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Class: 12
Subject: Physics
Topic: Atoms and Nuclei
No. of Questions: 30

1. Explain the significance of negative energy of electron in an orbit.

2. Consider a radioactive nucleus A which decays to a stable nucleus C through the following sequence:
   $B \rightarrow B \rightarrow C$
   Here, B is an intermediate nucleus which is also radioactive. Considering that there are N_o atoms of A initially, plot the graph showing the variation of number of atoms of A and B versus time.

3. A positronium atom is a bound state of an electron (e^-) and its antiparticle, the positron (e^+) revolving round their centre of mass. In which part of the em spectrum does the system radiate when it de-excites from its first excited state to the ground state?

4. A nuclear reactor is a powerful device, wherein nuclear energy is utilized for peaceful purposes. It is based upon controlled nuclear chain reaction. The nuclear chain reaction is controlled by the use of control rods (of boron or cadmium) and moderators like heavy water, graphite, etc.
   The whole reactor is protected with concrete walls 2 to 2.5 metre thick, so that radiations emitted during nuclear reactions may not produce harmful effects.
   Read the above passage and answer the following questions:
   (i) Give any two merits of nuclear reactors.
   (ii) What is radioactive waste?
   (iii) Why do people often oppose the location site of a nuclear reactor? What do you suggest?

5. Einstein was the first to establish the equivalence between mass and energy. According to him, whenever a certain mass (Δm) disappears in some process, the amount of energy released is $E = (\Delta m)\, c^2$, where c is velocity of light in vacuum ($=3 \times 10^8$ m/s). The revers is also true, i.e., whenever energy E disappears, and equivalent mass $(\Delta m) = E/c^2$ appers.
   Read the above passage and answer the following questions:
   (i) What is the energy released when 1 a.m.u. of mass disappears in a nuclear reaction?
   (ii) Doy you know any phenomenon in which energy materialises?
   (iii) What values of life do you learn from this famous relation?

6. Poonam's mother is diagnosed cancer. The attending physician told her that she has to undergo radiotherapy. While telling her the side effects of the treatment, the doctor told that her beautiful hair may fall and she may become bald. Poonam's mother refuses to get the treatment.
   Read the above passage and answer the following questions:
   (i) What would you do if you were in Poonam's place?
   (ii) What values of lip are associated with your attitude?

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7. Four nuclei of an element fuse together to form a heavier nucleus. If the process is accompanied by release of energy, which of the tow – the parent or the daughter nucleus would have higher binding energy per nucleon?

8. Explain the concept of nuclear energy with reference to binding energy curve.

9. What are delayed neutrons? Discuss their role.

10. Give reasons for
    A. Lighter elements are better moderators for a nuclear reactor than heavier elements.
    B. In a natural uranium reactor, heavy water is a preferred moderator to ordinary water.
    C. Cadmium rods are provided in a reactor.
    D. Very high temperatures as those obtained in the interior of the sun are required for fusion reaction to take place.

11. After two hours, $1/16^{th}$ of the initial amount of a certain radioactive isotope remains undecayed. The half-life of the isotope is

    A. 15 minutes
    B. 30 minutes
    C. 45 minutes
    D. 1 hour

12. The half life of Pa-218 is 3 minutes. What mass of a 16 g sample of Pa - 218 will remain after 15 minutes?

    A. 3.2 g
    B. 2.0 g
    C. 1.6 g
    D. 0.5 g

13. During a negative beta decay

    A. an atomic electron is ejected
    B. an electron which is already present within the nucleus is ejected
    C. a neutron in the nucleus decays emitting an electron
    D. a part of the binding energy of the nucleus is converted into an electron

14. The decay constant of a radioactive sample is λ. The half-life and mean-life of the sample are (respectively) given by

    A. $1/\lambda$ and $(\ln 2)/\lambda$
    B. $(\ln 2)/\lambda$ and $1/\lambda$
    C. $1/\lambda$ and $\lambda(\ln 2)$
    D. $\lambda(\ln 2)$ and $1/\lambda$

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15. A radioactive element X has atomic number Z and atomic mass number A. It decays by the emission of an alpha particle and a gamma ray. The new element is
    A.
    B. $^{A-2}_{Z-1}Y$
    C. $^{A-4}_{Z-2}Y$
    D. $^{A+1}_{Z}Y$
    E. $^{A+4}_{Z+2}Y$

16. The half-life of a radioactive substance depends upon
    A. its temperature
    B. the external pressure on it
    C. the mass of the substance
    D. the strength of the nuclear force between the nucleons of its atoms

17. A uranium nucleus (atomic number 92, mass number 238) emits an alpha particle and the resultant nucleus emits a β particle. The atomic and mass numbers, respectively of the final nucleus are
    A. 90, 240
    B. 90, 236
    C. 91, 234
    D. 92, 232

18. The equation $4^1_1H^+ \rightarrow ^4_2He^+ + 2e^+ + 26\,MeV$ represents
    A. β - decay
    B. γ - decay
    C. fusion
    D. fission

19. The binding energy per nucleon of C-12 is 7.68 MeV and of C-13 is 7.48 MeV. The energy (in MeV) required to remove the extra neutron from C-13 is nearly equal to
    A. 0.2
    B. 3.7
    C. 3.9
    D. 5

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20. A gamma ray photon creates an electron-positron pair. If the total kinetic energy of the electron-positron pair is 0.78 MeV, the energy of the gamma ray photon is (given the rest mass energy of electron = 0.51 MeV)

A. 0.27 MeV
B. 0.78 MeV
C. 1.29 MeV
D. 1.80 MeV

21. The transition from state n = 4 to n = 3 in a hydrogen-like atom results in an ultraviolet radiation. Infrared radiation will be obtained in the transition

A. $2 \rightarrow 1$
B. $3 \rightarrow 2$
C. $4 \rightarrow 2$
D. $5 \rightarrow 4$

22. The mass number of a nucleus is

A. always less than its atomic number
B. always more than its atomic number
C. always equal to its atomic number
D. sometimes more and sometimes equal to its atomic number

23. A star initially has 10^{40} deuterons. It produces energy via the processes ${}_1^2H + {}_1^2H \rightarrow {}_1^3H + p$ and ${}_1^2H + {}_1^3H \rightarrow {}_2^4He + n$ where the masses of the nuclei are: m(^{2}H) = 2.014 u, m(p) = 1.007 u, m(n) = 1.008 u and m(^{4}He) = 4.001 u. If the average power radiated by the star is 10^{16} W, the deuteron supply of the star will get exhausted in a time of the order of

A. 10^6 s
B. 10^8 s
C. 10^{12} s
D. 10^{16} s

24. Masses of two isobars ${}_{29}^{64}Cu$ and ${}_{30}^{64}Zn$ are 63.9298 u and 63.9292 u respectively. It can be concluded from the given information that

A. both the isobars are stable
B. ^{64}Zn is radioactive, decaying to ^{64}Cu through β-decay
C. ^{64}Cu is radioactive, decaying to ^{64}Zn through γ-decay
D. ^{64}Cu is radioactive, decaying to ^{64}Zn through β-decay.

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25. The order of magnitude of density of uranium nucleus is, ($m_p = 1.67 \times 10^{-27}$ kg)

A. 10^{20} kg m^{-3}
B. 10^{17} kg m^{-3}
C. 10^{14} kg m^{-3}
D. 10^{11} kg m^{-3}

26. The electron emitted in beta radiation originates from

A. inner orbits of atoms
B. free electrons existing in the nucleus
C. decay of a neutron in the nucleus
D. a photon escaping from the nucleus

27. Which of the following processes represents a gamma-decay?

A. ${}^{A}_{Z}X + \gamma \rightarrow {}^{A}_{Z-1}X + a + b$
B. ${}^{A}_{Z}X + {}^{1}_{0}n \rightarrow {}^{A-3}_{Z-2}X + c$
C. ${}^{A}_{Z}X \rightarrow {}^{A}_{Z}X + f$
D. ${}^{A}_{Z}X + {}^{}_{-1}e \rightarrow {}^{A}_{Z-1}X + g$

28. A nucleus of mass number 220, initially at rest, emits an α - particle. If the Q value of the reaction is 5.5 MeV, the energy of the emitted α - particle will be

A. 4.8 MeV
B. 5.4 MeV
C. 6.0 MeV
D. 6.8 MeV

29. A nucleus at rest splits into two nuclear parts having radii in the ratio 1 : 2. Their velocities are in the ratio

A. 8 : 1
B. 6 : 1
C. 4 : 1
D. 2 : 1

30. Which of the following statements is incorrect?

A. Nuclei having an odd number of protons and an odd number of neutrons are generally unstable.
B. The mass number of a nucleus is equal to its atomic number only for the nucleus ${}^{1}_{1}H$.
C. A radioactive element of half-life 1.5 years completely disintegrates in 4.5 years.
D. The mass per nucleon in an oxygen atom is slightly less than that in a hydrogen atom.

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