

## Nuclear Midterm Review

1. Which nuclear emission has the greatest mass and the least penetrating power?

- A) an alpha particle                      B) a beta particle  
C) a neutron                                D) a positron

2. Which particle has the greatest mass?

- A) an alpha particle                      B) a beta particle  
C) a neutron                                D) a positron

3. Which radioisotope has an atom that emits a particle with a mass number of 0 and a charge of +1?

- A)  ${}^3\text{H}$             B)  ${}^{16}\text{N}$             C)  ${}^{19}\text{Ne}$             D)  ${}^{239}\text{Pu}$

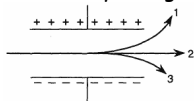
4. A beta particle may be spontaneously emitted from

- A) a ground-state electron            B) a stable nucleus  
C) an excited electron                D) an unstable nucleus

5. Which of these types of radiation has the greatest penetrating power?

- A) alpha            B) beta            C) gamma            D) positron

6. A mixture of emanations from radioactive atoms is passed through electrically charged plates, as shown in the diagram below.



The nuclear emanations 1, 2, and 3 are called, respectively,

- A) alpha, beta, and gamma            B) beta, gamma, and alpha  
C) gamma, alpha, and beta            D) gamma, beta, and alpha

7. Which statement best describes gamma radiation?

- A) It has a mass of 1 and a charge of 1.  
B) It has a mass of 0 and a charge of -1.  
C) It has a mass of 0 and a charge of 0.  
D) It has a mass of 4 and a charge of +2.

8. What is the half-life of a radioisotope if 25.0 grams of an original 200.-gram sample of the isotope remains unchanged after 11.46 days?

- A) 2.87 d            B) 3.82 d            C) 11.46 d            D) 34.38 d

9. Which fraction of an original 20.00-gram sample of nitrogen-16 remains unchanged after 36.0 seconds?

- A)  $\frac{1}{5}$             B)  $\frac{1}{8}$             C)  $\frac{1}{16}$             D)  $\frac{1}{32}$

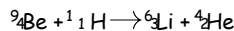
10. Which equation represents natural transmutation?

- A)  ${}_{5}^{10}\text{B} + {}_{2}^{4}\text{He} \rightarrow {}_{7}^{13}\text{N} + {}_{0}^{1}\text{n}$   
B)  ${}_{6}^{14}\text{C} \rightarrow {}_{7}^{14}\text{N} + {}_{-1}^{0}\text{e}$   
C)  $\text{S} + 2\text{e}^{-} \rightarrow \text{S}^{2-}$   
D)  $\text{Na} \rightarrow \text{Na}^{+} + \text{e}^{-}$

11. In which type of reaction is an atom of one element converted to an atom of a different element?

- A) decomposition                      B) neutralization  
C) saponification                        D) transmutation

12. Given the reaction:



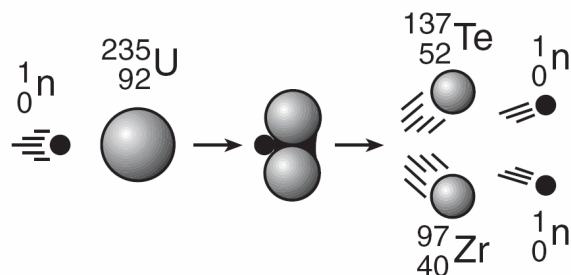
Which type of reaction is represented?

- A) natural transmutation            B) artificial transmutation  
C) fission                                D) fusion

13. What is one benefit associated with a nuclear fission reaction?

- A) The products are not radioactive.  
B) Stable isotopes are used as reactants.  
C) There is no chance of biological exposure.  
D) A large amount of energy is produced.

14. Base your answer to the following question on Given the diagram representing a reaction:



Which phrase best describes this type of reaction and the overall energy change that occurs?

- A) nuclear, and energy is released  
B) nuclear, and energy is absorbed  
C) chemical, and energy is released  
D) chemical, and energy is absorbed

15. In which reaction is mass converted to energy by the process of fission?

- A)  ${}_{7}^{14}\text{N} + {}_{1}^{1}\text{n} \rightarrow {}_{6}^{14}\text{C} + {}_{1}^{1}\text{H}$   
B)  ${}_{92}^{235}\text{U} + {}_{1}^{1}\text{n} \rightarrow {}_{35}^{87}\text{Br} + {}_{57}^{146}\text{La} + 3{}_{1}^{1}\text{n}$   
C)  ${}_{88}^{226}\text{Ra} \rightarrow {}_{86}^{222}\text{Ra} + {}_{2}^{4}\text{He}$   
D)  ${}_{1}^{2}\text{H} + {}_{1}^{2}\text{H} \rightarrow {}_{2}^{4}\text{He}$

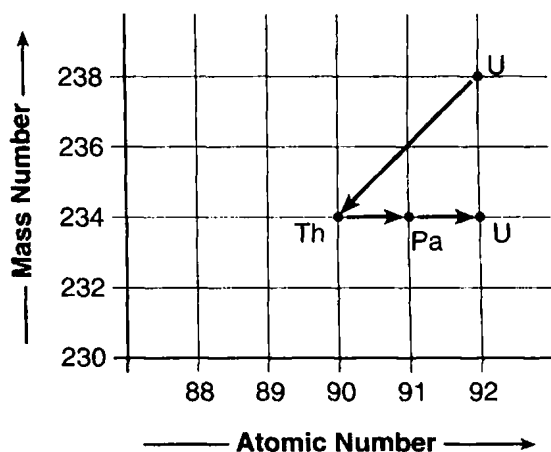
16. Which balanced equation represents a fusion reaction?

- A)  ${}_{92}^{235}\text{U} + {}_{1}^{1}\text{n} \rightarrow {}_{36}^{93}\text{Kr} + {}_{56}^{140}\text{Ba} + 3{}_{1}^{1}\text{n}$   
B)  ${}_{1}^{2}\text{H} + {}_{1}^{3}\text{H} \rightarrow {}_{2}^{4}\text{He} + {}_{1}^{1}\text{n}$   
C)  ${}_{7}^{14}\text{N} + {}_{2}^{4}\text{He} \rightarrow {}_{8}^{17}\text{O} + {}_{1}^{1}\text{H}$   
D)  ${}_{88}^{226}\text{Ra} \rightarrow {}_{86}^{222}\text{Rn} + {}_{2}^{4}\text{He}$

17. Which change takes place in a nuclear fusion reaction?

- A) Matter is converted to energy.  
B) Energy is converted to matter.  
C) Ionic bonds are converted to covalent bonds.  
D) Covalent bonds are converted to ionic bonds.

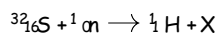
18. Base your answer to the following question on The chart below shows the spontaneous nuclear decay of U-238 to Th-234 to Pa-234 to U-234.



What is the correct order of nuclear decay modes for the change from U-238 to U-234?

- A)  $\beta^-$  decay,  $\gamma$  decay,  $\beta^-$  decay  
 B)  $\beta^-$  decay,  $\beta^-$  decay,  $\alpha$  decay  
 C)  $\alpha$  decay,  $\alpha$  decay,  $\beta^-$  decay  
 D)  $\alpha$  decay,  $\beta^-$  decay,  $\beta^-$  decay

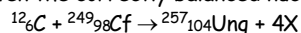
19. Given the nuclear reaction:



What does X represent in this reaction?

- A)  ${}^{31}_{15}\text{P}$     B)  ${}^{32}_{15}\text{P}$     C)  ${}^{31}_{16}\text{P}$     D)  ${}^{32}_{16}\text{P}$

20. Given the correctly balanced nuclear equation:



Which particle is represented by the X?

- A)  ${}^1_1\text{H}$     B)  ${}^1_0\text{n}$     C)  ${}^4_2\text{He}$     D)  ${}^0_{-1}\text{e}$

21. Which nuclides are used to date the remains of a once-living organism?

- A) C-14 and C-12    B) Co-60 and Co-59  
 C) I-131 and Xe-131    D) U-238 and Pb-206

22. Which radioactive isotope is used in geological dating?

- A) uranium-238    B) iodine-131  
 C) cobalt-60    D) technetium-99

23. Which isotope is used to treat cancer?

- A) C-14    B) U-238    C) Co-60    D) Pb-206

24. Which nuclide is used to investigate human thyroid gland disorders?

- A) carbon-14    B) potassium-37  
 C) cobalt-60    D) iodine-131

25. Which statement explains why nuclear waste materials may pose a problem?

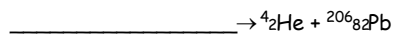
- A) They frequently have short half-lives and remain radioactive for brief periods of time.  
 B) They frequently have short half-lives and remain radioactive for extended periods of time.  
 C) They frequently have long half-lives and remain radioactive for brief periods of time.  
 D) They frequently have long half-lives and remain radioactive for extended periods of time.

26. Base your answer to the following question on the information below.

The radioisotope uranium-238 occurs naturally in Earth's crust. The disintegration of this radioisotope is the first in a series of spontaneous decays.

The sixth decay in this series produces the radioisotope radon-222. The decay of radon-222 produces the radioisotope polonium-218 that has a half life of 3.04 minutes. Eventually, the stable isotope lead-206 is produced by the alpha decay of an unstable nuclide.

Complete the nuclear equation below for the decay of the unstable nuclide that produces Pb-206, by writing a notation for the missing nuclide.



27. Base your answer to the following question on the information below.

A battery-operated smoke detector produces an alarming sound when its electrical sensor detects smoke particles. Some ionizing smoke detectors contain the radioisotope americium-241, which undergoes alpha decay and has a half-life of 433 years. The emitted alpha particles ionize gas molecules in the air. As a result, an electric current flows through the detector. When smoke particles enter the detector, the flow of ions is interrupted, causing the alarm to sound.

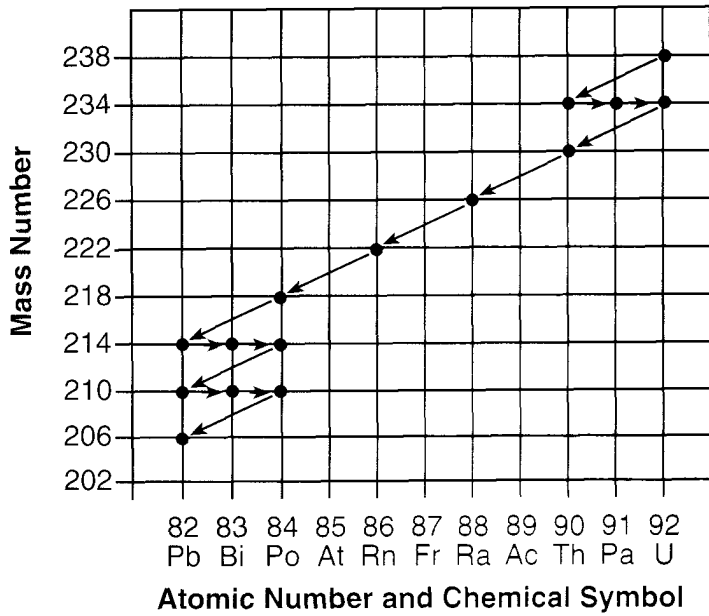
Complete the nuclear equation below for the decay of Am-241. Your response must include the symbol, mass number, and atomic number for each product.



Base your answers to questions 28 and 29 on the information below.

A U-238 atom decays to a Pb-206 atom through a series of steps. Each point on the graph below represents a nuclide and each arrow represents a nuclear decay mode.

### Uranium Disintegration Series



28. Explain why the U-238 disintegration series ends with the nuclide Pb-206.

29. Based on this graph, what particle is emitted during the nuclear decay of a Po-218 atom?

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Base your answers to questions 30 through 33 on the information below and on your knowledge of chemistry.

#### Nuclear Waste Storage Plan for Yucca Mountain

In 1978, the U.S. Department of Energy began a study of Yucca Mountain which is located 90 miles from Las Vegas, Nevada. The study was to determine if Yucca Mountain would be suitable for a long-term burial site for high-level radioactive waste. A three-dimensional (3-D) computer scale model of the site was used to simulate the Yucca Mountain area. The computer model study for Yucca Mountain included such variables as: the possibility of earthquakes, predicted water flow through the mountain, increased rainfall due to climate changes, radioactive leakage from the waste containers, and increased temperatures from the buried waste within the containers.

The containers that will be used to store the radioactive waste are designed to last 10,000 years. Within the 10,000-year time period, cesium and strontium, the most powerful radioactive emitters, would have decayed. Other isotopes found in the waste would decay more slowly, but are not powerful radioactive emitters.

In 1998, scientists discovered that the compressed volcanic ash making up Yucca Mountain was full of cracks. Because of the arid climate, scientists assumed that rainwater would move through the cracks at a slow rate. However, when radioactive chlorine-36 was found in rock samples at levels halfway through the mountain, it was clear that rainwater had moved quickly down through Yucca Mountain. It was only 50 years earlier when this chlorine-36 isotope had contaminated rainwater during atmospheric testing of the atom bomb.

Some opponents of the Yucca Mountain plan believe that the uncertainties related to the many variables of the computer model result in limited reliability of its predictions. However, advocates of the plan believe it is safer to replace the numerous existing radioactive burial sites around the United States with the one site at Yucca Mountain. Other opponents of the plan believe that transporting the radioactive waste to Yucca Mountain from the existing 131 burial sites creates too much danger to the United States. In 2002, after years of political debate, a final legislative vote approved the development of Yucca Mountain to replace the existing 131 burial sites.

30. State one risk associated with leaving radioactive waste in the 131 sites around the country where it is presently stored.
31. Why is water flow a crucial factor in deciding whether Yucca Mountain is a suitable burial site?
32. The information states "Within the 10,000-year time period, cesium and strontium, the most powerful radioactive emitters, would have decayed." Use information from Reference Table N to support this statement.
33. If a sample of cesium-137 is stored in a waste container in Yucca Mountain, how much time must elapse until only  $\frac{1}{32}$  of the original sample remains unchanged?