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**Research Article**

# Effects of Computer-Assisted Instruction with Conceptual Change Texts on Removing the Misconceptions of Radioactivity [1]

Ahmet YUMUŞAK[2], İsmail MARAŞ[3] & Mehmet ŞAHİN[4]

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**Abstract**

Training young scientists, enabling conceptual understanding in science education is quite important. Misconception is one of the important indications for whether the concepts are understood or not. The most important educational tools to remove misconceptions are conceptual change texts. In addition, one of the important methods to remove misconceptions is computer-assisted instruction. The goal of this study is to research the effects of the use of computer-assisted instruction (CAI), conceptual change texts (CCT), computer-assisted instruction with conceptual change texts (CAI+CCT), and use of traditional teaching method (TTM) on removing the misconceptions of science teacher candidates on the subject of radioactivity. Research sample was made of totally 92 students studying at four different groups of senior students in Celal Bayar University, Faculty of Education, Department of Science Education in 2011-2012 academic year. A different teaching method was used in each group. Experimental groups were randomly determined; in the first experimental group, computer-assisted instruction was used (23 students); in the second experimental group, conceptual change texts were used (23 students); in the third experimental group, computer-assisted instruction with conceptual change texts were used (23 students); and the fourth group, on which traditional education method was used, was called control group (23 students). Two-tier misconception diagnostic instrument, which was developed by the researcher, was used as data collection tool of the research. "Nonequivalent Control

[1] This article partially based on the authors' doctoral thesis.

[2] Department of Primary Education, Faculty of Education, Celal Bayar University, 45900 Demirci-Manisa, Turkey. E-mail: ahmetyumusak@hotmail.com

[3] Department of Physics, Faculty of Arts and Sciences, Celal Bayar University, 45040 Manisa, Turkey. E-mail: ismail.maras@bayar.edu.tr

[4] Department of Elementary Science Education, Faculty of Education, Dokuz Eylül Universty, 35150, Buca-İzmir, Turkey
e-mail: mehmet.sahin@deu.edu.tr

Groups Experimental Design" was used in this research in order to determine the efficiency of different teaching methods. Obtained data were analyzed by using SPSS 21.0. As a result of the research, it was determined that methods used on experimental groups were more successful than traditional teaching method practiced on control group in terms of removing misconceptions on radioactivity.

**Keywords**
computer-assisted instruction, conceptual change texts, physics education, misconceptions, radioactivity, two-tier misconception diagnostic instrument.

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### Introduction

Education and training of gifted young scientists is very important in terms of the future of countries. In Turkey, certain education programs to train gifted young scientists have started to be carried out (Tortop, 2013). It is necessary that new approaches and important applications are used to improve quality of this education. This study focuses on removing misconceptions in physics education, effectiveness of conceptual change texts and computer-assisted instruction and their use in different occasions.

Physics is a discipline which is practiced in many fields of daily life and exists in our lives. Concepts about physics that we meet very often in daily life are mostly used different from their scientific definitions.

Students have different thoughts and beliefs about physics concepts. They generally form these thoughts and beliefs, which are away from being scientific, as a result of their personal experiences. Consequently, they perceive and use concepts different from their scientific definitions. At the end of this process called "misconception" (Helm, 1980; Fisher, 1983), students have difficulty in understanding topics, and meaningful learning cannot be ensured. Misconception is not an incorrect answer that is given because of a mistake or lack of information. Misconception means that a concept's definition in the mind is different from its scientific definition (Eryılmaz and Sürmeli, 2002).

Some reasons of misconceptions are as followed: Teachers and textbooks (Bernhisel, 1999), environment of students (Chambers and Andre, 1997), students' insufficient prior knowledge and their misperception about concepts (Kathleen, 1994), teaching concepts with traditional methods and the fact that concepts used in everyday language are different in scientific language (Chi, 1992).

Many researches have been done about misconceptions in physics education so far. In literature there are many researches especially on heat-temperature, mechanics, electric and optics. But there are very few researches on some subjects, one of which is radioactivity. Some researches in the literature prove that students have misconceptions on radioactivity (Prather and Harrington, 2001; Alsop, 2001; Prather, 2005; Yalçın, 2003; Tortop et al., 2008).

Most of the researches on radioactivity have been carried out in order to determine misconceptions. In some researches, the aim is removing misconceptions and analyzing the effects of different teaching methods (Millar, Klassen and Eijkelhof, 1990; Mork, 2011; Cooper, Yeo and Zadnik, 2003). But the number of this kind of researches is quite few.

The first condition to be able to remove misconceptions is to determine them. Various methods have been used in order to determine misconceptions. The most frequently used methods are; Prediction-Observation-Explanation (Liew and Treagust, 1998), drawings (Smith and Metz, 1996), word association (Gussarsky and Gorodetsky, 1990), interviews (Osborne and Gilbert, 1980; Osborne and Cosgrove, 1983) and tests (Palmer, 1998; Tan et al., 2002; Voska and Heikkinen, 2000, Karataş et al, 2003).

Many different methods and strategies have been used in removing misconceptions such as multiple intelligence theory, meaningful learning, constructivist learning, mind map, semantic analysis tables, concept network, conceptual change texts, work sheets, computer-assisted instruction, analogies (simile) and metaphors. Conceptual change texts and computer-assisted instruction have been used in this research in order to remove misconceptions on the subject of radioactivity.

Conceptual change texts were firstly developed by Wang and Andre (1991). After that, many researchers developed and continued to use these methods, primarily Chambers and Andre (1997).

In conceptual change texts, firstly students are ensured to be aware of their misconceptions. After that, the reasons of these misconceptions are explained through examples and reasons. Students feel that their knowledge is insufficient in explaining new situations that they meet and conceptual change is ensured by showing them the concepts that are scientifically correct (Guzzetti, Snyder and Glass, 1992; Chambers and Andre, 1997).

Until today, there have been different researches on the effect of conceptual change texts on removing misconceptions. In some researches, effects of conceptual change texts and traditional texts on teaching concepts and removing misconceptions were compared (Wang and Andre**,** 1991; Chambers and Andre, 1997; Mikkila-Erdmann, 2001). At the end of these researches, it was determined that conceptual change texts are more effective than traditional texts in teaching concept and removing misconceptions. On the other hand, in their study, Diakidoy, Kendeou and Ioannides (2003) compared the effects of conceptual change texts and traditional method on conceptual learning. As a result of their study, conceptual change texts were more effective than traditional methods in terms of conceptual success. Yılmaz (2010) made a

similar study and found out that conceptual change texts were more effective than traditional method in removing misconceptions.

Computer assisted instruction is defined as; using computers for directly presenting course contents, repeating what is learnt with other methods, solving problems, making exercises and other similar practices as learning-teaching tools (Odabaşı, 1998). According to Uşun (2004), computer assisted instruction is a teaching method in which computer is used as an environment where learning occurs; this education reinforces both teaching process and student motivation, it can be used according to the learning speed of student, and it is made of the combination of self-learning's principles with computer technology.

This teaching method can be used in various ways while teaching a subject. Uşun (2004) mentioned that computer assisted instruction can be carried out generally through four methods, these are: Laboratory method, PC in each class method, personal PC method and learning through internet.

Animations and simulations are used in order to increase interaction during computer assisted instruction practices (Chang, Yang, and Chan, 2002; Jimoyiannis and Komis, 2001; Kim, Park, Lee and Lee, 2005). Animations and simulations boost understanding subjects and especially ease teaching abstract concepts in subjects (Sanger and Greenbowe, 2000; Gobert, Snyder, Houghton, 2002).

Researches on the issue show that computers have positive effects in increasing the success and improving the attitude of students besides easing their learning abilities. On the other hand, there are some researches showing that the method is effective in teaching concepts and removing misconceptions (Tao and Gunstone, 1999; Monaghan and Clement, 2000; Demirci, 2004; Kahraman and Demir, 2011).

Jimoyiannis and Komis (2001), conducted a study in order to compare the effect of computer simulations with the effect of traditional method on removing misconceptions on the topics of speed and acceleration. The study was conducted on students at the age of 15-16 who were separated into two groups (experiment and control). In the study, simulation assisted instruction was used in experiment group while traditional method was used in control group. At the end of the study, it was determined that computer simulations were more effective than traditional method in removing misconceptions on the subject of speed and acceleration.

Kim, Park, Lee and Lee (2005), conducted a study in order to analyze the effect of virtual reality simulations on students' cognitive complexity and conceptual change. They developed a simulation that presents virtual reality system of an object's movement. It was seen that, in terms of misconceptions, this simulation triggered the inner conflicts of students in understanding the movement of the object. At the same time, this program motivated students. By this simulation, students achieved scientific concepts on their own by using many different features of simulated physical situations. Thanks to the program, students structured concepts more substantially. At the end of the

study, it was seen that virtual reality simulations were very effective tools for correcting students' misconceptions.

The researches show that conceptual change texts and computer-assisted instruction are effective in removing misconceptions. It is clear that these methods are compared with traditional teaching method in the studies. But when compared with the more effective methods each other rather than traditional method, which one is more effective? Studies to answer this question are important to find the best method in teaching concepts and removing misconceptions. Consequently, two methods, which aren't traditional, are compared in this research and it is aimed to fill a gap in the literature.

In literature studies prove that students have misconceptions about radioactivity (Millar, Klaassen and Eijkelhof, 1990; Millar and Gill, 1993; Prather and Harrington, 2001; Alsop, 2001; Cooper, Yeo and Zadnik, 2003; Prather, 2005; Mork, 2011). Most of the studies have focused on determining misconceptions. In literature there aren't any studies to research effect of the use of conceptual change texts and computer-assisted instruction in order to remove misconceptions about radioactivity. Consequently, the goal of our study was chosen to view the effect of different methods for removing misconceptions about radioactivity. For this purpose, "Two-Tier Misconception Diagnostic Instrument" was developed to determine students' misconceptions about radioactivity. This instrument is thought to make a significant contribution to the literature.

The aim of this study is to research the effects of the use of computer-assisted instruction (CAI), conceptual change texts (CCT), computer-assisted instruction with conceptual change texts, and use of traditional teaching method on removing the misconceptions of science teacher candidates on the subject of radioactivity.

The research problems that were attempted to be tested in this research are as followed:

- Is there effect of the Computer- Assisted Instruction on removing prospective teachers' misconceptions of radioactivity?
- Is there effect of the Conceptual Change Texts on removing prospective teachers' misconceptions of radioactivity?
- Is there effect of the Computer-Assisted Instruction with Conceptual Change Texts on removing prospective teachers' misconceptions of radioactivity?

## Methods

### Research Model

"Semi Experimental Design" was used in this research in order to determine the efficiency of different teaching methods. In this method, groups that were created before were accepted as they were and one of them was determined to be experiment group while the other one was determined to be control group; the significant point in this process was that determining was carried out randomly (Kaptan, 1998; Karasar, 1999). After that, pretest was practiced on

two groups. Traditional methods were used in control groups while the method whose efficiency was researched was used in the experiment group while the lesson was given. Posttest was given to each group after the practice.

**Sampling of the Research**

Research sample was made of totally 92 students studying at four different divisions of senior students in Celal Bayar University, Faculty of Education, Department of Science Education in 2011-2012 academic year. A different teaching method was used in each group. Experimental groups were randomly determined; in the first experimental group, computer-assisted instruction was used (23 students); in the second experimental group, conceptual change texts were used (23 students); in the third experimental group, computer-assisted instruction with conceptual change texts were used (23 students); and the fourth group, on which traditional education method was used, was called control group (23 students).

**Data Tools**

Two-tier diagnostic instrument was used in this research in order to determine misconceptions; these tests are made of two stages, as can be understood from the name of them. Generally in the first stage of these tests, there is a question subject or information suggestion and various number of answer options following it. In the second stage of these tests, student is required to explain why he/she chose his/her answer in the first stage. This stage can be made of multiple answers, or made of a form including an open-ended option-multiple choice according to the findings obtained from literature analysis or interviews; this stage especially includes misconceptions of students (Karataş et al, 2003).

Two-tier test was firstly developed by Treagust (1988). Treagust suggested a method made of three main stages and totally ten steps. These three stages were:

- *Determining content,*
- *Obtaining information about students' misunderstandings*
- *Developing diagnostic test*

Two-tier test that was used in this research was developed on the basis of Treagust's (1988) suggestions.

In order to determine the reliability of this test, a pilot study was practiced on 84 students studying at Science Teaching Department. Firstly, item analysis was made by using these data. The analysis was made separately for the total test; for the first and second stages and two items were removed as they were determined to be inappropriate. Mean item difficulty index of the total test was 0.45; first stage mean item difficulty index was 0.47 and second stage mean item difficulty index was 0.49. These values showed that the test could be called difficult. Reliability coefficient of the first and second stages of the test was calculated according to Kuder-Richardson (KR-20) by using the information obtained from item analysis. KR-20 reliability coefficient of the first stage of the test was 0.68, while KR-20 reliability coefficient of the second stage of the test was 0.70. Cronbach Alpha (α) reliability coefficient was calculated by using SPSS package program and it was determined to be 0.65.

**Procedure**

While preparing conceptual change texts in this research, it was based "Conceptual Change Approach" defined by Posner et al. (1982). Posner et al. (1982) grouped conditions that should be carried out in order to remove misconceptions as: Dissatisfaction, Intelligibility, Plausibility and Fruitfulness.

Conceptual change texts that were used in this research were designed according to the four items mentioned above. Firstly, concepts of the conceptual change texts were determined. After completing this process, questions that were going to activate students' misconceptions, were asked. In the second section, common misconceptions about the topic were presented and the reasons of these misconceptions were explained. In the third section, detailed information was given about the reasons why these misconceptions were incorrect. In the last section of texts, scientific information about the misconception was presented to the students.

Prepared draft texts were presented to two academic members whose major was physics, one academic member whose major was physics education, one academic member whose major was physical sciences education, one academic member whose major was Turkish; they were required to analyze these texts in terms of content, teaching, features of conceptual change texts and grammar and some arrangements were made according to their views.

After these processes, a pilot study was made for these texts. Prepared draft texts were practiced in a class for eight hours, 2 hours per week; there were 25 students in this practice, they were not in experiment or control group and they had never seen these topics before. During practice, students' views were taken and necessary arrangements were made.

While designing the computer-assisted Instruction material of the research, these steps were followed:

- The topic was designed according to the content and students acquisitions about the subject of radioactivity that was determined before.
- In this design, concepts that couldn't be understood easily by students and misconceptions were taken into consideration.
- Pictures, simulations and animations were determined by taking content, student acquisitions and misconceptions into consideration. Simulations were taken from these addresses: http://www.furryelephant.com/content/radioactivity/teaching-learning/ and http://phet.colorado.edu/tr/simulations/category/physics.
- In this step, prepared design was computerized.
- Opinions of a physics educator, a computer expert and a teaching technologies and material development expert were taken about the developed material and necessary arrangements were made.
- PowerPoint program was used for presenting material.

After these processes, a pilot study was made for these texts. Prepared draft texts were practiced in a class for eight hours, 2 hours per week; there were 25

students in this practice, they were not in experiment or control group and they had never seen these topics before. During practice, students' views were taken and necessary arrangements were made.

Practice in this study continued for totally ten weeks, two course hours per week. Researcher carried out the practice in all groups. The program practiced on students included; structure of nucleus, nucleus identification, radioactivity, disintegration speed, half-life, alpha, beta, gamma disintegrations, radiation, penetration of radioactive rays, general features of nucleus reaction, fission and fusion. Two-tier misconception diagnostic instrument was practiced as pretest before starting practices in all of the control and experiment groups. Two-tier misconception diagnostic instrument was used again as the posttest in order to determine different teaching methods' effects on removing student misconceptions.

Traditional teaching method was used in control group. Researcher taught the topics to students by using direct lecture method**.** Researcher told the topic through course notes he prepared before, students took notes and researcher gave examples about the topic. Students only listened to the class and they gave answers only when they were asked questions. During lecture, researcher directly answered students' questions. Formulas, figures and reactions about the topic were drawn on the board. Lessons were taught with teacher-centered instruction and by using a limited number of resources. Discussion environment was created in some cases although not as often as in the experiment group. On the other hand, the topics were taught from simple to complex. At the end of the practices, problem solving activity was made for 2 course hours.

Computer assisted instruction was used in the first experiment group. The topics of radioactivity were told by using presentations including pictures, animations and simulations. Sample display images used in simulations in computer assisted instruction are given below.

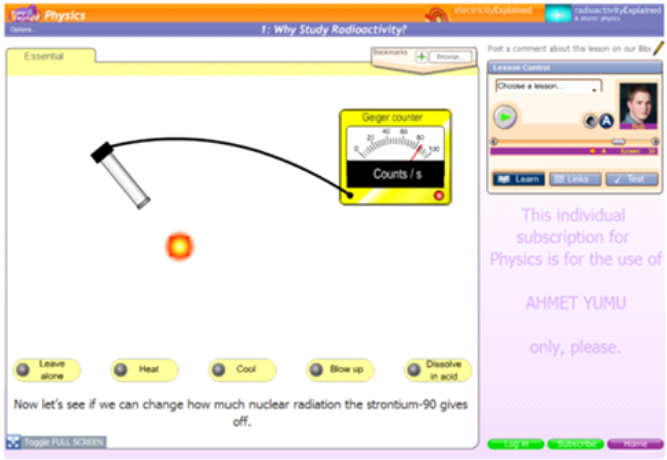


**Figure 1.** A simulation image about the analysis of the Physical and Chemical changes' effects on Radioactivity

Simulation in Figure 1 was used in order to show students that radioactivity would not be affected from physical and chemical changes.

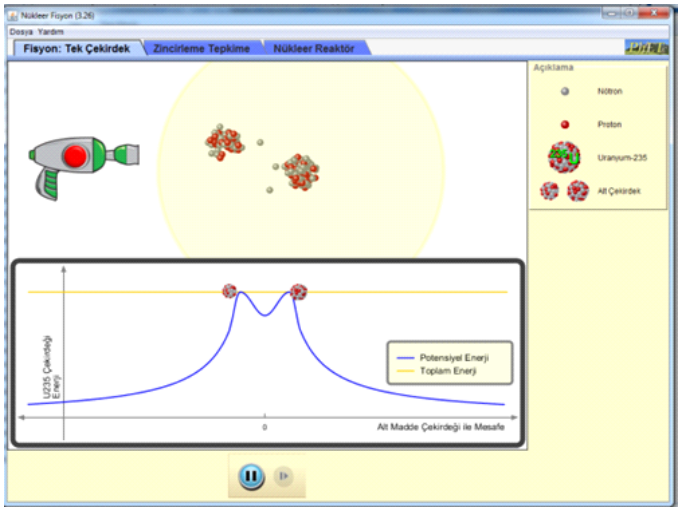


**Figure 2.** A simulation image about Fission phenomenon

Simulation in Figure 2 was used in order to show the energy that comes out after reaction and how fission reaction occurs to students graphically.

In this practice, learning activities were presented to students step by step. Students noted drawings in the presentation and information about the topic; when students had questions about a point, they asked during presentation, the presentation was stopped and explanations were made. On the other hand, after picture, animation and simulation presentations, short information about the topic was given. When there was something that a student couldn't understand, the presentation was repeated and students were as active as possible in order to ensure their attendance to lesson. They explained their thoughts easily about pictures, animation and simulations. At the end of the practices, problem solving activity was made for 2 course hours.

In the second experiment group, conceptual change texts were used in teaching radioactivity topics. Before the practice, short information was given to students about the feature of course and conceptual change texts. An example of used conceptual change texts is presented below.

**Table 1.** Example of a conceptual change text

| |
|---|
| **If a radioactive atom and a non-radioactive atom form a compound, does the new substance become radioactive?** |
| According to some students, if a radioactive atom and a non-radioactive atom form a compound, the new substance is not radioactive. |
| This is not correct. Radioactivity is related with nucleus structure. When a radioactive atom enters into the structure of a compound, it makes it radioactive. |
| Chemical reactions occur in electron levels in atom. So, chemical reactions don't change nuclear structure and created compound becomes radioactive. |

For example:

$_{88}Ra$ =>A radioactive element.

$$Ra + 1/2O_2 \rightarrow RaO$$

A radioactive compound.

In the practice in this group, conceptual change texts prepared according to the daily course topic, were distributed to students. After that, researcher asked the question in conceptual change text to the class. Everybody expressed opinions in class and a discussion environment was created. With this process, questions were created in the minds of students and they started to have doubts about themselves. Then, they were required to read the texts carefully. After reading, students' questions about texts were answered and necessary explanations were made. Discussion environment about concepts and misconceptions was created, non-scientific information was removed and it was intended to give students information that was accepted to be scientific.

In this group, the goal was to activate students as much as possible in order to ensure that they attend the course. For this purpose, in every stage of the course, researcher asked questions to students frequently and created a discussion environment and their views about topics were attempted to be revealed.

Computer assisted instruction with conceptual change texts were used in the third experiment group. In this group, besides computer assisted instruction, which was also used in the first experiment group, conceptual change texts, which were about the topic of course, were used in the last five minutes of courses. All of the practices applied in the first and second experiment group were also carried out in this group.

**Data Analysis**

While evaluating all of the data, significance level of hypotheses that were stated by experiment and control groups was determined to be 0.05.

Multivariate analysis of variance-MANOVA was used in the study in order to analyze the effect of more than one independent variable on more than one dependent variable in obtained data. In comparing paired samples, dependent paired samples t-test analysis was made. In line with the findings, in order to determine different groups among units, ANOVA and Bonferroni test was used besides Post Hoc analysis. On the other hand, in order to test the basic effects of experimental process which was applied in two-factor split spot designs in which independent measurement, related to procedures and repeated measurement, related to time, were mentioned, Two-Way ANOVA for Mixed Measures analysis was made. Obtained data was analyzed with SPSS 21.0 program.

**Analysis of Two-Tier Misconception Diagnostic Instrument**

Two-tier diagnostic instrument was used as Misconception diagnostic test in this study. In order to analyze two- tier diagnostic tests, generally, students'

answers to the first stage questions and the combinations of reasons that they chose for these answers are analyzed. This combination was taken into consideration in this study and students answers to misconception diagnostic test were evaluated according to the below mentioned criteria.

**Table 2.** Evaluation Criteria Used in Analyzing Two-Tier Questions (Karataş et al., 2003)

| Evaluation Criteria | Score |
|---|---|
| Correct Answer – Correct Reason | 3 |
| Incorrect Answer – Correct Reason | 2 |
| Correct Answer – Incorrect Reason | 1 |
| Incorrect Answer– Incorrect Reason | 0 |

**Results**

In this part of the study, findings obtained from misconception diagnostic test are presented. Data obtained from experimental studies were analyzed statistically and findings were interpreted.

**Table 3.** Students' two-tier diagnostic instrument paired pre-test post-test mean scores of t-test results

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TTM** | Pretest | 23 | 27.9130 | 6.82184 | 22 | 3.166 | .004* |
| | Posttest | 23 | 32.0870 | 2.77837 | | | |
| CAI** | Pretest | 23 | 27.0000 | 4.98179 | 22 | 7.484 | .000* |
| | Posttest | 23 | 38.8261 | 4.67734 | | | |
| CCT** | Pretest | 23 | 28.8696 | 6.76424 | 22 | 6.449 | .000* |
| | Posttest | 23 | 40.8696 | 5.69134 | | | |
| CAI+CCT** | Pretest | 23 | 25.4348 | 8.64358 | 22 | 9.402 | .000* |
| | Posttest | 23 | 45.5217 | 3.78239 | | | |

p*<0.05

**TTM**: Traditional Teaching Method; **CAI**: Computer Assisted Instruction; **CCT**: Conceptual Change Texts; **CAI+CCT**: Computer Assisted Instruction with Conceptual Change Texts.

When Table 3 is analyzed, it can be seen that there is a significant difference between each group's misconception diagnostic test pre-test mean scores and two-tier misconception diagnostic instrument posttest mean scores ($p<0.05$). According to this result, in removing misconceptions in radioactivity topic, traditional teaching method, computer assisted ınstruction, conceptual change texts, and computer assisted instruction with conceptual change texts were effective.

In order to test if there are significant differences in-groups in terms of two-tier misconception diagnostic instrument pretest and posttest mean scores, MANOVA was made. At the end of the analysis, it was seen that there were

significant differences in Two-tier misconception diagnostic instrument variable among groups Wilks Lambda (ʌ)=.427, F(6,174)=15.374, p<0.05. As MANOVA was found to be significant, it was determined that at least one dependent variable's mean difference was significant for groups. Eta-Square value was found to be $\eta^2$=.346. According to this, influence quantity was large size effect. This finding also shows that 34% of total variation of students' two-tier misconception diagnostic instrument was resulted from experimental practices.

ANOVA was applied for each dependent variable as follow-up tests in addition to MANOVA. Groups were compared with ANOVA for each dependent variable in order to interpret the resource of differences in terms of these dependent variables and results are presented in Table 4.

**Table 4.** ANOVA results of two-tier diagnostic instrument mean scores of pretest and posttest groups

| Group | | N | $\overline{X}$ | Sd | df | F | p | $\eta^2$ |
|---|---|---|---|---|---|---|---|---|
| Pretest | | | | | | | | |
| | TTM | 23 | 27.9130 | 6.82184 | | | | |
| | CAI | 23 | 27.0000 | 4.98179 | | | | |
| | CCT | 23 | 28.8696 | 6.76424 | 3-88 | 1.024 | .386 | .034 |
| | CAI+CCT | 23 | 25.4348 | 8.64358 | | | | |
| | Total | 92 | 27.3043 | 6.92779 | | | | |
| Posttest | | | | | | | | |
| | TTM | 23 | 32.0870 | 2.77837 | | | | |
| | CAI | 23 | 38.8261 | 4.67734 | | | | |
| | CCT | 23 | 40.8696 | 5.69134 | 3-88 | 37.664 | .000* | .562 |
| | CAI+CCT | 23 | 45.5217 | 3.75221 | | | | |
| | Total | 92 | 39.3261 | 6.48093 | | | | |

*p<0.05

According to Table 4, it wasn't found to be a significant difference between pretest and posttest mean scores, F (3, 88)=1.024, p>0.05, $\eta^2$=.034. This result shows that experiment and control group students' misconceptions about the topic of radioactivity were at the same level at the beginning.

There wasn't significant difference between misconception diagnostic posttest scores of students in terms of groups, F(3,88)=37.664, p<0.05, $\eta^2$=.562. As it was determined that, students' misconceptions were at the same level at the beginning, it can be said that teaching methods had different effects on removing misconceptions of students about the topic of radioactivity. When eta square ($\eta^2$) value is taken into consideration in order to determine effect size of posttest, it can be seen that group variable had large size effect on misconception diagnostic test ($\eta^2$=.562). This finding also shows that 56% of

total variance in misconception diagnostic posttest scores was resulted from experimental practices.

In order to test "according to which groups misconception diagnostic posttest mean scores varied", Bonferroni test and Post Hoc analysis was made and results are presented in Table 5.

**Table 5.** Results of Bonferroni Test according to Two-Tier Diagnostic Instrument Post-test Men Scores

| Group (I) | Group (J) | Differences Between Mean Values (I-J) | p |
|---|---|---|---|
| TTM | CAI | -6.7391* | .000** |
| | CCT | -8.7826* | .000** |
| | CAI+CCT | -13.4348* | .000** |
| CAI | TTM | 6.7391* | .000** |
| | CCT | -2.0435 | .694 |
| | CAI+CCT | -6.6957* | .000** |
| CCT | TTM | 8.7826* | .000** |
| | CAI | 2.0435 | .694 |
| | CAI+CCT | -4.6522* | .003** |
| CAI+CCT | TTM | 13.4348* | .000** |
| | CAI | 6.6957* | .000** |
| | CCT | 4.6522* | .003** |

**p<0.05

According to Table 5, misconception diagnostic test posttest mean scores of CAI, CCT and CAI+CCT groups were higher than the scores of TTM ($p<0.05$). There was not a significant difference between CAI and CCT groups' misconception diagnostic test posttest mean scores ($p>0.05$). Misconception diagnostic test posttest mean score of CAI+CCT group was higher than CAI and CCT groups misconception diagnostic test posttest mean score ($p<0.05$).

Two-factors ANOVA was conducted in order to determine if there was a difference between misconception diagnostic test mean scores of students – before and after the experiment- on whom different teaching methods were used. The results are presented in Table 6.

**Table 6.** ANOVA Results of Students' Two-Tier Diagnostic Instrument Mean Scores

| Resource of Variance | Sum of Squares | df | Mean of Squares | F | p | $\eta^2$ |
|---|---|---|---|---|---|---|
| Evaluation Among Experimental Group (Individual/Group) | 3630.718 | 91 3 88 | 279.790 | 8.821 | .000* | .231 |
| Error | 839.370 | 92 | 31.720 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Evaluation in Experimental | | 1 | | | | |
| Subject | 2791.34 | 3 | 6648.0 | 188.58 | .000 | .68 |
| Measurement (Pretest-Posttest) | 8 | 88 | 22 | 3 | * | 2 |
| Group*Measurement | 11207 | 18 | 485.58 | 13.775 | .000 | .32 |
| Error | | 3 | 7 | | * | 0 |
| Total | 6648.02 | | 35.252 | | | |
| | 2 | | | | | |
| | 1456.76 | | | | | |
| | 1 | | | | | |
| | 3102.21 | | | | | |
| | 7 | | | | | |
| | 14837.7 | | | | | |
| | 18 | | | | | |

*p<0.05

According to Table 6, in terms of main measurement effect, it can be said that there was a significant difference between students misconception diagnostic test mean scores before and after the test, -not in terms of different groups-F(1,88)=188.583, p<0.05. Applied teaching methods were effective in removing misconceptions about the topic of radioactivity. But this finding doesn't give definite information about the resources of changes. Eta square value was found to be $\eta^2$=.682. According to this, effect size is "large". This finding also shows that 68% of variance in students' misconception diagnostic test means scores was resulted from the main effect of measurement.

In terms of group effect, it can be said that, there was a significant difference between mean scores obtained from misconception diagnostic test pretest and posttest total scores of students on whom different teaching methods were used, F(3,88)=8.821, p<0.05. It was seen that applied teaching methods had different effects on changing students' misconception diagnostic test scores. As can be seen changes in groups from pretest and posttest weren't taken into consideration in this test. Eta square value was found to be $\eta^2$=.231. According to this, effect size is "large". This finding also shows that 23% of variance in students' misconception diagnostic test means scores was resulted from group effect.

In terms of Group*Measurement common effect, it can be said that there was a significant difference between the changes in misconception diagnostic test mean scores of students, on whom different teaching methods were applied, before and after the experiment F(3,88)=13.775, p<0.05. This finding show that applied teaching methods had different effects on changing students' misconception diagnostic test scores. Eta square value was found to be $\eta^2$=.320. According to this, effect size is "large". This finding also shows that

32% of the change in misconception diagnostic test means scores of students, on whom different teaching methods were applied, before and after the experiment, was resulted from Group* Measurement effect.

We mentioned above that in terms of Group*Measurement common effect, there was a significant difference between the changes in misconception diagnostic test mean scores of students, on whom different teaching methods were applied, before and after the experiment. Result of the statistic which was carried in order to determine from which groups this difference was resulted, is presented below.

In order to test the effects of applied teaching methods on the change of misconception diagnostic test mean scores of students before and after the experiment, groups' misconception diagnostic test pretest-posttest mean score differences were calculated (*difference misconception diagnostic test=posttest misconception diagnostic test – pretest misconception diagnostic test*) and it was tested if these score differences had significant difference. One-Way ANOVA was applied for this and results are presented below.

Descriptive statistics for groups' misconception diagnostic test pretest posttest mean score differences are presented in Table 7.

**Table 7.** Descriptive Statistics for Groups' Two-Tier Diagnostic Instrument Pretest-Posttest Mean Scores

| Group | N | $\overline{X}$ | Sd |
|---|---|---|---|
| TTM | 23 | 4.1739 | 6.32206 |
| CAI | 23 | 11.8261 | 7.57779 |
| CCT | 23 | 12.0000 | 8.92392 |
| CAI+CCT | 23 | 20.0870 | 10.24657 |
| Total | 92 | 12.0217 | 10.00986 |

Results of ANOVA analysis, which was made in order to test if there was a significant difference among groups' misconception diagnostic test pretest and posttest mean scores, are presented in Table 8.

**Table 8.** ANOVA Results of Groups' Two-tier Diagnostic Instrument Pretest and Posttest Mean Score Differences (*Difference Misconception Diagnostic Test*)

| Resource of the variance | Sum of Squares | df | Mean of Squares | F | p |
|---|---|---|---|---|---|
| Between Groups | 2913.522 | 3 | 971.174 | 13.775 | .000* |
| In-Groups | 6204.435 | 88 | 70.505 | | |
| Total | 9117.957 | 91 | | | |

*p<0.05

ANOVA results show that there was a significant difference between groups misconception diagnostic test pretest-posttest mean score differences $F(3,88)=13.775$, $p<0.05$. Bonferroni test was made in order to determine

"among which groups these differences exist" and results are presented in Table 9.

**Table 9.** Results of Bonferroni Test Two-tier Diagnostic Instrument Pretest-Posttest Mean Scores

(*Difference Misconception Diagnostic Test*)

| Group (I) | Group (J) | Differences Between Mean Values (I-J) | p |
|---|---|---|---|
| TTM | CAI | -7.65217* | .016** |
| | CCT | -7.82609* | .013** |
| | CAI+CCT | -15.91304* | .000 |
| CAI | TTM | 7.65217* | .016** |
| | CCT | -.17391 | 1.000 |
| | CAI+CCT | -8.26087* | .007 |
| CCT | TTM | 7.82609* | .013** |
| | CAI | .17391 | 1.000 |
| | CAI+CCT | -8.08696* | .009** |
| CAI+CCT | TTM | 15.91304* | .000** |
| | CAI | 8.26087* | .007** |
| | CCT | 8.08696* | .009** |

**p<0.05

According to Table 9, Two-tier Diagnostic Instrument scores of CAI, CCT and CAI+CCT were higher than TTM group ($p<0.05$). There was not a significant difference between difference two-tier diagnostic Instrument scores of CAI and CCT groups ($p>0.05$). Two-tier diagnostic Instrument score of CAI+CCT group was higher than TTM, CAI and CCT groups ($p<0.05$). According to these findings, we can say that in terms of student acquisitions in removing misconceptions, use of computer assisted instruction, conceptual change texts and computer assisted instruction with conceptual change texts were more effective than traditional teaching method. Computer assisted instruction with conceptual change texts were more effective in terms of student acquisitions in removing misconceptions than computer assisted instruction and conceptual change texts. It found to be a difference between computer assisted instruction and conceptual change texts in terms of student acquisitions in removing misconceptions.

Change amount of groups' pretest-posttest are presented in Figure 3.

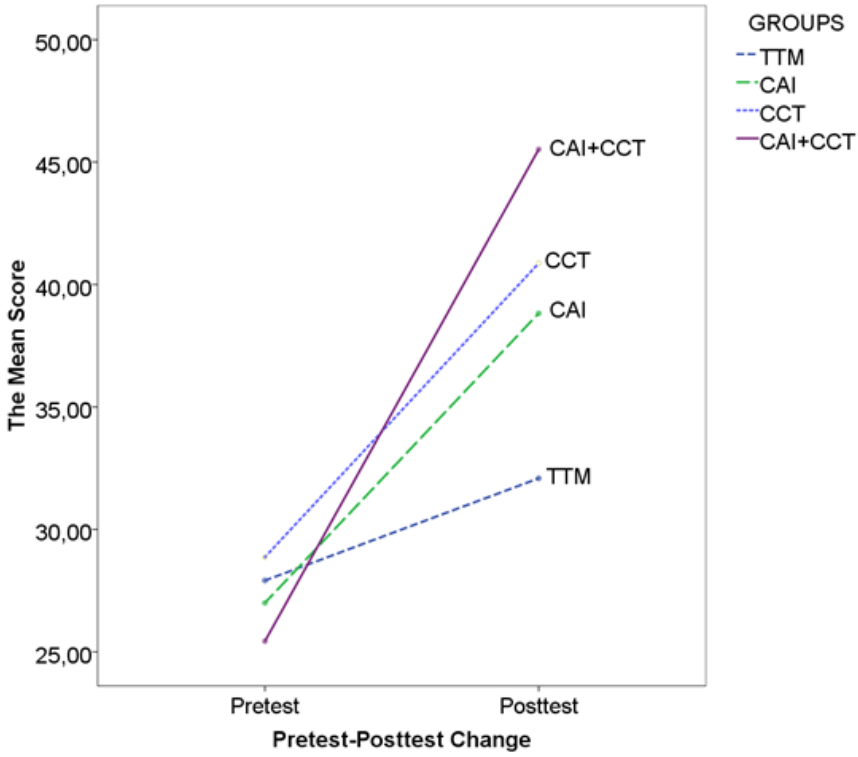


**Figure 3.** Changes in Students' Pretest-Posttest Mean Scores

**Discussion and Conclusion**

Results obtained in the research are presented below.

- The use of computer-assisted instruction (CAI), conceptual change texts (CCT), computer-assisted instruction with conceptual change texts (CAI+CCT), and use of traditional teaching method (TTM) are effective in removing misconceptions on the subject of radioactivity. But effect levels of these methods are different.
- Computer assisted instruction, conceptual change text and the computer-assisted instruction with conceptual change texts are more effective than traditional teaching method in removing misconceptions on the subject of radioactivity.
- The computer-assisted instructions with conceptual change texts are more effective than computer assisted instruction and conceptual change texts in removing misconceptions on the subject of radioactivity.
- There is not a difference between the effects of computer assisted instruction and conceptual change texts in removing misconceptions of students on the subject of radioactivity.

The results of "the use of computer-assisted instruction (CAI), conceptual change texts (CCT), computer-assisted instruction with conceptual change texts

(CAI+CCT), and use of traditional teaching method (TTM) are effective in removing misconceptions on the subject of radioactivity" is consistent with the results of studies in the literature (Canpolat and Pınarbaşı, 2002; Mikkila-Erdmann, 2001; Diakidoy et. al., 2003; Yılmaz, 2010; Ersoy, 2012; Monaghan and Clement, 2000; Köse et al., 2003; Ünal, 2007).

It was seen that computer assisted instruction is more effective than traditional teaching method in removing misconceptions on the subject of radioactivity. This result is consistent with the former results of studies in which traditional teaching method and computer assisted instruction were compared (Jimoyiannis and Komis, 2001; Coştu et al., 2002; Köse et al., 2003; Demirci, 2004; Kim et. al., 2005; Kahraman and Demir, 2011).

Most of the concepts in radioactivity topic are abstract concepts. Concretizing concepts that represent abstract issues is very important in order to understand them correctly. Computer assisted materials that are used to concretize concepts enable to show many processes to students which are impossible to show; thus, it becomes possible to remove students' misconceptions and prevent any possible misconceptions.

In traditional teaching method, student is in a passive situation. It is very difficult to concretize concepts. So, attention of students, who were in the group of traditional teaching method, weren't increased to a sufficient level and their attention couldn't be attracted. With computer assisted instruction, students' mental focusing was kept high all the time and their motivations and interest in the course was always kept alive. As a result, it was seen that computer assisted instruction was more effective than traditional teaching method in removing misconceptions of students on the subject of radioactivity. There are many studies in the literature which compare the effects of conceptual change texts and traditional teaching method in removing misconception. It was seen in most of these studies that, conceptual change texts are more effective than traditional teaching methods in removing misconceptions (Hynd and Alvermann, 1986; Diakidoy, Kendeou and Ioannnides, 2003; Geban and Başer, 2007; Yılmaz, 2010). Result of the present study is consistent with the results of former studies.

Computer assisted instruction and conceptual change texts were very effective methods in removing misconceptions. It can be thought that the use of these two methods together is more effective in removing misconceptions. On the other hand, they eased learning the concepts on the subject of radioactivity. So, using both methods were more effective than other methods in removing misconceptions on the subject of radioactivity. This result is consistent with the result of the study of Ünal (2007) who used conceptual change texts and computer assisted instruction together in order to remove misconceptions.

It found to be any difference between the effects of computer assisted instruction and conceptual change texts in removing students' misconceptions on the subject of radioactivity. There are very few studies in the literature that compare effects of these methods on removing misconceptions (Ersoy, 2012;

Tokatlı, 2010). Both methods have some advantages; conceptual change texts attract attention of students directly on misconceptions. Computer assisted instruction materials concretize abstract concepts. As mentioned before, the same effect level of these two methods can be the resulted from the advantages of these methods.

In this study, effects of different teaching methods on removing students' misconceptions on the subject of radioactivity, was researched. At the end of the research, it was seen that the most effective method in removing misconceptions on the subject of radioactivity was the computer assisted instruction with conceptual change texts. For removing misconceptions, it is very important to determine the effects of methods used in removing misconceptions except traditional teaching method, research the most effective one among these methods or study the results when two or more methods are used together in removing misconceptions. So, results of this research will make important contributions to teachers and researchers who think of using different methods in order to remove misconceptions.

This study can primarily lead instructors on which methods are more effective to remove misconceptions on the subject of radioactivity. It is important to choose teaching techniques and methods in order to achieve success in concept teaching.

If teachers determine misconceptions students have and use correct methods to remove misconceptions, they can make conceptual changes they want. "Two-Tier Misconception Diagnostic Instrument" which was developed to determine misconceptions will be very useful for teachers as a measuring tool.

According to the results: these are suggestions for researchers and teachers in the following;

**Suggestions**

- Similar too many other studies, in this study it was found that traditional teaching method is less effective than other methods in removing misconceptions of students. So, new methods that ensure active participation of students and ease their learning can be used instead of traditional teaching methods in courses like physics which include abstract concepts, in order to remove existing misconceptions of students.
- Computer assisted instruction is a very effective method for removing misconceptions of students. This view is supported by many studies in the literature. The result that we obtained in this study also supports this view. Computer simulations and animations that are used in scope of computer assisted instruction can ease and support understanding concepts. By taking misconceptions in physics, which are determined in the literature, into consideration, various simulations and animations can be developed in order to teach concepts correctly.
- In order to ensure students understand abstract concepts better, one can benefit from the opportunities of computer. Teachers can be supported with educations in order to ensure them have sufficient knowledge and

ability in order to use computers more fruitfully and effectively in teaching activities. For this reason, pre-service and in-service trainings can be given to teachers.

- In order to remove misconceptions, students' misconceptions should be activated during teaching process and contradiction between what they know and scientific information should be explicitly presented. Then, scientific information that will ensure conceptual change should be presented convincingly. Conceptual change texts can be used in this process. But besides conceptual change texts, using computer materials such as computer simulations, animations, slide projections and videos can ease and accelerate the process of conceptual change. So, conceptual change texts with computer assisted instruction materials can be applied as a more effective method for removing misconceptions.
- The practitioners' of conceptual change texts and computer assisted instruction are teachers. So, teacher candidates studying at the faculty of education can be informed about preparing and using conceptual change texts and model practices can be made. On the other hand, courses on "computer assisted instruction" can be added to education faculty programs.
- This research is limited to ten weeks of an academic semester, students of science teacher candidates and misconceptions on the subject of "radioactivity". Similar experimental studies can be applied on students at different learning levels, longer applications can be made and different topics can be used.
- In some researches on misconceptions, especially students' misconceptions were attempted to be determined. On the other hand, in some other researches, the focus was on removing misconceptions and effects of different teaching methods were researched. In future researches on different subjects, it can be more useful to focus on removing already determined misconceptions rather than focusing only on determining misconceptions.

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## Appendix

## Appendix 1. Two-Tier Misconception Diagnostic Instrument [in Turkish]

Cinsiyetiniz: Kız ( ) Erkek ( )

Bu çalışmanın amacı başarınızı ölçmek DEĞİL, sizin radyoaktivite konusuna ilişkin görüşlerinizi öğrenmektir. Bu konuda sizin düşünceleriniz çok önemli olup yanıtlarınızın doğru ya da yanlış olması önemli değildir. Lütfen her soruyu içtenlikle cevaplandırınız. Teşekkürler

1) "Radyoaktif bir maddeyi, fiziksel ve kimyasal bir takım işlemlere tabi tutarak -radyoaktif olma- özelliğini ortadan kaldırmak mümkündür." İfadesi hakkında ne düşünüyorsunuz?

A) Doğru bir ifadedir B) Yanlış bir ifadedir.

Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?

A) Radyoaktif olmayan bir madde ile tepkimeye sokulursa radyoaktif özelliğini kaybeder.
B) Çok yüksek sıcaklığa maruz bırakılan radyoaktif bir madde radyoaktif olma özelliğini kaybeder.
C) Toprak altına gömülen radyoaktif bir madde radyoaktif olma özelliğini kaybeder.
D) Radyoaktif olma özelliği atomun çekirdeğindeki durumlara bağlı olduğundan fiziksel ve kimyasal yöntemlerle ortadan kaldırılamaz.
E) ……
……

2) "Radyoaktif bir atomun kararlı bir atomla yaptığı bileşik radyoaktif özellik göstermez." İfadesi hakkında ne düşünüyorsunuz?

A) Doğru bir ifadedir B) Yanlış bir ifadedir.

Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?

A) Bileşiklerde her iki madde kendi özelliğini kaybederek yeni bir madde oluşturduğu için bileşik radyoaktif değildir.
B) Kimyasal tepkimeler atomda, elektron düzeylerinde meydana geldiği için çekirdeğin yapısı değişmez ve oluşan bileşik de radyoaktif olur.
C) Bileşik oluştururken elementin yapısı değişir ve radyoaktif özelliğini kaybeder. Dolayısıyla oluşan bileşik radyoaktif özellik göstermez.
D) Kararlı bir atomla bileşik yaptığı için kendi çekirdeği de kararlı hale geçer ve oluşan bileşik radyoaktif özellik göstermez.
E) ……
…….

3) "Radyoaktif bir atom α ışıması yaptıktan sonra farklı bir elemente dönüşür." ifadesi hakkında ne düşünüyorsunuz?

A) Doğru bir ifadedir B) Yanlış bir ifadedir.

Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?

A) α ışıması elementin kimyasal özelliklerini değiştirmeyeceği için farklı bir elemente dönüşmez.
B) Aynı elementtir sadece kararsız halden kararlı hale geçer.
C) α ışıması yapan bir atomun çekirdeğindeki proton sayısı azalır ve farklı bir elemente dönüşür.
D) Işıma yaparak sadece enerjisini kaybeder, farklı bir elemente dönüşmez.
E) ……
…….

4) "Dış bir kaynaktan yayılan düşük enerjili radyoaktif ışınıma maruz kalan bir kuş, radyoaktif kaynaktan uzaklaşsa bile kendisi radyoaktif hale gelir ve çevresine radyasyon yaymaya başlar." ifadesi hakkında ne düşünüyorsunuz?
A) Doğru bir ifadedir B) Yanlış bir ifadedir.
Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?

A) Kuşun hücrelerindeki atomların yapısı bozulmuştur ve bu atomlar ışıma yapar.
B) Kuş bir radyasyon kaynağı değildir.
C) Radyasyona maruz kalan kuşun hücrelerindeki atomlar kararsız hale geçer ve kuş radyoaktif olur.
D) Radyasyon kuşun hücreleri tarafından emilir ve daha sonra geri salınır.
E) ……
……

5) "Radyoaktif maddeler her zaman radyasyon yaymaz." ifadesi hakkında ne düşünüyorsunuz?
A) Doğru bir ifadedir B) Yanlış bir ifadedir.
Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?

A) Radyoaktif maddeler ancak radyasyona maruz kalırsa radyasyon yayar.
B) Radyoaktif maddeler ancak dışarıdan bir etki olursa radyasyon yayar.
C) Radyoaktif maddelerin bazıları kendiliğinden, bazıları da dışarıdan bir etki olunca radyasyon yayar.
D) Radyoaktif maddeler herhangi bir dış etki olmadan kendiliğinden ve sürekli radyasyon yayan maddelerdir.
E) ……
……

6) "Beta bozunmalarında çekirdekten elektron veya pozitron yayınlanır." ifadesi hakkında ne düşünüyorsunuz?
A) Doğru bir ifadedir B) Yanlış bir ifadedir.
Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?

A) Çekirdeğin içerisinde elektron ve pozitron bulunmadığı için bunların yayınlanması mümkün değildir.
B) Elektron ve pozitron bozunma anında çekirdeğin durgun (bağlanma) enerjisinden oluşur ve yayınlanır.
C) Çekirdek içerisinde elektron ve pozitron olduğundan yayınlanabilir.
D) Beta bozunmasında atomun elektron kabuklarındaki elektronlar yayınlanır.
E) ……
……

7) "Çekirdek reaksiyonlarında kütle korunur." İfadesi hakkında ne düşünüyorsunuz?
A) Doğru bir ifadedir B) Yanlış bir ifadedir.
Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?

A) Kütlenin küçük bir kısmı enerjiye dönüştüğü için kütle korunmaz.
B) Çekirdeğin yapısı ve özellikleri değişmediği için kütle korunur.
C) Çekirdek reaksiyonlarında proton sayısı veya nötron sayısı değişmediği için kütle korunur.
D) Atomun çekirdeği nötronlarla bombardıman edildiği için kütlesi artar.
E) ……
……

8) "Bir maddenin radyoaktif olma özelliğini o maddenin fiziksel ve kimyasal özellikleri etkiler". İfadesi hakkında ne düşünüyorsunuz?
A) Doğru bir ifadedir B) Yanlış bir ifadedir.
Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?

A) Atomların sahip olduğu enerji, maddenin fiziksel hallerinde değişiklik gösterdiğinden fiziksel özellikler radyoaktif olma özelliğini etkiler.
B) Atomun çekirdeği fiziksel ve kimyasal değişmelerden etkilenmeyeceği için fiziksel ve kimyasal özellikler radyoaktif olma özelliğini etkilemez.
C) Kimyasal değişmeler sonucu atomun elektronlarının düzenlenişi değiştiğinden kimyasal özellikler radyoaktif olma özelliğini etkiler.
D) Fiziksel ve kimyasal değişmeler sonucu atomun hem iç hem de dış yapısı değiştiğinden fiziksel ve kimyasal özellikler radyoaktif olma özelliğini etkiler.
E) ……
……

9) "Radyoaktif maddelerin yarılanma süreleri maddenin fiziksel haline bağlıdır." ifadesi hakkında ne düşünüyorsunuz?
A) Doğru bir ifadedir B) Yanlış bir ifadedir.
Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?

A) Maddelerin dayanıklılığı fiziksel hale göre değişmektedir.
B) Yarılanma süresi sadece çekirdeğin kararlılığına ve başlangıçtaki miktarına bağlıdır.
C) Maddelerin atomlarının enerjisi fiziksel hale göre değişmektedir.
D) Maddelerin fiziksel hali yarılama süresini etkilemez. Yarılanma süresi atomun cinsine bağlıdır.
E) ……
……

10) "Doğal ve yapay radyoaktif maddelerin insanlara zararları açısından arasında bir fark yoktur" ifadesi hakkında ne düşünüyorsunuz?
A) Doğru bir ifadedir B) Yanlış bir ifadedir.
Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?

A) Doğal ve yapay radyoaktif maddelerin ikisi de zararlıdır.
B) Doğal radyoaktif maddeler yapay radyoaktif maddelerden daha zararlıdır.
C) Doğal ve yapay radyoaktif maddelerin ikisi de zararsızdır.
D) Yapay radyoaktif maddeler doğal radyoaktif maddelerden daha zararlıdır.
E) ……
……

11) "Bütün radyasyon çeşitleri zararlıdır." ifadesi hakkında ne düşünüyorsunuz?
A) Doğru bir ifadedir B) Yanlış bir ifadedir.
Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?

A) Bütün radyasyon çeşitlerinin kaynağı radyoaktif maddelerdir.
B) Radyasyonların hepsi çok yüksek enerjiye sahip büyük dalga boylu ışınlardır.
C) Bütün radyasyon çeşitlerinin kaynağı nükleer reaksiyonlardır.
D) Radyasyon ışınım demektir, bütün ışımalar zararlı değildir.
E) ……
……

12) "Radyoaktivite kararsız atomların son yörüngelerinden elektron salmasıdır." ifadesi hakkında ne düşünüyorsunuz?
A) Doğru bir ifadedir B) Yanlış bir ifadedir.
Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?

A) Kararsız atomlar radyoaktivite olayı sonucunda son yörüngelerinden elektron salar ve kararlı hale geçer.
B) Radyoaktivite çekirdekte gerçekleşir, kararsız atom çekirdekleri ışıma yaparak kararlı hale geçer.

C) Radyoaktivite olayında atomlar çeşitli ışımalara maruz bırakılır ve bu olay sonucunda son yörüngelerinden elektron salınır.
D) Kararsızlık son yörüngelerdeki elektronların eksik olmasından kaynaklanır, dolayısıyla radyoaktivite olayında elektron salınmaz, elektron yakalanır.
E) ……
……

13) "Alfa bozunması kendiliğinden meydana gelir." ifadesi hakkında ne düşünüyorsunuz?
A) Doğru bir ifadedir B) Yanlış bir ifadedir.
Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?
A) Alfa bozunması için çekirdeğe dışarıdan enerji verilmelidir, bu da kendiliğinden olmaz.
B) Alfa bozunmasının gerçekleşmesi için çekirdeğin nötronlarla bombardıman edilmesi gerekir.
C) Alfa bozunması coulomb etkisinin bir sonucu olarak kendiliğinden meydana gelir.
D) Alfa bozunması için çekirdeğin radyoaktif bir madde ile etkileşmesi gerekir.
E) …..……
……..

14) "Gama ışınları alfa ve beta ışınları gibi kütlesi olan birer parçacıktır." ifadesi hakkında ne düşünüyorsunuz?
A) Doğru bir ifadedir B) Yanlış bir ifadedir.
Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?
A) Gama ışınları alfa ve beta ışınları gibi girici ışınlar olduğu için o da onlar gibi kütlesi olan bir parçacıktır.
B) Gama ışınları çekirdekten yayınlanan nötron parçacıklarıdır.
C) Gama ışınları durgun kütlesi sıfır olan elektromanyetik dalgalardır.
D) Gama ışınları çekirdekten yayınlanan proton parçacıklarıdır.
E) ……
……

15) "Gama ışıması yapan bir atom başka bir elemente dönüşür." ifadesi hakkında ne düşünüyorsunuz?
A) Doğru bir ifadedir B) Yanlış bir ifadedir.
Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?
A) Kütle ve atom numarası değiştiği için başka bir elemente dönüşür.
B) Atomun çekirdeğinden elektron fırlatıldığı için başka bir elemente dönüşür.
C) Atomun çekirdeğinden nötron fırlatıldığı için başka bir elemente dönüşür.
D) Kütle ve atom numarası değişmediği için başka bir elemente dönüşmez.
E) ……
……

16) "Çekirdek reaksiyonları çekirdeğin kendiliğinden ışıma yapması ile gerçekleşir." ifadesi hakkında ne düşünüyorsunuz?
A) Doğru bir ifadedir B) Yanlış bir ifadedir.
Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?
A) Çekirdek reaksiyonları atomun kendiliğinden parçalanması ya da birleşmesiyle oluşur.
B) Kararlı hale geçmek isteyen çekirdek kendiliğinden fazla enerjisini ortama salar ve kararlı hale geçer.
C) Çekirdek reaksiyonlarında çekirdek kendiliğinden proton veya nötron ışıması yapar.

D) Çekirdek reaksiyonları atom çekirdeğinin proton, elektron, nötron gibi belli enerjiye sahip parçacıklarla bombardıman edilmesiyle gerçekleşir.

E) ...……
……..

17) "Füzyon bölünme (parçalanma) reaksiyonudur." ifadesi hakkında ne düşünüyorsunuz?

A) Doğru bir ifadedir B) Yanlış bir ifadedir.

Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?

A) Füzyon kararsız radyoaktif çekirdeklerin nötronlarla bombardıman edilerek iki tane kararlı radyoaktif çekirdek oluşturması olayıdır.

B) Füzyon iki hafif çekirdeğin daha ağır bir çekirdek oluşturmak için birleşmesidir.

C) Güneş enerjisi füzyon reaksiyonları sonucu açığa çıkmaktadır. Bu kadar büyük enerji ise ancak çekirdeklerin parçalanması sonucu açığa çıkar.

D) Füzyon ağır bir çekirdeğin daha küçük iki çekirdeğe bölünmesidir.

E) ……
…….

18) "Nükleer parçalanma reaksiyonlarında çekirdek parçalanarak enerji açığa çıkarken nükleer kaynaşma reaksiyonlarında dışarıdan enerji alınır, dışarıya enerji verilmez." ifadesi hakkında ne düşünüyorsunuz?

A) Doğru bir ifadedir B) Yanlış bir ifadedir.

Seçtiğiniz cevabın nedeni aşağıdakilerden hangisidir?

A) Nükleer parçalanma ve nükleer kaynaşma reaksiyonları sonucunda eşit miktarda enerji açığa çıkar.

B) Nükleer parçalanma reaksiyonlarında enerji açığa çıkmaz aksine çekirdeği parçalamak için dışarıdan enerji verilmesi gerekir.

C) Her iki olayda da enerji açığa çıkar. Ancak nükleer kaynaşma reaksiyonlarında açığa çıkan enerji nükleer bölünme reaksiyonlarına kıyasla daha büyüktür.

D) İki çekirdeğin birleşmesi için dışarıdan alınan tüm enerji kullanıldığından nükleer kaynaşma reaksiyonlarında enerji açığa çıkmaz.

E) ……
……