

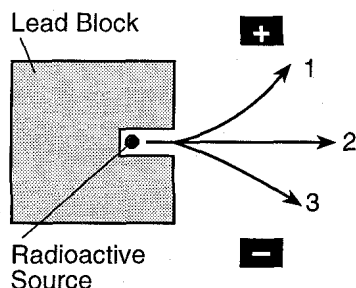
1. Given the equation representing a nuclear reaction in which X represents a nuclide:
- $${}_{90}^{232}\text{Th} \rightarrow {}_2^4\text{He} + X$$
- Which nuclide is represented by X ?
- A) ${}_{92}^{236}\text{Ra}$ B) ${}_{88}^{228}\text{Ra}$
 C) ${}_{92}^{236}\text{U}$ D) ${}_{88}^{228}\text{U}$
2. 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
3. An unstable nucleus loses the most mass if the nucleus emits
- A) an alpha particle B) a beta particle
 C) a positron D) a gamma ray
4. The nucleus of a radium-226 atom is unstable, which causes the nucleus to spontaneously
- A) absorb electrons B) absorb protons
 C) decay D) oxidize
5. Which list of nuclear emissions is arranged in order from the *least* penetrating power to the greatest penetrating power?
- A) alpha particle, beta particle, gamma ray
 B) alpha particle, gamma ray, beta particle
 C) gamma ray, beta particle, alpha particle
 D) beta particle, alpha particle, gamma ray
6. Which reaction is an example of natural transmutation?
- A) ${}_{94}^{239}\text{Pu} \rightarrow {}_{92}^{235}\text{U} + {}_2^4\text{He}$
 B) ${}_{13}^{27}\text{Al} + {}_2^4\text{He} \rightarrow {}_{15}^{30}\text{P} + {}_0^1\text{n}$
 C) ${}_{92}^{238}\text{U} + {}_0^1\text{n} \rightarrow {}_{94}^{239}\text{Pu} + 2 {}_{-1}^0\text{e}$
 D) ${}_{94}^{239}\text{Pu} + {}_0^1\text{n} \rightarrow {}_{56}^{147}\text{Ba} + {}_{38}^{90}\text{Sr} + 3 {}_0^1\text{n}$
7. Compared to the mass and the penetrating power of an alpha particle, a beta particle has
- A) less mass and greater penetrating power
 B) less mass and less penetrating power
 C) more mass and greater penetrating power
 D) more mass and less penetrating power

8. 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) ${}^{239}\text{Pu}$
9. Which particle is emitted when an atom of ${}^{85}\text{Kr}$ spontaneously decays?
- A) an alpha particle B) a beta particle
 C) a neutron D) a proton
10. Which two radioisotopes have the same decay mode?
- A) ${}^{37}\text{Ca}$ and ${}^{53}\text{Fe}$ B) ${}^{220}\text{Fr}$ and ${}^{60}\text{Co}$
 C) ${}^{37}\text{K}$ and ${}^{42}\text{K}$ D) ${}^{99}\text{Tc}$ and ${}^{19}\text{Ne}$
11. Which equation represents positron decay?
- A) ${}_{37}^{87}\text{Rb} \rightarrow {}_{-1}^0\text{e} + {}_{38}^{87}\text{Sr}$
 B) ${}_{92}^{277}\text{U} \rightarrow {}_{90}^{223}\text{Th} + {}_2^4\text{He}$
 C) ${}_{13}^{27}\text{Al} + {}_2^4\text{He} \rightarrow {}_{15}^{30}\text{P} + {}_0^1\text{n}$
 D) ${}_{6}^{11}\text{C} \rightarrow {}_{+1}^0\text{e} + {}_5^{11}\text{B}$
12. Given the nuclear equation:
- $${}_{10}^{19}\text{Ne} \rightarrow X + {}_9^{19}\text{F}$$
- What particle is represented by X ?
- A) alpha B) beta
 C) neutron D) positron
13. Which equation represents a spontaneous nuclear decay?
- A) $\text{C} + \text{O}_2 \rightarrow \text{CO}_2$
 B) $\text{H}_2\text{CO}_3 \rightarrow \text{CO}_2 + \text{H}_2\text{O}$
 C) ${}_{13}^{27}\text{Al} + {}_2^4\text{He} \rightarrow {}_{15}^{30}\text{P} + {}_0^1\text{n}$
 D) ${}_{38}^{90}\text{Sr} \rightarrow {}_{-1}^0\text{e} + {}_{39}^{90}\text{Y}$
14. Which nuclear emission has no charge and no mass?
- A) alpha particle B) beta particle
 C) gamma ray D) positron
15. Which nuclear decay emission consists of energy, only?
- A) alpha particle B) beta particle
 C) gamma radiation D) positron

16. Which type of radiation is most similar to high-energy x-rays?

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

17. The diagram below represents radiation passing through an electric field.



Which type of emanation is represented by the arrow labeled 2?

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

18. Which radioisotopes have the same decay mode and have half-lives greater than 1 hour?

- A) Au-198 and N-16
B) Ca-37 and Fe-53
C) I-131 and P-32
D) Tc-99 and U-233

19. Which nuclide has a half-life that is *less* than one minute?

- A) cesium-137 B) francium-220
C) phosphorus-32 D) strontium-90

20. 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?

- A) 1.04s B) 2.08s
C) 4.16s D) 8.3s

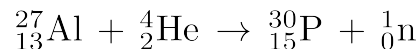
21. An original sample of K-40 has a mass of 25.00 grams. After 3.9×10^9 years, 3.125 grams of the original sample remains unchanged. What is the half-life of K-40?

- A) 1.3×10^9 y B) 2.6×10^9 y
C) 3.9×10^9 y D) 1.2×10^9 y

22. 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) $\frac{1}{32}$

23. Given the balanced equation representing a reaction:



Which type of reaction is represented by this equation?

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

24. 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

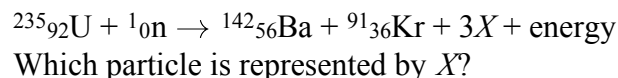
25. Which equation is an example of artificial transmutation?

- A) ${}_4^9\text{Be} + {}_2^4\text{He} \rightarrow {}_6^{12}\text{C} + {}_0^1\text{n}$
B) $\text{U} + 3\text{F}_2 \rightarrow \text{UF}_6$
C) $\text{Mg}(\text{OH})_2 + 2\text{HCl} \rightarrow 2\text{H}_2\text{O} + \text{MgCl}_2$
D) $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + \text{H}_2$

26. The change that is undergone by an atom of an element made radioactive by bombardment with high-energy protons is called

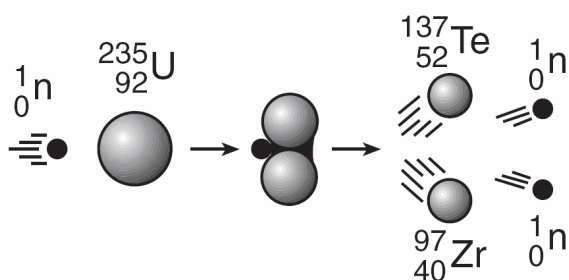
- A) natural transmutation
B) artificial transmutation
C) natural decay
D) radioactive decay

27. Given the balanced equation representing a nuclear reaction:



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

28. 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
29. In which reaction is mass converted to energy by the process of fission?

- A) ${}^{14}_7\text{N} + {}^1_0\text{n} \rightarrow {}^6_6\text{C} + {}^1_1\text{H}$
- B) ${}^{235}_{92}\text{U} + {}^1_0\text{n} \rightarrow {}^{87}_{35}\text{Br} + {}^{146}_{57}\text{La} + 3{}^1_0\text{n}$
- C) ${}^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Ra} + {}^4_2\text{He}$
- D) ${}^2_1\text{H} + {}^2_1\text{H} \rightarrow {}^4_2\text{He}$

30. An uncontrolled chain reaction takes place during the

- A) operation of a fission nuclear reactor
- B) explosion of an atomic bomb
- C) production of energy by the Earth's Sun
- D) fusion of light nuclei into heavier nuclei

31. Which statement best describes a primary occurrence in an uncontrolled fission reaction?

- A) Mass is created and energy is released.
- B) Mass is created and energy is stored.
- C) Mass is converted to energy, which is released.
- D) Mass is converted to energy, which is stored.

32. Which balanced equation represents nuclear fusion?

- A) ${}^2_1\text{H} + {}^2_1\text{H} \rightarrow {}^4_2\text{He}$
- B) $2\text{H}_2 + \text{O}_2 \rightarrow 2\text{H}_2\text{O}$
- C) ${}^6_3\text{Li} + {}^1_0\text{n} \rightarrow {}^3_1\text{H} + {}^4_2\text{He}$
- D) $\text{CaO} + \text{CO}_2 \rightarrow \text{CaCO}_3$

33. A nuclear reaction in which two light nuclei combine to form a more massive nucleus is called

- A) addition
- B) fission
- C) fusion
- D) substitution

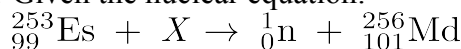
34. High energy is a requirement for fusion reactions to occur because the nuclei involved

- A) attract each other because they have like charges
- B) attract each other because they have unlike charges
- C) repel each other because they have like charges
- D) repel each other because they have unlike charges

35. Which pair of nuclei can undergo a fusion reaction?

- A) potassium-40 and cadmium-113
- B) zinc-64 and calcium-44
- C) uranium-238 and lead-208
- D) hydrogen-2 and hydrogen-3

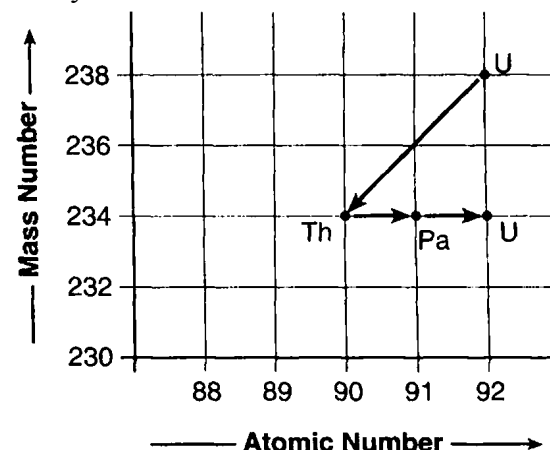
36. Given the nuclear equation:



Which particle is represented by X?

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

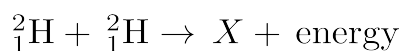
37. The chart below shows the spontaneous nuclear decay of U-238 to Th-234 to Pa-234 to U-234.



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

- A) β^- decay, γ decay, β^- decay
- B) β^- decay, β^- decay, α decay
- C) α decay, α decay, β^- decay
- D) α decay, β^- decay, β^- decay

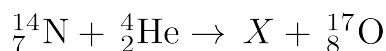
38. Given the fusion reaction:



Which particle is represented by X ?

- A) ${}^1_1\text{H}$ B) ${}^3_2\text{He}$ C) ${}^3_1\text{H}$ D) ${}^4_2\text{He}$

39. Given the equation:



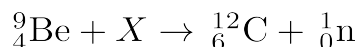
When the equation is balanced correctly, which particle is represented by X ?

- A) ${}^0_{-1}\text{e}$ B) ${}^1_1\text{H}$ C) ${}^2_1\text{H}$ D) ${}^1_0\text{n}$

40. Which reaction is matched correctly with the particle represented by letter X ?

- A) ${}^{226}_{88}\text{Ra} \rightarrow {}^{222}_{86}\text{Rn} + X$; X is an alpha particle.
 B) ${}^{234}_{90}\text{Th} \rightarrow {}^{234}_{91}\text{Pa} + X$; X is an alpha particle.
 C) ${}^{230}_{90}\text{Th} \rightarrow {}^{226}_{88}\text{Ra} + X$; X is a beta particle.
 D) ${}^{234}_{92}\text{U} \rightarrow {}^{230}_{90}\text{Th} + X$; X is a beta particle.

41. Given the nuclear reaction:



What is the identity of particle X ?

- A) alpha particle B) beta particle
 C) proton D) neutron

42. During a nuclear reaction, mass is converted into

- A) charge B) energy
 C) isomers D) volume

43. Which isotope is most commonly used in the radioactive dating of the remains of organic materials?

- A) ${}^{14}\text{C}$ B) ${}^{16}\text{N}$ C) ${}^{32}\text{P}$ D) ${}^{37}\text{K}$

44. Which radioactive isotope is used in geological dating?

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

45. Which isotope is used to treat cancer?

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

46. Which nuclide is paired with a specific use of that nuclide?

- A) carbon-14, treatment of cancer
 B) cobalt-60, dating of rock formations
 C) iodine-131, treatment of thyroid disorders
 D) uranium-238, dating of once-living organisms

47. The course of a chemical reaction can be traced by using a

- A) polar molecule
 B) diatomic molecule
 C) stable isotope
 D) radioisotope

48. Radioisotopes used for medical diagnosis must have

- A) long half-lives and be quickly eliminated by the body
 B) long half-lives and be slowly eliminated by the body
 C) short half-lives and be quickly eliminated by the body
 D) short half-lives and be slowly eliminated by the body

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

- A) kill bacteria in food
 B) kill cancerous tissue
 C) determine the age of animal skeletal remains
 D) determine the way in which a chemical reaction occurs

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

- A) increase the rate of nutrient decomposition
 B) kill microorganisms that are found in the food
 C) convert ordinary nutrients to more stable forms
 D) replace chemical energy with nuclear energy