1. An 80 milligram sample of a radioactive isotope decays to 5 milligrams in 32 days. What is the half-life of this element?
   A. 8 days  B. 2 days  C. 16 days  D. 4 days

2. A radioactive isotope has a half-life of 10 years. What fraction of the original mass will remain unchanged after 50 years?
   A. $\frac{1}{2}$  B. $\frac{1}{8}$  C. $\frac{1}{16}$  D. $\frac{1}{32}$

3. The radioactive isotope carbon-14 can be used for
   A. determining the age of a sample  B. determining medical disorders  C. controlling fission reaction  D. controlling speeds of neutrons

4. Which procedure is based on the half-life of a radioisotope?
   A. accelerating to increase kinetic energy  B. radiating to kill cancer cells  C. counting to determine a level of radioactivity  D. dating to determine age

5. The graph shown represents the decay of a radioactive isotope. What is the half-life of this isotope?
   A. 1 hour  B. 2 hours  C. 3 hours  D. 6 hours

6. In the equation $^{228}_{90}$Th → $^{228}_{88}$Ra + X, which particle is represented by the letter X?
   A. an alpha particle  B. a beta particle  C. a positron  D. a deuteron
7. Given the nuclear equation:
\[ ^{42}_{19}\text{K} \rightarrow ^{42}_{20}\text{Ca} + ^0_{-1}\text{e} + \text{energy} \]
This equation is an example of
A. alpha decay  B. beta decay  
C. fission  D. fusion

8. In the fusion reaction \[ ^1_1\text{H} + ^1_1\text{H} \rightarrow ^4_2\text{He} + ^1_0\text{n} + X \], the \( X \) represents
A. a released electron  
B. another neutron  
C. energy converted from mass  
D. mass converted from energy

9. Given the reaction:
\[ ^{24}_{11}\text{Na} \rightarrow ^{24}_{12}\text{Mg} + ^0_{-1}\text{e} \]
This reaction is best described as
A. alpha decay  B. beta decay 
C. fission  D. fusion

10. Which nuclear reaction is classified as alpha decay?
A. \[ ^{14}_{6}\text{C} \rightarrow ^{14}_{7}\text{N} + ^0_{-1}\text{e} \]
B. \[ ^{42}_{19}\text{K} \rightarrow ^{42}_{20}\text{Ca} + ^0_{-1}\text{e} \]
C. \[ ^{226}_{88}\text{Ra} \rightarrow ^{222}_{86}\text{Rn} + ^4_2\text{He} \]
D. \[ ^{3}_{1}\text{H} \rightarrow ^0_{-1}\text{e} + ^3_2\text{He} \]

11. A gamma ray is best described as having
A. no electric charge and no mass  
B. a negative charge and no mass  
C. a positive charge and a mass number of 2  
D. a positive charge and a mass number of 4

12. Given the nuclear equation:
\[ ^{232}_{90}\text{Th} \rightarrow ^{228}_{88}\text{Ra} + X \]
The letter \( X \) in the equation represents
A. an alpha particle  B. a beta particle  
C. a gamma ray  D. a neutron
13. Which nuclear equation represents beta decay?

A. $^{27}_{13}\text{Al} + ^{4}_{2}\text{He} \rightarrow ^{30}_{15}\text{P} + ^{1}_{0}\text{n}$

B. $^{238}_{92}\text{U} \rightarrow ^{234}_{90}\text{Th} + ^{4}_{2}\text{He}$

C. $^{14}_{6}\text{C} \rightarrow ^{14}_{7}\text{N} + ^{0}_{-1}\text{e}$

D. $^{37}_{18}\text{Ar} + ^{0}_{-1}\text{e} \rightarrow ^{37}_{17}\text{Cl}$

14. What was the original mass of a radioactive sample that decayed to 25 grams in four half-life periods?

A. 50 g B. 100 g C. 200 g D. 400 g

15. The final elements produced by radioactive decay differ from the original radioactive elements because the nuclei of the final elements are always

A. more stable. B. increased in mass.
C. half as radioactive. D. positively charged.

16. Which of the following is an example of nuclear fusion?

A. Hydrogen-1 and hydrogen-2 combine to form helium-3.

B. Polonium-210 decays into lead-206 and an alpha particle.

C. Carbon-14 breaks down into a beta particle and nitrogen-14.

D. Uranium-235 and a neutron produce barium-141, krypton-92, and three neutrons.

17. The three main types of nuclear radiation are alpha, beta, and gamma. Which of the following lists these types of radiation from highest penetrating power to lowest penetrating power?

A. alpha, gamma, beta B. beta, alpha, gamma
C. beta, gamma, alpha D. gamma, beta, alpha

18. Uranium forms thorium and helium, as shown in the equation below.

$^{238}_{92}\text{U} \rightarrow ^{234}_{90}\text{Th} + ^{4}_{2}\text{He}$

Which of the following does this equation represent?

A. decomposition reaction
B. physical change
C. radioactive decay
D. synthesis reaction
19. Which of the following statements accurately describes alpha particles in terms of charge and mass?

A. Alpha particles are positively charged and less massive than beta particles.
B. Alpha particles are negatively charged and less massive than beta particles.
C. Alpha particles are positively charged and more massive than beta particles.
D. Alpha particles are negatively charged and more massive than beta particles.

20. Which of the following statements applies to a nuclear fission reaction?

A. The reaction has no commercial applications.
B. The reaction takes place only at very high temperatures.
C. The reaction produces only short-lived radioactive waste.
D. The reaction releases large amounts of energy when nuclei split apart.

21. Which of the following statements best describes a difference between nuclear fission and nuclear fusion reactions?

A. Nuclei split during fission and combine during fusion.
B. Fission forms heavier elements, and fusion forms lighter elements.
C. Fission generates potential energy, and fusion generates kinetic energy.
D. Nuclei gain electrons during fission and release electrons during fusion.

22. In radiocarbon dating, carbon-14 undergoes decay to become nitrogen-14.

\[ _{6}^{14}\text{C} \rightarrow _{7}^{14}\text{N} + _{-1}^{0}\text{e} \]

What type of reaction is this?

A. fusion  B. neutralization
C. nuclear  D. oxidation

23. Which of the following statements describes a gamma ray?

A. A gamma ray has no mass.
B. A gamma ray has a positive charge.
C. A gamma ray can be stopped by a sheet of paper.
D. A gamma ray can be converted into a beta particle.
24. Uranium-238 undergoes radioactive decay according to the incomplete equation below.

\[
\frac{238}{92}\text{U} \rightarrow \frac{4}{2}\text{He} + X
\]

What is the decay product represented by X?

A. \(\frac{232}{90}\text{Th}\)  
B. \(\frac{234}{90}\text{Th}\)  
C. \(\frac{242}{94}\text{Pu}\)  
D. \(\frac{244}{94}\text{Pu}\)

25. The diagram below shows what happens to an atom of uranium-235 when bombarded by a neutron \(^1_0n\).

Which isotope is represented by X in the diagram?

A. \(^{140}_{56}\text{Ba}\)  
B. \(^{144}_{53}\text{Cs}\)  
C. \(^{146}_{57}\text{La}\)  
D. \(^{90}_{37}\text{Rb}\)

26. The loss of an alpha particle has what effect on the atomic number and mass number of an atom?

A. Atomic number and mass number both decrease.  
B. Atomic number increases; mass number decreases.  
C. Atomic number decreases; mass number increases.  
D. Atomic number and mass number both increase.

27. Which best contrasts nuclear fission and nuclear fusion?

A. fission: splitting of small nuclei  
fusion: joining of large nuclei  
B. fission: splitting of large nuclei  
fusion: joining of small nuclei  
C. fission: joining of small nuclei  
fusion: joining of large nuclei  
D. fission: needs extremely low temperatures  
fusion: needs slightly higher temperatures than fission

28. Which best describes alpha particles?

A. They are attracted to negative electric fields.  
B. They are composed of beta particles.  
C. They are able to penetrate concrete blocks.  
D. They are products of chemical reactions.
29. Which of the three types of radiation will penetrate the paper and wood?

A. alpha, beta, gamma  
B. alpha and beta only  
C. gamma only  
D. beta only

30. Which describes the difference between nuclear fission and nuclear fusion?

A. Nuclear fission is the process that produces the radiant energy of stars, and nuclear fusion splits a heavier nucleus into smaller nuclei.  
B. Nuclear fission splits a heavier nucleus into smaller nuclei, and nuclear fusion is the process that produces the radiant energy of stars.  
C. Nuclear fission produces the energy in the core of Earth, and nuclear fusion produces energy in nuclear power plants.  
D. Nuclear fission produces energy in nuclear power plants, and nuclear fusion produces the energy in the core of Earth.

31. Which group is in order of increasing ability to penetrate an object?

A. alpha, proton, beta  
B. alpha, beta, gamma  
C. beta, proton, alpha  
D. gamma, beta, alpha

32. Which is responsible for producing heat and light from the sun?

A. nuclear energy  
B. chemical energy  
C. electrical energy  
D. wind energy

33. What is the result of the radioactive decay of carbon-14 to nitrogen-14?

A. The nuclei become less stable.  
B. The nuclei become more stable.  
C. The number of protons decreases.  
D. The number of neutrons increases.

34. Which kind of emission is most similar to high-energy X-rays?

A. alpha  
B. beta  
C. neutron  
D. gamma
35. Given the reaction: \( ^{226}_{88}\text{Ra} \rightarrow ^{222}_{86}\text{Rn} + X \)
Which type of emanation is represented by \( X \)?

A. alpha particle  
B. beta particle  
C. proton  
D. positron

36. In the equation \( ^{234}_{90}\text{Th} \rightarrow ^{234}_{91}\text{Pa} + X \), which particle is represented by \( X \)?

A. \(-1^0e\)  
B. \(4^2\text{He}\)  
C. \(1^1\text{H}\)  
D. \(+1^0e\)

37. Given the reaction:
\[ ^1_2\text{H} + ^1_2\text{H} \rightarrow ^4_2\text{He} + \text{energy} \]
The process represented by the reaction is called

A. fission  
B. fusion  
C. artificial transmutation  
D. alpha decay

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

A. form heavy nuclides from light nuclides  
B. form light nuclides from heavy nuclides  
C. release a large amount of energy  
D. absorb a large amount of energy

39. Which process occurs in a controlled fusion reaction?

A. Light nuclei collide to produce heavier nuclei.  
B. Heavy nuclei collide to produce lighter nuclei.  
C. Neutron bombardment splits light nuclei.  
D. Neutron bombardment splits heavy nuclei.

40. Which conditions are required to form \( ^4_2\text{He} \) during the fusion reaction in the Sun?

A. high temperature and low pressure  
B. high temperature and high pressure  
C. low temperature and low pressure  
D. low temperature and high pressure
41. Which reaction illustrates fusion?

A. $^1_1\text{H} + ^1_1\text{H} \rightarrow ^2_2\text{He}

B. $^1_0\text{n} + ^{27}_{13}\text{Al} \rightarrow ^{24}_{11}\text{Na} + ^4_2\text{He}

C. $^{27}_{13}\text{Al} + ^4_2\text{He} \rightarrow ^{30}_{15}\text{P} + ^1_0\text{n}

D. $^{14}_{7}\text{N} + ^4_2\text{He} \rightarrow ^1_1\text{H} + ^{17}_8\text{O}

42. 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

43. When a uranium nucleus breaks up into fragments, which type of nuclear reaction occurs?

A. fusion  B. fission  
C. replacement  D. redox

44. The accompanying diagram represents a nuclear reaction in which a neutron bombards a heavy nucleus.

Which type of reaction does the diagram illustrate?

A. fission  B. fusion  
C. alpha decay  D. beta decay

45. Which statement best describes what happens in a fission reaction?

A. Heavy nuclei split into lighter nuclei. 
B. Light nuclei form into heavier nuclei. 
C. Energy is released and less stable elements are formed. 
D. Energy is absorbed and more stable elements are formed.
46. An original sample of a radioisotope had a mass of 10 grams. After 2 days, 5 grams of the radioisotope remains unchanged. What is the half-life of this radioisotope?

A. 1 day  
B. 2 days  
C. 5 days  
D. 4 days

47. An 80-gram sample of a radioisotope decayed to 10 grams after 24 days. What was the total number of grams of the original sample that remained unchanged after the first 8 days?

A. 60  
B. 20  
C. 30  
D. 40

48. A radioactive element has a half-life of 2 days. Which fraction represents the amount of an original sample of this element remaining after 6 days?

A. $\frac{1}{8}$  
B. $\frac{1}{2}$  
C. $\frac{1}{3}$  
D. $\frac{1}{4}$

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

A. breaking of bonds between atoms  
B. formation of bonds between atoms  
C. conversion of mass into energy  
D. conversion of energy into mass

51. 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

52. Which kind of nuclear radiation has high energy and no mass?

A. alpha  
B. beta  
C. gamma  
D. neutron

53. Which emanation has no mass and no charge?

A. alpha  
B. beta  
C. gamma  
D. neutron

54. When an alpha particle is emitted by an atom, the atomic number of the atom will

A. decrease by 2  
B. increase by 2  
C. decrease by 4  
D. increase by 4

55. When a beta particle is emitted by an atom, the atomic number of the atom will

A. decrease by 2  
B. increase by 2  
C. decrease by 4  
D. increase by 4

56. A neutron is a particle that

A. has a positive charge  
B. has a negative charge  
C. has no charge  
D. has the same charge as an electron
54. Which type of radiation is most similar to high energy x rays?

A. alpha  
B. beta  
C. neutron  
D. gamma

55. Which type of radiation has zero mass and zero charge?

A. alpha  
B. beta  
C. neutron  
D. gamma

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

A. alpha  
B. beta  
C. neutron  
D. gamma

57. Which of these particles has the greatest mass?

A. alpha  
B. beta  
C. neutron  
D. positron

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

A. $^{14}$C  
B. $^{16}$N  
C. $^{32}$P  
D. $^{37}$K

59. The equation below shows the radioactive decay of thorium (Th).

$$\begin{align*}
^{232}_{90} \text{Th} & \rightarrow ^{228}_{88} \text{Ra} + \boxed{\text{Radiation}} \\
\end{align*}$$

Which of the following particles is released in this reaction?

A. alpha ($^4_2$He)  
B. beta ($^0_1$e)  
C. neutron ($^1_0$n)  
D. proton ($^1_1$H)
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