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# The Development of a Concept Test for "Pure Matter and Mixtures" Unit

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The purpose of this study was to create a concept test with established reliability and validity to show seventh-grade students' conceptual comprehension of the science course's "Pure Matter and Mixtures" unit. The survey model, which is one of the quantitative research methodologies, was used to perform the research. The research group comprises 7th (n=272) and 8th (n=282) grade pupils studying in Ankara province's Çankaya and Yenimahalle districts throughout the autumn and spring semesters of the 2021-2022 academic year. The first stage of the test questions was multiple-choice with four possibilities, and the second stage was open-ended with the rationale for the question written. Expert comments were sought to guarantee the test's face and content validity. The hypothesis testing approach was employed to assess construct validity, and the test was found to be construct-valid. As a consequence of the analysis performed before the pilot deployment for the 35-question exam, 9 questions were deleted from the test, yielding a 26-question test. The discrimination of question 21 was discovered to be 0,27 as a result of the test's actual implementation. The decision was made to delete this question from the tests, and the test was completed with 25 questions. The actual implementation resulted in a KR-20 reliability coefficient of 0,83, a mean item difficulty of 0,56, and a mean item discrimination of 0,49. In light of the results of the present research, a high discrimination, medium difficulty, and reliable concept exam consisting of 25 questions was developed to measure conceptual understanding as well as misconceptions.

## Introduction

Concepts are the building blocks of knowledge that prevent confusion by creating a common language in communication (Novak & Canas, 2006). Scientific knowledge is formed as a result of relationships between concepts (Blosser, 1987; Çaycı, 2007). Since concepts are related to each other, it is extremely important that they are learned correctly throughout education and training and that their structuring is realized in a meaningful way (Ausubel, 1968). Science education aims to help students transfer concepts to their daily lives by

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enabling them to construct relationships with schemes in their minds without memorizing them (Yürük & Çakır, 2000). In order to realize science education in a good way, concepts must be learned correctly and meaningfully throughout primary and secondary education (Ayas, Köse & Taş, 2002).

Since chemistry is one of the main branches of science, science courses include basic chemistry concepts. Chemistry topics usually contain concepts that students cannot observe directly. For this reason, it is more difficult and complex for students to construct concepts in chemistry subjects than in other science concepts (Johnstone, 1991). In chemistry subjects, students need to visualize the concepts in their minds with high-level mental processes, so misconceptions are frequently encountered (Griffiths, 1994; Taber, 2000). Misconceptions can be defined as statements that are different from scientifically accepted knowledge and that individuals accept as true and that also prevent the learning of scientifically accepted knowledge (Chi & Roscoe, 2002; Yağbasan & Gülçiçek, 2003).

Failure to learn concepts correctly may cause students to experience problems in understanding and comprehension in their academic, daily and professional lives (Schulte, 2001). Identification of misconceptions is important in preventing these problems. For this reason, misconceptions about abstract and complex concepts in the basic subjects of chemistry should be identified before trying to correct them (Kabapınar, 2001). Although many techniques are used to identify misconceptions, tools such as interviews, open-ended questions, concept diagnostic tests, concept maps, and concept cartoons are mostly used in science subjects (Avcı Şeşen, 2019). Multiple-choice tests are frequently used to identify misconceptions and determine the level of concept understanding (Treagust, 1988). They are especially preferred by researchers because they can be applied to large samples and their results can be easily analyzed (Eryılmaz & Sürmeli, 2002). However, the disadvantage of multiple-choice tests is that the reasons for students' answers cannot be understood (Odom & Barrow, 1995). For this reason, Two-stage tests have been established, the first of which comprises multiple-choice questions and the second of which reveals the explanation for the chosen alternative (Mann & Treagust, 1988; Voska & Heikkinen, 2000). Since two-stage tests consist of multiple-choice questions, scoring is easy. They also enable the identification of alternative conceptions of a large number of students (Tsai & Chou, 2002). The second part of the test can be constructed as multiple-choice or multiple-choice with one open-ended option by employing the student misconceptions found from the literature research or interviews. At the same time, the entire second stage can also be prepared as open-ended. Thus, students' reasoning skills can be improved and alternative concepts that have not been identified before can be identified (Mann & Treagust, 1988; Voska & Heikkinen, 2000).

For the development of concept tests, Treagust (1988) presented an approach that included three main stages: content decision, gathering information about students' alternative conceptions, and constructing the test. The stages of this method;

- Content Decision

(1) Identification of relevant knowledge propositions
(2) Creating a concept map for the topic matter
(3) Connecting knowledge assertions to concept maps
(4) Confirming the validity of the content

- Gathering information about students' alternative conceptions

(5) Review of relevant literature

- Construction of Conceptual Understanding Test

(6) Development of a concept test
(7) Creating the specification table
(8) Implementation of the test

Considering some fundamental concepts of the chemistry such as, Atom and molecule (Griffiths & Preston, 1992; Harrison & Treagust, 1996; Lee, Eichinger, Anderson, Berkheimer, & Blakeslee, 1993; Unal & Zollman, 1999) elements, compounds and mixtures (Ayas & Demirbaş, 1997; Ben-Zvi , Eylon, & Silberstein, 1988; Briggs & Holding, 1986; Franco-Mariscal, Oliva-Martínez & Gil, 2016; Gökulu, 2017; Laverty & McGarwey, 1991; Papageorgiou & Sakka, 2000; Sanger, 2000; Stains & Talanquer, 2007; Taber, 2000) "Structure and Properties of Matter" unit (Avcı, Şeşen, & Kırbaşlar, 2018; Say & Özmen, 2018; Uzun, 2010), pure substance and mixtures (Vogelezang, 1987) and solution (Çalık, 2006; Çalık & Ayas, 2005) many misconceptions have been identified. When a deeper investigation was carried out, many studies separately identify misconceptions in the concepts of the atom, atomic models, molecule, element, compound, solution, heterogeneous mixture, homogeneous mixture, separation of mixtures, and factors affecting dissolution rate. However, to the best of our knowledge, this is the first study that covers all of the aforementioned issues and detects misconceptions about them.

The name and subject content of the 'Structure and Properties of Matter' unit in the MoNE (2013) Science Curriculum was changed and renamed as 'Pure Matter and Mixtures' in the MoNE (2018) Science Curriculum. When national studies are examined, two-stage concept tests (Avcı et. al., 2018; Say & Özmen, 2018; Uzun, 2010) are found to determine misconceptions about the unit "Structure and Properties of Matter". However, no concept test suitable for the subject scope of the 'Pure Matter and Mixtures' unit in the MoNE (2018) Science Curriculum was found. Based on these reasons, it is thought that developing a reliable and valid concept test to identify misconceptions in the Pure Matter and Mixtures unit (particulate structure of matter, pure substances, mixtures, and separation of mixtures) will contribute to the literature.

This study aims to develop a concept test including the concepts in the topics of the particulate structure of matter, pure matter, mixtures, and separation of mixtures.

## Method

The current research involves a test development to build up a valid and reliable Pure Matter and Mixtures Concept Test (PMMCT). The survey model, which is one of the quantitative research methodologies, was used to perform the study. In a world with many elements, survey models are arrangements created on the entire universe or a section of it to make a comprehensive judgment about the universe (Karasar, 2009). The opinions of samples on a subject or event, or the qualities of interest, abilities, attitudes, and so on, are determined in survey research. These are larger-sample studies when compared to others (Büyüköztürk, Çakmak, Akgün, Karadeniz & Demirel, 2018). The survey research technique was used in this study because a significant number of samples were required to build a concept test for the Pure Matter and Mixtures unit.

## Research Sample

The study was piloted with 282 eighth-grade students during the fall semester of the 2021-2022 academic year, and it was fully implemented with 272 seventh-grade students during the spring semester of the 2021-2022 academic year. The trial implementation was carried out with eighth-grade students since seventh-graders had not yet studied the topic at the time of the deployment.

## Data Collection Tool

The Pure Matter and Mixtures Concept Test (PMMCT) developed by the researcher, consisting of 4 options and 25 questions, was used within this study. The test was created by combining the knowledge gained in the Pure Matter and Mixtures unit with some common misconceptions found within literature.

## Data Collection Tool Development Process

PMMCT was designed to identify students' conceptual understandings and misconceptions about the Pure Matter and Mixtures unit. While developing the test, the main stages of content decision, gathering information about students' alternative conceptions, and constructing the test were followed as suggested by Treagust (1988). First of all, in the content determination phase, knowledge propositions were written by taking into account the attainments of the seventh-grade Pure Matter and Mixtures unit in the Science Curriculum (MoNE, 2018). A concept map was created to determine the suitability of the knowledge propositions to the subject scope. In order to ensure the validity of the propositions and the concept map, the opinions of one-up experts in chemistry and science education, a science teacher, and two students were consulted. In line with these opinions, necessary corrections were made where the concept map was found deficient. Afterward, national and international studies examining misconceptions within the scope of Pure Matter and Mixtures were examined (Arıkıl & Kalın, 2010; Akman & Özdilek, 2018; Bektaş, 2003; Ben-Zvi et al., 1988; Blanco & Prieto, 1997; Cokelez & Dumon, 2005; Çakmak, 2009; Çakır, 2005; Çalık & Ayas, 2005; Çökelez & Yalçın, 2012; Demirbaş, Altınışık, Tanrıverdi & Şahintürk, 2011; Dönmez, 2011; Ergün, 2013; Ergün & Sarıkaya, 2014; Geçgel & Şekerci, 2018; Griffiths & Preston, 1992; Gökulu, 2017; Gündüz, 2001; Güvener, 2019; Harrison & Treagust, 1996; Karacop & Doymuş, 2013; Karaer, 2007; Kartal, 2017; Kingir, Geban & Gunel, 2013; Kılıç, 2017; Meşeci, Tekin & Karamustafaoğlu, 2013; Nakiboğlu, Karakoç & Benlikaya 2002; Ormancı & Balım, 2014; Othman, Treagust & Chandrasegaran, 2008; Özgür & Bostan, 2007; Say & Özmen, 2018; Saydam, 2013; Şeker, 2006; Tezcan & Salmaz, 2005; Unal & Zollman, 1999; Uzuntiryaki & Geban, 2005; Yalçın, 2011) and a pool was created with misconceptions appropriate to the scope of the subject. Four-choice multiple-choice questions were prepared with the misconceptions selected concerning the attainment of the Science Curriculum. A specification table was prepared to see which attainment the questions belonged to and the misconceptions included in the questions. One chemistry education expert and four science education experts were engaged to determine the relevance of the test's questions and misconceptions to the attainment and student level. Information on the corrections made in line with the opinions is presented in the findings section. The test consisting of 44 questions was reduced to 35 questions as a result of expert opinions and made ready for pilot implementation. As a result of the item analysis at the end of the pilot implementation, 9 questions that were determined to be non-discriminative were removed from the test. The actual implementation was carried out with 26 questions. As a result of the analysis made at the end of the actual implementation, it was decided to remove one question from the test.

Thus, the test was finalized with 25 questions. In the findings section, the item analyses of the pilot and the actual implementation of the test are given in detail. At least one of the distractors of the prepared questions contains misconceptions in the literature. Furthermore, a huge blank was given at the bottom of each question to write the explanation for the response to detect any misconceptions that students may have.

## Analysis of the Data

Raw data of the multiple-choice section was input into the MS Excel Program. The reliability coefficient (KR-20), average discrimination (rjx) and average difficulty (Pj) indices for the entire test, as well as the discrimination (rjx) and difficulty (Pj) indices for each question, were calculated using the TAP program.

In the calculation of the item discrimination index in the TAP program, the scores of the upper group of 27% with high scores and the lower group of 27% with low scores are used. It is calculated by subtracting the ratio of those who answered the question correctly in the upper group from the ratio of those who answered the question correctly in the lower group. Item difficulty is calculated as the ratio of the number of correct answers to the number of test takers (Lewis, 2002).

## Findings

### *Findings Related to Validity*

*Content Validity*

Content validity is the indicator of whether the prepared items adequately measure the trait being measured. One method of ensuring content validity is to seek expert guidance. (Büyüköztürk et al., 2018). To assure content validity in this study, a specification table was created. The table of specifications for the final version of the test is given in Appendix 1.

To get the opinions of the experts, an expert form including questions, attainment, and misconceptions was prepared and sent to the experts. One chemistry education expert and four science education experts were consulted on the suitability of the questions to the students' levels, the appropriateness of the questions to the attainments, and the appropriateness of the misconceptions to the attainment and questions. Necessary corrections were made in line with the feedback from the experts.
These corrections are as follows:

- Some incorrect expressions in question stems and choices were corrected.
- Corrections were made in the coloring of the visuals for better understanding of some questions with visuals.
- Seven questions were removed from the test in line with the opinions that they would not be suitable for students' levels.
- Six questions were deleted from the test after it was determined that they did not match the requirements.

As a result of these corrections, 13 questions were removed from the 44-question test. After 13 questions were removed from the test, two attainments left no questions. For this reason, a total of 4 new questions were written for the two attainments, one science education specialist

and one chemistry education expert were consulted. After the experts found the 4 new questions appropriate for the student level and attainments, these questions were added to the test and the test was made up of 35 questions. In this context, it was decided to include at least one question corresponding to each attainment in the test and not to lose attainment.

*Face Validity*

Face validity means that the measurement tool appears to measure the feature it aims to measure (Karaca, 2021). The test's face validity was attempted to be assured by soliciting the opinions of two science education specialists, two science teachers, and ten students. Teachers and experts reported that the test's instructions and questions had the appearance of a concept test, while students reported that the test had the impression of a concept test. Based on these opinions, it can be said that the general appearance of the test and the questions are suitable for a concept test.

*Construct Validity*

Construct validity refers to the amount to which the questions used to assess performance, ability, attitude, and so on measure the feature to be assessed. Construct validity can be investigated utilizing techniques such as "hypothesis testing", "internal consistency analysis", "factor analysis" and "cluster analysis". The hypothesis testing approach may be used to examine the significance of test score differences across groups with known characteristics (Büyüköztürk, 2020). The studies that provide construct validity using this method are found in the literature (Karslı & Ayas, 2013; Samaie & Khosravian, 2014; Şahin, Yıldırım, Sürmeli & Güven, 2018; Yumuşak, Maraş & Şahin, 2016). The PMMCT's construct validity was tested on 65 seventh-grade students who were taught the Pure Matter and Mixtures unit and 65 seventh-grade students who were not. Table 1 displays the statistical data for the groupings.

Table 1. Statistical Results of Pure Matter and Mixtures Unit for the Instructed and Non-Instructed Groups

| Statistics | Instructed | Non-Instructed |
|---|---|---|
| N | 65 | 65 |
| Mean | 15,56 | 2,07 |
| Standard deviation | 4,69 | 2,27 |
| Skewness | -,141 | ,866 |
| Kurtosis | -,583 | -,326 |
| Minimum | 5 | 0 |
| Maximum | 24 | 8 |

If one has skewness coefficient and kurtosis coefficients equal to zero, the distribution is normally distributed, but this situation is not often encountered. When the skewness and kurtosis coefficients are between ±1, it means that the distribution does not deviate excessively from normal, that is, the data have a normal distribution (Büyüköztürk, Çokluk & Köklü, 2020). Table 1 shows that the skewness and kurtosis values are between ±1. Thus, it can be said that the data of both groups have a normal distribution. The independent groups t-test was performed to compare the data based on the normal distribution of the data. Table 2

shows the statistical findings of the independent group's t-test.

Table 2. Results of Independent Samples t-Test Results from the Scores of Pure Matter and Mixtures Unit Instructed and Non-Instructed Groups

| Group | N | X̄ | Ss | Sd | t | p |
|---|---|---|---|---|---|---|
| Instructed | 65 | 15,56 | 4,69 | 92,48 | -20,87 | ,000 |
| Non-Instructed | 65 | 2,07 | 2,27 | | | |

It is expected that a significant difference will exist between the data obtained from the group that was instructed by the Pure Matter and Mixtures unit and the data obtained from the group that was not, and the fact that these variations which favor instructed group can be used to demonstrate the construct validity of the test. As suggested by Table 2, a substantial variation between the groups ($t_{(92,4)}$=-20,87, p<0,05) are observed. When the averages are examined, the mean score of the instructed group ($\bar{x}$=15,56) is found to be greater than the mean score of the non-instructed group ($\bar{x}$=2,07). This demonstrates that the substantial difference is in favor of the trained group, indicating construct validity.

**Findings on Reliability and Item Analyses**

The TAP program was used to evaluate the reliability coefficient, item discrimination, and item difficulty indices of the test. Table 3 presents the item discrimination (rjx) and item difficulty (Pj) index values for the pilot test conducted with 282 students.

Table 3. Item Difficulty and Discrimination Index for the Pilot Implementation

| Question number | Difficulty index ($P_j$) | Discrimination index ($r_{jx}$) | Question number | Difficulty index ($P_j$) | Discrimination index ($r_{jx}$) |
|---|---|---|---|---|---|
| 1 | 0,36 | 0,44 | 19 | 0,33 | 0,17* |
| 2 | 0,26 | 0,18* | 20 | 0,67 | 0,46 |
| 3 | 0,64 | 0,50 | 21 | 0,64 | 0,44 |
| 4 | 0,74 | 0,22 | 22 | 0,35 | 0,46 |
| 5 | 0,28 | 0,26 | 23 | 0,22 | 0,20 |
| 6 | 0,78 | 0,25 | 24 | 0,28 | 0,31 |
| 7 | 0,20 | 0,15* | 25 | 0,62 | 0,46 |
| 8 | 0,42 | 0,45 | 26 | 0,54 | 0,47 |
| 9 | 0,54 | 0,32 | 27 | 0,44 | 0,28 |
| 10 | 0,57 | 0,27 | 28 | 0,27 | 0,18* |
| 11 | 0,74 | 0,37 | 29 | 0,31 | 0,27 |
| 12 | 0,23 | 0,10* | 30 | 0,51 | 0,41 |
| 13 | 0,25 | 0,20 | 31 | 0,35 | 0,35 |
| 14 | 0,20 | 0,11* | 32 | 0,60 | 0,32 |
| 15 | 0,26 | 0,16* | 33 | 0,23 | -0,03* |
| 16 | 0,16 | 0,07* | 34 | 0,44 | 0,36 |
| 17 | 0,31 | 0,30 | 35 | 0,40 | 0,41 |
| 18 | 0,37 | 0,31 | | | |

Values below *0,19

When the questions are evaluated according to their discrimination indices, it is stated that

0,40 and above is high discrimination, 0,30-0,39 is medium discrimination, 0,20-0,29 is insufficient discrimination, and therefore the question should be corrected to 0,19, and below is no discrimination and therefore the question should be removed from the test (Ebel, 1965). Item discrimination index can take values between -1 and +1. If the value is negative, this indicates that the question inversely discriminates individuals in terms of the measured characteristic, in other words, it means that individuals in the lower group answer the question more correctly than those in the upper group. This is an undesirable situation, so such questions should be removed from the test (Crocker & Algina, 2006). Based on this data, 9 questions with the numbers 2,7,12,14,15,16,19,28, and 33 with a discrimination index of less than 0,19 were deleted from the exam. The 8 questions numbered 4,5,6,10,13,23,27, and 29, with discrimination ranging from 0,20 to 0,29, were revised based on the comments of a science education specialist and four science teachers. Corrections were made in some places in the stem of the questions. After these corrections, three science teachers and twenty-five students were consulted to evaluate the changes made and the comprehensibility of the questions. Most of the teachers and students stated that the corrected statements were more understandable. Thus, the test was made ready for the actual implementation. The depiction of the statistics of the pilot implementation is presented in Table 4.

Table 4. Pilot Implementation Statistical Values

| Statistics | Before the item was deleted | After the item is deleted |
|---|---|---|
| Concept test number of questions | 35 | 26 |
| Number of students implemented | 282 | 282 |
| KR-20 | 0,68 | 0,71 |
| KR-21 | 0,63 | 0,67 |
| Mean item difficulty | 0,41 | 0,47 |
| Mean item discrimination | 0,29 | 0,37 |
| Standard deviation | 4,66 | 4,27 |
| Arithmetic mean | 14,49 | 12,37 |
| Median | 14 | 12 |
| Skewness | 0,383 | 0,337 |
| Kurtosis | 0,340 | -0,248 |

According to Table 4 are, the average item difficulty and average discrimination of the test increased after 9 questions were removed from the test. Thus, one can conclude that the test's strength to discriminate between the lower and upper groups are increased. The ideal normal distribution has zero skewness when the mean and median are equal to each other. In this case, the closer the difference is, the more normal the distribution is obtained (Can, 2018). As Table 4 suggests, the arithmetic mean of the test consisting of 26 questions is 12,37 and the median is 12. Although the values are not equal, they are quite close to each other and therefore it can be said that the values have a normal distribution. Since the skewness 0,337 and kurtosis -0,248 values are inside the interval [-1,1], the scores are distributed normally (Büyüköztürk et al., 2020).

With 9 questions removed and 8 questions corrected, the test consisted of 26 questions. The

actual implementation of the 26-question test was carried out with 272 seventh-grade students. The actual implementation was carried out to determine the conceptual understanding and misconceptions of the seventh-grade students and also to observe whether the discriminations of the corrected questions were within the desired value range. According to the study of the data from the actual implementation, the discrimination of question 21 was 0,27. It was decided to remove the 21st question from the test since removing it would not cause a loss of gain and there was no possibility of correcting the question and conducting another implementation. The test consists of 25 questions in its final form. The final form of the test with 25 questions is given in Appendix 2. Table 5 depicts the item difficulty and discrimination indices of each question after the removal of the 21st question from the test.

Table 5. Item Difficulty and Discrimination Indices for the Actual Implementation

| Question number | Difficulty index ($P_j$) | Discrimination index ($r_{jx}$) | Question number | Difficulty index ($P_j$) | Discrimination index ($r_{jx}$) |
|---|---|---|---|---|---|
| 1 | 0,40 | 0,63 | 14 | 0,67 | 0,48 |
| 2 | 0,72 | 0,44 | 15 | 0,54 | 0,63 |
| 3 | 0,81 | 0,38 | 16 | 0,61 | 0,53 |
| 4 | 0,37 | 0,45 | 17 | 0,33 | 0,46 |
| 5 | 0,86 | 0,38 | 18 | 0,67 | 0,45 |
| 6 | 0,60 | 0,70 | 19 | 0,56 | 0,65 |
| 7 | 0,61 | 0,34 | 20 | 0,42 | 0,38 |
| 8 | 0,62 | 0,43 | 22 | 0,60 | 0,54 |
| 9 | 0,82 | 0,44 | 23 | 0,38 | 0,50 |
| 10 | 0,42 | 0,36 | 24 | 0,58 | 0,51 |
| 11 | 0,33 | 0,38 | 25 | 0,39 | 0,57 |
| 12 | 0,56 | 0,62 | 26 | 0,32 | 0,45 |
| 13 | 0,82 | 0,46 | | | |

When the data in Table 5 is examined, it is discovered that the test difficulty values ranged between 0,32 and 0,86, while the item discrimination values ranged between 0,34 and 0,70. Table 6 shows the statistical values for the actual test implementation.

Table 6. Actual Implementation Statistical Values

| | |
|---|---|
| Concept test number of questions | 25 |
| Number of students implemented | 272 |
| KR-20 | 0,83 |
| KR-21 | 0,80 |
| Mean item difficulty | 0,56 |
| Mean item discrimination | 0,49 |
| Standard deviation | 5,15 |
| Arithmetic mean | 13,99 |
| Median | 14 |
| Skewness | 0,110 |
| Kurtosis | -0,630 |

Based on the numbers in Table 6, the discrimination of the test is 0,49 and the average difficulty is 0,56. Based on these numbers, the exam may be classified as of medium difficulty and high discrimination. The test's reliability coefficient was calculated using the Kuder Richardson-20 (KR-20) approach. Since the difficulty values of each question are known, this dependability coefficient was chosen (Çetin, 2019). When Table 6 is analyzed, it is discovered that the test's KR-20 reliability coefficient is 0,83. Given this number, the measurements obtained could be considered as reliable.

## Discussion, Conclusion and Recommendations

The goal of this research was to develop a concept test to measure the conceptual understandings of seventh-grade pupils and misconceptions about the Pure Matter and Mixtures unit. While developing the test, the test development stages suggested by Treagust (1988) were followed. Concept test development studies on various subjects following these test development stages are also found in the literature (Avcı et. al., 2018; Çetinkaya & Taş, 2016; Hasyim, Suwono & Susilo, 2018; Mulford & Robinson, 2002; Özden & Yenice, 2017; Sreenivasulu & Subramaniam, 2013). In the literature, as in this study, there are many studies in which misconceptions were determined with a two-stage test (Avcı et. al., 2018; Canpolat & Pınarbaşı, 2011; Ghalkhani & Mirzaei, 2018; Mulford & Robinson, 2002; Mutlu & Özel, 2008; Othman, et. al., 2008; Say & Özmen, 2018; Uzun, 2010; Varoğlu, Şen & Yılmaz, 2020; Yumuşak et. al.,2016).

Studies were conducted to ensure the developed test's content, face, and construct validity. For content validity, a specification table was prepared, and one chemistry education and four science education experts were consulted. For face validity, two science education experts, two science teachers, and ten students were consulted. To ensure construct validity, the independent samples t-test was utilized to observe if there was a significant difference between 65 seventh-grade students who were taught the Pure Matter and Mixtures unit and 65 seventh-grade students who were not, and there was a significant difference in favor of the group who were instructed the unit. The validity of the test developed with these procedures was ensured.

The average discrimination, average difficulty and reliability of the developed test were

calculated using the TAP program. The final version of the test had an average difficulty of 0,56 and a discrimination of 0,49. It is stated that the average discrimination of the tests should be above 0,30 (Kubiszyn & Borich, 2003). A discrimination value above 0,40 means that the upper and lower groups are distinguished from each other at a high level (Tekin, 2010). Since the mean discrimination of the developed test was 0,49, it can be said that the test has high discrimination. The percentage of respondents that properly answered the question is referred to as item difficulty. If the question is mostly answered correctly, it means that the question is easy and the difficulty value approaches 1. On the contrary, if the question is mostly answered incorrectly, it means that the question is difficult and the difficulty value approaches 0. The most favorable difficulty level for the reliability of the test to be at the highest level is 0,50, and this indicates that half of the respondents answered the test correctly and half answered incorrectly. (Reynolds, Livingston & Willson, 2008). The mean difficulty of the exam is 0,56, indicating that it is of medium difficulty. If the reliability coefficient of the test is less than 0,50, it is low, between 0,50 and 0,80 is medium, and 0,80 and above is high reliability (Salvucci, Walter, Conley, Fink & Saba, 1997). Considering this information, it can be concluded that the test is reliable since the reliability coefficient of the test is 0,83. All these data reveal that the developed test is of medium difficulty, high discrimination, reliable and valid.

The Pure Matter and Mixtures Concept Test developed as a result of this study can be used to determine the existing misconceptions and whether the concepts are learned correctly. In addition, it is possible to investigate the efficiency of the approaches and strategies utilized in the course implementation process. Researchers who want to develop concept tests in different subjects can follow the development stages of this test. This study will contribute to the literature not only due to the test development stages which are explained in detail but also the results are obtained as a reliable and valid concept test.

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## Appendix 1: Specification table

| Attainments | The misconception in the question | Question number |
|---|---|---|
| F.7.4.1.1. Tells the structure of the atom and the basic particles in its structure. | Atom can be crushed, its shape can change (Ergün, 2013; Ergün & Sarıkaya, 2014; Gündüz, 2001; Şeker, 2006; Tezcan & Salmaz, 2005). (While preparing this question, Sarıkaya, M. (1996). The concept test in the Particle Structure of Matter Concept Test study was used.) | 1 |
| | The atoms or molecules that make up a substance show the properties of that substance (atoms can be colored, conductive, etc.). (Ben-Zvi et al.,1988; Griffiths & Preston,1992; Kılıç, 2017; Saydam, 2013). | 10 |
| | The weight of atoms is also affected by the number of electrons and orbitals (Tezcan & Salmaz, 2005). | 6 |
| | Protons, neutrons and electrons are located in the nucleus (Bak & Ayaz, 2008; Dönmez, 2011; Kartal, 2017). | 13 |
| F.7.4.1.2. Questions about how ideas about the concept of the atom have changed from the past to the present. | Studies emphasize that students choose one of the other models instead of the modern atomic theory and explain the atom with this model (Unal & Zollman, 1999; Nakiboğlu et al., 2002). | 19 |
| | Students mostly prefer the Bohr atomic model to explain the atom (Çökelez & Yalçın, 2012; Nakiboğlu et al., 2002; Özgür & Bostan, 2007; Yalçın, 2011). | 4 |
| | It causes the students to perceive the figures and graphs in the books, which are modeled and shaped by experts interested in the atom, as real shapes; in this context, it can be said that a bigger problem arises when the shapes and models are different from each other. Therefore, every teacher must indicate that these shapes and models are analogical models (Bektaş, 2003; Çakmak, 2009; Harrison & Treagust, 1996). | 20 |
| F.7.4.1.3. Expresses that the same or different atoms will come together to form a molecule. | Atoms of the same genus and different genus form molecules, which in turn form compounds (Gökulu, 2017; Güvener, 2019; Karacop & Doymuş, 2013; Othman et al., 2008). | 3 |
| | Atoms are bigger than molecules (Cokelez & Dumon, 2005; Özgür & Bostan, 2007). Students make mistakes when comparing the sizes of atoms and cells (Ormancı & Balım, 2014; Özgür & Bostan, 2007; Yalçın, 2011). (Özgür & Bostan (2007) study was utilized in the preparation of this question). | 22 |
| F.7.4.1.4. It presents by creating various molecular models. | Atoms of the same genus and different genus form molecules, which in turn form compounds (Gökulu, 2017; Güvener, 2019; Karacop & Doymuş, 2013; Othman et al., 2008). | 3 |
| | They confuse the concepts of element and compound (Güvener, 2019; Kingir et al., 2013). | 9 |
| | Pure substances contain only one type of atom (Çakır, 2005; Çakmak, 2009; Say & Özmen, 2018). | 23 |
| | Mixture and compound models are often used interchangeably (Çakır, 2005; Güvener, 2019; Meşeci et al., 2013). | 26 |
| F.7.4.2.1. Gives examples by classifying pure substances as elements and compounds. | They confuse the concepts of element and compound (Kingir et al., 2013; Güvener, 2019). | 9 |
| | Pure substances contain only one type of atom. (Çakır, 2005; Çakmak, 2009; Say & Özmen, 2018). | 23 |
| | Sugar is an element (Karaer, 2007). Soda is a compound and compounds are pure (Karaer, 2007). | 8 |
| F.7.4.2.2. Expresses the names, symbols and some uses of the first 18 elements in the periodic system and common elements (gold, silver, copper, | Silver is an element and is not pure. Because different substances are mixed. (Meşeci et al., 2013). | 14 |

| | | |
|---|---|---|
| zinc, lead, mercury, platinum, iron and iodine). | | |
| | Possible Misconception: The symbols of the elements are abbreviated according to their Turkish names. | 18 |
| | Possible Misconception: Elements are represented by formulas and compounds by symbols. | 2 |
| F.7.4.2.3. Expresses the formulas, names and some usage areas of common compounds. | Possible Misconception: Elements are represented by formulas and compounds by symbols. | 2 |
| | Possible Misconception: Confusing the concepts of ammonia and nitric acid. | 7 |
| F.7.4.3.1. Classifies mixtures as homogeneous and heterogeneous and gives examples. It is emphasized that homogeneous mixtures can also be expressed as solutions. | All mixing events result in solution formation. All homogeneous and heterogeneously mixed substances are called solutions (Uzuntiryaki & Geban, 2005; Çalık & Ayas, 2005). | 24 |
| | If particles are composed of a single substance, they are homogeneous; if they are composed of more than one substance, they are heterogeneous" (Gökulu, 2017; Güvener, 2019). | 15 |
| | If the distance between particles is small, the substance is homogeneous; if it is large, the substance is heterogeneous (Gökulu, 2017; Güvener, 2019). | 17 |
| | Solutions cannot be separated (solvent and solute cannot be completely separated from each other) (Demirbaş et al., 2011). | 11 |
| | Vinegar (acetic acid + water) is not a homogeneous mixture (Geçgel & Şekerci, 2018). | 12 |
| F.7.4.3.2. Prepares solutions using solvents and solutes encountered in daily life. | During dissolution, the solute fills the spaces between the solvent (Arıkıl & Kalın, 2010). | 25 |
| | Solutions cannot be separated (solvent and solute cannot be completely separated from each other) (Demirbaş et al., 2011). | 11 |
| F.7.4.3.3. Determines the factors affecting the dissolution rate by experiment. | Students believed that dissolution would not occur without stirring, that is the solute would accumulate at the bottom after the stirring was stopped, or that stirring would increase the amount of solute (Blanco & Prieto, 1997; Çalık, 2006; Çalık & Ayas, 2005). | 5 |
| | If the temperature increases, the amount of solutes also increases (Şen & Yılmaz, 2012). | 21 |
| F.7.4.4.1. Selects and apply the appropriate method for the separation of mixtures. Evaporation, density difference and distillation are emphasized among the methods that can be used in the separation of mixtures. | The liquid-liquid homogeneous mixture is separated by the evaporation method (Geçgel & Şekerci, 2018). | 16 |

## Appendix 2: Pure Matter and Mixtures Concept Test

## SAF MADDE VE KARIŞIMLAR KAVRAM TESTİ

**1) Kömür parçasının üzerine çekiç ile vuruluyor. Kömür parçasında bulunan bir atomun şekli için aşağıdaki ifadelerden hangisi doğrudur?**

**A)** Ezilir ve yassılaşır.

**B)** Önce ezilir sonra eski haline geri döner.

**C)** Bazı parçalar kopar ve atom küçülür.

**D)** Şekli değişmez.

**Cevabınızın nedenini yazınız.**

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**2)** **I)** Tuz ruhu

**II)** Altın

**III)** Su

**Yukarıda verilenlerin formül veya sembol olarak sınıflandırılması aşağıdakilerden hangisinde doğru olarak verilmiştir?**

| | Formül | Sembol |
|---|---|---|
| **A)** | I ve III | II |
| **B)** | II | I ve III |
| **C)** | I | II ve III |
| **D)** | I ve II | III |

**Cevabınızın nedenini yazınız.**

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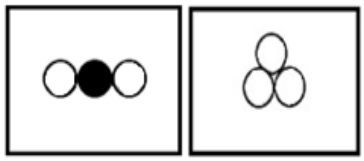
**3)**



**I** **II**

**Yukarıda verilen şekillerde farklı renklerde belirtilen atomların dizilişleri gösterilmektedir. Şekillere göre aşağıdaki ifadelerden hangisi doğrudur?**

**A)** I ve II bileşiktir.

**B)** I ve II elementtir.

**C)** I element, II bileşiktir.

**D)** I bileşik, II elementtir.

**Cevabınızın nedenini yazınız.**

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**4) Günümüzde kabul gören modern atom teorisine uygun ifade aşağıdakilerden hangisinde verilmiştir?**

**A)** Elektronlar belirli uzaklıktaki katmanlarda hareket ederler.

**B)** Elektronlar bulunma olasılıklarının yüksek olduğu bölgelerde dönerler.

**C)** Elektronlar çekirdeğin etrafındaki dairesel yörüngelerde dolanırlar.

**D)** Elektronlar çekirdeğin çevresindeki enerji düzeylerinde hareket ederler.

**Cevabınızın nedenini yazınız.**

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**5) Su bulunan kabın içine bir miktar tuz atılıyor. Bir süre kaşık yardımıyla karıştırılıyor. Aşağıda verilen ifadelerden hangisi doğrudur?**

**A)** Karıştırma işlemi sona erdiğinde çözünmede sona erer ve madde kabın dibine çöker.

**B)** Karıştırma işlemi ile kaptaki çözünen madde miktarı artar.

**C)** Karıştırma işlemi çözünmenin hızlı gerçekleşmesini sağlar.

**D)** Karıştırma işlemi olmadan kapta çözünme gerçekleşmez.

**Cevabınızın nedenini yazınız.**

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**6) Aşağıdakilerden hangisi bir atom kütlesinin belirlenmesinde etkilidir?**

**A)** Proton, elektron, nötron ve yörünge sayıları

**B)** Proton ve nötron sayıları

**C)** Elektron ve yörünge sayıları

**D)** Proton, elektron ve yörünge sayıları

**Cevabınızın nedenini yazınız.**

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7) •Gübre yapımında kullanılır.

•Halk arasındaki adı kezzaptır.

•Bir hidrojen, bir azot ve üç oksijenin birleşmesi ile oluşur.

**Yukarıda ifade edilen özelliklere sahip olan bileşik aşağıdakilerden hangisidir?**

**A)** Amonyak **B)** Sülfürik asit

**C)** Nitrik asit **D)** Glikoz

**Cevabınızın nedenini yazınız.**

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8) Ayşe okul çıkışı eve dönerken, canı gazoz ister ve aynı zamanda annesinin kendisinden toz şeker istediğini hatırlar. Bakkala girip gazoz ve toz şekeri alarak yola koyulur. Yolda giderken bir anda aklına fen dersinde işledikleri saf madde ve karışımlar konusu gelir, şeker ve gazozun bileşik mi, element mi yoksa karışım mı olduğunu düşünür.

**Ayşe'nin düşündüğü sorunun doğru cevabı aşağıdakilerden hangisidir?**

**A)** Şeker bileşik, gazoz karışımdır.

**B)** Şeker element, gazoz karışımdır.

**C)** Şeker bileşik, gazoz bileşiktir.

**D)** Şeker element, gazoz bileşiktir.

**Cevabınızın nedenini yazınız.**

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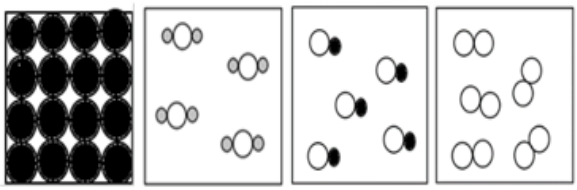
9) 


**Yukarıdaki şekillerde atomlar farklı renk ve farklı büyüklükte gösterilmiştir. Şekillere göre aşağıdaki ifadelerden hangisi doğrudur?**

**A)** I ve IV elementtir; II ve III bileşiktir.

**B)** I ve IV bileşiktir; II ve III elementtir.

**C)** I, III ve IV elementtir; II bileşiktir.

**D)** I, II ve III bileşiktir; IV elementtir.

**Cevabınızın nedenini yazınız.**

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**10) Mavi renkli paket lastiğinde bulunan atomlar hakkında aşağıdaki ifadelerden hangisi doğrudur?**

**A)** Atomlar esnek ve mavi renktedir.

**B)** Atomlar esnek değildir ve mavi renkte değildir.

**C)** Atomlar esnektir fakat mavi renkte değildir.

**D)** Atomlar esnek değildir fakat mavi renktedir.

**Cevabınızın nedenini yazınız.**

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**11) Aşağıda verilen ifadelerden hangisi doğrudur?**

**A)** Çözücü ve çözünen maddeler birbirlerinden hem fiziksel hem de kimyasal yöntemlerle ayrıştırılırlar.

**B)** Çözücü ve çözünen maddeler birbirlerinden fiziksel yöntemlerle ayrıştırılırlar.

**C)** Çözücü ve çözünen maddeler birbirlerinden kimyasal yöntemlerle ayrıştırılırlar.

**D)** Çözücü ve çözünen maddeler birbirlerinden ayrıştırılamazlar.

**Cevabınızın nedenini yazınız.**

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**12)** Mert evde karışımlar konusunu tekrar ederken biraz ara vermeye karar verir. Odasından çıktığında annesinin yerleri sildiğini görür. Mutfağa girer ve bardağa ayran koyarak odasına geri döner. Odasına girdiğinde etrafın sirke koktuğunu fark eder. Fen öğretmenin derste sirke ve ayranı karışımlara örnek olarak verildiğini hatırlar. Sirke ve ayranın homojen karışım mı yoksa heterojen karışım mı olduğunu düşünmeye başlar.

**Mert'in düşündüğü sorunun doğru cevabı aşağıdakilerden hangisidir?**

**A)** Sirke (asetik asit+su) homojen karışımdır, ayran homojen karışımdır.

**B)** Sirke (asetik asit+su) heterojen karışımdır, ayran heterojen karışımdır.

**C)** Sirke (asetik asit+su) heterojen karışımdır, ayran homojen karışımdır.

**D)** Sirke (asetik asit+su) homojen karışımdır, ayran heterojen karışımdır.

**Cevabınızın nedenini yazınız.**

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**13) Aşağıda verilen ifadelerden hangisi doğrudur?**

**A)** Protonlar, nötronlar ve elektronlar çekirdekte yer alır.

**B)** Protonlar ve nötronlar çekirdekte, elektronlar çekirdek dışında yer alır.

**C)** Protonlar, nötronlar ve elektronlar çekirdek dışında yer alır.

**D)** Protonlar çekirdekte, nötronlar ve elektronlar çekirdek dışında yer alır.

**Cevabınızın nedenini yazınız.**

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**14) Gümüş ile ilgili aşağıdaki ifadelerden hangisi doğrudur?**

**A)** Saf madde değildir.

**B)** Hg ile gösterilir.

**C)** Periyodik tabloda yer alır.

**D)** Farklı cins atomlardan oluşur.

**Cevabınızın nedenini yazınız.**

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**15) Karışımlarla ilgili;**

- ..... Tek tür atomlardan oluşursa homojen karışım oluşur.
- ..... Birden fazla tür atomlardan oluşursa heterojen karışım oluşur.

**yukarıda verilen ifadelerden doğru olanların başına "D", yanlış olanların başına "Y" yazıldığında hangi sıralama elde edilir?**

**A)** D **B)** Y **C)** D **D)** Y
Y D D Y

**Cevabınızın nedenini yazınız.**

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**16) Metin:** Sıvı-sıvı homojen karışımı ayırmak için buharlaştırma yönteminden yararlanılır.

**Seçkin:** Damıtma yönteminde maddelerin kaynama noktaları farkından yararlanılır.

**Mutlu:** Buharlaştırma yönteminde çözücü madde buharlaşır.

**Öğrencilerin belirttiği ifadelerle ilgili olarak aşağıdakilerden hangisi söylenebilir?**

**A)** Metin doğru, Seçkin ve Mutlu yanlış bilgi vermiştir.

**B)** Metin ve Seçkin yanlış, Mutlu doğru bilgi vermiştir.

**C)** Metin yanlış, Seçkin ve Mutlu doğru bilgi vermiştir.

**D)** Metin ve Seçkin doğru, Mutlu yanlış bilgi vermiştir.

**Cevabınızın nedenini yazınız.**

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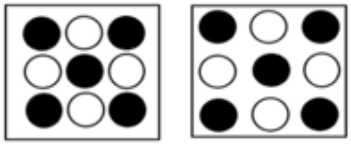
**17)**



**I** **II**

(I. şekildeki tanecikler arası mesafe II. şekildekine göre daha azdır.)

**Yukarıdaki şekillerde aynı atomlar aynı renklerde gösterilmiştir. Şekillere göre aşağıdaki ifadelerdenhangisi doğrudur?**

**A)** I homojen karışım, II heterojen karışımdır.

**B)** I heterojen karışım, II homojen karışımdır.

**C)** I ve II homojen karışımdır.

**D)** I ve II heterojen karışımdır.

**Cevabınızın nedenini yazınız.**

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**18)**

| **Element** | **Sembol** |
|---|---|
| **I)** Kalsiyum | Ka |
| **II)** Alüminyum | Al |
| **III)** Bor | B |
| **IV)** Fosfor | F |

**Yukarıda element isimleri ve sembolleri karşılıklı olarak verilmiştir. Hangileri doğrudur?**

**A)** I ve IV

**B)** II ve III

**C)** II, III ve IV

**D)** I, II, III ve IV

**Cevabınızın nedenini yazınız.**

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**19) Aşağıda verilen açıklamalardan hangisi günümüzde kabul gören atom teorisine uygun bir ifadedir?**

**A)** Atomun yapısında (+) ve (-) yükler eşit sayıda bulunur.

**B)** Atom küçük ve bölünemez taneciklerden oluşmaktadır.

**C)** Atom negatif yüklü elektronlarla çevrili çok küçük pozitif yüklü bir çekirdekten oluşmaktadır.

**D)** Atom merkezde çekirdek ve etrafında elektron bulutu yapısından oluşmaktadır.

**Cevabınızın nedenini yazınız.**

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**20) Aşağıdaki verilen ifadelerden hangisi doğrudur?**

**A)** Bilim insanları atom modellerini ve şekillerini ışık mikroskobunda görerek çizmiştir.

**B)** Bilim insanları atom modellerini ve şekillerini bilimsel gözlemlerden çıkarımlar yaparak çizmiştir.

**C)** Bilim insanları atom modellerini ve şekillerini görerek çizmiştir.

**D)** Bilim insanları atom modellerini ve şekillerini deneyler yaparak çizmiştir.

**Cevabınızın nedenini yazınız.**

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**21) Aşağıda verilen büyüklük karşılaştırmalarından hangisi doğrudur?**

**A)** Bir tane su molekülü > Bir tane oksijen atomu> Bir tane insan karaciğer hücresi

**B)** Bir tane insan karaciğer hücresi > Bir tane oksijen atomu > Bir tane su molekülü

**C)** Bir tane insan karaciğer hücresi > Bir tane su molekülü > Bir tane oksijen atomu

**D)** Bir tane su molekülü > Bir tane insan karaciğer hücresi = Bir tane oksijen atomu

**Cevabınızın nedenini yazınız.**

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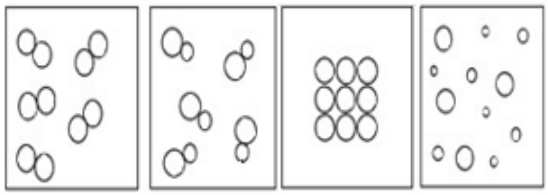
**22)**



**I** **II** **III** **IV**

**Yukarıda verilen şekillerde farklı boyutlarda atomlar gösterilmektedir. Şekillere göre aşağıdaki ifadelerden hangisi doğrudur?**

**A)** I ve III saf maddedir; II ve IV saf madde değildir.

**B)** I ve III saf madde değildir; II ve IV saf maddedir.

**C)** I, III, IV saf maddedir; II saf madde değildir.

**D)** I, II, III saf maddedir; IV saf madde değildir.

**Cevabınızın nedenini yazınız.**

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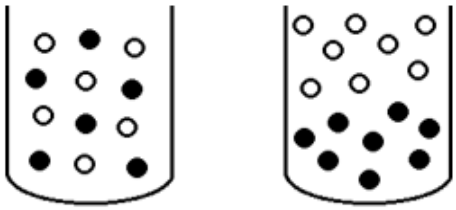
**23)**



**A kabı** **B kabı**

**Yukarıda verilen şekillere göre aşağıdaki ifadelerden hangisi doğrudur?**

**A)** A kabındaki karışım çözeltidir, B kabındaki karışım çözelti değildir.

**B)** A ve B kaplarındaki karışımlar çözelti değildir.

**C)** A kabındaki karışım çözelti değildir, B kabındaki karışım çözeltidir.

**D)** A ve B kaplarındaki karışımlar çözeltidir.

**Cevabınızın nedenini yazınız.**

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**24) Bir miktar su bulunan kaba bir küp şeker atılıyor. Çözünme sonrasında şeker ve su moleküllerinin konumu için aşağıda verilen ifadelerden hangisi doğrudur?**

**A)** Şeker molekülleri su molekülleri arasında eşit bir şekilde dağılır.

**B)** Su molekülleri şeker molekülleri arasındaki boşluğu doldurur.

**C)** Şeker molekülleri çoğunlukla kabın alt kısmında yer alır.

**D)** Su molekülleri şeker moleküllerinin etrafını sarar.

**Cevabınızın nedenini yazınız.**

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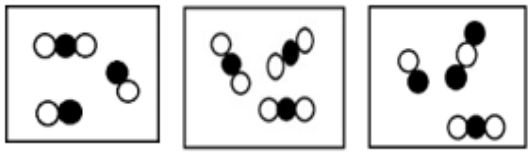
**25)**



I II III

**Yukarıdaki şekillerde aynı atomlar aynı renklerde gösterilmiştir. Şekillere göre aşağıdaki ifadelerden hangisi doğrudur?**

**A)** I, II ve III bileşiktir.

**B)** I, II ve III karışımdır.

**C)** I bileşiktir; II, III karışımdır.

**D)** I ve III karışımdır; II bileşiktir.

**Cevabınızın nedenini yazınız.**

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