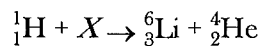


1. Given the nuclear equation:

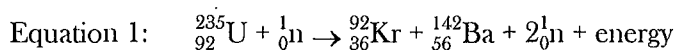


The particle represented by  $X$  is

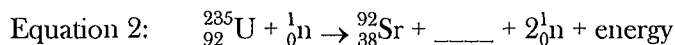
- |                      |                         |
|----------------------|-------------------------|
| 1) ${}^9_4\text{Li}$ | 3) ${}^{10}_5\text{Be}$ |
| 2) ${}^9_4\text{Be}$ | 4) ${}^{10}_6\text{C}$  |
2. Atoms of I-131 spontaneously decay when the
- 1) stable nuclei emit alpha particles
  - 2) stable nuclei emit beta particles
  - 3) unstable nuclei emit alpha particles
  - 4) unstable nuclei emit beta particles
3. Which radioisotope has an atom that emits a particle with a mass number of 0 and a charge of +1?
- |                        |                             |
|------------------------|-----------------------------|
| 1) ${}^3_1\text{H}$    | 3) ${}^{19}_{10}\text{Ne}$  |
| 2) ${}^{16}_7\text{N}$ | 4) ${}^{239}_{94}\text{Pu}$ |
4. A beta particle may be spontaneously emitted from
- 1) a ground-state electron
  - 2) a stable nucleus
  - 3) an excited electron
  - 4) an unstable nucleus
5. Which two radioisotopes have the same decay mode?
- |   |  |
|---|--|
| 1) ${}^{37}_{20}\text{Ca}$ and ${}^{53}_{26}\text{Fe}$  | 3) ${}^{37}_{19}\text{K}$ and ${}^{42}_{19}\text{K}$   |
| 2) ${}^{220}_{86}\text{Fr}$ and ${}^{60}_{27}\text{Co}$ | 4) ${}^{99}_{43}\text{Tc}$ and ${}^{19}_{10}\text{Ne}$ |
6. Which nuclear emission has no charge and no mass?
- |                   |              |
|-------------------|--------------|
| 1) alpha particle | 3) gamma ray |
| 2) beta particle  | 4) positron  |
7. Which nuclear emission has the greatest penetrating power?
- |                   |                    |
|-------------------|--------------------|
| 1) alpha particle | 3) gamma radiation |
| 2) beta particle  | 4) positron        |
8. Which nuclear decay emission consists of energy, only?
- |                   |                    |
|-------------------|--------------------|
| 1) alpha particle | 3) gamma radiation |
| 2) beta particle  | 4) positron        |
9. What is the half-life and decay mode of Au-198?
- 1) 1.345 days and alpha decay
  - 2) 1.345 days and beta decay
  - 3) 2.69 days and alpha decay
  - 4) 2.69 days and beta decay

Base your answers to questions 10 and 11 on in the information below.

When a uranium-235 nucleus absorbs a slow-moving neutron, different nuclear reactions may occur. One of these possible reactions is represented by the complete, balanced equation below.



For this reaction, the sum of the masses of the products is slightly less than the sum of the masses of the reactants. Another possible reaction of U-235 is represented by the incomplete, balanced equation below.



10. Write a notation for the missing product in equation 2.
11. Determine the half-life of krypton-92 if only 6.0 milligrams of an original 96.0-milligram sample remains unchanged after 7.36 seconds.

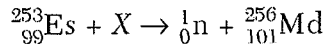
12. What is the total number of years that must pass before only 25.00 grams of an original 100.0-gram sample of C-14 remains unchanged?  
 1) 2865 y                      3) 11 460 y  
 2) 5730 y                      4) 17 190 y
13. What is the half-life of a radioisotope if 25.0 grams of an original 200.-gram sample of the isotope remains unchanged after 11.46 days?  
 1) 2.87 d                      3) 11.46 d  
 2) 3.82 d                      4) 34.38 d
14. Which nuclide has a half-life that is *less* than one minute?  
 1) cesium-137                      3) phosphorus-32  
 2) francium-220                      4) strontium-90
15. An original sample of the radioisotope fluorine-21 had a mass of 80.0 milligrams. Only 20.0 milligrams of this original sample remain unchanged after 8.32 seconds. What is the half-life of fluorine-21?  
 1) 1.04s                      3) 4.16 s  
 2) 2.08                      4) 8.3
16. An original sample of K-40 has a mass of 25.00 grams. After  $3.9 \times 10^9$  years, 3.125 grams of the original sample remains unchanged. What is the half-life of K-40?  
 1)  $1.3 \times 10^9$  y                      3)  $3.9 \times 10^9$  y  
 2)  $2.6 \times 10^9$  y                      4)  $1.2 \times 10^9$  y
17. In which type of reaction is an atom of one element converted to an atom of a different element?  
 1) decomposition                      3) saponification  
 2) neutralization                      4) transmutation

18. A change in the nucleus of an atom that converts the atom from one element to another element is called  
 1) combustion                      3) polymerization  
 2) neutralization                      4) transmutation
19. What is one benefit associated with a nuclear fission reaction?  
 1) The products are not radioactive.  
 2) Stable isotopes are used as reactants.  
 3) There is no chance of biological exposure.  
 4) A large amount of energy is produced.
20. Which nuclide is listed with its half-life and decay mode?  
 1) K-37, 1.24 h,  $\alpha$                       3) Rn-222,  $1.6 \times 10^3$  y,  $\alpha$   
 2) N-16, 7.2 s,  $\beta^-$                       4) U-235,  $7.1 \times 10^8$  y,  $\beta^-$
21. Given the balanced equation representing a nuclear reaction:  
 ${}_{92}^{235}\text{U} + {}_0^1\text{n} \rightarrow {}_{56}^{142}\text{Ba} + {}_{36}^{91}\text{Kr} + 3X + \text{energy}$   
 Which particle is represented by X?  
 1)  ${}_0^1\text{e}$                       3)  ${}_2^4\text{He}$   
 2)  ${}_1^1\text{H}$                       4)  ${}_0^1\text{n}$
22. Which balanced equation represents a fusion reaction?  
 1)  ${}_{92}^{235}\text{U} + {}_0^1\text{n} \rightarrow {}_{36}^{92}\text{Kr} + {}_{56}^{140}\text{Ba} + 3{}_0^1\text{n}$   
 2)  ${}_1^2\text{H} + {}_1^3\text{H} \rightarrow {}_2^4\text{He} + {}_0^1\text{n}$   
 3)  ${}_7^{14}\text{N} + {}_2^4\text{He} \rightarrow {}_8^{17}\text{O} + {}_1^1\text{H}$   
 4)  ${}_{88}^{226}\text{Ra} \rightarrow {}_{86}^{222}\text{Rn} + {}_2^4\text{He}$

23. In which type of reaction do two lighter nuclei combine to form one heavier nucleus?

- 1) combustion
- 2) reduction
- 3) nuclear fission
- 4) nuclear fusion

24. Given the nuclear equation:



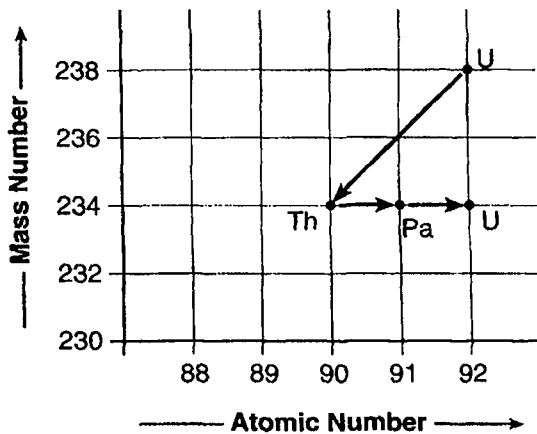
Which particle is represented by X?

- 1)  ${}^4_2\text{He}$
- 2)  ${}^0_{-1}\text{e}$
- 3)  ${}^1_0\text{n}$
- 4)  ${}^0_{+1}\text{e}$

25. Which equation represents the radioactive decay of  ${}_{88}^{226}\text{Ra}$ ?

- 1)  ${}_{88}^{226}\text{Ra} \rightarrow {}_{86}^{222}\text{Rn} + {}^4_2\text{He}$
- 2)  ${}_{88}^{226}\text{Ra} \rightarrow {}_{89}^{226}\text{Ac} + {}^0_{-1}\text{e}$
- 3)  ${}_{88}^{226}\text{Ra} \rightarrow {}_{87}^{226}\text{Fr} + {}^0_{+1}\text{e}$
- 4)  ${}_{88}^{226}\text{Ra} \rightarrow {}_{88}^{225}\text{Ra} + {}^1_0\text{n}$

26. 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?

- 1)  $\beta^-$  decay, decay,  $\beta^-$  decay
- 2)  $\beta^-$  decay,  $\beta^-$  decay,  $\alpha$  decay
- 3)  $\alpha$  decay,  $\alpha$  decay,  $\beta^-$  decay
- 4)  $\alpha$  decay,  $\beta^-$  decay,  $\beta^-$  decay

27. Energy is released during the fission of Pu-239 atoms as a result of the

- 1) formation of covalent bonds
- 2) formation of ionic bonds
- 3) conversion of matter to energy
- 4) conversion of energy to matter

28. A nuclear fission reaction and a nuclear fusion reaction are similar because both reactions

- 1) form heavy nuclides from light nuclides
- 2) form light nuclides from heavy nuclides
- 3) release a large amount of energy
- 4) absorb a large amount of energy

29. The energy released by a nuclear reaction results primarily from the

- 1) breaking of bonds between atoms
- 2) formation of bonds between atoms
- 3) conversion of mass into energy
- 4) conversion of energy into mass

30. Which radioisotope is used for diagnosing thyroid disorders?

- 1) U-238
- 2) Pb-206
- 3) I-131
- 4) Co-60

31. Which isotope is used to treat cancer?

- 1) C-14
- 2) U-238
- 3) Co-60
- 4) Pb-206

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

- 1) carbon-14
- 2) potassium-37
- 3) cobalt-60
- 4) iodine-131

33. Which risk is associated with using nuclear fission to produce energy in a power plant?

- 1) depletion of hydrocarbons
- 2) depletion of atmospheric oxygen
- 3) exposure of workers to radiation
- 4) exposure of workers to sulfur dioxide

34. A serious risk factor associated with the operation of a nuclear power plant is the production of

- 1) acid rain
- 2) helium gas
- 3) greenhouse gases, such as  $\text{CO}_2$
- 4) radioisotopes with long half-lives

35. What is a problem commonly associated with nuclear power facilities?

- 1) A small quantity of energy is produced.
- 2) Reaction products contribute to acid rain.
- 3) It is impossible to control nuclear fission.
- 4) It is difficult to dispose of wastes.

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

- 1) C-14 and C-12      3) I-131 and Xe-131  
2) Co-60 and Co-59    4) U-238 and Pb-206

37. Which radioactive isotope is used in geological dating?

- 1) uranium-238      3) cobalt-60  
2) iodine-131      4) technetium-99

38. Which procedure is based on the half-life of a radioisotope?

- 1) accelerating to increase kinetic energy  
2) radiating to kill cancer cells  
3) counting to determine a level of radioactivity  
4) dating to determine age

39. Radioisotopes used for medical diagnosis must have

- 1) long half-lives and be quickly eliminated by the body  
2) long half-lives and be slowly eliminated by the body  
3) short half-lives and be quickly eliminated by the body  
4) short half-lives and be slowly eliminated by the body

40. A radioisotope is called a tracer when it is used to

- 1) kill bacteria in food  
2) kill cancerous tissue  
3) determine the age of animal skeletal remains  
4) determine the way in which a chemical reaction occurs

41. Radiation used in the processing of food is intended to

- 1) increase the rate of nutrient decomposition  
2) kill microorganisms that are found in the food  
3) convert ordinary nutrients to more stable forms  
4) replace chemical energy with nuclear energy

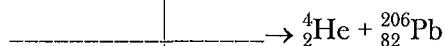
Base your answers to questions 42 through 44 on the information below.

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.

42. Determine the original mass of a sample of Po-218, if 0.50 milligram of the sample remains unchanged after 12.16 minutes.

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



44. Explain, in terms of electron configuration, why atoms of the radioisotope produced by the sixth decay in the U-238 disintegration series do not readily react to form compounds.

45. List the nuclear emissions, alpha particle, beta particle, and gamma rays, in order from the *least* penetrating power to the greatest penetrating power