as 1-1-0-1, while false negative (incorrect answer, correct reasoning) were coded as 0-1-1-1. Other combinations were included in the knowledge deficiency category. This scoring approach has enabled a multidimensional analysis of students' conceptual understanding, taking into account not only their knowledge level but also the justification of their answers and their level of confidence. Four-tier patterns used the MCT and their interpretations are presented in Table 2.

Tablo 2. Four-tier coding patterns used in MCT

<b>First-tier (Content)</b>	<b>Second-tier (Confidence)</b>	<b>Third-tier (Reason)</b>	<b>Fourth-tier (Confidence)</b>	<b>Interpretation</b>
1	1	1	1	Scientific knowledge
1	1	0	1	False positive
0	1	1	1	False negative
0	1	0	1	Misconception

### Reliability Analysis of the Test

The developed MCT can be used to reveal both students' scientific knowledge level and their conceptual misconceptions. In this regard, the reliability of the four-tier test was evaluated using two different scoring approaches.

#### *Reliability 1. Reliability of Scientific Knowledge*

This is the reliability coefficient calculated by considering the responses where students gave correct answers in the first and third tiers and marked the "I am sure" option in the second and fourth tiers (1-1-1-1).

#### *Reliability 2. Reliability of Misconception*

This reliability coefficient is calculated based on the responses where students gave false answers in the first and third tiers and selected the "I am sure" option in the second and fourth tiers (0-1-0-1). In the literature, a reliability coefficient of .70 or above for measurement tools is generally considered acceptable (Freankel et al., 2012; Büyüköztürk et al., 2019). However, it is also noted that this value may be lower in tests designed to identify misconceptions (Kaltakçı, 2012).

#### *Validity Analysis of the Test*

The validity of the test was examined through factor analysis, the correlation between correct answers and confidence scores, the probability of positive and negative incorrect responses, and expert opinion.

##### *Validity 1. Factor Analysis*

One of the most frequently used methods for gathering evidence regarding construct validity is factor analysis, which aims to reveal the underlying dimensions of the measurement tool by examining the relationships between test items (Pedhazur & Schmelkin, 1991). In this regard, the suitability of the data obtained for the developed MCT for factor analysis was evaluated using the Kaiser–Mayer–Olkin (KMO) coefficient and Bartlett's sphericity test. A KMO value above .60 and a significant Bartlett test indicate that the data are suitable for factor analysis (Alpar, 2022). In this study, exploratory factor analysis (EFA) was conducted on the data obtained from the four-tier test to examine the construct validity of the instrument, and the results of these analyses are reported in the Findings section. Additionally, within the scope of item analysis, the difficulty and discrimination indices of each item were calculated and evaluated according to the relevant criteria.

##### *Validity 2. Correlation Between Correct Answer Scores and Confidence Scores*

To examine the relationship between students' correct answers and their confidence levels, three separate correlation coefficients were calculated: "first tier with second tier," "third tier with fourth tier," and "first and third tiers with second and fourth tiers."

##### *Validity 3. False Positive and False Negative Probabilities*


To support content validity, probabilities related to knowledge gaps, as well as false positive and false negative situations, were examined, and expert opinions were also utilized. The literature states that the averages of positive and negative incorrect responses in tests designed to measure misconceptions should be below 10% (Hestenes & Halloun, 1995).

##### *Validity 4. Expert Opinion*

Expert opinions were utilized in the development of the test items. During the preparation of open-ended questions, the opinions of an academic expert in science, a science teacher, and an academic expert in measurement and evaluation were sought. These experts evaluated the draft test in terms of content and face

validity, and the final version of the test was created by making the necessary adjustments based on their feedback. The structure of the developed test is presented in the sample question in Figure 1.

13.1 Some particle models are shown in the figure.



I                      II                      III

Which of the above models can be said to represent an element?

A) I                      B) II                      C) III

13.2 Are you sure about your answer to the previous question?

A) I am sure                      B) I am not sure

13.3 Why did you select the above option?

A) An element is formed when at least two different atoms combine.  
 B) Atoms of different sizes combine to form elements.  
 C) The atoms that form an element do not bond with each other.  
 D) Elements are composed of atoms of a single type.  
 E) The atoms that make up an element are different from each other.

13.4 Are you sure about the answer you gave to the previous question?

A) I am sure                      B) I am not sure

Figure 1. Sample question from the matter concept test

## Findings and Discussion

The data were collected during the second semester of the 2024–2025 academic year using the MCT developed by the researcher.

### *Findings Related to the Reliability of the MCT*

As a result of reliability analyses, the KR-20 internal consistency coefficient was calculated for the test's scores of scientific knowledge and misconceptions. The KR-20 value for the scientific knowledge score (calculated based on correct answers; 1 point was awarded when "correct answer" and "I am sure" were marked, and 0 points otherwise) was found to be 0.816. The KR-20 value calculated for the misconception scores (1 point when the false answer and 'I am sure' are marked, 0 points in other cases) was found to be .743. The fact that both coefficients are above .70 indicates that the test is sufficiently reliable in terms of scientific knowledge and misconception dimensions. (Gomez – Rodriguez et al., 2020; Vrotsou et al., 2018). Özmen & Sever (2024) reported a KR-20 value of .79 in their study, where they developed a three-tier test and noted that the contribution of the test's different tiers to measurement affected reliability. Yun et al. (2023) emphasized that internal consistency coefficients above .70 in four-tier tests are a positive indicator of the test's structural integrity and item fit. Hasançelebi et al. (2020) also stated that alpha values above .80 in multidimensional measurement tools indicate reliability. In this context, the obtained KR-20 coefficients indicate that the test can reliably measure students' conceptual understanding, and its four-tier structure supports this process.

### *Findings Related to the Validity of the MCT*

#### *Validity 1. Factor Analysis*

According to the EFA results for the misconception test, the KMO value is .652, indicating that the sample size is adequate. The Bartlett's sphericity test ( $X^2 = 179.1$ ,  $df = 120$ ,  $p = .000$ ) was statistically significant, indicating that the correlation matrix obtained for EFA is not a unit matrix and is therefore suitable for factor analysis. Figure 2 shows the cluster plot from the EFA results for the Misconception Diagnosis Test.

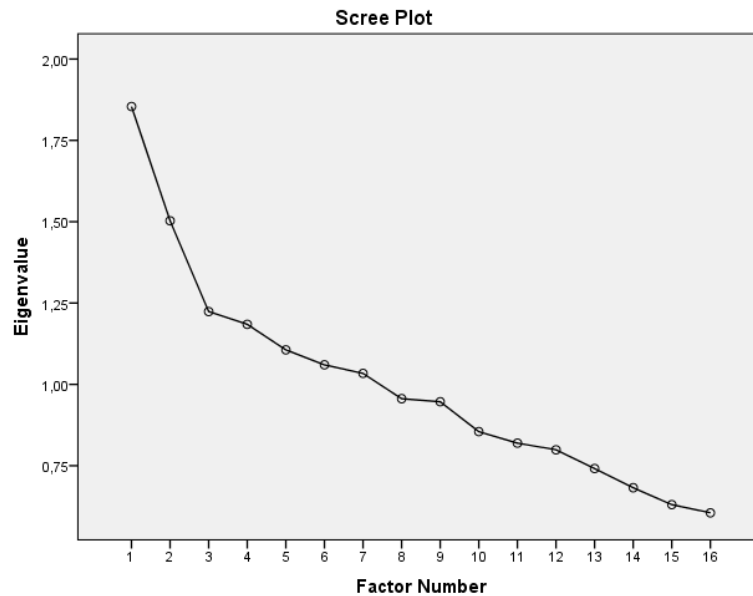


Figure 2. Scree plot

Upon examination of the graph, it can be seen that it begins to flatten from the fifth point onwards, indicating that the test has four factors. The factor loadings and explained variance values are presented in Table 3. The analysis findings show that the factor loadings of all items are at an acceptable level. Furthermore, the fact that the total explained variance ratios are above 40% is considered sufficient evidence of construct validity for tests developed in the field of educational sciences and measurement and evaluation (Tabachnick & Fidell, 2013). However, the high explained variance ratio is interpreted as a situation that increases the power of the measurement tool.

Table 3. MCT factor loadings

Test Questions	F1	F2	F3	F4
S1	0,718			
S7	0,642			
S9	0,348			
S14	0,402			
S15	0,51			
S3		0,54		
S8		0,612		
S13		0,432		
S16		0,45		
S2			0,487	
S4			0,432	
S6			0,823	
S11			0,418	
S5				0,834
S10				0,785
S12				0,779
Eigenvalue	2,351	1,793	1,353	1,292
Explained Variance	0,147	0,112	0,085	0,081
Explained Total Variance	0,424			
Reliability	0,737	0,728	0,724	0,708
Overall Scale Reliability	0,743			

As a result of the exploratory factor analysis (EFA) conducted for the MCT, four factors with eigenvalues ranging from 1.292 to 2.351 and eigenvalues above one were obtained. The first factor comprises five items (S1, S7, S9, S14, and S15) and accounts for 14.7% of the variance. The factor loadings for this factor range from 0.348 to 0.718. The second factor comprises 4 items (S3, S8, S13, and S16) and accounts for 11.2% of the variance; factor

loadings range from 0.432 to 0.612. The third factor consists of 4 items (S2, S4, S6, and S11) and explains 8.5% of the variance; factor loadings range from 0.418 to 0.823. The fourth factor comprises 3 items (S5, S10, and S12) and accounts for 8.1% of the variance, with factor loadings ranging from 0.779 to 0.834. The four factors explain a total of 42.4% of the variance. The reliability coefficients based on factors range from 0.708 to 0.737, and the overall reliability coefficient of the test is 0.743. All factor loadings were found to be above 0.30, and as a result, it was determined that the items related to the misconception test exhibit a four-factor structure.

#### *Validity 2. Correlation Between Correct Answer Scores and Confidence Scores*

The correlation coefficients calculated for the relationships between correct answers and confidence scores are presented in Table 4. In this context, the values obtained by comparing the first tier with the second tier, the third tier with the fourth tier, and both tiers together are compared.

Table 4. Correlation values of MCT

		Second Tier Scores
First Tier Scores	r	,293**
	p	,000
		Fourth Tier Scores
Third Tier Scores	r	,244**
	p	,000
		Second and Fourth Tier Scores
First and Third Tier Scores	r	,273**
	p	,000

Büyükoztürk et al. (2019) state that a correlation coefficient value of 1.00 indicates a perfect positive relationship between two variables, while a value of -1.00 indicates a perfect negative relationship. A coefficient value of 0.00 indicates that there is no relationship between the variables. According to the generally accepted classification, the absolute value of the coefficient between 0.70 and 1.00 is considered a strong relationship, between 0.30 and 0.70 is considered a moderate relationship, between 0.00 and 0.30 is considered a weak relationship. Pallant (2017) stated that when  $Irl < .40$ , the relationship is low. There is a low positive relationship between the first and second tier scores ( $r = .293$ ,  $p < .05$ ). There is a low-level positive relationship between the third and fourth tier scores ( $r = .214$ ,  $p < .05$ ). A low-level positive relationship was found between the first and third tier scores and the second and fourth tier scores ( $r = .273$ ,  $p < .05$ ). All scores increase and decrease in the same direction.

#### *Validity 3. False Positive and False Negative Probabilities*

The literature suggests that maintaining the positive and negative error rates below 10% in tests designed to identify misconceptions is crucial for validity (Hestenes & Halloun, 1995). The analyses conducted in this study found that the average false positive rate was 5.2%, while the average false negative rate was 3.7%. The fact that both rates are below 10% is a result that supports the validity of the developed test.

#### *Validity 4. Expert Opinion*

The content validity of the test was ensured by consulting with field experts. Consulting expert opinion to support the content validity of measurement tools is a frequently used approach in the literature (Peterson & Treagust, 1989; Zengin & Bozkurt, 2022). Furthermore, it is stated that expert contributions provide structural support to the content validity process by strengthening the consistency of test items with the conceptual framework (Sireci & Faulkner-Bond, 2014).

Some of the 33 items included in the initial development of the MCT were removed from the test based on expert opinions, as they contained content that repeated similar concepts in a way that could harm content validity. Removal of items also shortened the test administration time and made it more economical, and in line with the findings obtained from factor analysis and item analysis. In this context, assessments of the difficulty and discriminative power levels of the items were evaluated based on the criteria presented in Table 5; items with a difficulty (p) below .20 (difficult), items close to 1.00 (very easy), and items with a discriminative power index (r) below .20 were not considered.

Table 5. Evaluation criteria based on item difficulty and item discrimination index values

<b>Difficulty Index</b>	<b>Evaluation of the Item</b>	<b>Distinctiveness Index</b>	<b>Evaluation of the Item</b>
0.70 – 1	Very easy	0.19 and smaller	Very weak, must be removed (Weak)
0.5 – 0.69	Easy	0.20 – 0.29	Needs correction and improvement (Moderate)
0.30 – 0.49	Moderately difficult	0.30 – 0.39	Quite good, but still could be improved (Good)
0.29 and below	Difficult	0.40 and larger	Very good item (Very good)

Note: This table was created based on widely accepted principles in the field of measurement and evaluation in education and was adapted from the study by Hasançelebi et al. (2020).

Table 6 presents the difficulty and discriminating power levels of the items in the final version of the MCT, and the values indicate that both are within acceptable ranges. The four-tier structure of the developed test allows for analyzing not only whether students give correct answers but also the underlying reasons for these answers and the students' confidence levels. In this respect, the test has been evaluated as a diagnostic tool that can reveal students' misconceptions in greater depth. Similarly, Bessas et al. (2024) emphasized that the four-tier test structure is effective in identifying misconceptions by revealing the thinking processes behind student responses. Özmen & Sever (2024) stated that three-tier tests reveal students' ability to establish cause-and-effect relationships, allowing for a more precise observation of their orientation toward alternative concepts. The study conducted by Şen et al. (2017) also emphasized that multi-tier tests make significant contributions to distinguishing students' superficial knowledge and identifying false conceptualizations. In this context, the four-tier structure of the developed test provides the opportunity to assess not only students' knowledge levels but also their tendencies toward misconceptions and cognitive confidence processes in a multidimensional manner.

Table 6. Difficulty and distinctiveness levels of questions remaining in the MCT

<b>Question Number</b>	<b>Difficulty Index</b>	<b>Difficulty Level</b>	<b>Discrimination Index</b>	<b>Discrimination Level</b>
1.1	0.42	Moderate	0.48	Very Good
1.3	0.36	Moderate	0.39	Good
2.1	0.38	Moderate	0.31	Good
2.3	0.30	Moderate	0.30	Good
3.1	0.43	Moderate	0.41	Very Good
3.3	0.43	Moderate	0.50	Very Good
4.1	0.46	Moderate	0.34	Good
4.3	0.22	Difficult	0.32	Good
5.1	0.50	Moderate	0.46	Very Good
5.3	0.32	Moderate	0.48	Very Good
6.1	0.39	Moderate	0.45	Very Good
6.3	0.19	Difficult	0.34	Good
7.1	0.38	Moderate	0.41	Very Good
7.3	0.32	Moderate	0.30	Good
8.1	0.51	Moderate	0.43	Very Good
8.3	0.34	Moderate	0.33	Good
9.1	0.41	Moderate	0.52	Very Good
9.3	0.24	Difficult	0.47	Very Good
10.1	0.42	Moderate	0.39	Good
10.3	0.17	Difficult	0.40	Very Good
11.1	0.47	Moderate	0.49	Very Good
11.3	0.39	Moderate	0.38	Good
12.1	0.40	Moderate	0.54	Very Good
12.3	0.12	Difficult	0.35	Good
13.1	0.37	Moderate	0.50	Very Good
13.3	0.30	Moderate	0.48	Very Good
14.1	0.52	Moderate	0.48	Very Good
14.3	0.39	Moderate	0.58	Very Good
15.1	0.42	Moderate	0.33	Good
15.3	0.36	Moderate	0.36	Good
16.1	0.58	Moderate	0.48	Very Good
16.3	0.41	Moderate	0.58	Very Good

Findings Related to Misconceptions

Table 7. Classification of students' responses on the topic of matter in MCT

Content	Factor 1												Factor 2					Factor 3				Factor 4			
	1	7	9	14	15	Mean	3	8	13	16	Mean	2	4	6	11	Mean	5	10	12	Mean					
% First Tier	43,95	35,58	41,63	51,16	41,16	42,70	41,40	45,12	33,95	53,95	43,60	37,67	45,35	35,58	43,72	40,58	48,37	40,93	40,23	43,18					
% First Two Tiers	43,95	35,35	41,40	50,93	41,16	42,56	41,40	44,88	32,26	53,95	43,37	37,67	45,35	34,88	43,49	40,35	48,14	40,93	38,84	42,64					
% First Three Tiers	19,07	6,98	16,05	36,05	21,40	19,91	26,05	19,77	17,91	28,84	23,14	18,37	3,49	13,02	19,07	13,49	21,63	14,65	8,37	14,88					
% First Four Tiers	19,07	6,98	15,58	35,81	21,40	19,77	25,81	19,53	17,91	28,84	23,02	18,37	3,49	13,02	18,84	13,43	21,63	14,65	8,14	14,81					
% Scientific Knowledge	19,07	6,98	15,58	35,81	21,40	19,77	25,81	19,53	17,91	28,84	23,02	18,37	3,49	13,02	18,84	13,43	21,63	14,65	8,14	14,81					
% False Positive	24,65	28,14	25,12	14,88	19,77	22,51	15,12	25,12	15,35	24,88	20,12	19,30	41,63	21,86	24,19	26,74	26,28	26,05	30,47	27,60					
% False Negative	16,28	21,63	6,28	2,56	10,93	11,53	14,42	9,30	12,33	6,28	10,58	11,16	6,05	4,42	14,19	8,95	6,28	5,35	5,12	5,58					
% Misconception	39,77	42,33	51,40	45,81	47,44	45,35	43,95	44,88	53,49	39,30	45,41	50,00	48,40	59,30	41,63	49,88	45,35	52,56	53,95	50,62					
% Lack of Knowledge 1	0	0	0,47	0	0,23	0,14	0,23	0,23	0	0	0,12	0	0	0	0,23	0,06	0	0	0,23	0,08					
% Lack of Knowledge 2	0	0	0	0	0	0,09	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
% Lack of Knowledge 3	0	0	0,23	0	0,23	0	0	0	0,23	0,06	0	0	0	0	0	0	0	0	0,23	0,08					
% Lack of Knowledge 4	0,23	0,23	0,23	0	0	0,14	0,23	0	0,23	0,23	0,12	0	0,23	0	0,23	0,12	0,23	0,23	0	0,16					
% Lack of Knowledge 5	0	0	0	0	0	0	0	0,23	0	0,12	0	0	0	0,70	0,23	0,23	0	0	0,47	0,23					
% Lack of Knowledge 6	0	0,23	0	0	0	0	0	0	0,23	0	0,06	0	0	0	0	0	0	0	0,70	0,23					
% Lack of Knowledge 7	0	0	0	0	0	0	0,23	0	0	0,06	0	0	0	0	0	0	0	0	0,23	0,08					
% Lack of Knowledge 8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
% Lack of Knowledge 9	0	0,23	0	0	0	0,05	0	0	0	0	0	0	0	0	0	0	0	0	0	0					
% Lack of Knowledge 10	0	0	0,47	0	0,47	0,19	0	0,23	0	0	0,06	0,23	0	0,23	0	0,12	0	0,70	0,23	0,31					
% Lack of Knowledge 11	0	0	0,23	0	0	0,05	0	0	0,23	0,23	0,17	0,23	0	0,23	0,23	0	0	0,47	0,23	0,23					
% Lack of Knowledge 12	0	0,23	0	0,47	0	0,14	0	0,47	0,23	0,23	0,23	0,70	0	0,23	0,23	0,29	0	0	0	0					

Table 8. Misconceptions in MCT

Misconception Number	Misconceptions	Item–Tier Combinations
KY 1	Water is not a matter.	1.1.a 1.2.a 1.3.a 1.4.a
KY 2	Sugary water is a pure matter.	1.1.a 1.2.a 1.3.b 1.4.a
KY 3	Sugary water has a formula.	1.1.c 1.2.a 1.3.e 1.4.a
KY 4	Pure matters can be separated by physical means.	1.1.c 1. 2.a 1.3 f 1.4.a
KY 5	Ethyl alcohol - water is a heterogeneous mixture.	2.1.a 2.2.a 2.3.b 2.4.a
KY 6	Ethyl alcohol - water separated by evaporation	2.1.a 2.2.a 2.3.e 2.4.a
KY 7	Olive oil has a higher density than water	2.1.b2.2.a2.3.c2.4.a 2.1.b 2.2.a 2.3.d 2.4.a
KY 8	Atoms do not have energy levels.	3.1.b 3.2.a 3.3.a 3.4.a
KY 9	Atoms do not have a nucleus.	3.1.b 3.2.a 3.3.e 3.4.a
KY 10	Some matters do not contain atoms	3.1.c 3.2.a 3.3.c 3.4.a
KY 11	Atoms are not the building blocks of all matters found in nature.	3.1.c 3.2.a 3.3.f 3.4.a
KY 12	Homogeneous solid-liquid mixtures, such as salt water, are separated from each other by filtration.	4.1.b 4.2.a 4.3.a 4.4.a
KY 13	Homogeneous liquid-liquid mixtures are separated from each other by the density difference method.	4.1.b 4.2.a 4.3.a 4.4.a 4.1.c 4.2.a 4.3.c 4.4.a
KY 14	Homogeneous mixtures, such as salt-water and alcohol-water, are separated from each other by density difference.	4.1.b 4.2.a 4.3.b 4.4.a
KY 15	Alcohol and water have different densities, so they are separated using a separating funnel.	4.1.c 4.2.a 4.3.e 4.4.a
KY 16	When the liquid evaporates, the mixture becomes heterogeneous.	5.1.a 5.2.a 5.3.d 5.4.a
KY 17	When the mixture evaporates, the amount of sugar decreases compared to the initial state.	5.1.c 5.2.a 5.3.b 5.4.a
KY 18	The sugar evaporates and disappears compared to the second state.	5.1.c 5.2.a 5.3.e 5.4.a
KY 19	During dissolution, the amount of matter decreases.	6.1.b 6.2.a 6.3.b 6.4.a
KY 20	Sugar dissolves in hot tea.	6.1.b 6.2.a 6.3.d 6.4.a
KY 21	During dissolution, the amount of sugar increases.	6.1.c 6.2.a 6.3.a 6.4.a 7.1.b7.2.a7.3.a7.4.a, 7.1.b7.2.a7.3.e7.4.a,
KY 22	The atoms of compounds are the same.	16.1.a16.2.a16.3.a16.4.a, 16.1.c16.2.a16.3.d16.4.a, 16.1.c16.2.a16.3.e 16.4.a 7.1.a 7.2.a 7.3.c 7.4.a, 7.1.a 7.2.a 7.3.d 7.4.a,
KY 23	The atoms of elements are different from each other.	8.1.b 8.2.a 8.3.a 8.4.a, 13.1.b13.2.a13.3.b13.4.a 13.1.a13.2.a13.3.e13.4.a
KY 24	When at least three different types of atoms come together, an element is formed.	8.1.b 8.2.a 8.3.c 8.4.a
KY25	Compounds are formed when more than one molecule comes together.	8.1.c 8.2.a 8.3.d 8.4.a
KY 26	Steel is a pure matter.	9.1.b 9.2.a 9.3.a 9.4.a
KY 27	Seawater is a heterogeneous mixture.	9.1.a 9.2.a 9.3.b 9.4.a
KY 28	Not all solutions are homogeneous.	9.1.a 9.2.a 9.3.c 9.4.a
KY 29	Steel is a compound.	9.1.b 9.2.a 9.3.d 9.4.a
KY 30	Milk does not mix with anything.	10.1.a10.2.a10.3.a10.4.a
KY 31	Milk is a pure matter.	10.1.a10.2.a10.3.b10.4.a
KY 32	Fog forms a homogeneous mixture because it does not disperse evenly everywhere.	10.1.c10.2.a10.3.c10.4.a
KY 33	Fog is a homogeneous mixture because it has a single color.	10.1.c10.2.a10.3.e10.4.a 11.1.b11.2.a11.3.d11.4.a,
KY 34	Increasing the temperature accelerates the melting of the matter.	11.1.b11.2.a11.3.e11.4.a, 11.1.c11.2.a11.3.c 11.4.a
KY 35	As the disappearance time of matters increases, the melting rate increases.	11.1.c11.2.a11.3.b 11.4.a
KY 36	Salt and coffee mix in water and all turn into the same matter.	12.1.c12.2.a12.3.a 12.4.a

KY 37	In mixtures of water, salt, and coffee, coffee settles to the bottom, forming a homogeneous mixture.	12.1.c12.2.a12.3.c 12.4.a
KY 38	Olive oil and sugar are homogeneous because they do not mix completely in water.	12.1.a12.2.a12.3.b 12.4.a
KY 39	Olive oil is a homogeneous mixture because it forms a separate layer from the sugary water.	12.1.a12.2.a 12.3.f 12.4.a
KY 40	When at least two different atoms combine, an element is formed.	13.1.b13.2.a13.3.a 13.4.a
KY 41	The atoms that make up the element do not bond with each other.	13.1.a13.2.a13.3.c 13.4.a 14.1.b14.2.a14.3.a14.4.a, 14.1.b14.2.a14.3.d14.4.a, 14.1.c14.2.a14.3.c14.4.a, 14.1.c14.2.a14.3.e 14.4.a
KY 42	The element is represented by its first letter.	15.1.b15.2.a15.3.b 15.4.a
KY 43	The name of the CO compound is carbon hydrogen.	15.1.b15.2.a15.3.c 15.4.a
KY 44	The name of the CO compound is calcium oxide.	15.1.c15.2.a15.3.d 15.4.a
KY 45	The name of the SO <sub>2</sub> compound is nitrogen oxide.	15.1.c15.2.a15.3.e 15.4.a
KY 46	The name of the SO <sub>2</sub> compound is sodium dioxide.	15.1.c15.2.a15.3.e 15.4.a

The findings of the analysis related to misconceptions are presented in Table 7, Table 8, Table 9, and Figure 3. The findings show that students exhibit various conceptual errors regarding the matter. Table 7 shows the distribution of students' responses on the matter subject across factor groups. The factors represent different dimensions of the test and reveal the general pattern of students' conceptual tendencies regarding the subject of matter. When the obtained average values are examined, it was determined that for items within Factor 1 (1, 7, 9, 14, 15), the average percentage of scientific knowledge among students was 19.77%, while the misconception rate was 45.35%. For items under Factor 2 (3, 8, 13, 16), the average scientific knowledge was 23.02%, and the misconception rate was 45.41%. In Factor 3 (2, 4, 6, 11), the average scientific knowledge of students was 13.43%, and the misconception rate was 49.88%. Finally, in Factor 4 (5, 10, 12), the average scientific knowledge was 14.81%, and the misconception rate was 50.62%. These findings show that students' conceptual understanding of matter is generally weak, with misconceptions being particularly concentrated in the third and fourth factors. Therefore, students have superficial knowledge of some concepts, but this knowledge is underpinned by persistent misinterpretations. Table 8 lists 46 misconceptions in the MCT, grouped into four main categories: "pure matter," "atom," "mixture," and "separation of mixtures."

Table 9 and Figure 1 show the percentage rates of misconceptions in MCT. Upon examining the findings, it was determined that the most common misconceptions among students were related to items KY 22 (*Compounds have the same atoms.*) and KY 42 (*Elements are represented by their first letter.*). This result indicates that students have difficulty establishing a relationship between the structure of the atom and the concept of pure matters. The misconceptions observed at low rates, "sugary water is a pure matter (KY 2)" and "sugary water has a formula (KY 3)," reveal that students evaluate the distinction between matters and mixtures based on superficial characteristics.

Table 9. Percentage distribution of the misconceptions identified in the MCT

	KY 1	KY 2	KY 3	KY 4	KY 5	KY 6	KY 7	KY 8	KY 9	KY 10
<b>N</b>	44	17	24	24	37	45	29	57	11	17
<b>% Mean</b>	10,23	3,95	5,58	5,58	8,60	10,47	6,74	13,26	2,56	3,95
	KY 11	KY 12	KY 13	KY 14	KY 15	KY 16	KY 17	KY 18	KY 19	KY 20
<b>N</b>	35	12	79	8	27	55	30	28	61	50
<b>% Mean</b>	8,14	2,79	18,37	1,86	6,28	12,79	6,98	6,51	14,19	11,63
	KY 21	KY 22	KY 23	KY 24	KY 25	KY 26	KY 27	KY 28	KY 29	KY 30
<b>N.</b>	45	169	152	23	43	60	37	31	25	31
<b>% Mean</b>	10,47	39,30	35,35	5,35	10,00	13,95	8,60	7,21	5,81	7,21
	KY 31	KY 32	KY 33	KY 34	KY 35	KY 36	KY 37	KY 38	KY 39	KY 40
<b>N</b>	56	17	33	72	16	30	44	25	48	48
<b>% Mean</b>	13,02	3,95	7,67	16,74	3,72	6,98	10,23	5,81	11,16	11,16
	KY 41	KY 42	KY 43	KY 44	KY45	KY46				
<b>N</b>	45	158	38	39	7	11				
<b>% Mean</b>	10,47	36,74	8,84	9,07	1,63	2,56				

Note. N: The number of students who selected the corresponding misconception (total n=430). % Mean: The mean percentage indicating the mean occurrence rate of given misconception

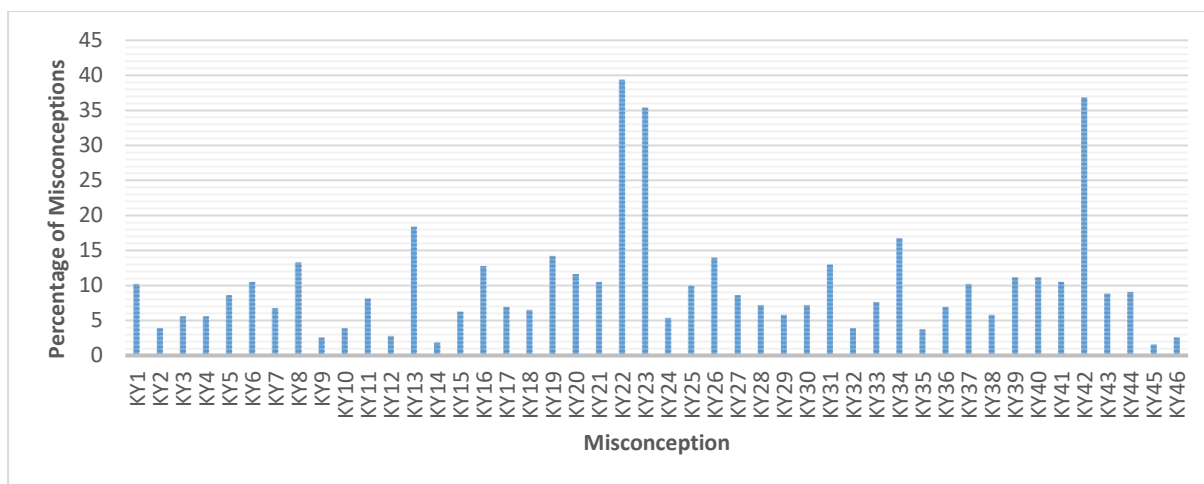


Figure 3. Percentages of misconceptions in MCT

The rates of misconceptions have been determined in the literature, and misconceptions with an average of 10% or higher have been considered significant (Caleon & Subramaniam, 2009; Kaltakçı, 2012; Kiray & Şimşek, 2020; Taban & Kiray, 2022). Considering this criterion, in this study, the misconceptions numbered KY 1, KY 6, KY 8, KY 13, KY 16, KY 19, KY 20, KY 21, KY 22, KY 23, KY 25, KY 26, KY 31, KY 34, KY 37, KY 39, KY 40, KY 41, and KY 42 were found to exceed the 10% threshold. These findings indicate that students continue to experience conceptual difficulties, particularly in pure matters, atoms, mixtures, and the separation of mixtures.

## Conclusions and Recommendations

The MCT developed within the scope of this study was designed to assess middle school students' conceptual understanding of the matter subject in a multidimensional manner. The four-tier structure of the test allowed for the evaluation of students' conceptual knowledge not only at the recall level but also in terms of justification and confidence in their responses. As a result of reliability analyses, the KR-20 value for the scientific knowledge score was .816, while the KR-20 value for the misconception score was .743; both values, above .70, supported the test's reliability.

Exploratory factor analysis findings revealed that the test has a four-factor structure. The variance ratios explained by the factors, whose eigenvalues ranged from 1.292 to 2.351 in terms of percentage ranged from 8.1% to 14.7%, and the total explained variance reached was 42.4%. The fact that all factor loadings were above .30 indicates that the test items are consistent with the structures they aim to measure and supports the test's construct validity. In analyses of test validity, the positive false rate was 5.2% and the negative false rate was 3.7%. These rates below 10% indicate that the test is at an acceptable level of conceptual accuracy and validity. Furthermore, correlation analyses revealed low but significant positive relationships among the test tiers. This finding shows that the four-tier structure offers a mutually supportive measurement system and is suitable for evaluating students' conceptual understanding in a multidimensional way.

As a result of item analyses and expert opinions, the initial 33-item version of the test was reduced to 16 items while maintaining content validity. During this process, items showing overlapping conceptual content, inappropriate item difficulty or discrimination indices, weak factor loadings or potential threats to content validity based on expert evaluations were removed from the test. The fact that the difficulty and discriminative levels of the items were within appropriate ranges showed that the test could reliably distinguish students' conceptual levels. This finding indicates that the developed four-tier test is a valid and reliable measurement tool and can make significant contributions to the field of application.

The results of the factor-based analysis show that students' conceptual understanding of the matter subject is weak overall and that misconceptions concentrated in the third and fourth factors indicate learning difficulties in these areas. This situation suggests that students' knowledge levels remain superficial and that they tend to resort to alternative thinking models when trying to understand scientific concepts. The study also identified students' misconceptions regarding matter. The analyses revealed that students experienced conceptual difficulties, particularly in pure matters, atoms, mixtures, and the separation of mixtures. Misconceptions observed at a rate of 10% or higher revealed that students tend to relate the particulate structure of the matter at the macroscopic

level and have difficulty understanding abstract concepts. This result shows that the developed four-tier test can reveal these misconceptions in a multidimensional way.

In conclusion, the developed four-tier test is a valid and reliable measurement tool that can effectively distinguish students' scientific knowledge levels, knowledge gaps, and misconceptions. Although numerous studies in the literature aim to reveal students' misconceptions about matters, the absence of a four-tier diagnostic test developed for middle school students makes this study unique in its field. In this respect, the test is suitable for determining students' conceptual difficulties with matter and for planning instructional interventions to address them. Through this test, the areas where students' misconceptions are concentrated can be identified, and the underlying cognitive processes can be examined in depth. Furthermore, the test can serve as a functional assessment tool to determine the contributions of different teaching methods and instructional materials to the elimination of students' misconceptions.

## Ethical Statement

\* The research was conducted in accordance with ethical principles, and the necessary permissions were obtained from the Hacettepe University Social and Human Sciences Research Ethics Committee, with decision dated 02/11/2023 and numbered E-51944218-300-00003177317.

## Conflict of Interest

\* There is no conflict of interest among the authors in the conduct and publication of this study.

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\* This study is derived from the first author's doctoral thesis and covers a section of the thesis.

## References

- Alın, G., & İzgi, Ü. (2017). İlköğretim öğrencilerinin yıldızlar konusuna ilişkin kavram yanlışlarının incelenmesi. *Sosyal Bilimler Dergisi*, 4(10), 202 – 214.
- Alpar, R. (2022). *Spor, sağlık ve eğitim bilimlerinden örneklerle uygulamalı istatistik ve geçerlik-güvenirlilik: SPSS'de çözümleme adımları ile birlikte* (7. baskı). Detay Yayıncılık.
- Akbolat, E., Soyalp, F. & Arsen, S. (2023). Fen bilimleri 7. sınıf güneş sistemi ünitesinde artırılmış gerçeklik kullanımının kavram yanlışları üzerine etkisi [Bildiri sunumu]. *TRB2 Uluslararası Eğitim Bilimleri Kongresi*, Van.
- Akdağ Kılıcı, T. (2019). *Ortaokul 7. sınıf öğrencilerinin atom kavramı hakkındaki kavram yanlışları* (Yayımlanmamış yüksek lisans tezi). Necmettin Erbakan Üniversitesi.
- Avcı, F., Acar Şeşen, B. & Kırbaşlar, F. G. (2018). Maddenin yapısı ve özellikleri ünitesine yönelik iki aşamalı teşhis testinin geliştirilmesi. *Kastamonu Educational Journal*, 26(4), 1007 – 1019. DOI:10.24106/kefdergi.434239
- Bessas, N., Tzanaki, E., Vavougiou, D. & Plagianakos, V. P. (2024). Diagnosing students' misconception in hydrostatic pressure through a 4-tier test. *Helion*, 10(23), 1 – 19. <https://doi.org/10.1016/j.heliyon.2024.e40425>
- Büyüköztürk, Ş., Kılıç Çakmak, E., Akgün, Ö. E., Karadeniz, Ş & Demirel, F. (2019). *Bilimsel araştırma yöntemleri* (26. Baskı). Pegem Akademi Yayıncılık.
- Caleon, I., & Subramaniam, R. (2010). Development and application of three-tier diagnostic test to assess secondary students' understanding of waves. *International Journal of Science Education*, 7(32), 939 – 961. <https://doi.org/10.1080/09500690902890130>

- Clement, J. (1993). Using bridging analogies and anchoring intuitions to deal with students' preconceptions in physics. *Journal of Research in Science Teaching*, 30(10), 1241–1257.
- Çalgıcı, G., Yıldırım, M., & Duru, M. K. (2020). 5. sınıf öğrencilerinin madde ve hal değişimi konusunda kavram yanlışlarının oyunlaştırma ile giderilmesi. *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi (EFMED)*, 14(2), 1278 – 6086. Doi: 10.17522/balikesirnef.814908
- Çelik, E. (2024). 8. sınıf öğrencilerinin ısı ve sıcaklık konusundaki kavram yanlışlarının belirlenmesi ve kavramsal değişim metinleri ile kavram yanlışlarının iyileştirilmesi (Yayınlanmamış yüksek lisans tezi). Harran Üniversitesi.
- Çetinkaya, M. & Taş, E. (2018). Etkinlik temelli web materyalinin 6. sınıf “vücudumuzda sistemler” ünitesindeki kavram yanlışlarının giderilmesine etkisi. *International e-Journal of Educational Studies (IEJES)*, 2(4), 92 – 113. <https://doi.org/10.31458/iejcs.428319>
- Çil, E., Gökçen, E. & İren, I. (2025). Fen bilimleri öğretmen adaylarının okyanus hakkındaki kavram yanlışlarının belirlenmesi. *Fen, Matematik, Girişimcilik ve Teknoloji Eğitimi Dergisi*, 8(2), 187 – 213. DOI: 10.36681/fmgtd.24010
- Demirtaş, M. (2023). Ortaokul öğrencilerinin basit elektrik devreleriyle ilgili kavram yanlışlarını ölçmek amacıyla üç aşamalı kavram yanlışları testi geliştirilmesi (Yayınlanmamış yüksek lisans tezi). Fırat Üniversitesi.
- Dessty, A., Sayekti, I. C., Abduh, M., & Sukartono. (2025). Development of a four-tier diagnostic test for misconception in natural science of primary school pupils. *Journal of Turkish Science Education*, 22(2), 338 – 353.
- Elmas, R. & Pamuk, S. (2021). Öğretmen adaylarının kavram yanlışlarının üç aşamalı kavram yanlışları testi ile belirlenmesi. *Afyon Kocatepe Üniversitesi Sosyal Bilimler Dergisi*, 23(4), 1386 – 1403. <https://doi.org/10.32709/akusosbil.916063>
- Estacio, R. D., Reyes, E. A. S. & Apusaga, N. C. (2024). Exploring engineering students' misconceptions about motion and forces using concept cartoons, *Mimbar Pendidikan*, 9(1), 13 – 32. <https://doi.org/10.17509/mimbardik.v9i1>
- Eryılmaz, A. (2002). Effects of conceptual assignments and conceptual change discussions on students' misconceptions and achievement regarding force and motion. *Journal of Research in Science Teaching*, 39, 1001–1015. <https://doi.org/10.1002/tea.10054>
- Eryılmaz, A. & Sürmeli, E. (2002). Üç - aşamalı sorularla öğrencilerin ısı ve sıcaklık konularındaki kavram yanlışlarının ölçülmesi. *V. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi*.
- Freankel, J. R., Wallen, N. E & Hyun, H. H. (2012). *How to design and evaluate research in education* (8th ed.). McGraw – Hill.
- Geçgel, G. & Şekerci, A. R. (2018). Bazı kimya konularındaki alternatif kavramların tanılayıcı dallanmış ağaç tekniği kullanarak belirlenmesi. *Mersin Üniversitesi Eğitim Fakültesi Dergisi*, 14(1), 1 – 18. <https://doi.org/10.17860/mersinefd.290254>
- Gomez – Rodriguez, R., Díaz – Pulido, B., Gutierrez – Ortega, C., Sanchez – Sanchez, B. & Torres – Lacomba, M. (2020). Cultural adaptation and psychometric validation of the standardised nordic questionnaire Spanish version in musicians. *International Journal of Environmental Research and Public Health* 17(2), 653. <https://doi.org/10.3390/ijerph17020653>
- Gökulu, A. (2017). 8. sınıf öğrencilerin element, bileşik, karışım kavramlarını anlama düzeyleri ve kavram yanlışlarının incelenmesi. *Kastamonu Eğitim Dergisi*, 25(2), 1 – 16.
- Hasançelebi, B., Terzi, Y. & Küçük, Z. (2020). Madde güçlük indeksi ve madde ayırt edicilik indeksine dayalı çeldirici analizi. *Gümüşhane Üniversitesi Fen Bilimleri Enstitüsü Dergisi*, 10(1), 224 – 240.
- Haryono, H. E. & Aini, K. N. (2020). Diagnosis misconceptions of junior high school in lamongan on the heat concept using the three – tier test. *Journal of Physics: Conference Series*, 1806(1), 012002.
- Haryono, H. E., Aini, K. N., Samsudin, A., & Siahaan, P. (2021). Diagnosis of student misconception in heat material using tier test. *Jurnal Pembelajaran Fisika*, 9(2), 155 – 162. <http://dx.doi.org/10.23960/jpf.v9.n2.202104>
- Hermita, N., Suhandi, A., Syaodih, E., Samsudin, A., Isjoni, I., Johan, H., Rosa, F., Setyaningsih, R., Sapiadil, S. & Safitri, D. (2017). Constructing and implementing a four tier test about static electricity to diagnose pre-service elementary school teacher' misconceptions. *Journal of Physics: Conference Series*, 895, 012167. <https://doi.org/10.1088/1742-6596/895/1/012167>
- Hestenes, D., & Halloun, I. (1995). Interpreting the force concept inventory: a response to huffman and heller. *The Physics Teacher*, 33, 502 – 506. <https://doi.org/10.1119/1.2344278>
- Jumilah, J., & Wasis, W. (2023). Development of four-tier diagnostic test instrument to introduce misconceptions and identify causes of student misconceptions in the sub-topic of Bernoulli's principle. *Jurnal Penelitian Pendidikan IPA (JPPIPA)*, 9(7), 5773 – 5781.
- Jung, J. (2020). Diagnosing causes of pre-service literature teachers' misconceptions on the narrator and focalizer using a two-tier test. *Educational Sciences*, 10(4), 104 – 124.

- Karaaslan, G., & Turanlı, N. (2018). Karmaşık sayılar konusundaki kavram yanlışları ve hataları belirlemek için alternatif bir araç: tanılayıcı dallanmış ağaç. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi (H.U. Journal of Education)*, 33(1), 72 – 89. Doi:10.16986/HUJE.2017030356
- Kabasakal, H. Z., & Uygur, S. (2021). Öğretmenlerin özel öğrenme güçlüğüne ilişkin bilgi düzeyleri, görüş ve kavram yanlışlarının incelenmesi. *International Social Mentality And Researcher Thinkers Journal*, 7(51), 2736 – 2754. <http://dx.doi.org/10.31576/smrj.1121>
- Kaltakçı, D. (2012). *Development and application of a four – tier test to asses pre – service physics teachers' misconceptions about geometrical optics* (Yayınlanmamış doktora tezi). Middle East Technical University.
- Kaltakçı Gürel, D., Eryılmaz, A., & McDermott, L. C. (2017). Development and application of a four-tier test to assess pre-service physics teachers' misconceptions about geometrical optics. *Research in Science & Technological Education*, 35(2), 238 – 260. <https://doi.org/10.1080/02635143.2017.1310094>
- Kandemir, M. A. & Apaydın, Z. (2020). Sınıf öğretmenlerinin fen bilimleri dersinde öğrencilerin sahip olduğu kavram yanlışlarını belirlemelerine ve gidermelerine yönelik bir değerlendirme. *Türkiye Bilimsel Araştırmalar Dergisi (TÜBAD)*, 5(2), 183 – 198.
- Karaer, H. (2019). Determination of some misconceptions in solution concentrations of the teacher candidates and examination regarding to some comprehension levels. *Erciyes Journal Of Education (Eje)*, 3(2), 87 – 104.
- Kardaş, F., Bayrakçeken, S., & Taşdemir, F. N. (2020). Onuncu sınıf öğrencilerinin çözeltiler konusuna yönelik kavram yanlışlarının belirlenmesi. *International Social Sciences Studies Journal*, 6(71), 4405 – 4412. <http://dx.doi.org/10.26449/sss.2713>
- Kartimi, K., Yunita, Y., Fuadi, F. N., & Addiin, I. (2021). A four-tier diagnostic instrument: An analysis of elementary student misconceptions in science topic. *Jurnal Penelitian Pendidikan IPA (JPPIPA)*, 7(Special Issue), 61 – 68.
- Kaya, B., Ateş, A., & Kılıç, S. (2019). Üniversite öğrencilerinin küresel ısınma konusundaki bilişsel (zihinsel) yapıları ve kavram yanlışlarının belirlenmesi. *International Journal of Social Science*, 74, 29 – 40. <http://dx.doi.org/10.9761/JASSS7731>
- Kıray, S. A., Aktan, F., Kaynar, H., Kılınc, S. & Görkemli, T. (2015). A descriptive study of pre-service science teachers' misconceptions about sinking-floating. *Asia – Pacific Forum on Science Learning and Teaching*, 16(2).
- Kıray, S. A., & Şimşek, S. (2020). Determination and evaluation of the science teacher candidates' misconceptions about density by using four-tier diagnostic test. *International Journal of Science and Mathematics Education*, 19, 935 – 955. <https://doi.org/10.1007/s10763-020-10087-5>
- Kordaki, M., & Psomos, P. (2014). Diagnosis and treatment of students' misconceptions with an intelligent concept mapping tool. *Procedia - Social and Behavioral Sciences*, 191, 838 – 842. <https://doi.org/10.1016/j.sbspro.2015.04.478>
- Küçükkeskin, E. & Kılıç, D. (2024). Hücre bölünmeleri konusunda öğrencilerin kavramsal anlamalarını belirlemeye yönelik iki aşamalı test geliştirilmesi. *Fen Bilimleri Öğretimi Dergisi*, 12(1), 99 – 121. <https://doi.org/10.56423/fbod.1380581>
- Lindell, R. S., Peak, E., & Foster, T. M. (2007). Are they all created equal? A comparison of different concept inventory development methodologies. *Physics Education Research Conference Proceedings*.
- Ma, H., Yang, H., Li, C., Ma, S., & Li, G. (2025). The effectiveness and sustainability of tier diagnostic technologies for misconception detection in science education: A systematic review. *Sustainability*, 17(7), 3145. <https://doi.org/10.3390/su17073145>
- Mert, E., Apaydın, Z., & Omca Çobanoğlu, E. (2023). Examination of thesis written on misconceptions in primary science education: between 2012 – 2022. *Journal of Computer and Education Research*, 12(23), 125 – 147.
- Millî Eğitim Bakanlığı (MEB) (2018). Fen bilimleri dersi öğretim programı (İlkokul ve ortaokul 3, 4, 5, 6, 7, ve 8. Sınıflar). Ankara. <https://mufredat.meb.gov.tr/ProgramDetay.aspx?PID=325>
- Milli Eğitim Bakanlığı (MEB) (2024). Fen bilimleri dersi öğretim programı (İlkokul ve ortaokul 3, 4, 5, 6, 7, ve 8. Sınıflar). Ankara. <https://mufredat.meb.gov.tr/>
- Kartal, M. (2017). *Fen bilgisi öğretmen adaylarının bazı kimya kavramlarını anlama seviyeleri ve kavram yanlışlarının belirlenmesi* (Yüksek lisans tezi). Necmettin Erbakan Üniversitesi.
- Önal, B., & Aksu, Z. (2025). 5. Sınıf öğrencilerinin çevre ve alan konusundaki kavram yanlışlarının giderilmesinde gerçekçi matematik eğitimi yaklaşımının etkililiği. *Social Sciences Studies Journal*, 11(4), 630 – 646. <https://doi.org/10.5281/zenodo.15282824>
- Önder Çelikkanlı, N. (2019). *Elektriklenme konusunda dört aşamalı kavram yanlışlığı testi geliştirme* (Yayınlanmamış doktora tezi). Gazi Üniversitesi.
- Özmen, F. & Sever, R. (2024). Küresel sorunlar üç aşamalı kavramsal anlama testi geliştirme çalışması. *Turkish Studies – Educational Sciences*, 19(1), 137 – 164.

- Pallant, J. (2017). *SPSS survival manual: A step by step guide to data analysis using IBM SPSS* (12th ed.). McGraw-Hill Education.
- Pan, S. J. – A., (2021). Taiwanese and American graduate students' misconceptions regarding responsible conduct of research: a cross-national comparison using a two-tier test approach. *Science and Engineering Ethics*, 27(20). <https://doi.org/10.1007/s11948-021-00297-7>
- Pedhazur, E. J., & Pedhazur Schmelkin, L. (1991). *Measurement, design and analysis: An integrated approach*. Psychology Press.
- Peterson, R. F. & Treagust, D. F. (1989). Grade – 12 students' misconceptions of covalent bonding and structure. *Journal of Chemical Education*, 66(6), 459 – 460.
- Putica, K. B. (2022). Development and validation of a four-tier test for the assessment of secondary school students' conceptual understanding of amino acids, proteins, and enzymes. *Research in Science Education*, 53, 651 – 668. <https://doi.org/10.1007/s11165-022-10075-5>
- Ristante, R. H., Suryanda, A. & Indraswari, L. A. (2023). The development of ecosystem misconception diagnostic test. *International Journal of Evaluation and Research in Education (IJERE)*, 12(4), 2246 – 2259.
- Sadler, P. M. (1998). Psychometric models of student conceptions in science: Reconciling qualitative studies and distractor-driven assessment instruments. *Journal of Research in Science Teaching*, 35(3), 265 – 296.
- Sancar, M., & Koparan, T. (2019). Ortaokul öğrencilerinin çokgenler konusundaki kavram yanlışlarının giderilmesinde kavram karikatürlerinin etkisinin incelenmesi. *Karaelmas Journal of Educational Sciences*, 7, 101 – 122.
- Sarı, A. & Bayram, H. (2018). Kavram haritası ve bilgisayar destekli öğretimin 7. sınıf öğrencilerinin madde konusundaki kavram yanlışlarının giderilmesine etkisi. *The Journal of Academic Social Science Studies*, 67, 29 – 47. <http://dx.doi.org/10.9761/JASSS7579>
- Serttaş, S., & Yenilmez Türkoğlu, A. (2020). Diagnosing students' misconceptions of astronomy through concept cartoons. *Participatory Educational Research (PER)*, 7(2), 164 – 182. <http://dx.doi.org/10.17275/per.20.27.7.2>
- Siong, L. C., Tyung, O. Y., Phang, F. A. & Pusppanathan, J. (2023). The use of concept cartoons in overcoming the misconception in electricity concepts. *Participatory Educational Research (PER)*, 10(1), 310 – 329. <http://dx.doi.org/10.17275/per.23.17.10.1>
- Sireci, S. & Faulkner – Bond, M. (2014). Validity evidence based on test content. *Psicothema*, 26(1), 100 – 107.
- Smith, J. P., diSessa, A. A., & Roschelle, J. (1993). Misconceptions reconceived: A constructivist analysis of knowledge in transition. *The Journal of the Learning Sciences*, 3(2), 115-163. [https://doi.org/10.1207/s15327809jls0302\\_1](https://doi.org/10.1207/s15327809jls0302_1)
- Suprpto, N. & Abidah, A. (2020). Using online three-tier diagnostic test to assess conceptions of ionization energy. *Periodico Tche Quimica*, 17(36), 196 – 212.
- Şen, Ş., Yılmaz, A. & Geban, Ö. (2017). Üç aşamalı elektrokimya kavram testinin geliştirilmesi. *Karaelmas Fen ve Mühendislik Dergisi*, 8(1), 324 – 330.
- Şenel Çoruhlu, T., & Terzioğlu, S. D. (2024). Ortaokul 5. Sınıf fen bilimleri dersinde eğitsel şarkı kullanımının öğrencilerin kavram yanlışlarını gidermedeki etkisi: mantarlar örneği. *Trakya Eğitim Dergisi*, 14(2), 1146 – 1159.
- Taban, T., & Kiray, S. A. (2022). Determination of science teacher candidates' misconceptions on liquid pressure with four-tier diagnostic test. *International Journal of Science and Mathematic*, 20, 1791 – 1811. <https://doi.org/10.1007/s10763-021-10224-8>
- Tabachnick, B. G. & Fidell, L. (2013). *Using Multivariate Statistic* (8th. ed.). Pearson Education
- Türkdoğan, A., Güler, G., Bülbül, H. İ., & Danişman, Ş. (2015). Türkiye'de matematik eğitiminde kavram yanlışlarıyla ilgili çalışmalar: Tematik bir inceleme. *Mersin Üniversitesi Eğitim Fakültesi Dergisi*, 11(3), 216 – 231. <https://doi.org/10.17860/mersinefd.255437>
- Uyanık, G. & Serin, M. K. (2016). Sınıf öğretmeni adaylarının bazı temel fen konularındaki kavram yanlışlarının belirlenmesi. *Amasya Üniversitesi Eğitim Fakültesi Dergisi*, 5(2), 510 – 538.
- Uzoğlu, M., & Gürbüz, F. (2013). Fen ve teknoloji adaylarının ısı ve sıcaklık konusundaki kavram yanlışlarının belirlenmesinde öğrenme amaçlı mektup yazma aktivitesinin kullanılması. *International Journal of Social Science*, 6(4), 501 – 517.
- Ünal, S., Coştu, B. & Ayas, A. (2010). Secondary school students' misconceptions of covalent bonding. *Journal of Turkish Science Education*, 7(2), 3 – 29.
- Vosniadou, S. (Ed.). (2008). *International handbook of research on conceptual change*. Routledge.
- Vrotsou, K., Machon, M., Rivas - Ruiz, F., Carrasco, E., Contreras - Fernandez, E., Mateo - Abad, M., Güell, C. & Vergara, I. (2018). Psychometric properties of the Tilburg Frailty Indicator in older Spanish people. *Archives of Gerontology And Geriatrics*, 78, 203 – 212. <https://doi.org/10.1016/j.archger.2018.05.024>
- Yun, V. W. S., Ulang, N. M. & Husain, S. H. (2023). Measuring the internal consistency and reliability of the hierarchy of controls in preventing infections diseases on construction sites: the kuder – richardson (KR

– 20) and cronbach’s alpha. *Journal of Advanced Research in Applied Sciences and Engineering Technology*, 33(1), 392 – 405.

Zengin, Y. & Bozkurt, E. (2022). 9. sınıf kuvvet ve hareket konusu ile ilgili kavram yanılgılarını belirlemek için üç aşamalı bir testin geliştirilmesi. *International Journal of Social, Humanities and Administrative Sciences*, 8(50), 380 – 390. <http://dx.doi.org/10.31589/JOSHAS.921>

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## Appendix

### THE MATTER CONCEPT TEST

Dear students,

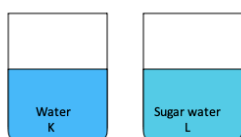
This study aims to **identify students' misconceptions about matter**. Please read each item below carefully and mark the section that best applies to you. Each relevant section is separate and serves a specific purpose. It is vital for the scientific validity of this study that your answers are honest. Thank you for your contribution to this research.

Çiğdem H. TAMKAVAS

Gender: Female  Male

Grade:

1.1 The K container in the figure contains water, as does the L container.



- I. Both are homogeneous.
- II. The K container contains a compound, while the L container contains a solution.
- III. The matter in both containers is represented by a formula.

Which of the previous statements can be made?

- A) II and III                      B) I and II                      C) I, II, and III

1.2 Are you sure about your answer to the previous question?

- A) I am sure                      B) I am not sure

1.3 Why did you select the above option?

- A) There are no matter in water, so water is not a pure matter.
- B) Sugary water is a pure matter and is represented by formulas.
- C) Water is a compound consisting of hydrogen and oxygen, while sugary water is a homogeneous mixture consisting of sugar and water.
- D) The matter in both containers is a pure matter and cannot be represented by formulas.
- E) Water and sugary water have formulas.
- F) Both water and sugary water can be separated physically.

1.4 Are you sure about the answer you gave to the previous question?

- A) I am sure                      B) I am not sure

2.1 In Science class, the teacher wants to separate olive oil-water and ethyl alcohol-water mixtures using the apparatus shown in the diagram

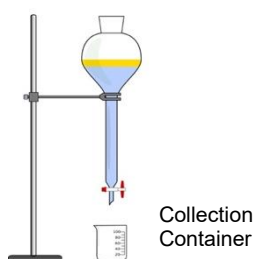


Figure – 1



Figure – 2

The teacher performs the following steps using these mixtures.

- They place the olive oil-water mixture into the apparatus shown in Figure 1. Then, they open the spout of the separating funnel and transfer the liquid collected in the collection container to another container.
- He places the ethyl alcohol-water mixture into the apparatus shown in Figure 2 and heats it. After a while, he separates the liquid accumulated in the collection container and transfers it to another container.

Accordingly, which of the following **cannot be said** about the procedures performed by the teacher?





Based on this, which of the following statements can be made about the models?

- A) Setup – 1 is a molecular structure containing two types of atoms.
- B) Setup – 2 is a compound molecule containing two atoms.
- C) Setup – 3 is an element molecule containing one type of atom.

7.2 Are you sure about your answer to the previous question?

- A) I'm sure
- B) I'm not sure

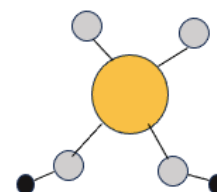
7.3 Why did you select the above option?

- A) The atoms in the molecules that form compounds are the same.
- B) Elements contain only one type of atom in their structure.
- C) The atoms of elements are different from each other.
- D) The atoms that make up an element have different colors.
- E) When two atoms of the same type combine, a compound is formed.

7.4 Are you sure about the answer you gave to the previous question?

- A) I am sure
- B) I am not sure

8.1 A student uses Styrofoam spheres and toothpicks of different colors and sizes to create the model shown in the image to illustrate the atomic model of a matter.



Which of the following statements can be made about the prepared model?

- A) It is a model of a molecule consisting of 7 atoms.
- B) It is a model of an element consisting of 7 atoms.
- C) It is a model of a compound consisting of 7 molecules.

8.2 Are you sure about the answer you gave to the previous question?

- A) I am sure
- B) I am not sure

8.3 Why did you select the above option?

- A) Atoms of different types come together to form elements.
- B) Molecules are formed when two or more atoms come together.
- C) When at least three different types of atoms come together, an element is formed.
- D) Compounds are formed when two or more molecules come together.
- E) The atoms that make up a molecule are different from each other.

8.4 Are you sure about the answer you gave to the previous question?

- A) I am sure
- B) I am not sure

9.1 Which of the following cannot be said?

- A) Seawater is an example of a solution.
- B) Steel is an example of a mixture.
- C) Heterogeneous mixtures are named as solutions.

9.2 Are you sure about the answer you gave to the previous question?

- A) I am sure
- B) I am not sure

9.3 Why did you select the above option?

- A) Steel is a pure matter.
- B) Seawater is a heterogeneous mixture.
- C) Not all solutions are homogeneous.
- D) Steel is a compound.
- E) Heterogeneous mixtures are called simple mixtures.

9.4 Are you sure about the answer you gave to the previous question?

- A) I am sure
- B) I am not sure

10.1 Which of the following can be said to be a homogeneous mixture?

- A) Milk
- B) Cola
- C) Fog

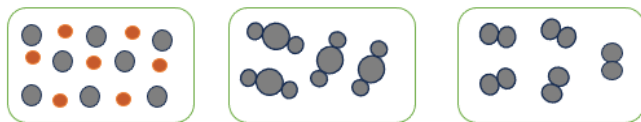


- B) Olive oil and sugar are homogeneous because they do not mix completely in water.  
 C) In mixtures of water, salt, and coffee, coffee settles to the bottom, forming a homogeneous mixture.  
 D) Water, alcohol, and sugar form a homogeneous mixture because they are the same color.  
 E) The mixture formed by water, alcohol, and sugar is evenly distributed throughout.  
 F) Olive oil forms a separate layer from sugary water, so it is a homogeneous mixture.

12.4 Are you sure about your answer to the previous question?

- A) I am sure                      B) I am not sure

13.1 Some particle models are shown in the figure.



I                      II                      III  
 Which of the above models can be said to represent an element?

- A) I                      B) II                      C) III

13.2 Are you sure about your answer to the previous question?

- A) I am sure                      B) I am not sure

13.3 Why did you select the above option?

- A) An element is formed when at least two different atoms combine.  
 B) Atoms of different sizes combine to form elements.  
 C) The atoms that form an element do not bond with each other.  
 D) Elements are composed of atoms of a single type.  
 E) The atoms that make up an element are different from each other.

13.4 Are you sure about the answer you gave to the previous question?

- A) I am sure                      B) I am not sure

14.1 Which of the following elements and symbols is correct?

	Element	Symbol
A)	Sulfur	S
B)	Nitrogen	A
C)	Magnesium	Ma

14.2 Are you sure about your answer to the previous question?

- A) I am sure                      B) I am not sure

14.3 Why did you select the above option?

- A) The symbol for nitrogen is the letter A.  
 B) The symbol for sulfur is represented by the letter S.  
 C) The symbol for magnesium is represented by the letter Ma.  
 D) The symbol for sulfur is K, and the symbol for magnesium is Mg.  
 E) The symbol for nitrogen is Az and the symbol for sulfur is K.

14.4 Are you sure about your answer to the previous question?

- A) I am sure                      B) I am not sure

15.1 Formula

CO<sub>2</sub>: Calcium oxygen  
 CO: Carbon monoxide  
 SO<sub>2</sub>: Sulfur dioxide

Which of the compound formulas given above has an incorrect name?

- A) SO<sub>2</sub>                      B) CO                      C) CO<sub>2</sub>

15.2 Are you sure about your answer to the previous question?

- A) Yes                      B) I am not sure

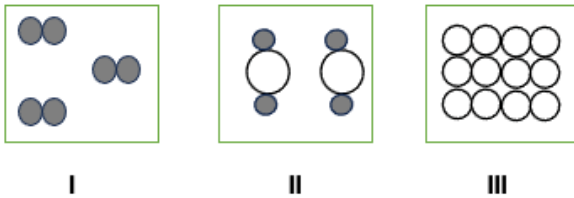
**15.3 Why did you select the above option?**

- A) The name of the CO<sub>2</sub> compound is calcium oxide.
- B) The name of the CO compound is carbon hydrogen.
- C) The name of the CO compound is calcium oxide.
- D) The name of the SO<sub>2</sub> compound is nitrogen oxide.
- E) The name of the SO<sub>2</sub> compound is sodium dioxide
- F) The name of the CO<sub>2</sub> compound is carbon dioxide.

**15.4 Are you sure about your answer to the previous question?**

- A) I am sure
- B) I am not sure

**16.1 The particle models of some matters are given below.**



**Which of the following can be said to be a compound?**

- A) I
- B) II
- C) III

**16.2 Are you sure about your answer to the previous question?**

- A) I am sure
- B) I am not sure

**16.3 Why did you select the above option?**

- A) In Figure 1, atoms of the same type form compounds.
- B) In Figure 2, since there are at least 3 atoms together, it is a compound.
- C) The atoms of different types in Figure 2 form a compound.
- D) The same atoms in Figure 3 form compounds.
- E) The atoms in Figure 3 are of the same type, so they form a compound.

**16.4 Are you sure about your answer to the previous question?**

- A) I am sure
- B) I am not sure