

PRACTICE EXERCISES
SINGLE CORRECT CHOICE TYPE QUESTIONS

This section contains Single Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONLY ONE is correct.

1. A radio isotope has a half life of 10 sec. If initially there are 1000 isotopes in sample which falls from rest from top of a building of height 3000 m. The number of nuclei in the sample is at a height of 1000 m from the ground is (take $g = 10 \text{ ms}^{-2}$)

(A) 50 (B) 250
(C) 29 (D) 100

2. A radioactive substance is being produced at a constant rate of 200 nuclei. The decay constant of the substance is 1 s^{-1} . Assuming that initially there are no nuclei present, the time (in second) after which the number of nuclei will become 100 is

(A) 1 s (B) $\log_e(2)$ s
(C) $\frac{1}{\log_e(2)}$ s (D) 2 s

3. A radioactive material of half-life T was produced in a nuclear reactor at different instants, the quantity produced second time was twice of that produced first time. If now their present activities are A_1 and A_2 respectively then their age difference equals

(A) $\frac{T}{\log_e 2} \left| \log_e \left(\frac{2A_1}{A_2} \right) \right|$ (B) $T \left| \log_e \left(\frac{A_1}{A_2} \right) \right|$
(C) $\frac{T}{\log_e 2} \left| \log_e \left(\frac{A_2}{2A_1} \right) \right|$ (D) $T \left| \log_e \left(\frac{A_2}{2A_1} \right) \right|$

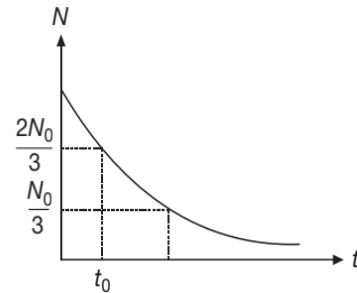
4. The atomic weight of boron is 10.81 and it has two isotopes $^{10}_5\text{B}$ and $^{11}_5\text{B}$. The ratio of $^{10}_5\text{B} : ^{11}_5\text{B}$ in nature would be

(A) 19:81 (B) 10:11
(C) 15:16 (D) 81:19

5. Radioactivity is

(A) spontaneous process
(B) irreversible process
(C) self disintegration process
(D) all the above

6. Figure shows the variation of the number of radioactive atoms left undecayed with time. The time corresponding to $N = \frac{N_0}{3}$ is



(A) $3t_0$ (B) $t_0 \log_e(2)$
(C) $\frac{t_0 \log_e(3)}{\log_e\left(\frac{3}{2}\right)}$ (D) $t_0 \log_e(3)$

7. If one starts with one curie of radioactive substance having half life of 12 hour, the activity left after a period of 1 week will be about

(A) 1 curie (B) 120 micro curie
(C) 60 micro curie (D) 8 mili curie

8. There are two radio nuclei A and B out of which A is an alpha emitter and B is a beta emitter. Their disintegration constants are in the ratio of 1:2. The ratio of number of atoms of A and B at any time t so that probabilities of getting alpha and beta particles are same at that instant is

(A) 1:2 (B) 1:e
(C) 2:1 (D) e:1

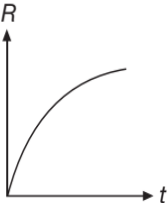
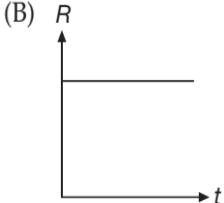
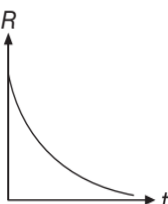
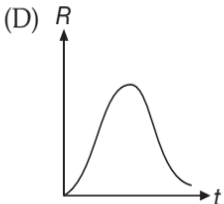
9. Cobalt-57 is radioactive, emitting β particles. The half-life for this is 270 day. If 100 mg of this is kept in an open container, the mass of cobalt-57 after 540 day will be

(A) 50 mg (B) $\frac{50}{\sqrt{2}}$ mg
(C) 25 mg (D) zero

10. The half life of radon is 3.8 days. After how many days will $\frac{1}{10}$ th of the radon sample remain behind

(A) 1.262 days (B) 12.62 days
(C) 126.2 days (D) 1262 days

11. The half-life of a radioactive material is T . After $\frac{T}{2}$ time, the material left is

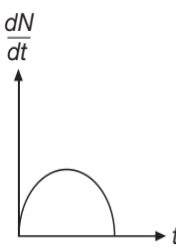
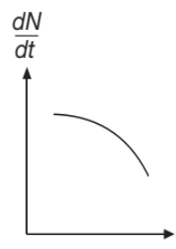
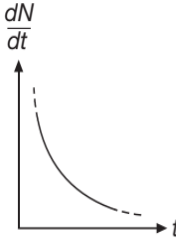
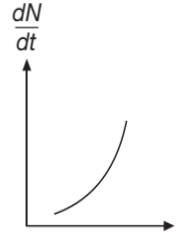
- (A) $\frac{1}{2}$ (B) $\frac{3}{4}$
 (C) $\frac{1}{\sqrt{2}}$ (D) $\frac{1}{4}$
12. In any fission process the ratio $\frac{\text{mass of fission products}}{\text{mass of parent nucleus}}$ is
 (A) Less than 1
 (B) Greater than 1
 (C) Equal to 1
 (D) Depends on the mass of the parent nucleus
13. α -particle emitted during various radioactive processes have same
 (A) speed (B) momentum
 (C) kinetic energy (D) specific charge
14. The half life of a radioactive substance is 4 day. Initially at $t=0$ there are 100 nuclei of this substance then in the sample we will obtain
 (A) 50 undecayed nuclei after 4 day
 (B) 25 undecayed nuclei after 6 day
 (C) 75 undecayed nuclei after 2 day
 (D) Cannot be said
15. A radioactive nucleus X decays to a stable nucleus Y . Then the graph of rate of formation of Y against time t will be
 (A)  (B) 
 (C)  (D) 
16. In the beta decay, the mass number and atomic number of the daughter nuclei respectively
 (A) increase by 2
 (B) decrease by 1
 (C) do not change at all
 (D) mass number remains same but atomic number increases by 1
17. The mean lives of a radioactive substance are 1620 year and 405 year for α -emission and β -emission respectively. The time during which three-fourth of a sample will decay if it is decaying both by α -emission and β -emission simultaneously is
 (A) 249 year (B) 449 year
 (C) 133 year (D) 99 year
18. Decay constant of radium is λ . By a suitable process its compound radium bromide is obtained. The decay constant of radium bromide will be
 (A) λ (B) More than λ
 (C) Less than λ (D) Zero
19. Half life of a radioactive substance A is two times the half life of another radioactive substance B . Initially the number of nuclei of A and B are N_A and N_B respectively. After three half lives of A number of nuclei of both are equal. Then the ratio $\frac{N_A}{N_B}$ is
 (A) $\frac{1}{3}$ (B) $\frac{1}{6}$
 (C) $\frac{1}{4}$ (D) $\frac{1}{8}$
20. The energy released (in MeV) due to annihilation of 1 kg mass completely to energy is
 (A) 7.625×10 MeV (B) 10.5×10^{29} MeV
 (C) 2.8×10^{-28} MeV (D) 5.625×10^{29} MeV
21. Which of the following is not a mode of decay of radioactive elements?
 (A) Alpha decay (B) Positron emission
 (C) Fission (D) Electron capture
22. In a sample of a radioactive substance, the fraction of the initial number of nuclei will remain undecayed after a time $t = \frac{T}{2}$, where T is the half life of radioactive substance is
 (A) $\frac{1}{\sqrt{2}}$ (B) $\frac{1}{4}$
 (C) $\frac{1}{2\sqrt{2}}$ (D) $\frac{1}{\sqrt{2}-1}$
23. A radioactive decay counter is switched on at $t=0$. A β -active sample is present near the counter. The counter registers the number of β -particles emitted by the sample. The counter registers 1×10^5 β -particles at $t=36$ sec and 1.11×10^5 β -particles at $t=108$ sec. Half life of this sample is
 (A) 5.2 sec (B) 10.8 sec
 (C) 15.4 sec (D) 20.6 sec
24. The atomic ratio between the uranium isotopes ^{238}U and ^{234}U in a mineral sample is found to be 1.8×10^4 . The half life of ^{234}U is 2.5×10^5 year. The half-life of ^{238}U is



- (A) 4.5×10^9 year (B) 5.4×10^9 year
 (C) 4.5 year (D) 5.4 year
25. How would the radio isotope of magnesium with atomic mass 27 undergo radioactive decay?
 (A) Electron capture (B) Alpha decay
 (C) Beta decay (D) Gamma ray emission
26. The decay constants of a radioactive substance for α and β emission are λ_α and λ_β respectively. If the substance emits α and β simultaneously, the average half life of the material will be
 (A) $T_\alpha - T_\beta$ (B) $T_\alpha + T_\beta$
 (C) $\frac{T_\alpha T_\beta}{T_\alpha + T_\beta}$ (D) None of these
27. If 10% of a radioactive substance decays in every 5 year, then the percentage of the substance that will have decayed in 20 year will be
 (A) 40% (B) 50%
 (C) 65.6% (D) 34.4%
28. The rate of decay of a radioactive element
 (A) increases with increase in time
 (B) decreases with increase in time
 (C) remains constant with increase in time
 (D) decreases exponentially with time
29. Consider the following nuclear reaction

$$X^{200} \rightarrow A^{110} + B^{90} + \text{Energy}$$
 If the binding energy per nucleon for X , A and B are 7.4 MeV, 8.2 MeV and 8.2 MeV respectively, the energy released will be
 (A) 90 MeV (B) 110 MeV
 (C) 200 MeV (D) 160 MeV
30. A nucleus X initially at rest, undergoes alpha decay according to the equation

$${}^Z_{232}X \rightarrow {}^A_{90}Y + \alpha$$
 What fraction of the total energy released in the decay will be the kinetic energy of the alpha particle?
 (A) $\frac{90}{92}$ (B) $\frac{228}{232}$
 (C) $\sqrt{\frac{228}{232}}$ (D) $\frac{1}{2}$
31. The total energy E of a sub-atomic particle of rest mass m_0 moving at non-relativistic speed v is
 (A) $E = m_0 c^2$ (B) $E = \frac{1}{2} m_0 v^2$
 (C) $E = m_0 c^2 + \frac{1}{2} m_0 v^2$ (D) $E = m_0 c^2 - \frac{1}{2} m_0 v^2$
32. The radioactivity of a sample is x at a time t_1 and y at a time t_2 . If the mean life of the specimen is τ , the number of atoms that have disintegrated in the time interval $(t_2 - t_1)$ is
 (A) $xt_1 - yt_2$ (B) $x - y$
 (C) $\frac{x - y}{\tau}$ (D) $(x - y)\tau$
33. The energy released by the fission of a single uranium nucleus is 200 MeV. The number of fissions of uranium nucleus per second required to produce 16 MW of power is
 (Assume efficiency of the reactor is 50%)
 (A) 2×10^6 (B) 2.5×10^6
 (C) 5×10^6 (D) None of these
34. The activity of a radioactive substance is R_1 at time t_1 and R_2 at time t_2 ($> t_1$). Its decay constant is λ . Then
 (A) $R_1 t_1 = R_2 t_2$ (B) $R_2 = R_1 e^{\lambda(t_2 - t_1)}$
 (C) $\frac{R_1 - R_2}{t_2 - t_1} = \text{constant}$ (D) $R_2 = R_1 e^{\lambda(t_1 - t_2)}$
35. In PROBLEM 34, number of atoms decayed between time interval t_1 and t_2 are
 (A) $\frac{\log_e(2)}{\lambda}(R_1 - R_2)$ (B) $R_1 e^{-\lambda t_1} - R_2 e^{-\lambda t_2}$
 (C) $\lambda(R_1 - R_2)$ (D) $\left(\frac{R_1 - R_2}{\lambda}\right)$
36. Half-lives of two radioactive substances A and B are respectively 20 minute and 40 minute. Initially, the samples of A and B have equal number of nuclei. After 80 minute the ratio of the remaining numbers of A and B nuclei is
 (A) 1:16 (B) 4:1
 (C) 1:4 (D) 1:1
37. In a radioactive series, ${}_{92}\text{U}^{238}$ changes to ${}_{82}\text{Pb}^{206}$ through n_1 α -decay process and n_2 β -decay process
 (A) $n_1 = 8, n_2 = 8$ (B) $n_1 = 6, n_2 = 6$
 (C) $n_1 = 8, n_2 = 6$ (D) $n_1 = 6, n_2 = 8$

38. In free space, the intensity of 5 eV neutron beam is reduced by a factor of one half. Half life of neutron is 12.8 min. The distance travelled by neutron beam is
 (A) 2800 km (B) 23800 km
 (C) 28 km (D) 2 km
39. When secular radioactive equilibrium is reached between Radium and Uranium, then which of the following relation hold true. Given that,
 λ_R is decay constant of Radium
 N_R is number of nuclei of Radium
 λ_U is decay constant of Uranium
 N_U is number of nuclei of Uranium
 (A) $\frac{\lambda_R}{\lambda_U} = \frac{N_U}{N_R}$ (B) $\frac{\lambda_R}{\lambda_U} = \frac{N_R}{N_U}$
 (C) $\frac{\lambda_R}{\lambda_U} = \sqrt{\frac{N_R}{N_U}}$ (D) $\frac{\lambda_R}{\lambda_U} = \sqrt{\frac{N_U}{N_R}}$
40. A γ -ray photon is emitted
 (A) after ionization of an atom
 (B) due to conversion of a neutron into a proton in the nucleus
 (C) after de-excitation of a nucleus
 (D) due to conversion of a proton into a neutron in the nucleus
41. The count rate from 100 cm³ of a radioactive liquid is c . Some of this liquid is now discarded. The count rate of the remaining liquid is found to be $\frac{c}{10}$ after three half-lives. The volume of the remaining liquid, in cm³, is
 (A) 20 (B) 40
 (C) 60 (D) 80
42. The rate of disintegration of fixed quantity of a radioactive element can be increased by
 (A) increasing the temperature
 (B) increasing the pressure
 (C) increasing the humidity
 (D) It is not possible
43. A 100 ml solution having activity 50 dps is kept in a beaker. It is now constantly diluted by adding water at a constant rate of 10 ml/sec and at the same time the solution is constantly being taken out at the rate of 2 ml/sec. The activity of 10 ml solution which is taken out, assuming half life to be effectively very large is
 (A) $10 \left[1 - \left(\frac{2}{7} \right)^{\frac{1}{4}} \right]$ (B) $10 \left[1 - \left(\frac{5}{7} \right)^{\frac{1}{2}} \right]$
 (C) $50 \left[1 - \left(\frac{5}{7} \right)^{\frac{1}{4}} \right]$ (D) $50 \left[1 - \left(\frac{2}{7} \right)^{\frac{1}{2}} \right]$
44. An isotope of potassium ${}^{40}_{19}\text{K}$ has a half life of 1.4×10^9 year and decays to Argon ${}^{40}_{18}\text{Ar}$ which is stable. A sample of rock taken from the moon contains both potassium and argon in the ratio $\frac{1}{7}$. Age of the rock is
 (A) 2.8×10^9 year (B) 3.5×10^9 year
 (C) 4.2×10^9 year (D) 8.2×10^{10} year
45. The count rate of a Geiger-Muller counter for the radiation of radioactive material of half life of 30 minutes decreases to 5 s^{-1} after 2 hours. The initial count rate was
 (A) 25 s^{-1} (B) 80 s^{-1}
 (C) 625 s^{-1} (D) 20 s^{-1}
46. The half-life of a certain radioactive element is such that $\frac{7}{8}$ of a given quantity decays in 12 day. What fraction remains undecayed after 24 day?
 (A) 0 (B) $\frac{1}{128}$
 (C) $\frac{1}{64}$ (D) $\frac{1}{32}$
47. When a free neutron decays to form a proton and an electron, then choose the incorrect statement
 (A) the relation may be expressed as ${}_0n^1 \rightarrow {}_1p^1 + {}_{-1}e^0$
 (B) every electron comes out with the same energy
 (C) the electron shares the major part of the energy released
 (D) all the above
48. Radioactive element decays to form a stable nuclide, then the rate of decay of reactant $\left(\frac{dN}{dt} \right)$ will vary with time (t) as shown in figure
 (A)  (B) 
 (C)  (D) 
49. If 10% of a radioactive material decays in 5 day, then the amount of original material left after 20 day is approximately



- (A) 60% (B) 65%
(C) 70% (D) 75%

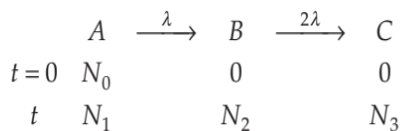
50. It has been observed that the most stable nuclei have generally the neutron to proton ratio as

- (A) 1 : 2 (B) 2 : 1
(C) 1 : 4 (D) 1 : 1

51. A radioactive isotope is being produced at a constant rate A . The isotope has a half-life T . Initially there are no nuclei, after a time $t \gg T$, the number of nuclei becomes constant. The value of this constant is

- (A) AT (B) $\frac{A}{T} \ln(2)$
(C) $AT \ln(2)$ (D) $\frac{AT}{\ln(2)}$

52. Figure below shows initial steps of a radioactive series



The ratio of N_1 to N_2 , when N_2 is maximum is

- (A) $\frac{\ln 2}{2}$
(B) 2
(C) $\frac{1}{2}$
(D) At no time this is possible

53. Select the wrong statement.

- (A) Radioactivity is a statistical process
(B) Radioactivity is a spontaneous process
(C) Radioactivity is the neutral characteristics of few elements
(D) Radioactive elements cannot be produced in the laboratory

54. A radioactive element ${}_Z X^A$ emits an α -particle and changes into

- (A) ${}_{z-2} Y^A$ (B) ${}_z Y^{A-4}$
(C) ${}_{z-2} Y^{A-4}$ (D) ${}_{z+2} Y^A$

55. In gamma ray emission from a nucleus

- (A) only the proton number changes
(B) both the neutron number and the proton number change
(C) there is no change in the proton number and the neutron number
(D) only the neutron number changes

56. At time $t = 0$, N_1 nuclei of decay constant λ_1 and N_2 nuclei of decay constant λ_2 are mixed. The decay rate of the mixture at time t is

- (A) $N_1 N_2 \lambda_1 \lambda_2 e^{-(\lambda_1 + \lambda_2)t}$ (B) $\left(\frac{N_1}{N_2}\right) e^{-(\lambda_1 - \lambda_2)t}$

- (C) $N_1 \lambda_1 e^{-\lambda_1 t} + N_2 \lambda_2 e^{-\lambda_2 t}$ (D) $N_1 N_2 e^{-(\lambda_1 + \lambda_2)t}$

57. Which of the following is its own antiparticle?

- (A) photon (B) electron
(C) proton (D) π -meson

58. A bone containing 200 g carbon-14 has a β -decay rate of 375 decay/min. Calculate the time that has elapsed since the death of the living one. Given the rate of decay for the living organism is equal to 15 decay per min per gram of carbon and half-life of carbon-14 = 5730 year

- (A) 27190 year (B) 1190 year
(C) 17190 year (D) None of these

59. Estimate the age of an ancient wooden piece if it is known that the specific activity of C^{14} nuclide in it amounts to $\frac{3}{5}$ of that in freshly felled trees. Given that

the half-life of C^{14} nuclide is 5570 year.

- (A) 1000 year (B) 2000 year
(C) 3000 year (D) 4000 year

60. A radioactive material decays by simultaneous emission of two particles with respective half lives 1620 and 810 year. The time (in year) after which one-fourth of the material remains is

- (A) 1080 (B) 2430
(C) 3240 (D) 4860

61. A radioactive isotope is being produced at a constant rate X . Half life of the radioactive substance is Y . After some time the number of radioactive nuclei become constant. The value of this constant is

- (A) XY (B) $\frac{X}{Y}$
(C) $\frac{XY}{\log_e(2)}$ (D) $(XY) \log_e(2)$

62. If the half-lives of a radioactive element for α and β decay are 4 year and 12 year respectively, then the percentage of the element that remains after 12 year will be

- (A) 6.25% (B) 5.25%
(C) 4.25% (D) 3.50%

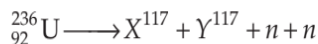
63. Assuming that all laws of thermodynamics can be applied to a nucleus, the α decay of a nucleus may be regarded as an

- (A) isothermal process (B) isobaric process
(C) adiabatic process (D) isochoric process

64. The graph of $\log\left(\frac{R}{R_0}\right)$ versus A (R = radius of a nucleus and A = mass number) is

- (A) a circle (B) an ellipse
(C) a parabola (D) a straight line

65. Consider the fission reaction



i.e. two nuclei of same mass number 117 are found plus two neutrons. The binding energy per nucleon of X and Y is 8.5 MeV whereas of U^{236} is 7.6 MeV. The total energy liberated is

- (A) 2000 MeV (B) 200 MeV
(C) 20 MeV (D) 2 MeV

66. In a radioactive substance at $t=0$, the number of atoms is 8×10^4 . Its half life period is 3 year. The number of atoms 1×10^4 will remain after interval

- (A) 9 year (B) 8 year
(C) 6 year (D) 24 year

67. The activity of a radioactive sample is measured as 9750 counts (minute)⁻¹ at $t=0$ and 975 counts (minute)⁻¹ at $t=5$ minute. The decay constant is nearly

- (A) 0.922 min^{-1} (B) 0.691 min^{-1}
(C) 0.461 min^{-1} (D) 0.230 min^{-1}

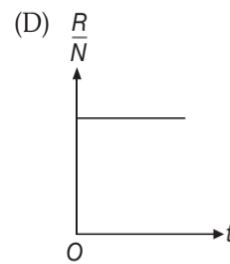
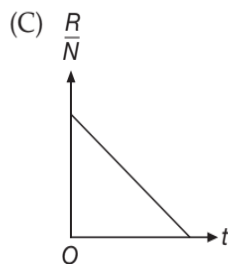
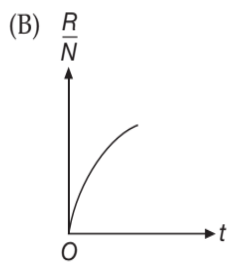
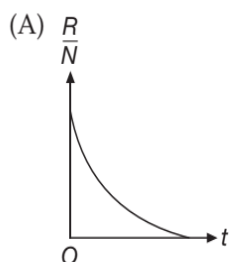
68. The half life of a certain radioactive element is 1 year. The percentage of the radioactive element decayed in 6 months will be

- (A) 29.3% (B) 39.5%
(C) 70.5% (D) 14.5%

69. Magic numbers are

- (A) 2, 8, 18, 28, 50, 164....
(B) 2, 8, 18, 50, 82, 164....
(C) 2, 8, 20, 28, 50, 82, 126....
(D) 2, 20, 50, 82, 164, 224....

70. A radioactive sample has N_0 active atoms at $t=0$. If the rate of disintegration at any time is R the number of atoms is N , then the ratio $\frac{R}{N}$ varies with time as



71. The half life of radium is 1600 years. The fraction of the sample of radium that would remain after 6400 years is

- (A) $\frac{1}{2}$ (B) $\frac{1}{4}$
(C) $\frac{1}{8}$ (D) $\frac{1}{16}$

72. The half life of ${}^{198}\text{Au}$ is 2.7 day. The probability that any ${}^{198}\text{Au}$ nucleus will decay in one second is

- (A) 10^{-6} (B) 3×10^{-6}
(C) 5×10^{-6} (D) 10^{-5}

73. A and B are isotopes. B and C are isobars. If d_A , d_B and d_C be the densities of nuclei A, B and C respectively then

- (A) $d_A > d_B > d_C$ (B) $d_A < d_B < d_C$
(C) $d_A = d_B = d_C$ (D) $d_A = d_B < d_C$

74. A sample contains large number of nuclei. The probability that a nucleus in sample will decay after four half lives is

- (A) $\frac{1}{4}$ (B) $\frac{3}{4}$
(C) $\frac{15}{16}$ (D) $\frac{7}{16}$

75. If u denotes 1 atomic mass unit. One atom of an element has mass exactly equal to Au , where A is mass number of element

- (A) $A=1$
(B) $A=12$
(C) $A=16$
(D) A can take up any integral value from 1 to 110

76. A sample contains 10^{-2} kg, each of two substances A and B with half lives 4 sec and 8 sec respectively. Their atomic masses are in the ratio 1:2. Amounts of A and B after an interval of 16 sec are respectively

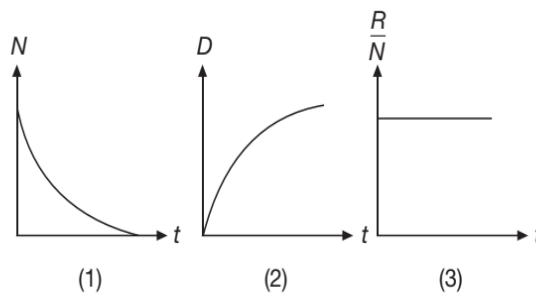
- (A) 2.5 mg, 2.5 mg (B) 0.625 mg, 2.5 mg
(C) 5 mg, 0.625 mg (D) 5 mg, 2.5 mg

77. The activity of a sample of radioactive material is R_1 at time t_1 and R_2 at time t_2 ($t_2 > t_1$). If mean life of the radioactive sample is T , then
- (A) $R_1 t_1 = R_2 t_2$ (B) $\frac{R_1 - R_2}{t_2 - t_1} = \text{constant}$
- (C) $R_2 = R_1 \exp\left(\frac{t_1 - t_2}{T}\right)$ (D) $R_2 = R_1 \exp\left(\frac{t_1}{T t_2}\right)$
78. Samples of two radioactive nuclides, X and Y , each have equal activity A_0 at time $t = 0$. X has a half-life of 24 year and Y a half-life of 16 year. The samples are mixed together. What will be the total activity of the mixture at $t = 48$ years ?
- (A) $\frac{1}{12} A_0$ (B) $\frac{1}{4} A_0$
- (C) $\frac{3}{16} A_0$ (D) $\frac{3}{8} A_0$
79. At time $t = 0$, N_1 nuclei of decay constant λ_1 and N_2 nuclei of decay constant λ_2 are mixed. The decay rate of mixture is
- (A) $-N_1 N_2 e^{-(\lambda_1 + \lambda_2)t}$
- (B) $-\left(\frac{N_1}{N_2}\right) e^{-(\lambda_1 + \lambda_2)t}$
- (C) $-(N_1 \lambda_1 e^{-\lambda_1 t} + N_2 \lambda_2 e^{-\lambda_2 t})$
- (D) $-N_1 \lambda_1 N_2 \lambda_2 e^{-(\lambda_1 + \lambda_2)t}$
80. An event on a distant star causes the emission of a burst of radiation containing β -particles, γ -rays and light. Which one of the following statements about the order in which these radiations arrive at, the earth is correct.
- (A) The light would arrive first
- (B) The γ -rays would arrive first
- (C) The light and the γ -rays would arrive together, ahead of the β -particles
- (D) The light and the β -particles would arrive together, ahead of the γ -rays
81. Two radioactive elements R and S disintegrate as
- $$R \rightarrow P + \alpha, \lambda_R = 4.5 \times 10^{-3} \text{ year}^{-1}$$
- $$S \rightarrow Q + \beta, \lambda_S = 3 \times 10^{-3} \text{ year}^{-1}$$
- Starting with number of atoms of R and S in the ratio of 2 : 1, this ratio after the lapse of three half lives of R will be
- (A) 3 : 2 (B) 1 : 3
- (C) 1 : 1 (D) 2 : 1
82. A count rate meter shows a count of 240 per minute from a given radioactive source. One hour later, the meter shows a count rate of 30 per minute. The half-life of the source is
- (A) 20 min (B) 40 min
- (C) 80 min (D) 120 min
83. The ratio of molecular mass of two radioactive substances is $\frac{3}{2}$ and the ratio of their decay constant is $\frac{4}{3}$. Then the ratio of their initial activity per mole will be
- (A) 2 (B) $\frac{8}{9}$
- (C) $\frac{4}{3}$ (D) $\frac{9}{8}$
84. Half-life of a radioactive substance is 20 minutes. Difference between points of time when it is 33% disintegrated and 67% disintegrated is approximately
- (A) 10 min (B) 20 min
- (C) 30 min (D) 40 min
85. A radioactive substance X decays into another radioactive substance Y . Assuming that initially only X was present, λ_x and λ_y be the disintegration constants of X and Y , N_x and N_y be the number of nuclei of X and Y at any time t , then the number of nuclei N_y will be maximum when
- (A) $\frac{N_x}{N_x - N_y} = \frac{\lambda_x}{\lambda_x - \lambda_y}$
- (B) $\frac{N_y}{N_x - N_y} = \frac{\lambda_y}{\lambda_x - \lambda_y}$
- (C) $\lambda_y N_x = \lambda_x N_y$
- (D) $\lambda_y N_y = \lambda_x N_x$
86. The half lives of a radioactive sample are 30 year and 60 year for two simultaneous decay processes. The time after which, only one-fourth of the sample will remain is
- (A) 10 year (B) 20 year
- (C) 40 year (D) 60 year
87. The SI units of decay constant is
- (A) m^{-1} (B) mm^{-1}
- (C) s^{-1} (D) year
88. A nucleus of mass 218 amu in free state decays to emit an alpha particle (mass 4 amu). The kinetic energy of the alpha particle is found to be 6.7 MeV. The recoil energy of the daughter nucleus (in MeV) is

- (A) 0.125 (B) 1.25
(C) 12.5 (D) 0.0125
89. A radioactive sample S_1 having an activity of $5 \mu\text{Ci}$ has twice the number of nuclei as another sample S_2 which has an activity of $10 \mu\text{Ci}$. The half lives of S_1 and S_2 can be
(A) 20 years and 5 years, respectively
(B) 20 years and 10 years, respectively
(C) 10 years each
(D) 5 years each
90. The masses of two radioactive substances A and B are same and their half-lives are 1 year and 2 year respectively. The ratio of their activities after six year will be
(A) 1:4 (B) 4:1
(C) 1:8 (D) 8:1
91. In the options given below, let E denote the rest mass energy of a nucleus and n a neutron. The correct option is
(A) $E(^{236}_{92}\text{U}) > E(^{137}_{53}\text{I}) + E(^{97}_{39}\text{Y}) + 2E(n)$
(B) $E(^{236}_{92}\text{U}) < E(^{137}_{53}\text{I}) + E(^{97}_{39}\text{Y}) + 2E(n)$
(C) $E(^{236}_{92}\text{U}) < E(^{140}_{56}\text{Ba}) + E(^{94}_{36}\text{Kr}) + 2E(n)$
(D) $E(^{235}_{92}\text{U}) < E(^{140}_{56}\text{Ba}) + E(^{94}_{36}\text{Kr}) + E(n)$
92. A sample of radioactive material has mass m , decay constant λ , and molecular weight M . Avogadro constant N_A . The initial activity of the sample and activity at time t is
(A) $\lambda m, \lambda m e^{-\lambda t}$
(B) $\frac{\lambda m}{M}, \frac{\lambda m}{M} e^{-\frac{m}{M}t}$
(C) $\frac{\lambda m N_A}{M}, \left(\frac{\lambda m N_A}{M}\right) e^{-\lambda t}$
(D) $m N_A e^{\lambda}, m N_A e^{-\lambda t}$
93. Solar constant of the sun is $\sigma = 8.106 \times 10^4 \text{ J min}^{-1} \text{ m}^{-2}$ and average sun earth distance is $1.5 \times 10^8 \text{ km}$. The yearly loss in the mass of the sun is
(A) $13.8 \times 10^{17} \text{ kg}$ (B) $1.38 \times 10^{19} \text{ kg}$
(C) $1.38 \times 10^{17} \text{ kg}$ (D) $13.8 \times 10^{20} \text{ kg}$
94. Certain radioactive substance reduces to 25% of its value in 16 day. Its half-life is
(A) 32 day (B) 8 day
(C) 64 day (D) 28 day
95. A star initially has 10^{40} deuterons. It produces energy via the processes $^2_1\text{H} + ^2_1\text{H} \rightarrow ^3_1\text{H} + p$ and $^2_1\text{H} + ^3_1\text{H} \rightarrow ^4_2\text{He} + n$. Where the masses of the nuclei are:
 $m(^2\text{H}) = 2.014 \text{ amu}$, $m(p) = 1.007 \text{ amu}$, $m(n) = 1.008$ and $m(^4\text{He}) = 4.001 \text{ amu}$. If the average power radiated by the star is 10^{16} W , the deuteron supply of the star is exhausted in a time of the order of
(A) 10^6 s (B) 10^8 s
(C) 10^{12} s (D) 10^{16} s
96. The half life period of a radioactive substance is 140 day. After how much time, 15 g will decay from a 16 g sample of the substance?
(A) 140 day (B) 560 day
(C) 420 day (D) 280 day
97. Consider a nuclear decay process
 $A \longrightarrow B \longrightarrow C$ (stable)
At a certain time, the activity of nuclei A is x and the net rate of increase of number of nuclei B is y . The activity of nuclei B at this instant is
(A) y (B) $x - y$
(C) $y - x$ (D) x
98. The mean lives of a radioactive material for α and β radiations are 1620 year and 520 year respectively. The material decays simultaneously for α and β decay. The time after which one fourth of the material remains undecayed is
(A) 540 year (B) 324 year
(C) 720 year (D) 840 year
99. Packing fraction is given by the relation
(A) $\frac{A}{M-A}$ (B) $\frac{A-M}{A}$
(C) $\frac{M}{M-A}$ (D) $\frac{M-A}{A}$
100. Probability (P) that a radioactive nucleus will not decay in time t will be (given decay constant = λ)
(A) $e^{-\lambda t}$ (B) $1 - e^{-\lambda t}$
(C) $e^{\lambda t}$ (D) $1 - e^{\lambda t}$
101. In the following nuclear reaction, Y stands for
 $^{27}_{13}\text{Al} + ^4_2\text{He} \longrightarrow ^{30}_{15}\text{P} + Y$
(A) 1_0n (B) $^0_{-1}e$
(C) ^1_1H (D) $^0_{+1}e$

102. The ratio activity of an element decreases 64 times its original value in 60 sec. Then the half life of the element is
 (A) 5 sec (B) 10 sec
 (C) 20 sec (D) 30 sec
103. The half-life of a radioactive material is T . After $\frac{T}{2}$ time, the material left is
 (A) $\frac{1}{2}$ (B) $\frac{3}{4}$
 (C) $\frac{1}{\sqrt{2}}$ (D) $\frac{1}{4}$
104. Let T be the mean life of a radioactive sample. 75% of the active nuclei present in the sample initially will decay in time
 (A) $2T$ (B) $\frac{T}{2}\ln(2)$
 (C) $4T$ (D) $2T\ln(2)$
105. If 1 mg of U^{235} is completely annihilated, the energy liberated is
 (A) 9×10^{10} J (B) 9×10^{19} J
 (C) 9×10^{18} J (D) 9×10^{17} J
106. The count rate of activity of a radioactive sample of a very large population decreased from 1024 to 128 in 3 minutes. Then the rate of disintegration at the end of 5 minutes is
 (A) 96 (B) 64
 (C) 48 (D) 32
107. The fraction of the initial number of active nuclei which remains undecayed after half of a half-life of the radioactive sample is
 (A) $\frac{1}{4}$ (B) $\frac{1}{2\sqrt{2}}$
 (C) $\frac{1}{\sqrt{2}}$ (D) $\sqrt{2} - 1$
108. The binding energy per nucleon for deuteron (${}^2_1\text{H}$) and helium (${}^4_2\text{He}$) are 1.1 MeV and 7.0 MeV, respectively. The energy released when two deuterons fuse to form a helium nucleus is
 (A) 47.12 MeV (B) 23.6 MeV
 (C) 11.8 MeV (D) 34.4 MeV
109. The instantaneous concentration N , the initial concentration N_0 , the radioactive constant λ can be written as
 (A) $N = N_0 e^{\lambda t}$ (B) $N = N_0 e^{-\lambda t}$
 (C) $N = N_0 e^{-\lambda}$ (D) $N = N_0 e^{\lambda}$
110. A radioactive nucleus can decay by either emitting an α particle or by emitting a β particle. Probability of α decay is 75% while that of β decay is 25%. The decay constant of α decay is λ_1 and that of β decay is λ_2 . Then, $\frac{\lambda_1}{\lambda_2}$ is
 (A) 3 (B) $\frac{1}{3}$
 (C) 1 (D) 2
111. An element A decays into element C by a two step process given below.
 $A \rightarrow B + {}_2\text{He}^4$
 $B \rightarrow C + 2e^-$
 Then,
 (A) A and B are isotopes
 (B) A and B are isobars
 (C) A and C are isotopes
 (D) A and C are isobars
112. How many α particles are emitted in the decay
 ${}_{92}^{235}\text{X} \longrightarrow \text{Y}_{88}^{219}$
 (A) 4 (B) 5
 (C) 6 (D) no comments
113. The count rate observed from a radioactive source at t second was N_0 and at $4t$ second it was $\frac{N_0}{16}$. The count rate observed, at $\left(\frac{11}{2}\right)t$ second will be
 (A) $\frac{N_0}{128}$ (B) $\frac{N_0}{64}$
 (C) $\frac{N_0}{32}$ (D) None of these
114. The rate of disintegration of a radioactive substance falls from 800 decay/min to 100 decay/min in 6 hours. The half-life of the radioactive substance is
 (A) $\frac{6}{7}$ hour (B) 2 hrs
 (C) 3 hrs (D) 1 hr
115. In the above decay, how many β particles are given out?
 (A) 4 (B) 5
 (C) 6 (D) no comments
116. ${}_{86}\text{A}^{222} \rightarrow {}_{84}\text{B}^{210}$. In this reaction how many α and β particles are emitted
 (A) $6\alpha, 3\beta$ (B) $3\alpha, 4\beta$
 (C) $4\alpha, 3\beta$ (D) $3\alpha, 6\beta$

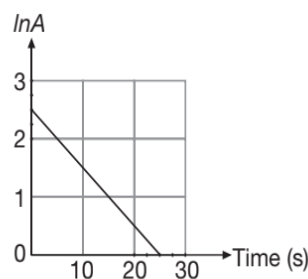
117. If N_0 is the original amount of the substance of half-life period $t_{1/2} = 5$ year, then the amount of substance decayed after 15 year is
- (A) $\frac{N_0}{8}$ (B) $\frac{N_0}{16}$
 (C) $\frac{7N_0}{8}$ (D) $\frac{N_0}{4}$
118. Nuclei of radioactive element A are produced at a rate t^2 at any time t . The element A has decay constant λ . Let N be the number of nuclei of element A at any time t . At time $t = t_0$, $\frac{dN}{dt}$ is minimum. Then the number of nuclei of element A at time $t = t_0$ is
- (A) $\frac{2t_0 - \lambda t_0^2}{\lambda^2}$ (B) $\frac{t_0 - 2t_0^2}{\lambda^2}$
 (C) $\frac{2t_0 - \lambda t_0^2}{\lambda}$ (D) $\frac{t_0 - \lambda t_0^2}{\lambda}$
119. A certain radioactive substance has half-life of 5 year. For a nucleus in a sample of the radioactive substance, the probability of decay in ten year is
- (A) 50% (B) 75%
 (C) 100% (D) 60%
120. Two identical samples (same material and same amount) P and Q of a radioactive substance having mean life T are observed to have activities A_P and A_Q respectively at the time of observation. If P is older than Q , then the difference in their age is
- (A) $T \ln\left(\frac{A_P}{A_Q}\right)$ (B) $T \ln\left(\frac{A_Q}{A_P}\right)$
 (C) $T\left(\frac{A_P}{A_Q}\right)$ (D) $T\left(\frac{A_Q}{A_P}\right)$
121. The radius R of a nucleus changes with the nucleon number A of nucleus as
- (A) $R \propto A^{\frac{2}{3}}$ (B) $R \propto A^{\frac{1}{3}}$
 (C) $R \propto A^0$ (D) $R \propto A$
122. The activity of a radioactive sample A_0 decreases to one third of the original value in 9 years. Its activity 9 years further, will be
- (A) $\frac{A_0}{3}$ (B) $\frac{A_0}{6}$
 (C) $\frac{A_0}{9}$ (D) $\frac{A_0}{18}$
123. Sun radiates energy in all direction. The average energy received at earth is 1.4 kWm^{-2} . The average distance between the earth and the sun is 1.5×10^{11} m. If this energy is released by conservation of mass into energy, then the mass lost per day by the sun is approximately
- (A) 4.4×10^9 kg (B) 7.6×10^{14} kg
 (C) 3.8×10^{12} kg (D) 3.8×10^{14} kg
124. The net force between two nucleons 1 fm apart is F_1 if both are protons, F_2 if both are neutrons, and F_3 if one is a neutron and the other is a proton.
- (A) $F_1 < F_2 < F_3$ (B) $F_2 < F_1 < F_3$
 (C) $F_1 < F_2 = F_3$ (D) $F_1 = F_2 < F_3$
125. In a radioactive decay, let N represent the number of residual active nuclei, D the number of daughter nuclei, and R the rate of decay at any time t . Three curves are shown in figure. The correct ones are



- (A) 1 and 3 (B) 2 and 3
 (C) 1 and 2 (D) all are correct

126. A and B are two radioactive substances whose half lives are 1 year and 2 year respectively. Initially 10 g of A and 1 g of B is taken. The time (approximate) after which they will have same quantity remaining is
- (A) 6.62 year (B) 5 year
 (C) 3.2 year (D) 7 year
127. The half life of the radioactive substance is 40 days. The substance will disintegrate completely in
- (A) 40 days (B) 400 days
 (C) 4000 days (D) infinite time

128. The graph shows the variation of the count rate A of a radioactive source with time t .





If $\ln(12) = 2.5$, then A as a function of t is given by

- (A) $A = 2.5e^{-10t}$ (B) $A = 12e^{10t}$
 (C) $A = 2.5e^{-0.1t}$ (D) $A = 12e^{-0.1t}$

129. A radioactive nuclide is produced at the constant rate of n per second (say, by bombarding a target with neutrons). The expected number N of nuclei in existence t seconds after the number is N_0 is given by

- (A) $N = N_0e^{-\lambda t}$
 (B) $N = \frac{n}{\lambda} + N_0e^{-\lambda t}$
 (C) $N = \frac{n}{\lambda} + \left(N_0 - \frac{n}{\lambda}\right)e^{-\lambda t}$
 (D) $N = \frac{n}{\lambda} + \left(N_0 + \frac{n}{\lambda}\right)e^{-\lambda t}$

(where λ is the decay constant of the sample)

130. A radioactive substance contains 10000 nuclei and its half-life period is 20 day. The number of nuclei present at the end of 10 day is

- (A) 7070 (B) 9000
 (C) 8000 (D) 7500

131. A stationary nucleus of mass 24 amu emits a gamma photon. The energy of the emitted photon is 7 MeV. The recoil energy of the nucleus is

- (A) 2.2 keV (B) 1.1 keV
 (C) 3.1 keV (D) 22 keV

132. In any fission process the ratio $\frac{\text{mass of fission products}}{\text{mass of parent nucleus}}$ is

- (A) Less than 1
 (B) Greater than 1
 (C) Equal to 1
 (D) Depends on the mass of the parent nucleus

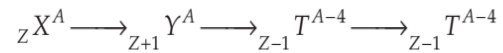
133. Two radioactive samples of different elements (half lives t_1 and t_2 respectively) have same number of nuclei at $t = 0$. The time after which their activities are same is

- (A) $\frac{t_1 t_2}{0.693(t_2 - t_1)} \ln\left(\frac{t_2}{t_1}\right)$ (B) $\frac{t_1 t_2}{0.693} \ln\left(\frac{t_2}{t_1}\right)$
 (C) $\frac{t_1 t_2}{0.693(t_1 + t_2)} \ln\left(\frac{t_2}{t_1}\right)$ (D) None of these

134. The radioactivity of a sample is R_1 at time t_1 and R_2 at time t_2 . If the half life of the sample be T , the number of atoms that have disintegrated in time $(t_2 - t_1)$ is proportional to

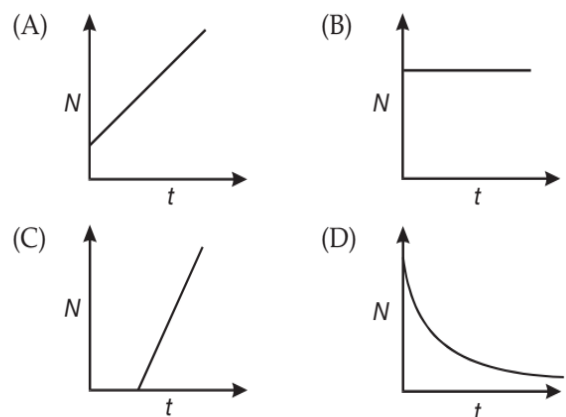
- (A) $R_1 t_1 - R_2 t_2$ (B) $(R_1 - R_2)^{-1}$
 (C) $\frac{(R_1 - R_2)}{T}$ (D) $(R_1 - R_2)T$

135. In the given reaction, the radioactive radiations are emitted in the sequence as



- (A) α, β, γ (B) β, α, γ
 (C) γ, α, β (D) α, γ, β

136. The graph between the instantaneous concentration (N) of a radioactive element and time (t) is



137. A radioactive nuclide can decay simultaneously by two different processes which have individual decay constants λ_1 and λ_2 respectively. The effective decay constant of the nuclide is λ given by

- (A) $\lambda = \sqrt{\lambda_1 \lambda_2}$ (B) $\frac{1}{\lambda} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$
 (C) $\lambda = \frac{1}{2}(\lambda_1 + \lambda_2)$ (D) $\lambda = \lambda_1 + \lambda_2$

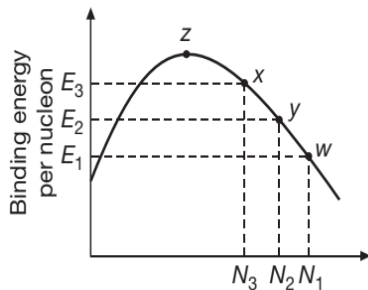
138. Masses of two isobars ${}^{64}_{29}\text{Cu}$ and ${}^{64}_{30}\text{Zn}$ are 63.9298 u and 63.9292 u respectively. It can be concluded from this data that

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

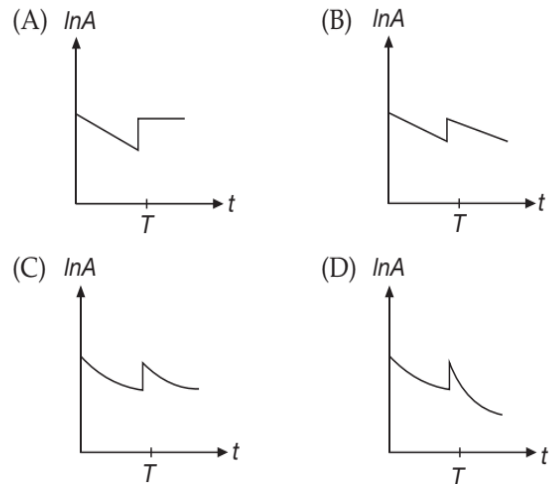
139. A fraction f_1 of a radioactive sample decays in one half life, and a fraction f_2 decays in one mean life.

- (A) $f_1 > f_2$
 (B) $f_1 < f_2$
 (C) $f_1 = f_2$
 (D) Data insufficient to arrive at a conclusion

140. The half life of ^{131}I is 8 days. Given a sample of ^{131}I at time $t = 0$. We can assert that
- no nucleus will decay before $t = 4$ days
 - no nucleus will decay before $t = 8$ days
 - all nuclei will decay before $t = 16$ days
 - a given nucleus may decay at any time after $t = 0$
141. In the process of fission, the binding energy per nucleon
- increases
 - decreases
 - remains unchanged
 - increases for mass number $A < 56$ nuclei but decreases for mass number $A > 56$ nuclei
142. Consider the nuclear fission reaction $W \rightarrow X + Y$. What is the Q value (energy released) of the reaction?



- $E_1N_1 - (E_2N_2 + E_3N_3)$
 - $(E_2N_2 + E_3N_3 - E_1N_1)$
 - $E_2N_2 + E_1N_1 - E_3N_3$
 - $E_1N_1 + E_3N_3 - E_2N_2$
143. If the half life and the mean life of the radioactive element is denoted by t and T respectively then
- $t = T$
 - $t = \frac{1}{T}$
 - $t < T$
 - $t > T$
144. The radioactivity of a substance is measured in terms of disintegration per second. 3×10^{10} disintegration per second is
- 1 eV
 - 1 MeV
 - 1 rutherford
 - 1 curie
145. Half-life of a radioactive substance is 20 minutes. The time between 20% and 80% decay will be
- 40 minutes
 - 20 minutes
 - 25 minutes
 - 30 minutes
146. At time $t = 0$, some radioactive gas is injected into a sealed vessel. At time T , some more of the same gas is injected into the same vessel. Which one of the following graphs best represents the variation of the logarithm of the activity A of the gas with time t ?



147. If N_1 atoms of a radioactive element emit N_2 beta particles per second, then the decay constant of the element (in s^{-1}) is
- $\frac{N_2}{N_1}$
 - $\frac{N_1}{N_2}$
 - $N_2 \log_e(2)$
 - $N_1 \log_e(2)$
148. In the disintegration series
- $${}_{92}^{238}\text{U} \xrightarrow{\alpha} X \xrightarrow{\beta^-} {}_Z^A\text{Y}$$
- The respective values of Z and A are
- 92, 236
 - 88, 230
 - 90, 234
 - 91, 234
149. Radioactivity is not influenced by
- pressure
 - electronic configuration
 - temperature
 - all of these
150. A radioactive material has a mean lives of 1620 year and 660 year for α and β emission respectively. The material decay by simultaneous α and β emission. The time in which one fourth of the material remains intact is
- 4675 year
 - 720 year
 - 650 year
 - 324 year
151. The binding energies of nuclei X and Y are E_1 and E_2 respectively. Two atoms of X fuse to give one atom of Y and an energy Q is released. Then
- $Q > E_2 - 2E_1$
 - $Q < 2E_1 - E_2$
 - $Q = E_2 - 2E_1$
 - $Q = 2E_1 - E_2$
152. Free ^{238}U nuclei kept in a train emit alpha particles. When the train is stationary and a uranium nucleus decays, a passenger measures that the separation between the alpha particle and the recoiling nucleus



becomes x in time t after the decay. If a decay takes place when the train is moving at a uniform speed v , the distance between the alpha particle and the recoiling nucleus at a time t after the decay, as measured by the passenger will be

- (A) $x + vt$
 (B) $x - vt$
 (C) x
 (D) Depends on the direction of the train

153. A radioactive nucleus is being produced at a constant rate α per second. Its decay constant is λ . If N_0 are the number of nuclei at time $t = 0$, then maximum number of nuclei possible are

- (A) $\frac{\alpha}{\lambda}$ (B) $N_0 + \frac{\alpha}{\lambda}$
 (C) N_0 (D) $\frac{\lambda}{\alpha} + N_0$

154. A radioactive isotope A decays into another isotope B which has a half-life equal to half the half-life of A . Both isotopes emit α -particles during their decay B decays into a stable nucleus. If a sample consists initially of atoms of A only, then the net activity of the sample initially

- (A) decreases with time
 (B) increases with time
 (C) remains constant
 (D) any of the above may be true

155. The probability of survival of a radioactive nucleus for one mean life is

- (A) $1 - \frac{1}{e}$ (B) $\frac{1}{e}$
 (C) $\frac{\log_e(2)}{e}$ (D) $1 - \frac{\log_e(2)}{e}$

156. The binding energy per nucleon of ${}_1\text{H}^2$ and ${}_2\text{He}^4$ are 1.1 eV and 7 MeV respectively. The energy released in the process ${}_1\text{H}^2 + {}_1\text{H}^2 = {}_2\text{He}^4$ is

- (A) 20.8 MeV (B) 16.6 MeV
 (C) 25.2 MeV (D) 23.6 MeV

157. There are two radioactive substances A and B such that decay constant of B is twice that of A . Initially both have equal number of nuclei. After n half lives of A , the rate of disintegration of both are equal. The value of n is

- (A) 16 (B) 4
 (C) 2 (D) 1

158. Suppose a radioactive substance disintegrates completely in 10 days. Each day it disintegrates at a rate which is twice the rate of the previous day. The

percentage of the material left to be disintegrated after passing of 9 days is

- (A) 10 (B) 20
 (C) 25 (D) 50

159. Mirror nuclei are those in which the number of protons in the parent nuclei

- (A) is less than the daughter nuclei by one
 (B) is more than the daughter nuclei by two
 (C) equal to the neutron number
 (D) exceeds the number of neutrons in the daughter nuclei by unity by one positron emission

160. The decay of ${}_{92}^{238}\text{U}$ to ${}_{93}^{239}\text{Np}$ by β -emission is not possible because

- (A) β -decay only occurs in isotopes of low mass
 (B) ${}_{93}^{239}\text{Np}$ is not a stable isotope
 (C) mass number cannot increase in a decay process
 (D) atomic number cannot increase in a decay process.

161. Half life period and mean life time of a radioactive element are

- (A) inversely proportional to each other
 (B) directly proportional to each other
 (C) equal to each other
 (D) not related to each other

162. If P_α , P_β and P_γ be the penetrating powers of α , β and γ radiations respectively then

- (A) $P_\alpha = P_\beta = P_\gamma$ (B) $P_\alpha > P_\beta > P_\gamma$
 (C) $P_\alpha < P_\beta < P_\gamma$ (D) $P_\alpha = P_\beta < P_\gamma$

163. A radioactive nuclide emits an α , β and a γ ray in close succession, the atomic mass of the end product is reduced by

- (A) 8 a.m.u. (B) about 4 a.m.u.
 (C) 2 a.m.u. (D) 1 a.m.u.

164. The life time of a neutron is about 10^3 s and its rest energy is 940 MeV, then the mean free path of a 5 eV neutron in vacuum is closest to

- (A) 10 km (B) 100 km
 (C) 1000 km (D) 10000 km

165. A certain radioactive element disintegrates for an interval of time equal to its mean life. The fraction of the original amount that remains undecayed is

- (A) e (B) $\frac{1}{e}$
 (C) e^2 (D) $\frac{1}{e^2}$

166. If N denotes the concentration of a radioactive element, then the rate of change of concentration with time (t) can be written as

(A) $\frac{dN}{dt} \propto N$ (B) $-\frac{dN}{dt} \propto N$
 (C) $-\frac{dN}{dt} \propto e^N$ (D) $-\frac{dN}{dt} \propto e^{-N}$

167. In the sun about 4 billion kg of matter is converted to energy each second. The power output of the sun in watt is

(A) 3.6×10^{26} (B) 0.36×10^{26}
 (C) 36×10^{26} (D) 0.036×10^{26}

168. A radioactive isotope has a decay constant and a molar mass M . Taking the Avogadro constant to be L , what is the activity of a sample of mass m of this isotope?

(A) λmL (B) $\frac{\lambda mL}{M}$
 (C) $\frac{\lambda ML}{m}$ (D) $\frac{mL}{\lambda M}$

169. If 90% of a radioactive sample is left undecayed after time t has elapsed. The percentage of initial sample that will decay in a total time $2t$ is

(A) 20% (B) 19%
 (C) 40% (D) 38%

170. A nucleus with $Z = 92$ emits the following particles in a sequence given. $\alpha, \beta^-, \beta^-, \alpha, \alpha, \alpha, \alpha, \alpha, \beta^-, \beta^-, \alpha, \beta^+, \beta^+, \alpha$.

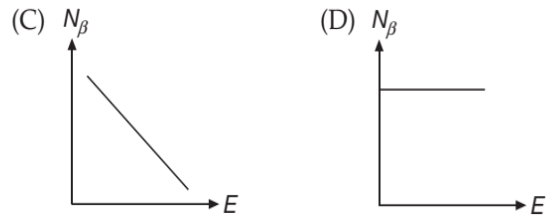
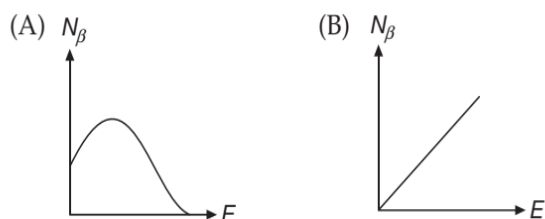
The Z of the resulting nucleus is

(A) 74 (B) 76
 (C) 78 (D) 82

171. A freshly prepared radioactive sample of half-life 1 hour emits radiations that are 128 times as intense as the permissible safe limit. The minimum time after which this sample can be safely used is

(A) 14 hours (B) 7 hours
 (C) 128 hours (D) 256 hours

172. The curve representing the energy spectrum of β -particles is



173. Consider the following reaction



If $m({}_1\text{H}^2) = 2.0141 \text{ u}$; $m({}_2\text{He}^4) = 4.0024 \text{ u}$.

The energy Q released (in MeV) in this fusion reaction is

(A) 12 (B) 6
 (C) 24 (D) 48

174. The equations $\frac{dN}{dt} = -\lambda N$ and $N = N_0 e^{-\lambda t}$ describes

how the number N of undecayed atoms in a sample of radioactive material, which initially (at $t = 0$) contained N_0 undecayed atoms, varies with time t . Which one of the following statements about is correct?

- (A) λdt gives the fraction of atoms present which will decay in the next small time interval dt
 (B) λ is the time needed for N to fall from N_0 to the value $\frac{N_0}{e}$.
 (C) λ is equal to the half-life of the sample.
 (D) λ is the number of atoms left after a time equal to e second.

175. A radioactive element X converts into another stable element Y . If half life of X is 2 hr, initially only X to be present and after time t , the ratio of atoms of X and Y is found to be 1:4, then time t in hr is

(A) 2 (B) 4
 (C) between 4 and 6 (D) 6

176. The fraction of atoms of radioactive element that decays in 6 day is $\frac{7}{8}$. The fraction that decays in 10 day will be

(A) $\frac{70}{80}$ (B) $\frac{77}{88}$
 (C) $\frac{31}{32}$ (D) $\frac{35}{36}$

177. The radioactive emissions which produce an isotope of the original nucleus are

(A) one alpha and four beta
 (B) one alpha and two beta



- (C) one alpha and one beta
(D) two alpha and one beta
178. When the nucleus of an atom absorbs one of the atom's orbital electrons, the process is known as K-capture. Which equation (in which X denotes the appropriate particle) represents this process
- (A) ${}_{26}^{55}\text{Fe} + {}_0^{-1}X \rightarrow {}_{25}^{55}\text{Mn}$
 (B) ${}_{28}^{63}\text{Ni} \rightarrow {}_{-1}^0X + {}_{29}^{63}\text{Cu}$
 (C) ${}_{5}^{10}\text{B} + {}_0^1X \rightarrow {}_3^7\text{U} + {}_2^4\text{He}$
 (D) ${}_{3}^7\text{Li} + {}_1^1X \rightarrow {}_4^8\text{Be}$
179. A radioactive nucleus A finally transforms into a stable nucleus B . Then A and B can be
- (A) isotones (B) isotopes
(C) isobars (D) None of these
180. In a sample of radioactive material, what percentage of the initial number of active nuclei will decay during one mean life?
- (A) 37% (B) 50%
(C) 63% (D) 69.3%
181. Number of nuclei of a radioactive substance at time $t = 0$ are 1000 and 900 at time $t = 2$ s. Then number of nuclei at time $t = 4$ s will be
- (A) 700 (B) 790
(C) 800 (D) 810
182. If ${}_{92}\text{U}^{238}$ changes to ${}_{85}\text{At}^{210}$ by a series of α and β decays, the number of α and β decays undergone is
- (A) 5 and 7 (B) 7 and 5
(C) 7 and 7 (D) 7 and 9

MULTIPLE CORRECT CHOICE TYPE QUESTIONS

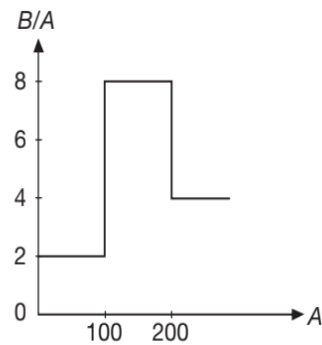
This section contains Multiple Correct Choice Type Questions. Each question has four choices (A), (B), (C) and (D), out of which ONE OR MORE is/are correct.

1. For a certain radioactive substance, it is observed that after 4 hours, only 6.25% of the original sample is left undecayed. It follows that
- (A) the half life of the sample is 1 hour
 (B) the mean life of the sample is $\frac{1}{\ln 2}$ hour
 (C) the decay constant of the sample is $\ln 2$ hour $^{-1}$
 (D) after a further 4 hours, the amount of the substance left over would be only 0.39% of the original amount
2. Energy released in Radioactive decay process $X \rightarrow Y + y$ is equal to
- (A) sum of rest energy of Y and y minus rest energy of X .
 (B) sum of binding energy of Y and y minus binding of X .
 (C) Rest energy of X minus sum of rest energy of Y and y
 (D) Binding energy of X minus sum of binding energy of Y and y
3. Which of the following statement(s) is correct?
- (A) The rest mass of a stable nucleus is less than that of constituent nucleons.
 (B) The rest mass of a stable nucleus is greater than the sum of the rest masses of its constituent nucleons.
 (C) In nuclear fusion, energy is released by fusing two nuclei of medium mass.
 (D) In nuclear fission, energy is released by fragmentation of a very heavy nucleus.
4. In radioactivity decay according to law $N = N_0 e^{-\lambda t}$ Which of the following is/are true?
- (A) Probability that a nucleus will decay is $1 - e^{-\lambda t}$
 (B) Probability that a nucleus will decay four half lives is $\frac{15}{16}$
 (C) Fraction nuclei that will remain after two half lives is zero
 (D) Fraction of nuclei that will remain after two half-lives is $\frac{1}{4}$
5. A nuclide A undergoes α decay and another nuclide B undergoes β^- decay. Select the correct statement(s).
- (A) All the α -particles emitted by A will have almost the same speed.
 (B) The α -particles emitted by A may have widely different speeds.
 (C) All the β -particles emitted by B will have almost the same speed.
 (D) The β -particles emitted by B may have widely different speeds.

6. Let m_p be the mass of a proton, m_n the mass of a neutron, M_1 the mass of a ${}^{20}_{10}\text{Ne}$ nucleus and M_2 the mass of a ${}^{40}_{20}\text{Ca}$ nucleus. Then,
- (A) $M_2 = 2M_1$ (B) $M_2 > 2M_1$
 (C) $M_2 < 2M_1$ (D) $M_1 < 10(m_n + m_p)$
7. Regarding a nucleus, select the correct option(s)
- (A) Density of a nucleus is directly proportional to mass number A
 (B) Density of all the nuclei is almost constant, of the order of 10^{17} kgm^{-3}
 (C) Nucleus radius of the order of 10^{-15} m
 (D) Nucleus radius $\propto A$
8. A radioactive sample has initial concentration N_0 of nuclei. Select the correct statement(s).
- (A) The number of undecayed nuclei present in the sample decays exponentially with time.
 (B) The activity (R) of the sample at any instant is directly proportional to the number of undecayed nuclei present in that sample at that time.
 (C) The number of decayed nuclei grows exponentially with time.
 (D) The number of decayed nuclei grows linearly with time.
9. A radioactive sample has initial concentration N_0 of nuclei.
- (A) The number of undecayed nuclei present in the sample decays exponentially with time.
 (B) The activity (R) of the sample at any instant is directly proportional to the number of undecayed nuclei present in the sample at that time.
 (C) The number of decayed nuclei grows linearly with time.
 (D) The number of decayed nuclei grows exponentially with time.
10. For nuclei having $A > 120$, select the correct statement(s)
- (A) The binding energy of nucleus decreases as A increases.
 (B) The binding energy per nucleon decreases as A increases.
 (C) If the nucleus breaks into two roughly equal parts, energy is released.
 (D) If two nuclei fuse to form a bigger nucleus energy is released.
11. Choose correct statement(s) from following
- (A) The binding energy per nucleon decreases as atomic number increases
 (B) Density of all nuclei is almost the same
 (C) Potential difference applied to an X-ray tube is of the order of hundred thousand volt
 (D) The ratio of square of velocity and radius $\left(\frac{v^2}{r}\right)$ of an orbiting electron in hydrogen atom is independent of principal quantum number (n)
12. When the nucleus of an electrically neutral atom undergoes a radioactive decay process it will remain neutral after the decay, if the process is
- (A) α -decay (B) β -decay
 (C) γ -decay (D) e^- capture process
13. In which of the following decays, the atomic number decreases.
- (A) α -decay (B) β^+ -decay
 (C) β^- -decay (D) γ -decay
14. Choose the correct options.
- (A) Isotopes have same number of atomic number
 (B) Isobars have same atomic weight
 (C) Isotones have same number of neutrons
 (D) In neutral isotope atoms number of electrons are same
15. Choose the correct options
- (A) By gamma radiations atomic number is not changed
 (B) By gamma radiations mass number is not changed
 (C) By the emission of one α and two β particles isotopes are produced
 (D) By the emission of one α and four β particles isobars are produced
16. A muonic hydrogen atom is a hydrogen atom with electron replaced by a muon whose mass is 212 times the mass of an electron, then
- (A) Bohr radius of the muonic atom is 250 fm
 (B) Ground state energy of muonic atom is 2883 eV
 (C) angular momentum in ground state is $\frac{h}{2\pi}$
 (D) angular momentum in ground state is $\frac{106h}{\pi}$
17. Which of the following are correct?
- (A) A neutron can be decayed into a proton only inside a nucleus
 (B) A proton can be changed into a neutron only inside a nucleus
 (C) An isolated neutron can be changed into a proton
 (D) An isolated proton can be changed into a neutron
18. At $t = 0$, number of radioactive nuclei of a radioactive substance are x and its radioactivity is y . Half-life of radioactive substance is T . Then



- (A) $\frac{x}{y}$ is constant throughout
 (B) $\frac{x}{y} > T$
 (C) value of xy remains half after one half-life
 (D) value of xy remains one fourth after one half-life
19. A nitrogen nucleus ${}^{14}_7\text{N}$ absorbs a neutron and can transform into lithium nucleus ${}^7_3\text{Li}$ under suitable conditions, after emitting
 (A) 4 protons and 4 neutrons
 (B) 5 protons and 1 beta minus particles
 (C) 2 alpha and 2 gamma particles
 (D) 1 alpha particle, 4 protons and 2 beta minus particles.
20. Magnetic field does cause deflection for
 (A) α -particles (B) β^+ -rays
 (C) β^- -rays (D) γ -rays
21. Polonium ${}_{84}\text{Po}^{210}$ emits α -particles and is converted into ${}_{82}\text{Pb}^{206}$. This reaction is used for producing electric power in a space mission. Po^{210} has half life of 138.6 days. Assuming an efficiency of 10%. Select the correct statement(s)
 Given: $M(\text{Po}^{210}) = 209.98264 \text{ amu}$; $M(\alpha) = 4.0026 \text{ amu}$
 $M(\text{Pb}^{206}) = 205.97440 \text{ amu}$; $1 \text{ amu} = 931 \text{ MeV energy}$
 (A) 10 g Po^{210} is required to produce 1.2×10^7 Joule energy
 (B) Decay constant of Po^{210} is 0.005 day^{-1}
 (C) Q -value of α -decay process is $8.4 \times 10^{-13} \text{ J}$
 (D) None of these is correct
22. Select the incorrect statement(s)
 (A) Density of nucleus increases as mass number increases.
 (B) Cadmium rods are used to slow down fast moving neutrons in a nuclear reactor.
 (C) It is easier to remove an orbital electron but quite difficult to release a nucleon.
 (D) Fragments produced in fission of ${}^{235}\text{U}$ are radioactive.
23. In the beta decay process ${}^A_Z\text{X} \rightarrow {}^A_{Z+1}\text{Y} + e^-$
 (A) total energy is conserved
 (B) mass number is conserved
 (C) charge is conserved
 (D) spin angular momentum is conserved
24. Regarding the nuclear forces, select the correct option(s)
 (A) They are short range forces
 (B) They are charge independent forces
 (C) They are not electromagnetic forces
 (D) They are exchange forces
25. In an endoergic nuclear reaction, an incoming particle collides with stationary nucleus. Then the
 (A) kinetic energy of incoming particle is greater than Q -value of reaction in ground frame
 (B) kinetic energy of incoming particle is equal to the Q -value of reaction in centre of mass frame
 (C) linear momentum of particle-nucleus system is conserved
 (D) energy is released in the process
26. Assume that the nuclear binding energy per nucleon $\left(\frac{B}{A}\right)$ versus mass number (A) is as shown in the figure. Use this plot to choose the correct choice(s) given below.



- (A) Fusion of two nuclei with mass numbers lying in the range of $1 < A < 50$ will release energy.
 (B) Fusion of two nuclei with mass numbers lying in the range of $51 < A < 100$ will release energy.
 (C) Fission of a nucleus lying in the mass range of $100 < A < 200$ will release energy when broken into two equal fragments.
 (D) Fission of a nucleus lying in the mass range of $200 < A < 260$ will release energy when broken into two equal fragments.
27. Two radioactive substances have half lives T and $2T$. Initially they have equal number of nuclei. After time $t = 4T$, the ratio of their number of nuclei is x and the ratio of their activity is y . Then
 (A) $x = \frac{1}{8}$ (B) $x = \frac{1}{4}$
 (C) $y = \frac{1}{2}$ (D) $y = \frac{1}{4}$

REASONING BASED QUESTIONS

This section contains Reasoning type questions, each having four choices (A), (B), (C) and (D) out of which ONLY ONE is correct. Each question contains STATEMENT 1 and STATEMENT 2. You have to mark your answer as

Bubble (A) If both statements are TRUE and STATEMENT 2 is the correct explanation of STATEMENT 1.

Bubble (B) If both statements are TRUE but STATEMENT 2 is not the correct explanation of STATEMENT 1.

Bubble (C) If STATEMENT 1 is TRUE and STATEMENT 2 is FALSE.

Bubble (D) If STATEMENT 1 is FALSE but STATEMENT 2 is TRUE.

- Statement-1:** 1 amu is equal to 931.5 MeV.

Statement-2: 1 amu is equal to $\frac{1}{12}$ th the mass of C^{12} atom.
- Statement-1:** The ionising power of β -particle is less compared α -particle but their penetrating power is more.

Statement-2: The mass of β -particles is less than the mass of α -particle.
- Statement-1:** After emission of one α -particle and two β -particles, atomic number remains unchanged

Statement-2: Mass number changes by four.
- Statement-1:** A certain radioactive substance has a half life period of 30 days. The disintegration constant is 0.0231 day^{-1} .

Statement-2: Decay constant varies inversely as half life.
- Statement-1:** Between α , β and γ radiations, penetrating power of γ -rays is maximum.

Statement-2: Ionising power of γ -rays is least.
- Statement-1:** γ -rays are produced by the transition of a nucleus from some higher energy state to some lower energy state.

Statement-2: Electromagnetic waves are always produced by the transition process.
- Statement-1:** In a nuclear process, energy is released if total binding energy of daughter nuclei is more than the total binding energy of parent nuclei.

Statement-2: If energy is released, then total mass of daughter nuclei is less than the total mass of parent nuclei.
- Statement-1:** During β -decay a proton converts into a neutron and an electron. No other particle is emitted.

Statement-2: During β -decay linear momentum of system should remain constant.
- Statement-1:** Binding energy per nucleon is of the order of MeV.

Statement-2: $1 \text{ MeV} = 1.6 \times 10^{-13} \text{ J}$
- Statement-1:** Half life of a certain radio-active element is 100 days. After 200 days fraction left undecayed will be 50%.

Statement-2: $\frac{N}{N_0} = \left(\frac{1}{2}\right)^{t/t_{1/2}}$, where symbols have usual meaning.
- Statement-1:** β -particles emitted from radioactive nuclei has continuous energy ranging from zero to a certain maximum value.

Statement-2: In β -decay a neutron is converted into a proton, an electron and an antineutrino. The total energy emitted in β -decay is shared by β -particle and antineutrino.
- Statement-1:** The nuclear energy can be obtained by the nuclear fission of heavier nuclei as well as by fusion of lighter nuclei.

Statement-2: The binding energy per nucleon with increases in mass number, first increases and then decreases.
- Statement-1:** γ -photons are emitted during annihilation process of electron and positron.

Statement-2: High energy photons are emitted due to conversion of mass into energy.
- Statement-1:** 25% of the radioactive nucleus remains active after 200 days for an element of half life 100 days.

Statement-2: $N = N_0 \left(\frac{1}{2}\right)^{\frac{t}{T}}$ where symbols have usual meaning.
- Statement-1:** Rate of radioactivity can not be increased or decreased by increasing or decreasing pressure or temperature.

Statement-2: Rate depends on number of nuclei present in the radioactive sample.
- Statement-1:** If binding energy per nucleon increases after a nuclear reaction then the reaction is exothermic.

Statement-2: If there is decrease in mass in nuclear reaction then the reaction is exothermic.



17. **Statement-1:** If we compare the stability of two nuclei, then that nucleus is more stable whose total binding energy is more.
Statement-2: More the mass defect during formation of a nucleus more will be the binding energy.
18. **Statement-1:** Radioactivity is independent of the physical and chemical conditions of substance.
Statement-2: Radioactivity is a property of the nucleus.
19. **Statement-1:** Only those nuclei which are heavier than lead are radioactive.
Statement-2: Nuclei of elements heavier than lead are unstable.

LINKED COMPREHENSION TYPE QUESTIONS

This section contains Linked Comprehension Type Questions or Paragraph based Questions. Each set consists of a Paragraph followed by questions. Each question has four choices (A), (B), (C) and (D), out of which only one is correct. (For the sake of competitiveness there may be a few questions that may have more than one correct options)

Comprehension 1

The nuclei of a radioactive element X are being produced at a constant rate α and this element decays to a stable nucleus Y with a decay constant λ and half-life $T_{1/2}$. At time $t = 0$, there are N_0 nuclei of the element X . Based on the information given, answer the following questions.

1. The number N_X of nuclei of X at time $t = T_{1/2}$ is

(A) $\frac{\alpha - \lambda N_0}{2\lambda}$ (B) $(2\lambda N_0 - \alpha)\frac{1}{\lambda}$
 (C) $\left(\lambda N_0 + \frac{\alpha}{2}\right)\frac{1}{\lambda}$ (D) $\frac{\alpha + \lambda N_0}{2\lambda}$

2. The number N_Y of nuclei of Y at time t is

(A) $\alpha t - \left(\frac{\alpha - \lambda N_0}{\lambda}\right)e^{-\lambda t} + \left(\frac{\alpha - \lambda N_0}{\lambda}\right)$
 (B) $\alpha t + \left(\frac{\alpha - \lambda N_0}{\lambda}\right)e^{-\lambda t} - \left(\frac{\alpha - \lambda N_0}{\lambda}\right)$
 (C) $\alpha t + \left(\frac{\alpha - \lambda N_0}{\lambda}\right)e^{-\lambda t}$
 (D) $\alpha t - \left(\frac{\alpha - \lambda N_0}{\lambda}\right)e^{-\lambda t}$

3. The number N_Y of nuclei of Y at $t = T_{1/2}$ is

(A) $\frac{\alpha}{\lambda} \log_e(2) + \frac{3}{2} \left(\frac{\alpha - \lambda N_0}{\lambda}\right)$
 (B) $\frac{\alpha}{\lambda} \log_e(2) + \frac{1}{2} \left(\frac{\alpha - \lambda N_0}{\lambda}\right)$
 (C) $\frac{\alpha}{\lambda} \log_e(2) - \frac{1}{2} \left(\frac{\alpha - \lambda N_0}{\lambda}\right)$
 (D) $\frac{\alpha}{\lambda} \log_e(2) - 2 \left(\frac{\alpha - \lambda N_0}{\lambda}\right)$

Comprehension 2

The mass of a nucleus ${}^A_Z X$ is less than the sum of the masses of $(A-Z)$ number of neutrons and Z number of protons in the nucleus. The energy equivalent to the corresponding mass difference is known as the binding energy of the nucleus. A heavy nucleus of mass M can break into two light nuclei of masses m_1 and m_2 only if $(m_1 + m_2) < M$. Also two light nuclei of masses m_3 and m_4 can undergo complete fusion and form a heavy nucleus of mass M' only if $(m_3 + m_4) > M'$. The masses of some neutral atoms are given in the table below

${}^1_1\text{H}$	1.007825 u	${}^2_1\text{H}$	2.014102 u
${}^6_3\text{Li}$	6.015123 u	${}^7_3\text{Li}$	7.016004 u
${}^{152}_{64}\text{Gd}$	151.919803 u	${}^{206}_{82}\text{Pb}$	205.974455 u
${}^3_1\text{H}$	3.016050 u	${}^4_2\text{He}$	4.002603 u
${}^{70}_{30}\text{Zn}$	69.925325 u	${}^{82}_{34}\text{Se}$	81.916709 u
${}^{209}_{83}\text{Bi}$	208.980388 u	${}^{210}_{84}\text{Po}$	209.982876 u

$$(1 \text{ u} = 932 \text{ MeVc}^{-2})$$

Based on above information, answer the following questions.

4. The correct statement is
 (A) The nucleus ${}^6_3\text{Li}$ can emit an alpha particle
 (B) The nucleus ${}^{210}_{84}\text{Po}$ can emit a proton

- (C) Deuteron and alpha particle can undergo complete fusion.
 (D) The nuclei ${}_{30}^{70}\text{Zn}$ and ${}_{34}^{82}\text{Se}$ can undergo complete fusion

5. The kinetic energy (in keV) of the alpha particle, when the nucleus ${}_{84}^{210}\text{Po}$ at rest undergoes alpha decay, is
 (A) 5319 (B) 5422
 (C) 5707 (D) 5818

Comprehension 3

A radionuclide with half life T is produced in a reactor at a constant rate P nuclei per second. During each decay, energy E_0 is released. If production of radionuclide is started at $t=0$. Based on above information, answer the following questions.

6. The number of nuclei in the radionuclide at any instant t is given by

(A) $N = \frac{PT}{\log_e 2} \left(1 - e^{-\frac{t \log_e 2}{T}} \right)$

(B) $N = PT \left(1 - e^{-\frac{t}{T}} \right)$

(C) $N = PT \log_e 2 \left(1 - e^{-\frac{t}{T \log_e 2}} \right)$

(D) $N = PT \left(1 - e^{-\frac{t}{2T}} \right)$

7. The rate of release of energy as a function of time is

(A) $\frac{PE_0}{\log_e 2} \left(1 - e^{-\frac{t \log_e 2}{T}} \right)$ (B) $PE_0 \left(1 - e^{-\frac{t \log_e 2}{T}} \right)$

(C) $PE_0 \log_e 2 \left(1 - e^{-\frac{t \log_e 2}{T}} \right)$ (D) $PE_0 \left(1 - e^{-\frac{t}{2T}} \right)$

8. Total energy released upto time t is

(A) $PtE_0 - \frac{PTE_0}{\log_e 2} \left(1 - e^{-\frac{t \log_e 2}{T}} \right)$

(B) $PtE_0 - PTE_0 \left(1 - e^{-\frac{t \log_e 2}{T}} \right)$

(C) $PtE_0 - PTE_0 \log_e 2 \left(1 - e^{-\frac{t \log_e 2}{T}} \right)$

- (D) None of these

Comprehension 4

Two radioactive nuclei A and B , both convert into a stable nucleus C . The nucleus A converts into C after emitting two α -particles and three β -particles, the nucleus B converts into C after emitting one α -particle and five

β -particles. A time $t = 0$, nuclei of A are $4N_0$ and that of B are N_0 . The half-life of A for converting to C is 1 min and that of B is 2 min. Initially number of nuclei of C are zero. Based on above information, answer the following questions.

9. If atomic numbers and mass numbers of A and B are Z_1, Z_2, A_1 and A_2 respectively, then

(A) $Z_1 - Z_2 = 6$

(B) $A_1 - A_2 = 4$

(C) Both (A) and (B) are correct

(D) Both (A) and (B) are wrong

10. The number of nuclei of C , when number of nuclei of A and B are equal is

(A) $2N_0$ (B) $3N_0$

(C) $\frac{9N_0}{2}$ (D) $\frac{5N_0}{2}$

11. The rate of disintegrations of A and B are equal at time t_0 (in minute), then

(A) $t_0 = 4$

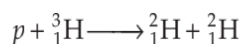
(B) $t_0 = 6$

(C) $t_0 = 8$

(D) $t_0 = 2$

Comprehension 5

Nuclear reactions are performed for artificial transmutation of elements for there are two types of nuclear reactions, exoergic and endoergic. In exoergic reactions energy is released. In endoergic reactions energy has to supplied for the reaction proceed. In exoergic reactions nuclear energy is converted into kinetic energy. In endoergic reactions, energy input is required in the form of kinetic energy to be converted into nuclear binding energy. The minimum energy required for the reaction to take place is called threshold energy. Consider the reaction given by



Given that the atomic masses are

$$m({}_1^1\text{H-atom}) = 1.007825 \text{ amu } (u)$$

$$m({}_1^3\text{H-atom}) = 3.016049 \text{ amu } (u)$$

$$m({}_1^2\text{H-atom}) = 2.014102 \text{ amu } (u)$$

Based on above information, answer the following questions.

12. Protons are incident on ${}^3_1\text{H}$ at rest. The threshold energy for the reaction is

(A) 5.4 MeV

(B) 10 MeV

(C) 2 MeV

(D) 8 MeV

13. When ${}^3_1\text{H}$ are incident on protons, then threshold energy is
 (A) 10 MeV (B) 8 MeV
 (C) 16 MeV (D) 20 MeV
14. Which of the following statement is correct?
 (A) Less energy is required for nuclear reaction if light part is at rest and heavy particle is incident
 (B) More energy is required for nuclear reaction when heavy particle is incident and light particle is at rest
 (C) Threshold energy does not depend on which particle is at rest
 (D) Threshold energy does not depend on Q-value of reaction

Comprehension 6

All nuclei consist of two type of particles i.e., protons and neutrons. Nuclear force is the strongest force and the stability of nucleus is determined by the neutron-proton ratio or mass defect or Binding energy per nucleons or packing fraction. The shape of nucleus is calculated by quadrupole moment. The spin of nucleus depends on even or odd mass number. The volume of nucleus depends on the mass number. The whole mass of atom (nearly 99%) is centred at the nucleus and the magnetic moment of nucleus is measured in terms of the nuclear magnetons. Based on above information, answer the following questions.

15. The correct statement(s) about nuclear force is/are
 (A) charge dependent
 (B) short ranges forces
 (C) non conservative force
 (D) spin dependent force
16. Binding energy per nucleon is maximum
 (A) for lighter order element (low mass number)
 (B) for heavier order element (high mass number)
 (C) for middle order element
 (D) equal for all order elements
17. Volume (V) of the nucleus is related with mass number (A) as
 (A) $V \propto A^2$ (B) $V \propto A^{\frac{1}{3}}$
 (C) $V \propto A^{\frac{2}{3}}$ (D) $V \propto A$

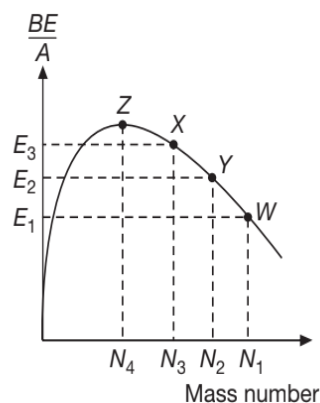
Comprehension 7

The atomic masses of the hydrogen isotopes are given for reference. The mass of hydrogen ${}^1_1\text{H}^1$ is 1.007825 amu, deuterium ${}^2_1\text{H}^2$ is 2.014102 amu and tritium ${}^3_1\text{H}^3$ is 3.016049 amu. Based on the information provided, answer the following questions.

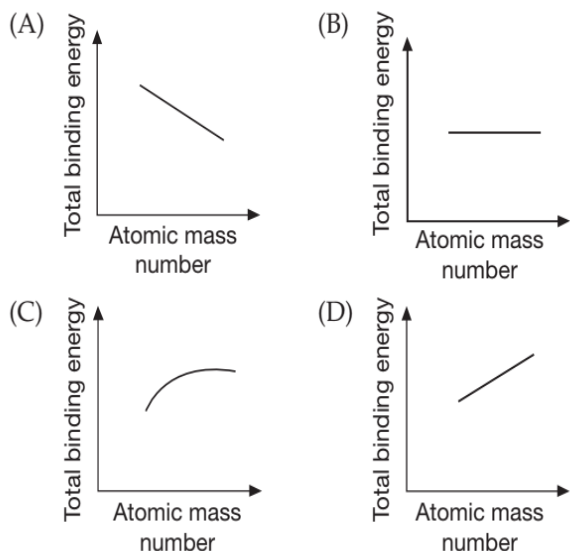
18. The energy released in the reaction
 ${}_1\text{H}^2 + {}_1\text{H}^2 \longrightarrow {}_1\text{H}^3 + {}_1\text{H}^1$ is nearly
 (A) 1 MeV (B) 2 MeV
 (C) 4 MeV (D) 8 MeV
19. The number of fusion reactions required to generate 1 kWh is nearly
 (A) 10^8 (B) 10^{18}
 (C) 10^{28} (D) 10^{38}
20. The mass of deuterium ${}_1\text{H}^2$ that would be required to generate 1 kWh is
 (A) 3.7 kg (B) 3.7 g
 (C) 3.7×10^{-5} kg (D) 3.7×10^{-8} kg

Comprehension 8

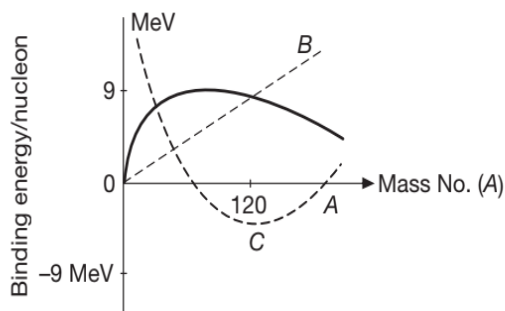
Consider the nuclear fission reaction $W \rightarrow X + Y$. Based on the graph given showing binding energy per nucleon vs number of nucleons, answer the following.



21. The Q value of the reaction is
 (A) $E_1N_1 - (E_2N_2 + E_3N_3)$
 (B) $(E_2N_2 + E_3N_3 - E_1N_1)$
 (C) $E_2N_2 + E_1N_1 - E_3N_3$
 (D) $E_1N_1 + E_3N_3 - E_2N_2$
22. If M_W is the mass of W, M_X is mass of X and M_Y is mass of Y nucleus, choose the correct statement.
 (A) $\frac{M_W}{N_1} > \frac{M_Y}{N_2} > \frac{M_X}{N_3}$ (B) $\frac{M_W}{N_1} < \frac{M_Y}{N_2} < \frac{M_X}{N_3}$
 (C) $\frac{M_W}{N_1} < \frac{M_Y}{N_2} > \frac{M_X}{N_3}$ (D) $\frac{M_W}{N_1} > \frac{M_Y}{N_2} < \frac{M_X}{N_3}$
23. The graph representing the relationship between atomic mass number A and the total binding energy (BE) of the nucleus, for nuclei heavier than Z is



24. When a slow neutron is captured by a U^{235} nucleus, a fission results which releases 200 MeV of energy. If the output of a nuclear reactor is 1.6 MW, the rate of nuclei (per sec) undergoing fission is
- (A) 8×10^{-3} (B) 1×10^{13}
 (C) 1×10^{25} (D) 5×10^{16}
25. The binding energy per nucleon versus mass number is best represented by the curve



- (A) A (B) B
 (C) C (D) None of these

Comprehension 9

In a nuclear fusion reactor, the reaction occurs in two stages.

Stage-I: Two deuterium (${}_1D^2$) nuclei fuse to form a tritium (${}_1T^3$) nucleus with a proton as a by-product. The reaction may be represented as $D(D, p)T$.

Stage-II: A tritium nucleus fuses with another deuterium nucleus to form a helium (${}_2He^4$) nucleus with a neutron as a by product. The reaction is represented as $T(D, n)\alpha$.

Given that $m({}_1D^2) = 2.014102 \text{ u (atom)}$

$$m({}_1T^3) = 3.016049 \text{ u (atom)}$$

$$m({}_2He^4) = 4.002603 \text{ u (atom)}$$

$$m({}_1H^1) = 1.007825 \text{ u (atom)}$$

$$m({}_0n^1) = 1.008665 \text{ u}$$

Based on above information, answer the following questions.

26. The energy released in the Stage-II of fusion reaction, is
- (A) 4.033 MeV (B) 17.587 MeV
 (C) 40.33 MeV (D) 1.7587 MeV
27. The energy released in the combined reaction per deuterium, is given by
- (A) 4.207 MeV (B) 5.207 MeV
 (C) 6.207 MeV (D) 7.207 MeV
28. The percentage of the mass energy of the initial deuterium is released is
- (A) 0.184% (B) 0.284%
 (C) 0.384% (D) 0.484%

Comprehension 10

Many unstable nuclei can decay spontaneously to a nucleus of lower mass but different combination of nucleons. The process of spontaneous emission of radiation is called Radioactivity in which the decay rate is actually exponentially decrease with time. Also, radioactive decay is a statistical process which is independent of all external conditions. Based on above information, answer the following questions.

29. If T_H is the half life and T_M is the mean life, which of the following statements is correct?
- (A) $T_M > T_H$ (B) Both are equal
 (C) $T_M < T_H$ (D) Nothing can be said
30. If n is the number of α -particles being emitted per second by N atoms of a radioactive element, then half life of element, in second, will be
- (A) $\frac{n}{N} \text{ s}$ (B) $\frac{N}{n} \text{ s}$
 (C) $\frac{0.693}{n} \text{ s}$ (D) $\frac{0.693n}{N} \text{ s}$
31. The activity of radioactive substance of decay constant λ is R_1 at time t_1 and R_2 at time $t_2 (> t_1)$, then
- (A) $R_1 t_1 = R_2 t_2$ (B) $\frac{R_1 - R_2}{t_2 - t_1} = \text{constant}$
 (C) $R_2 = R_1 e^{-\lambda(t_2 - t_1)}$ (D) $R_1 t_2 = R_2 t_1$

Comprehension 11

A radioactive sample has mass m , decay constant λ and molecular weight M . If Avogadro number is N_A then answer the following questions.

32. The initial number of nuclei present is
- (A) $\frac{m}{N_A}$ (B) $\frac{M}{m}N_A$
 (C) $\frac{m}{M}N_A$ (D) MN_A
33. The number of decayed nuclei after time t is
- (A) $\frac{m}{M}N_A e^{-\lambda t}$ (B) $\frac{m}{M}e^{-\lambda t}$
 (C) $\frac{m}{M}N_A(1 - e^{-\lambda t})$ (D) $\frac{m}{M}(1 - e^{-\lambda t})$
34. The activity of sample after time t is
- (A) $\left(\frac{mN_A\lambda}{M}\right)e^{-\lambda t}$ (B) $\frac{m}{M}N_A\lambda(1 - e^{-\lambda t})$
 (C) $\frac{M}{m}N_A\lambda e^{-\lambda t}$ (D) None of these

Comprehension 12

Scientists are working hard to develop nuclear fusion reactor. Nuclei of heavy hydrogen, ${}^2_1\text{H}$ known as deuteron and denoted by D can be thought of as a candidate for fusion reactor. The D-D reaction is ${}^2_1\text{H} + {}^2_1\text{H} \longrightarrow {}^3_2\text{He} + n + \text{energy}$. In the core of fusion reactor, a gas of heavy hydrogen is fully ionized into deuteron nuclei and electrons. This collection of ${}^4_1\text{H}$ nuclei and electrons is known as plasma. The nuclei move randomly in the reactor core and occasionally come close enough for nuclear fusion to take place. Usually, the temperatures in the reactor core are too high and no material wall can be used to confine the plasma. Special techniques are used which confine the plasma for a time t_0 before the particles fly away from the core. If n is the density (number/volume) of deuterons, the product nt_0 is called Lawson number. In one of the criteria, a reactor is termed

successful if Lawson number is greater than $5 \times 10^{14} \text{ scm}^{-3}$. It may be helpful to use the following: Boltzmann constant $k = 8.6 \times 10^{-5} \text{ eVK}^{-1}$; $\frac{e^2}{4\pi\epsilon_0} = 1.44 \times 10^{-9} \text{ eVm}$. Based on above information, answer the following questions.

35. In the core of nuclear fusion reactor, the gas becomes plasma because of
- (A) strong nuclear force acting between the deuterons
 (B) Coulomb force acting between the deuterons
 (C) Coulomb force acting between deuteron-electron pairs
 (D) the high temperature maintained inside the reactor core
36. Assume that two deuteron nuclei in the core of fusion reactor at temperature T are moving towards each other, each with kinetic energy 1.5 kT , when the separation between them is large enough to neglect Coulomb potential energy. Also neglect any interaction from other particles in the core. The minimum temperature T required for them to reach a separation of $4 \times 10^{-15} \text{ m}$ is in the range
- (A) $1 \times 10^9 \text{ K} < T < 2 \times 10^9 \text{ K}$
 (B) $2 \times 10^9 \text{ K} < T < 3 \times 10^9 \text{ K}$
 (C) $3 \times 10^9 \text{ K} < T < 4 \times 10^9 \text{ K}$
 (D) $4 \times 10^9 \text{ K} < T < 5 \times 10^9 \text{ K}$
37. Results of calculations for four different designs of a fusion reactor using D-D reaction are given below. Which of these is most promising based on Lawson criterion?
- (A) Deuteron density $= 2 \times 10^{12} \text{ cm}^{-3}$, confinement time $= 5 \times 10^{-3} \text{ s}$
 (B) Deuteron density $= 8 \times 10^{14} \text{ cm}^{-3}$, confinement time $= 9 \times 10^{-1} \text{ s}$
 (C) Deuteron density $= 4 \times 10^{23} \text{ cm}^{-3}$, confinement time $= 1 \times 10^{-11} \text{ s}$
 (D) Deuteron density $= 1 \times 10^{24} \text{ cm}^{-3}$, confinement time $= 4 \times 10^{-12} \text{ s}$

MATRIX MATCH/COLUMN MATCH TYPE QUESTIONS

Each question in this section contains statements given in two columns, which have to be matched. The statements in COLUMN-I are labelled A, B, C and D, while the statements in COLUMN-II are labelled p, q, r, s (and t). Any given statement in COLUMN-I can have correct matching with **ONE OR MORE** statement(s) in COLUMN-II. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following examples:

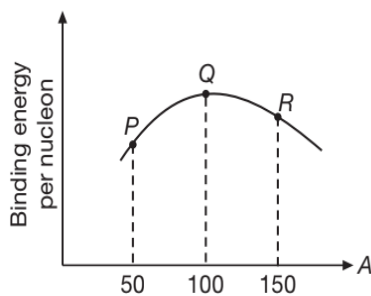
If the correct matches are $A \rightarrow p, s$ and t ; $B \rightarrow q$ and r ; $C \rightarrow p$ and q ; and $D \rightarrow s$ and t ; then the correct darkening of bubbles will look like the following:

	p	q	r	s	t
A	p	q	r	s	t
B	p	q	r	s	t
C	p	q	r	s	t
D	p	q	r	s	t

1. Some laws/processes are given in **COLUMN-I**. Match these with the physical phenomena given in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) Nuclear fusion	(p) Converts some matter into energy
(B) Nuclear fission	(q) Generally possible for nuclei with low atomic number
(C) β -decay	(r) Generally possible for nuclei with higher atomic number
(D) Exothermic nuclear reaction	(s) Essentially proceeds by weak nuclear forces.

2. Corresponding to the graph of binding energy per nucleon vs mass number (A) shown in figure, match the following two columns.



COLUMN-I	COLUMN-II
(A) $P + P \rightarrow Q$	(p) Energy is released
(B) $P + P + P \rightarrow R$	(q) Energy is absorbed
(C) $P + R \rightarrow 2Q$	(r) No energy transfer will take place
(D) $P + Q \rightarrow R$	(s) Data insufficient

3. Match the quantities in **COLUMN-I** with their respective values in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) Pair Production	(p) Few MeV
(B) Inverse photoelectric effect	(q) 20 KeV
(C) De-excitation of Be^{+4} atom from second excited state	(r) 54 eV
(D) K_{α} X-ray photons of molybdenum $Z = 42$	(s) 0.1 eV

4. Match the following two columns.

COLUMN-I	COLUMN-II
(A) The energy of air molecules at room temperature	(p) 0.02 eV
(B) Binding energy of heavy nuclei per nucleon	(q) 2 eV
(C) X-ray photon energy	(r) 10 keV
(D) Photon energy of visible light	(s) 7 MeV

5. Match the processes given in **COLUMN-I** with their characteristics in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) Alpha decay	(p) Mono energetic particles are emitted
(B) Beta decay	(q) Poly energetic particles are emitted
(C) Positron emission	(r) Angular momentum is conserved
(D) Electron capture	(s) Can take place inside and outside nucleus

6. Match the quantities in **COLUMN-I** with their respective values in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) 1 rutherford	(p) 1 disintegration/sec
(B) 1 becquerel	(q) 3.7×10^{10} dis/sec
(C) 1 curie	(r) 10^6 dis/sec
(D) Activity of 1 g Ra^{226}	(s) 10^{10} dis/sec

7. In the following chain, $A \rightarrow B \rightarrow C$. A and B are radioactive, while C is stable. Initially we have only A and B nuclei. There are no nuclei of C present in sample. As the time passes, match the two columns.

COLUMN-I	COLUMN-II
(A) Number of nuclei of $(A + B)$	(p) will increase continuously
(B) Number of nuclei of B	(q) will decrease continuously
(C) Number of nuclei of $(C + B)$	(r) will first increase then decrease
(D) Number of nuclei of $(A + C)$	(s) data insufficient

8. Match the processes given in COLUMN-I with their characteristics in COLUMN-II.

COLUMN-I	COLUMN-II
(A) α -decay	(p) Atomic number of the product nucleus decreases
(B) β^+ -decay	(q) Atomic number of the product nucleus increases
(C) β^- -decay	(r) Atomic number of the product nucleus not necessarily changes
(D) Electron capture	(s) some mass is converted into energy

9. Match the following two columns.

COLUMN-I	COLUMN-II
(A) After emission of one α and one β particles	(p) atomic number will decrease by 3
(B) After emission of two α and one β particles	(q) atomic number will decrease by 2

(Continued)

COLUMN-I	COLUMN-II
(C) After emission of one α and two β particles	(r) mass number will decrease by 8
(D) After emission of two α and two β particles	(s) mass number will decrease by 4

10. Match the processes given in COLUMN-I with their characteristics in COLUMN-II.

COLUMN-I	COLUMN-II
(A) α -decay	(p) Mass number decreases
(B) β^- -decay	(q) Atomic number decreases
(C) β^+ -decay	(r) Mass number does not change
(D) γ -decay	(s) Chemical symbol of nucleus changes
	(t) Energy is released

11. Match the reactions/processes given in COLUMN-I with their characteristics given in COLUMN-II.

COLUMN-I	COLUMN-II
(A) Spontaneous radioactive decay of an uranium nucleus initially at rest as given by reaction ${}_{92}^{238}\text{U} \longrightarrow {}_{90}^{234}\text{Th} + {}_2^4\text{He} + \dots$	(p) Number of protons is increased
(B) Fusion reaction of two hydrogen nuclei as given by reaction ${}_1^1\text{H} + {}_1^1\text{H} \longrightarrow {}_1^2\text{H} + \dots$	(q) Momentum is conserved
(C) Fission of U^{235} nucleus initiated by a thermal neutron as given by reaction ${}_0^1n + {}_{92}^{235}\text{U} \longrightarrow {}_{56}^{144}\text{Ba} + {}_{36}^{89}\text{Kr} + 3{}_0^1n$	(r) Mass and energy are interconvertible
(D) β^- -decay (negative beta decay)	(s) Charge is conserved
	(t) Angular momentum is conserved

12. Match COLUMN-I of the nuclear processes with COLUMN-II containing parent nucleus and one of the end products of each process and then select the correct answer using the codes given below the lists.

COLUMN-I	COLUMN-II
(A) Alpha decay	(p) ${}^{15}_8\text{O} \longrightarrow {}^{15}_7\text{N} + \dots$
(B) β^+ -decay	(q) ${}^{238}_{92}\text{U} \longrightarrow {}^{234}_{90}\text{Th} + \dots$
(C) Fission	(r) ${}^{185}_{83}\text{Bi} \longrightarrow {}^{184}_{82}\text{Pb} + \dots$
(D) Proton emission	(s) ${}^{239}_{94}\text{Pu} \longrightarrow {}^{140}_{57}\text{La} + \dots$

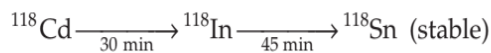
13. At $t = 0$, x nuclei of a radioactive substance emit y nuclei per second. Match the following two columns.

COLUMN-I	COLUMN-II
(A) Decay constant λ	(p) $(\ln 2) \left(\frac{x}{y} \right)$
(B) Half-life	(q) $\frac{x}{y}$
(C) Activity after time $t = \frac{1}{\lambda}$	(r) $\frac{y}{e}$
(D) Number of nuclei after time $t = \frac{1}{\lambda}$	(s) None of these

INTEGER/NUMERICAL ANSWER TYPE QUESTIONS

In this section, the answer to each question is a numerical value obtained after doing series of calculations based on the data given in the question(s).

- Calculate the activity of 0.5 mg of radon-222 in curie. It is known that half-life of radon is 3.8 days.
- If 20 g of a radioactive substance due to radioactive decay reduces to 10 g in 4 minutes, then in what time (in minutes) 80 g of the same substance will reduce to 20 g
- An unstable element is produced in a nuclear reactor at a constant rate. If its half life is 100 years, how much time in years is required to produce 50% of the equilibrium quantity?
- How many head-on, elastic collisions must a neutron have with deuterium nucleus to reduce its energy from 1 MeV to 0.025 eV.
- There are two radio nuclei A and B . A is an alpha emitter and B a beta emitter. Their disintegration constants are in ratio of 1 : 2. The ratio of number of atoms of A and B at any time t so that probabilities of getting alpha and beta particles are same at that instant is
- A ${}^7\text{Li}$ target is bombarded with a proton beam current of 10^{-4} A for 1 hour to produce ${}^7\text{Be}$ of activity 1.8×10^8 disintegrations per second. Assuming that one ${}^7\text{Be}$ radioactive nucleus is produced by bombarding 1000 protons, determine its half-life, in days, to the nearest three digit integer.
- Number of nuclei of a radioactive substance at $t = 0$ are 1000 and 900 at $t = 2$ sec. The number of nuclei at $t = 4$ sec will be $x \times 10$, then the value of x in number $x \times 10$ is
- At time $t = 0$, activity of a radioactive substance is 1600 Bq, at $t = 8$ s activity remains 100 Bq. Find the activity, in Bq, at $t = 2$ s.
- Calculate the energy (in MeV) required to extract a neutron from a carbon nucleus with mass number 13, if $m({}_6\text{C}^{13}) = 13.00335 \text{ u}$, $m({}_6\text{C}^{12}) = 12.0000 \text{ u}$, $m_n = 1.00867 \text{ u}$ and $m_p = 1.00783 \text{ u}$.
- The mean lives of a radioactive substance are 1620 and 405 years for α -emission and β -emission respectively. Find out the time (in years) after which three fourth of a sample will decay if it is decaying both by α -emission and β -emission simultaneously. (Take $\ln 2 = 0.693$)
- An environment study showed that the Chernobyl disaster released 6.0 MCi of ${}^{137}\text{Cs}$ into the environment. The mass of ${}^{137}\text{Cs}$ released is $10x \text{ kg}$. If the half life of ${}^{137}\text{Cs}$ is 30.2 years, calculate x .
- In U^{238} ore containing Uranium the ratio of U^{234} to Pb^{206} nuclei is 3. Assuming that all the lead present in the ore is final stable product of U^{238} , half life of U^{238} to be 4.5×10^9 years calculate the age of ore. (in 10^9 years)
- A ${}^{118}\text{Cd}$ radionuclide goes through the transformation chain.



The half lives are written below the respective arrows. A time $t = 0$ only Cd was present. Find the percentage of nuclei transformed into stable over 60 minutes.

14. A nucleus at rest undergoes a decay emitting an α -particle of de-Broglie wavelength 5.76×10^{-15} m. If the mass of daughter nucleus is 223.610 amu and that of α -particle is 4.002 amu. The mass of the parent nucleus is $22x$ amu, then calculate x if $1 \text{ amu} = 931.47 \text{ MeV}/c^2$
15. A radioactive sample decays with a mean life of 20 millisecond. A capacitor of capacitance $100 \mu\text{F}$ is charged to some potential and then the plates are connected through a wire of resistance R . What should be the value of R in ohm so that the ratio of the charge on the capacitor to the activity of the radioactive sample remain constant in time?
16. A thermonuclear device consists of a torus (of diameter 3 m with a tube of diameter 1 m), containing deuterium gas at 10^{-2} mm mercury pressure and at 27°C . A bank of capacitors of $1200 \mu\text{F}$ is discharged through the tube at 40 kV. If only 10% of the electrical energy is transformed to plasma kinetic energy, then the maximum temperature attained is $\dots \times 10^2$ K. Assuming that the energy is equally shared between the deuterons and electrons in the plasma. Take $\pi^2 \approx 10$, $g = 10 \text{ ms}^{-2}$
17. There are two radioactive substances A and B . Decay constant of B is two times that of A . Initially both have equal number of nuclei. After n half lives of A , rate of disintegration of both are equal, calculate n .
18. The mass defect for the nucleus of helium is 0.0302 amu. Calculate the binding energy per nucleon for helium in MeV. Take $1 \text{ amu} = 930 \text{ MeV}/c^2$.
19. Half life of radioactive substance A is two time that of B . Initially number of nuclei of A and B are N_A and N_B respectively. After three half lives of A number of nuclei of both are equal. Then the ratio $\frac{N_B}{N_A}$ is
20. A neutron at rest decays. Assuming the resulting proton to remain at rest. Calculate the energy of the antineutrino in 10^5 eV. Given that, $m_n = 1.0087 \text{ u}$, $m_p = 1.0072 \text{ u}$, $m_e = 0.00055 \text{ u}$
21. ${}^{23}\text{Ne}$ decays to ${}^{23}\text{Na}$ by negative beta emission. Mass of ${}^{23}\text{Ne}$ is 22.994465 amu mass of ${}^{23}\text{Na}$ is 22.989768 amu. Calculate the maximum kinetic energy of emitted electrons in MeV, neglecting the kinetic energy of recoiling product nucleus
22. The nucleus ${}_{92}\text{U}^{238}$ is unstable against α -decay with a half-life of about 4.5×10^9 years. Calculate the kinetic energy of the emitted α -particle in MeV to the nearest integer. Given that $m({}_{92}\text{U}^{238}) = 238.05081 \text{ u}$; $m({}_2\text{He}^4) = 4.00260 \text{ u}$; $m({}_{90}\text{Th}^{234}) = 234.04363 \text{ u}$
23. A neutron with an energy of 4.6 MeV collides with protons and is retarded. Assuming that upon each collision neutron is deflected by 45° find the number of collisions which will reduce its energy to 0.23 eV.
24. The nuclei of two radioactive isotopes of same substance A^{236} and A^{234} are present in the ratio 4:1 in an ore obtained from Mars. Their half lives are 30 min and 60 min respectively. Both isotopes are alpha emitters and the activity of the isotope with half life 30 min is one Rutherford. Calculate after how much time (in min) their activities will become identical.
25. The mean lives of a radioactive substance are 1200 yr and 600 yr for α -emission and β -emission respectively. Find out the time, in year, during which three fourth of a sample will decay if it is decaying both by α -emission and β -emission simultaneously.
Given $\log_e(4) \approx 1.4$
26. A uranium U^{235} nucleus liberates an energy of 200 MeV per fission. Calculate the energy liberated in 10^{14} J, when a uranium bomb containing 1.5 kg is exploded.
27. There are two radioactive substances A and B . Decay constant of B is two times that of A . Initially both have equal number of nuclei. After n half lives of A , rate of disintegration of both are equal, calculate n .
28. A heavy nucleus having mass number 200 gets disintegrated into small fragments of mass number 80 and 120. If binding energy per nucleon for parent atom is 6.5 MeV and for daughter nuclei is 7 MeV and 8 MeV respectively, then the energy released in the decay will be $x \times 10^5$ eV, then calculate x .
29. A nuclear reactor is designed to deliver 4 MW power. The nuclear fuel consists of Uranium-235 to run the reactor with amount of energy released per fission 200 MeV. Calculate amount of fuel needed (in grams) to run the reactor at designed rating with 100% efficiency for one year.
30. The radioactivity of an old sample of whisky due to tritium (half life 12.5 years) was found to be only about 4% of that measured in a recently purchased bottle marked 10 years old. Find the age of sample in years.

ARCHIVE: JEE MAIN
1. [Online April 2019]

The ratio of mass densities of nuclei ^{40}Ca and ^{16}O is close to

- (A) 0.1 (B) 1
(C) 2 (D) 5

2. [Online April 2019]

Two radioactive materials A and B have decay constants 10λ and λ , respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of A to that of B will be $\frac{1}{e}$ after a time

- (A) $\frac{1}{10\lambda}$ (B) $\frac{11}{10\lambda}$
(C) $\frac{1}{9\lambda}$ (D) $\frac{1}{11\lambda}$

3. [Online April 2019]

Two radioactive substances A and B have decay constants 5λ and λ respectively. At $t=0$, a sample has the same number of the two nuclei. The time taken for the ratio of the number of nuclei of become $\left(\frac{1}{e}\right)^2$ will be

- (A) $\frac{1}{2\lambda}$ (B) $\frac{1}{4\lambda}$
(C) $\frac{1}{\lambda}$ (D) $\frac{2}{\lambda}$

4. [Online April 2019]

Half lives of two radioactive nuclei A and B are 10 minutes and 20 minutes, respectively. If, initially a sample has equal number of nuclei, then after 60 minutes, the ratio of decayed numbers of nuclei A and B will be

- (A) 9:8 (B) 3:8
(C) 8:1 (D) 1:8

5. [Online 2019]

A sample of radioactive material A , that has an activity of 10 mCi (where $1\text{ Ci} = 3.7 \times 10^{10}$ dps) has twice the number of nuclei as another sample of a different radioactive material B which has an activity of 20 mCi. The correct choices for half-lives of A and B (in days) would then be respectively

- (A) 10 and 40 (B) 20 and 5
(C) 20 and 10 (D) 5 and 10

6. [Online January 2019]

At a given instant, say $t=0$, two radioactive substances A and B have equal activities. The ratio $\frac{R_B}{R_A}$

of their activities after time t itself decays with time t as e^{-3t} . If the half-life of A is $\ln 2$, the half-life of B is

- (A) $4\ln 2$ (B) $\frac{\ln 2}{2}$
(C) $\frac{\ln 2}{4}$ (D) $2\ln 2$

7. [Online January 2019]

Using a nuclear counter the count rate of emitted particles from a radioactive source is measured. At $t=0$ it was 1600 counts per second and $t=8$ seconds it was 100 counts per second. The count rate observed, as counts per second, at $t=6$ seconds is close to

- (A) 400 (B) 360
(C) 150 (D) 200

8. [Online January 2019]

Consider the nuclear fission $\text{Ne}^{20} \rightarrow 2\text{He}^4 + \text{C}^{12}$. Given that the binding energy/nucleon of Ne^{20} , He^4 and C^{12} are, respectively, 8.03 MeV, 7.07 MeV and 7.86 MeV, identify the correct statement

- (A) Energy of 12.4 MeV will be supplied
(B) 8.3 MeV energy will be released
(C) Energy of 3.6 MeV will be released
(D) Energy of 9.7 MeV has to be supplied

9. [2018]

It is found that if a neutron suffers an elastic collinear collision with deuterium at rest, fractional loss of its energy is p_d ; while for its similar collision with carbon nucleus at rest, fractional loss of energy is p_c . The values of p_d and p_c are respectively

- (A) (0.89, 0.28) (B) (0.28, 0.89)
(C) (0, 0) (D) (0, 1)

10. [Online 2018]

A solution containing active cobalt $^{60}_{27}\text{Co}$ having activity of $0.8\ \mu\text{Ci}$ and decay constant λ is injected in an animal's body. If 1 cm^3 of blood is drawn from the animal's body after 10 hrs of injection, the activity found was 300 decays per minute. What is the volume of blood that is flowing in the body? ($1\text{ Ci} = 3.7 \times 10^{10}$ decays per second and at $t=10$ hrs, $e^{-\lambda t} = 0.84$).

- (A) 4 litres (B) 7 litres
(D) 5 litres (D) 6 litres

11. [Online 2018]

An unstable heavy nucleus at rest breaks into two nuclei which move away with velocities in the ratio of 8:27. The ratio of the radii of the nuclei (assumed to be spherical) is



- (A) 3:2 (B) 2:3 (A) 20.4 eV (B) 10.2 eV
 (C) 4:9 (D) 8:27 (C) 12.1 eV (D) 16.8 eV

12. [Online 2018]

At some instant, a radioactive sample S_1 having an activity $5 \mu\text{Ci}$ has twice the number of nuclei as another sample S_2 which has an activity of $10 \mu\text{Ci}$. The half lives of S_1 and S_2 are

- (A) 20 years and 10 years, respectively
 (B) 10 years and 20 years, respectively
 (C) 20 years and 5 years, respectively
 (D) 5 years and 20 years, respectively

13. [2017]

A radioactive nucleus A with a half-life T , decays into a nucleus B . At $t=0$, there is no nucleus B . At sometime t , the ratio of the number of B to that of A is 0.3. Then, t is given by

- (A) $t = \frac{T \log 2}{2 \log(1.3)}$ (B) $t = T \frac{\log(1.3)}{\log 2}$
 (C) $t = T \log(1.3)$ (D) $t = \frac{T}{\log(1.3)}$

14. [Online 2017]

Two deuterons undergo nuclear fusion to form a Helium nucleus. Energy released in this process is (given binding energy per nucleon for deuteron = 1.1 MeV and for helium = 7.0 MeV)

- (A) 25.8 MeV (B) 32.4 MeV
 (C) 30.2 MeV (D) 23.6 MeV

15. [Online 2017]

Imagine that a reactor converts all given mass into energy and that it operates at a power level of 10^9 watt. The mass of the fuel consumed per hour in the reactor will be (velocity of light, c is $3 \times 10^8 \text{ ms}^{-1}$)

- (A) $4 \times 10^{-2} \text{ g}$ (B) $6.6 \times 10^{-5} \text{ g}$
 (C) 0.8 g (D) 0.96 g

16. [2016]

Half-lives of two radioactive elements A and B are 20 minutes and 40 minutes, respectively. Initially, the samples have equal number of nuclei. After 80 minutes, the ratio of decayed numbers of A and B nuclei will be

- (A) 5:4 (B) 1:16
 (C) 4:1 (D) 1:4

17. [Online 2016]

A neutron moving with a speed v makes a head on collision with a stationary hydrogen atom in ground state. The minimum kinetic energy of the neutron for which inelastic collision will take place is

18. [Online 2015]

Let N_β be the number of β particles emitted by 1 gram of Na^{24} radioactive nuclei (half life = 15 hrs) in 7.5 hours, N_β is close to (Avogadro number = $6.023 \times 10^{23} / \text{g mole}$)

- (A) 6.2×10^{21} (B) 7.5×10^{21}
 (C) 1.25×10^{22} (D) 1.75×10^{22}

19. [2014]

The radiation corresponding to $3 \rightarrow 2$ transition of hydrogen atom falls on a metal surface to produce photoelectrons. These electrons are made to enter a magnetic field of $3 \times 10^{-4} \text{ T}$. If the radius of the largest circular path followed by these electrons is 10.0 mm, the work function of the metal is close to

- (A) 1.8 eV (B) 1.1 eV
 (C) 0.8 eV (D) 1.6 eV

20. [2012]

Assume that a neutron breaks into a proton and an electron. The energy released during this process is

(Mass of neutron = $1.6725 \times 10^{-27} \text{ kg}$)

Mass of proton = $1.6725 \times 10^{-27} \text{ kg}$

Mass of electron = $9 \times 10^{-31} \text{ kg}$)

- (A) 7.10 MeV (B) 6.30 MeV
 (C) 5.1 MeV (D) 0.51 MeV

21. [2011]

The half life of a radioactive substance is 20 minutes. The approximate time interval $(t_2 - t_1)$ between the time t_2 when $\frac{2}{3}$ of it has decayed and time t_1 when $\frac{1}{3}$ of it had decayed is

- (A) 7 min (B) 14 min
 (C) 20 min (D) 28 min

22. [2010]

A radioactive nucleus (initial mass number A and atomic number Z) emits 3α -particles and 2 positrons. The ratio of number of neutrons to that of protons in the final nucleus will be

- (A) $\frac{A-Z-4}{Z-2}$ (B) $\frac{A-Z-8}{Z-4}$
 (C) $\frac{A-Z-4}{Z-8}$ (D) $\frac{A-Z-12}{Z-4}$

Directions: Question number 23-24 are based on the following paragraph.

A nucleus of mass $M + \Delta m$ is at rest and decays into two daughter nuclei of equal mass $\frac{M}{2}$ each. Speed of light is c .

23. [2010]

The speed of daughter nuclei is

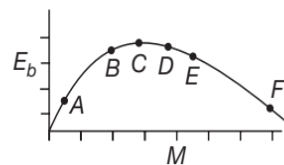
- (A) $c\sqrt{\frac{\Delta m}{M + \Delta m}}$ (B) $c\frac{\Delta m}{M + \Delta m}$
 (C) $c\sqrt{\frac{2\Delta m}{M}}$ (D) $c\sqrt{\frac{\Delta m}{M}}$

24. [2010]

The binding energy per nucleon for the parent nucleus is E_1 and that for the daughter nuclei is E_2 . Then

- (A) $E_1 = 2E_2$ (B) $E_2 = 2E_1$
 (C) $E_1 > E_2$ (D) $E_2 > E_1$

25. [2009]



The above is a plot of binding energy per nucleon E_b , against the nuclear mass M ; A, B, C, D, E, F correspond to different nuclei. Consider four reactions

- (i) $A + B \rightarrow C + \epsilon$ (ii) $C \rightarrow A + B + \epsilon$
 (iii) $D + E \rightarrow F + \epsilon$ (iv) $F \rightarrow D + E + \epsilon$

where ϵ is the energy released. In which reaction is ϵ positive?

- (A) (i) and (iv) (B) (i) and (iii)
 (C) (ii) and (iv) (D) (ii) and (iii)

ARCHIVE: JEE ADVANCED

Single Correct Choice Type Problems

(In this section each question has four choices (A), (B), (C) and (D), out of which ONLY ONE is correct)

1. [JEE (Advanced) 2019]

In a radioactive sample, ${}_{19}^{40}\text{K}$ nuclei either decay into stable ${}_{20}^{40}\text{Ca}$ nuclei with decay constant 4.5×10^{-10} per year or into stable ${}_{18}^{40}\text{Ar}$ nuclei with decay constant 0.5×10^{-10} per year. Given that in this sample all the stable ${}_{20}^{40}\text{Ca}$ and ${}_{18}^{40}\text{Ar}$ nuclei are produced by the ${}_{19}^{40}\text{K}$ nuclei only. In time $t \times 10^9$ years, if the ratio of the sum of stable ${}_{20}^{40}\text{Ca}$ and ${}_{18}^{40}\text{Ar}$ nuclei to the radioactive ${}_{19}^{40}\text{K}$ nuclei is 99, the value of t will be

- (A) 1.15 (B) 9.2
 (C) 2.3 (D) 4.6

2. [JEE (Advanced) 2016]

An accident in a nuclear laboratory resulted in deposition of a certain amount of radioactive material of half-life 18 days inside the laboratory. Tests revealed that the radiation was 64 times more than the permissible level required for safe operation of the laboratory. What is the minimum number of days after which the laboratory can be considered safe for use?

- (A) 64 (B) 90
 (C) 108 (D) 120

3. [JEE (Advanced) 2016]

The electrostatic energy of Z protons uniformly distributed throughout a spherical nucleus of radius R

is given by $E = \frac{3Z(Z-1)e^2}{5 \cdot 4\pi\epsilon_0 R}$. The measured masses

of the neutron, ${}^1_1\text{H}$, ${}^{15}_7\text{N}$ and ${}^{15}_8\text{O}$ are 1.008665 u, 1.007825 u, 15.000109 u and 15.003065 u, respectively. Given that the radii of both the ${}^{15}_7\text{N}$ and ${}^{15}_8\text{O}$ nuclei are same, $1 \text{ u} = 931.5 \text{ MeV } c^{-2}$ (c is the speed of light) and $\frac{e^2}{(4\pi\epsilon_0)} = 1.44 \text{ MeV fm}$. Assuming that

the difference between the binding energies of ${}^{15}_7\text{N}$ and ${}^{15}_8\text{O}$ is purely due to the electrostatic energy, the radius of either of the nuclei is ($1 \text{ fm} = 10^{-15} \text{ m}$)

- (A) 2.85 fm (B) 3.03 fm
 (C) 3.42 fm (D) 3.80 fm

4. [JEE (Advanced) 2015]

A fission reaction is given by ${}_{92}^{236}\text{U} \rightarrow {}_{54}^{140}\text{Xe} + {}_{38}^{94}\text{Sr} + x + y$, where x and y are two particles. Considering ${}_{92}^{236}\text{U}$ to be at rest, the kinetic energies of the products are denoted by K_{Xe} , K_{Sr} , K_x (2 MeV) and K_y (2 MeV), respectively. Let the binding energies per nucleon of ${}_{92}^{236}\text{U}$, ${}_{54}^{140}\text{Xe}$ and ${}_{38}^{94}\text{Sr}$ be 7.5 MeV, 8.5 MeV and 8.5 MeV, respectively. Considering different conservation laws, the correct options is/are

- (A) $x = n$, $y = n$, $K_{\text{Sr}} = 129 \text{ MeV}$, $K_{\text{Xe}} = 86 \text{ MeV}$
 (B) $x = p$, $y = e^-$, $K_{\text{Sr}} = 129 \text{ MeV}$, $K_{\text{Xe}} = 86 \text{ MeV}$
 (C) $x = p$, $y = n$, $K_{\text{Sr}} = 129 \text{ MeV}$, $K_{\text{Xe}} = 86 \text{ MeV}$
 (D) $x = n$, $y = n$, $K_{\text{Sr}} = 86 \text{ MeV}$, $K_{\text{Xe}} = 129 \text{ MeV}$

16. [IIT-JEE 2001]

The electron emitted in beta radiation originates from

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

17. [IIT-JEE 2000]

Two radioactive materials X_1 and X_2 have decay constants 10λ and λ respectively. If initially they have the same number of nuclei, then the ratio of the number of nuclei of X_1 to that of X_2 will be $\frac{1}{e}$ after a time

- (A) $\frac{1}{10\lambda}$
- (B) $\frac{1}{11\lambda}$
- (C) $\frac{11}{10\lambda}$
- (D) $\frac{1}{9\lambda}$

18. [IIT-JEE 1999]

The half life period of a radioactive element X is same as the mean life time of another radioactive element Y . Initially both of them have the same number of atoms. Then,

- (A) X and Y have the same decay rate initially.
- (B) X and Y decay at the same rate always.
- (C) Y will decay at a faster rate than X .
- (D) X will decay at a faster rate than Y .

19. [IIT-JEE 1999]

Which of the following statements is correct?

- (A) Beta rays are same as cathode rays.
- (B) Gamma rays are high energy neutrons.
- (C) Alpha particles are singly ionised helium atoms.
- (D) Protons and neutrons have exactly the same mass.

20. [IIT-JEE 1999]

^{22}Ne nucleus, after absorbing energy, decays into two α -particles and an unknown nucleus. The unknown nucleus is

- (A) Nitrogen
- (B) Carbon
- (C) Oxygen
- (D) Boron

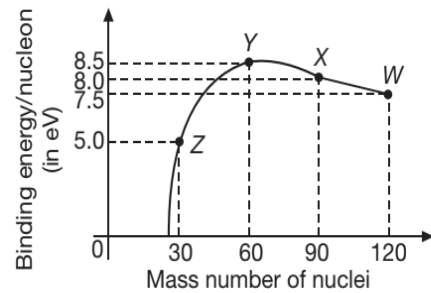
21. [IIT-JEE 1999]

Order of magnitude of density of uranium nucleus is ($m_p = 1.67 \times 10^{-27}$ kg)

- (A) 10^{20} kgm^{-3}
- (B) 10^{17} kgm^{-3}
- (C) 10^{14} kgm^{-3}
- (D) 10^{11} kgm^{-3}

22. [IIT-JEE 1999]

Binding energy per nucleon vs mass number curve for nuclei is shown in the figure. W , X , Y and Z are four nuclei indicated on the curve. The process that would release energy is



- (A) $Y \longrightarrow 2Z$
- (B) $W \longrightarrow X + Z$
- (C) $W \longrightarrow 2Y$
- (D) $X \longrightarrow Y + Z$

23. [IIT-JEE 1998]

The half-life of ^{131}I is 8 days. Given a sample of ^{131}I at time $t = 0$, we can assert that

- (A) no nucleus will decay before $t = 4$ days
- (B) no nucleus will decay before $t = 8$ days
- (C) all nuclei will decay before $t = 16$ days
- (D) a given nucleus may decay at any time after $t = 0$

24. [IIT-JEE 1997]

Masses of two isobars $^{64}_{29}\text{Cu}$ and $^{64}_{30}\text{Zn}$ are 63.9298 u and 63.9292 u respectively. It can be concluded from these data that

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

25. [IIT-JEE 1994]

Consider α -particles, β -particles and γ -rays each having an energy of 0.5 MeV. In increasing order of penetrating powers, the radiations are

- (A) α, β, γ
- (B) α, γ, β
- (C) β, γ, α
- (D) γ, β, α

26. [IIT-JEE 1994]

Fast neutrons can easily be slowed down by

- (A) the use of lead shielding
- (B) passing them through heavy water
- (C) elastic collisions with heavy nuclei
- (D) applying a strong electric field

27. [IIT-JEE 1993]

A star initially has 10^{40} deuterons. It produces energy via the processes $^1_1\text{H}^2 + ^1_1\text{H}^2 \longrightarrow ^1_1\text{H}^3 + p$ and $^1_1\text{H}^2 + ^1_1\text{H}^3 \longrightarrow ^2_2\text{He}^4 + n$. If the average power

radiated by the star is 10^{16} W, the deuteron supply of the star is exhausted in a time of the order of

- (A) 10^6 s (B) 10^8 s
(C) 10^{12} s (D) 10^{16} s

(The masses of nuclei are: $m(\text{H}^2) = 2.014$ u, $m(p) = 1.007$ u, $m(n) = 1.008$ u, $m(\text{He}^4) = 4.001$ u)

28. [IIT-JEE 1989]

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

- (A) $\frac{1}{\lambda}$ and $\frac{(\log_e 2)}{\lambda}$ (B) $\frac{(\log_e 2)}{\lambda}$ and $\frac{1}{\lambda}$
(C) $\lambda(\log_e 2)$ and $\frac{1}{\lambda}$ (D) $\frac{\lambda}{(\log_e 2)}$ and $\frac{1}{\lambda}$

29. [IIT-JEE 1988]

A freshly prepared radioactive source of half-life 2 h emits radiation of intensity which is 64 times the permissible safe level. The minimum time after which it would be possible to work safely with this source is

- (A) 6 h (B) 12 h
(C) 24 h (D) 128 h

30. [IIT-JEE 1987]

Four physical quantities are listed in COLUMN-I. Their values are listed in COLUMN-II in a random order

COLUMN-I	COLUMN-II
1. Thermal energy of air molecules at room temperature.	i. 0.02 eV
2. Binding energy of heavy nuclei per nucleon.	ii. 2 eV
3. X-ray photon energy.	iii. 10 keV
4. Photon energy of visible light.	iv. 7 MeV

The correct matching of columns I and II is given by

- 1 2 3 4
(A) i iv iii ii
(B) i iii ii iv
(C) ii i iii iv
(D) ii iv i iii

31. [IIT-JEE 1987]

During a nuclear fusion reaction

- (A) a heavy nucleus breaks into two fragments by itself
(B) a light nucleus bombarded by thermal neutrons breaks up
(C) a heavy nucleus bombarded by thermal neutrons breaks up
(D) two light nuclei combine to give a heavier nucleus and possibly other products

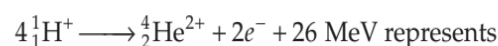
32. [IIT-JEE 1987]

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

33. [IIT-JEE 1983]

The equation:



- (A) β -decay (B) γ -decay
(C) fusion (D) fission

34. [IIT-JEE 1983]

Beta rays emitted by a radioactive material are

- (A) electromagnetic radiations
(B) the electrons orbiting around the nucleus
(C) charged particles emitted by the nucleus
(D) neutral particles

35. [IIT-JEE 1981]

The half-life of the radioactive radon is 3.8 days. The time, at the end of which $1/20^{\text{th}}$ of the radon sample will remain undecayed, is (given $\log_{10} e = 0.4343$)

- (A) 3.8 day (B) 16.5 day
(C) 33 day (D) 76 day

Multiple Correct Choice Type Problems

(In this section each question has four choices (A), (B), (C) and (D), out of which ONE OR MORE is/are correct)

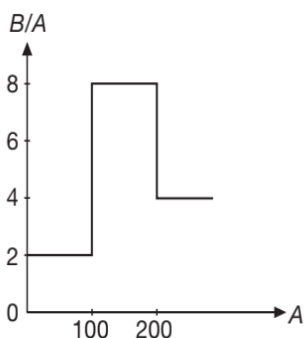
1. [JEE (Advanced) 2018]

In a radioactive decay chain, ${}_{90}^{232}\text{Th}$ nucleus decays to ${}_{82}^{212}\text{Pb}$ nucleus. Let N_α and N_β be the number of α and β^- particles, respectively, emitted in this decay process. Which of the following statements is (are) true?

- (A) $N_\alpha = 5$ (B) $N_\alpha = 6$
(C) $N_\beta = 2$ (D) $N_\beta = 4$

2. [JEE (Advanced) 2008]

Assume that the nuclear binding energy per nucleon $\left(\frac{B}{A}\right)$ versus mass number (A) is as shown in the figure. Use this plot to choose the correct choice(s) given below.



- (A) Fusion of two nuclei with mass numbers lying in the range of $1 < A < 50$ will release energy.
- (B) Fusion of two nuclei with mass numbers lying in the range of $51 < A < 100$ will release energy.
- (C) Fission of a nucleus lying in the mass range of $100 < A < 200$ will release energy when broken into two equal fragments.
- (D) Fission of a nucleus lying in the mass range of $200 < A < 260$ will release energy when broken into two equal fragments.

3. [IIT-JEE 1998]

Let m_p be the mass of proton, m_n the mass of neutron. M_1 the mass of ${}^{20}_{10}\text{Ne}$ nucleus and M_2 the mass of ${}^{40}_{20}\text{Ca}$ nucleus. Then

- (A) $M_2 = 2M_1$
- (B) $M_2 > 2M_1$
- (C) $M_2 < 2M_1$
- (D) $M_1 < 10(m_n + m_p)$

4. [IIT-JEE 1994]

Which of the following statement(s) is (are) correct?

- (A) The rest mass of a stable nucleus is less than the sum of the rest masses of its separated nucleons
- (B) The rest mass of a stable nucleus is greater than the sum of the rest masses of its separated nucleons
- (C) In nuclear fission, energy is released by fusing two nuclei of medium mass (approximately 100 amu)
- (D) In nuclear fission, energy is released by fragmentation of a very heavy nucleus

5. [IIT-JEE 1992]

When a monochromatic point source of light is at a distance of 0.2 m from a photo-electric cell, the cut-off voltage and the saturation current are respectively 0.6 V and 18.0 mA. If the same source is placed 0.6 m away from the photoelectric cell, then

- (A) the stopping potential will be 0.2 V.
- (B) the stopping potential will be 0.6 V.
- (C) the saturation current will be 6.0 mA.
- (D) the saturation current will be 2.0 mA.

6. [IIT-JEE 1986]

The mass number of a nucleus is

- (A) always less than its atomic number
- (B) always more than its atomic number
- (C) sometimes equal to its atomic number
- (D) sometimes more than and sometimes equal to its atomic number

7. [IIT-JEE 1984]

From the following equations pick out the possible nuclear fusion reactions

- (A) ${}_6\text{C}^{13} + {}_1\text{H}^1 \longrightarrow {}_6\text{C}^{14} + 4.3 \text{ MeV}$
- (B) ${}_6\text{C}^{12} + {}_1\text{H}^1 \longrightarrow {}_7\text{N}^{13} + 2 \text{ MeV}$
- (C) ${}_7\text{N}^{14} + {}_1\text{H}^1 \longrightarrow {}_8\text{O}^{15} + 7.3 \text{ MeV}$
- (D) ${}_{92}\text{U}^{235} + {}_0n^1 \longrightarrow {}_{54}\text{Xe}^{140} + {}_{36}\text{Sr}^{94} + {}_0n^1 + \gamma + 200 \text{ MeV}$

Comprehension Type Questions

This section contains Linked Comprehension Type Questions or Paragraph based Questions. Each set consists of a Paragraph followed by questions. Each question has four choices (A), (B), (C) and (D), out of which only one is correct. (For the sake of competitiveness there may be a few questions that may have more than one correct options).

Comprehension I

If the measurement errors in all the independent quantities are known, then it is possible to determine the error in any dependent quantity. This is done by the use of series expansion and truncating the expansion at the first power of the error. For example, consider the relation $z = \frac{x}{y}$. If the errors

in x , y and z are Δx , Δy and Δz , respectively, then

$$z \pm \Delta z = \frac{x \pm \Delta x}{y \pm \Delta y} = \frac{x}{y} \left(1 \pm \frac{\Delta x}{x}\right) \left(1 \pm \frac{\Delta y}{y}\right)^{-1}$$

The series expansion for $\left(1 \pm \frac{\Delta y}{y}\right)^{-1}$, to first power in $\frac{\Delta y}{y}$, is $1 \mp \left(\frac{\Delta y}{y}\right)$. The relative errors in independent variables are always added. So, the error in z will be $\Delta z = z \left(\frac{\Delta x}{x} + \frac{\Delta y}{y}\right)$.



The above derivation makes the assumption that $\frac{\Delta x}{x} \ll 1$, $\frac{\Delta y}{y} \ll 1$. Therefore, the higher powers of these quantities are neglected. (There are two questions based on PARAGRAPH, the question given below is one of them).

1. [JEE (Advanced) 2018]

Consider the ratio $r = \frac{(1-a)}{(1+a)}$ to be determined by measuring a dimensionless quantity a . If the error in the measurement of a is $\Delta a \left(\frac{\Delta a}{a} \ll 1 \right)$, then what is the error Δr in determining r ?

- (A) $\frac{\Delta a}{(1+a)^2}$ (B) $\frac{2\Delta a}{(1+a)^2}$
 (C) $\frac{2\Delta a}{(1-a^2)}$ (D) $\frac{2a\Delta a}{(1-a^2)}$

2. [JEE (Advanced) 2018]

In an experiment the initial number of radioactive nuclei is 3000. It is found that 1000 ± 40 nuclei decayed in the first 1.0 s. For $|x| \ll 1$, $\ln(1+x) = x$ up to first power in x . The error $\Delta \lambda$, in the determination of the decay constant λ , in s^{-1} , is

- (A) 0.04 (B) 0.03
 (C) 0.02 (D) 0.01

Comprehension 2

The mass of a nucleus ${}^A_Z X$ is less than the sum of the masses of $(A-Z)$ number of neutrons and Z number of protons in the nucleus. The energy equivalent to the corresponding mass difference is known as the binding energy of the nucleus. A heavy nucleus of mass M can break into two light nuclei of masses m_1 and m_2 only if $(m_1 + m_2) < M$. Also two light nuclei of masses m_3 and m_4 can undergo complete fusion and form a heavy nucleus of mass M' only if $(m_3 + m_4) > M'$. The masses of some neutral atoms are given in the table below

${}^1_1\text{H}$	1.007825 u	${}^2_1\text{H}$	2.014102 u
${}^6_3\text{Li}$	6.015123 u	${}^7_3\text{Li}$	7.016004 u
${}^{152}_{64}\text{Gd}$	151.919803 u	${}^{206}_{82}\text{Pb}$	205.974455 u
${}^3_1\text{H}$	3.016050 u	${}^4_2\text{He}$	4.002603 u

(Continued)

${}^{70}_{30}\text{Zn}$	69.925325 u	${}^{82}_{34}\text{Se}$	81.916709 u
${}^{209}_{83}\text{Bi}$	208.980388 u	${}^{210}_{84}\text{Po}$	209.982876 u

(1 u = 932 MeVc⁻²)

Based on above information, answer the following questions.

3. [JEE (Advanced) 2013]

The correct statement is

- (A) The nucleus ${}^6_3\text{Li}$ can emit an alpha particle
 (B) The nucleus ${}^{210}_{84}\text{Po}$ can emit a proton
 (C) Deuteron and alpha particle can undergo complete fusion.
 (D) The nuclei ${}^{70}_{30}\text{Zn}$ and ${}^{82}_{34}\text{Se}$ can undergo complete fusion

4. [JEE (Advanced) 2013]

The kinetic energy (in keV) of the alpha particle, when the nucleus ${}^{210}_{84}\text{Po}$ at rest undergoes alpha decay, is

- (A) 5319 (B) 5422
 (C) 5707 (D) 5818

Comprehension 3

The β^- -decay process, discovered around 1900, is basically the decay of a neutron (n). In the laboratory, a proton (p) and an electron (e^-) and observed as the decay products of the neutron. Therefore, considering the decay of a neutron as a two body decay process, it was predicted theoretically that the kinetic energy of the electron should be a constant. But experimentally, it was observed that the electron kinetic energy has a continuous spectrum. Considering a three-body decay process, i.e., $n \rightarrow p + e^- + \bar{\nu}_e$, around 1930, Pauli explained the observed electron energy spectrum. Assuming the anti-neutrino ($\bar{\nu}_e$) to be massless and possessing negligible energy and the neutron to be at rest, momentum and energy conservation principles are applied. From this calculation, the maximum kinetic energy of the electron is 0.8×10^6 eV. The kinetic energy carried by the proton is only the recoil energy. Based on above information, answer the following questions.

5. [IIT-JEE 2012]

What is the maximum energy of the anti-neutrino?

- (A) zero
 (B) Much less than 0.8×10^6 eV
 (C) Nearly 0.8×10^6 eV
 (D) Much larger than 0.8×10^6 eV

6. [IIT-JEE 2012]

If the anti-neutrino had a mass of $3 \text{ eV}c^{-2}$ (where c is the speed of light) instead of zero mass, what should be the range of the kinetic energy, K , of the electron?

- (A) $0 \leq K \leq 0.8 \times 10^6 \text{ eV}$
- (B) $3 \text{ eV} \leq K \leq 0.8 \times 10^6 \text{ eV}$
- (C) $3 \text{ eV} \leq K < 0.8 \times 10^6 \text{ eV}$
- (D) $0 \leq K < 0.8 \times 10^6 \text{ eV}$

Comprehension 4

Scientists are working hard to develop nuclear fusion reactor. Nuclei of heavy hydrogen, ${}^2_1\text{H}$ known as deuteron and denoted by D can be thought of as a candidate for fusion reactor. The D-D reaction is ${}^2_1\text{H} + {}^2_1\text{H} \longrightarrow {}^3_2\text{He} + n + \text{energy}$. In the core of fusion reactor, a gas of heavy hydrogen is fully ionized into deuteron nuclei and electrons. This collection of ${}^2_1\text{H}$ nuclei and electrons is known as plasma. The nuclei move randomly in the reactor core and occasionally come close enough for nuclear fusion to take place. Usually, the temperatures in the reactor core are too high and no material wall can be used to confine the plasma. Special techniques are used which confine the plasma for a time t_0 before the particles fly away from the core. If n is the density (number/volume) of deuterons, the product nt_0 is called Lawson number. In one of the criteria, a reactor is termed successful if Lawson number is greater than $5 \times 10^{14} \text{ scm}^{-3}$. It may be helpful to use the following: Boltzmann constant $k = 8.6 \times 10^{-5} \text{ eV}K^{-1}$; $\frac{e^2}{4\pi\epsilon_0} = 1.44 \times 10^{-9} \text{ eVm}$. Based on above information, answer the following questions.

7. [IIT-JEE 2009]

In the core of nuclear fusion reactor, the gas becomes plasma because of

- (A) strong nuclear force acting between the deuterons
- (B) Coulomb force acting between the deuterons
- (C) Coulomb force acting between deuteron-electron pairs
- (D) the high temperature maintained inside the reactor core

8. [IIT-JEE 2009]

Assume that two deuteron nuclei in the core of fusion reactor at temperature T are moving towards each other, each with kinetic energy 1.5 kT , when the separation between them is large enough to neglect Coulomb potential energy. Also neglect any interaction from other particles in the core. The minimum temperature T required for them to reach a separation of $4 \times 10^{-15} \text{ m}$ is in the range

- (A) $1 \times 10^9 \text{ K} < T < 2 \times 10^9 \text{ K}$
- (B) $2 \times 10^9 \text{ K} < T < 3 \times 10^9 \text{ K}$
- (C) $3 \times 10^9 \text{ K} < T < 4 \times 10^9 \text{ K}$
- (D) $4 \times 10^9 \text{ K} < T < 5 \times 10^9 \text{ K}$

9. [IIT-JEE 2009]

Results of calculations for four different designs of a fusion reactor using D-D reaction are given below. Which of these is most promising based on Lawson criterion?

- (A) Deuteron density = $2 \times 10^{12} \text{ cm}^{-3}$, confinement time = $5 \times 10^{-3} \text{ s}$
- (B) Deuteron density = $8 \times 10^{14} \text{ cm}^{-3}$, confinement time = $9 \times 10^{-1} \text{ s}$
- (C) Deuteron density = $4 \times 10^{23} \text{ cm}^{-3}$, confinement time = $1 \times 10^{-11} \text{ s}$
- (D) Deuteron density = $1 \times 10^{24} \text{ cm}^{-3}$, confinement time = $4 \times 10^{-12} \text{ s}$

Matrix Match/Column Match Type Questions

Each question in this section contains statements given in two columns, which have to be matched. The statements in **COLUMN-I** are labelled A, B, C and D, while the statements in **COLUMN-II** are labelled p, q, r, s (and t). Any given statement in **COLUMN-I** can have correct matching with **ONE OR MORE** statement(s) in **COLUMN-II**. The appropriate bubbles corresponding to the answers to these questions have to be darkened as illustrated in the following examples:

If the correct matches are $A \rightarrow p, s$ and t ; $B \rightarrow q$ and r ; $C \rightarrow p$ and q ; and $D \rightarrow s$ and t ; then the correct darkening of bubbles will look like the following:

	p	q	r	s	t
A	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>
B	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>
C	<input checked="" type="radio"/>	<input checked="" type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
D	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input checked="" type="radio"/>	<input checked="" type="radio"/>

1. [IIT-JEE 2006]

Some laws/processes are given in **COLUMN-I**. Match these with the physical phenomena given in **COLUMN-II**.

COLUMN-I	COLUMN-II
(A) Nuclear fusion	(p) Converts some matter into energy
(B) Nuclear fission	(q) Generally possible for nuclei with low atomic number

(Continued)



COLUMN-I	COLUMN-II
(C) β -decay	(r) Generally possible for nuclei with higher atomic number
(D) Exothermic nuclear reaction	(s) Essentially proceeds by weak nuclear forces.

2. [JEE (Advanced) 2015]

Match the nuclear processes given in COLUMN-I with the appropriate option(s) in COLUMN-II.

COLUMN-I	COLUMN-II
(A) Nuclear fusion	(p) absorption of thermal neutrons by ${}_{92}^{235}\text{U}$
(B) Fission in a nuclear reactor	(q) ${}_{27}^{60}\text{Co}$ nucleus
(C) β -decay	(r) Energy production in stars via hydrogen conversion to helium
(D) γ -ray emission	(s) Heavy water (t) Neutrino emission

3. [JEE (Advanced) 2013]

Match COLUMN-I of the nuclear process with COLUMN-II containing parent nucleus and one of the end products of each process and then select the correct answer using the codes given below the lists.

COLUMN-I	COLUMN-II
(A) Alpha decay	(p) ${}_{8}^{15}\text{O} \rightarrow {}_{7}^{17}\text{N} + \dots$
(B) β^+ decay	(q) ${}_{92}^{238}\text{U} \rightarrow {}_{90}^{234}\text{Th} + \dots$
(C) Fission	(r) ${}_{83}^{185}\text{Bi} \rightarrow {}_{82}^{184}\text{Pb} + \dots$
(D) Proton emission	(s) ${}_{94}^{239}\text{Pu} \rightarrow {}_{57}^{140}\text{La} + \dots$

4. [IIT-JEE 2007]

Some laws/processes are given in COLUMN-I. Match these with the physical phenomena given in COLUMN-II and indicate your answer by darkening appropriate bubbles in the 4×4 matrix given in the ORS.

COLUMN-I	COLUMN-II
(A) Transition between two atomic energy levels	(p) Characteristic X-rays
(B) Electron emission from a material	(q) Photoelectric effect
(C) Mosley's law	(r) Hydrogen spectrum
(D) Change of photon energy into kinetic energy of electrons	(s) β -decay

Integer/Numerical Answer Type Questions

(In this section, the answer to each question is a numerical value obtained after series of calculations based on the data provided in the question(s)).

1. [JEE (Advanced) 2019]

Suppose a ${}_{88}^{226}\text{Ra}$ nucleus at rest and in ground state undergoes α -decay to a ${}_{86}^{222}\text{Rn}$ nucleus in its excited state. The kinetic energy of the emitted α particle is found to be 4.44 MeV. ${}_{86}^{222}\text{Rn}$ nucleus then goes to its ground state by γ -decay. The energy of the emitted γ photon is _____ keV.

(Given: atomic mass of ${}_{88}^{226}\text{Ra} = 226.005$ u, atomic mass of ${}_{86}^{222}\text{Rn} = 222.000$ u, atomic mass of α particle = 4.000 u, $1 \text{ u} = 931 \text{ MeV}c^{-2}$, c is speed of the light).

2. [JEE (Advanced) 2017]

${}^{131}\text{I}$ is an isotope of Iodine that β decays to an isotope of Xenon with a half-life of 8 days. A small amount of a serum labelled with ${}^{131}\text{I}$ is injected into the blood of a person. The activity of the amount of ${}^{131}\text{I}$ injected was 2.4×10^5 Becquerel (Bq). It is known that the injected serum will get distributed uniformly in the blood stream in less than half an hour. After 11.5 h, 2.5 ml of blood is drawn from the person's body, and gives an activity of 115 Bq. The total volume of blood in the person's body, in litres is approximately (you may use $e^2 \approx 1 + x$ for $|x| \ll 1$ and $\ln 2 \approx 0.7$).

3. [JEE (Advanced) 2016]

The isotope ${}_{5}^{12}\text{B}$ having a mass 12.014 u undergoes β -decay to ${}_{6}^{12}\text{C}$. ${}_{6}^{12}\text{C}$ has an excited state of the nucleus (${}_{6}^{12}\text{C}^*$) at 4.041 MeV above its ground state. If ${}_{5}^{12}\text{B}$ decays to ${}_{6}^{12}\text{C}^*$, the maximum kinetic energy of the β -particle in units of MeV is

($1u = 931.5 \text{ MeV } c^{-2}$, where c is the speed of light in vacuum).

4. [JEE (Advanced) 2015]

For a radioactive material, its activity A and rate of change of its activity R are defined as $A = -\frac{dN}{dt}$ and $R = -\frac{dA}{dt}$, where $N(t)$ is the number of nuclei at time t . Two radioactive source P (mean life τ) and Q (mean life 2τ) have the same activity at $t=0$. Their rate of change of activities at $t=2\tau$ are R_P and R_Q , respectively. If $\frac{R_P}{R_Q} = \frac{n}{e}$, then the value of n is

5. [JEE (Advanced) 2015]

A nuclear power plant supplying electrical power to a village uses a radioactive material of half life T years as the fuel. The amount of fuel at the beginning is such that the total power requirement of the village is 12.5% of the electrical power available from the plant at that time. If the plant is able to meet the total power needs of the village for a maximum period of nT years, then the value of n is

6. [JEE (Advanced) 2013]

A freshly prepared sample of a radioisotope of half-life 1386 s has activity 10^3 disintegrations per second. Given that $\log_e 2 = 0.693$, find the fraction of the

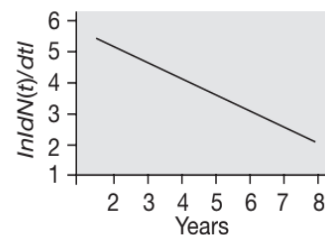
initial number of nuclei (expressed in nearest, integer percentage) that will decay in the first 80 s after preparation of the sample.

7. [JEE (Advanced) 2011]

The activity of a freshly prepared radioactive sample is 10^{10} disintegrations per second, whose mean life is 10^9 s. The mass of an atom of this radioisotope is 10^{-25} kg. Find the mass (in mg) of the radioactive sample.

8. [IIT-JEE 2010]

To determine the half-life of a radioactive element, a student plots a graph of $\ln\left|\frac{dN(t)}{dt}\right|$ versus t . Here $\frac{dN(t)}{dt}$ is the rate of radioactive decay at time t . If the number of radioactive nuclei of this element decreases by a factor of p after 4.16 yr, the value of p is



ANSWER KEYS—TEST YOUR CONCEPTS AND PRACTICE EXERCISES
**Test Your Concepts-I
(Based on Nucleus Properties and Binding Energy)**

- 4.53 fm
- 10.2 MeV
- 6.94 amu
- $\frac{S_1}{S_2} = \left(\frac{A_1}{A_2}\right)^{\frac{2}{3}}$
- $2.4 \times 10^{17} \text{ kgm}^{-3}$
- $4.7 \times 10^{-14} \text{ kg}$
- 34.969 amu
- 28.3 MeV
- 39.231 MeV, 5.604 MeV

**Test Your Concepts-II
(Based on Radioactivity)**

- 81
- $1.55 \times 10^6 \text{ J}$
- $1.4 \times 10^{17} \text{ s}$
- $3.81 \times 10^{-4} \text{ year}^{-1}$, $3.14 \times 10^{-2} \text{ year}^{-1}$
- (a) 0.113 min^{-1} (b) 6.132 min
- $1.26 \times 10^{-11} \%$
- (a) $1.42 \times 10^{14} \text{ per year}$ (b) $1.41 \times 10^{14} \text{ per year}$
(c) $5.4 \times 10^7 \text{ year}$
- $N_2 \approx N_0 e^{-\lambda_2 t}$, $N_2 \approx \frac{\lambda_1}{\lambda_2} N_0 e^{-\lambda_1 t}$
- 0.39
- (a) 5724 year (b) $12.58 \text{ dismin}^{-1} \text{g}^{-1}$
- $1.12 \times 10^{-6} \text{ g}$

- 1.88×10^{-3}
- (a) $6.90 \times 10^{16} \text{ nuclei}$ (b) $8.00 \times 10^{13} \text{ decay/s}$
(c) $1.25 \times 10^{12} \text{ s}^{-1}$
- $\lambda_p N_p = \lambda_d N_d$
- 1.5×10^{18}
- 4.5×10^9
- 3.86 Ci
- $\frac{1}{4}$
- 0.259
- 30×10^{21}

**Test Your Concepts-II
(Based on Nuclear Reactions, Alpha, Beta, Gamma Decay, Fission and Fusion)**

- (a) Not possible (b) Possible
- 1.54 MeV
- 8.78 day
- 0.73 MeV
- 0.1308 MeV
- (a) 1.02 MeV (b) 2.82 MeV
- 4.4 MeV
- 0.961 MeV
- 120.35 g
- (a) $8.09 \times 10^{13} \text{ J}$ (b) $2.7 \times 10^6 \text{ kg}$
- (a) -1.18 MeV (b) $43^\circ 18'$
- 127.6 MeV
- 4.31 MeV
- $1.79 \times 10^{-4} \text{ kg}$

Single Correct Choice Type Questions

1. B	2. B	3. C	4. A	5. D	6. C	7. C	8. C	9. C	10. B
11. C	12. A	13. D	14. D	15. C	16. D	17. B	18. A	19. D	20. D
21. C	22. A	23. B	24. A	25. C	26. C	27. D	28. D	29. D	30. B
31. C	32. D	33. D	34. D	35. D	36. C	37. C	38. B	39. A	40. C
41. D	42. D	43. C	44. C	45. B	46. C	47. D	48. C	49. B	50. D
51. D	52. B	53. D	54. C	55. C	56. C	57. A	58. C	59. D	60. A

61. C	62. A	63. C	64. D	65. B	66. A	67. C	68. A	69. C	70. D
71. D	72. B	73. C	74. C	75. B	76. B	77. C	78. D	79. D	80. C
81. C	82. A	83. C	84. B	85. D	86. C	87. C	88. A	89. A	90. A
91. A	92. C	93. C	94. B	95. C	96. B	97. B	98. A	99. D	100. A
101. A	102. B	103. C	104. D	105. A	106. D	107. C	108. B	109. B	110. A
111. C	112. A	113. B	114. B	115. A	116. B	117. C	118. A	119. B	120. B
121. B	122. C	123. D	124. C	125. D	126. A	127. D	128. D	129. C	130. A
131. B	132. A	133. A	134. D	135. B	136. D	137. D	138. D	139. B	140. D
141. A	142. B	143. C	144. D	145. A	146. B	147. A	148. D	149. D	150. C
151. C	152. C	153. A	154. B	155. B	156. D	157. D	158. D	159. D	160. C
161. B	162. C	163. B	164. D	165. B	166. B	167. A	168. B	169. B	170. C
171. B	172. A	173. C	174. A	175. C	176. C	177. B	178. A	179. B	180. C
181. D	182. C								

Multiple Correct Choice Type Questions

1. A, B, C, D	2. B, C	3. A, D	4. A, B, D	5. A, D
6. C, D	7. B, C	8. A, B, C	9. A, B, D	10. B, C
11. B, C	12. C, D	13. A, B	14. A, B, C, D	15. A, B, C
16. A, B, C	17. B, C	18. A, B, D	19. A, C, D	20. A, B, C
21. A, B, C	22. A, B	23. A, B, C	24. A, B, C, D	25. A, B, C
26. B, D	27. B, C			

Reasoning Based Questions

1. D	2. B	3. B	4. A	5. B	6. C	7. A	8. D	9. B	10. D
11. A	12. AB	13. A	14. D	15. B	16. B	17. D	18. A	19. D	

Linked Comprehension Type Questions

1. D	2. B	3. C	4. C	5. A	6. A	7. B	8. A	9. B	10. C
11. B	12. A	13. C	14. C	15. B	16. C	17. D	18. C	19. B	20. D
21. B	22. A	23. C	24. D	25. A	26. B	27. D	28. C	29. A	30. C
31. C	32. C	33. C	34. A	35. D	36. A	37. B			

Matrix Match/Column Match Type Questions

1. A → (p, q)	B → (p, r)	C → (p, s)	D → (p, q, r)
2. A → (p)	B → (p)	C → (p)	D → (s)
3. A → (p)	B → (q)	C → (r)	D → (q)
4. A → (p)	B → (s)	C → (r)	D → (q)
5. A → (p, r)	B → (q, r, s)	C → (q, r)	D → (p, r)
6. A → (r)	B → (p)	C → (q)	D → (q)
7. A → (q)	B → (s)	C → (p)	D → (s)
8. A → (p, s)	B → (p)	C → (q, s)	D → (p)
9. A → (s)	B → (p, r)	C → (s)	D → (q, r)



10. $A \rightarrow (p, q, s, t)$	$B \rightarrow (r, s, t)$	$C \rightarrow (q, r, s, t)$	$D \rightarrow (r, t)$
11. $A \rightarrow (q, r, s, t)$	$B \rightarrow (q, r, s, t)$	$C \rightarrow (q, r, s, t)$	$D \rightarrow (p, q, r, s, t)$
12. $A \rightarrow (q)$	$B \rightarrow (p)$	$C \rightarrow (s)$	$D \rightarrow (r)$
13. $A \rightarrow (s)$	$B \rightarrow (p)$	$C \rightarrow (r)$	$D \rightarrow (s)$

Integer/Numerical Answer Type Questions

1. 77	2. 8	3. 100	4. 8	5. 2
6. 100	7. 8	8. 800	9. 5	10. 449
11. 7	12. 2	13. 31	14. 8	15. 200
16. 4706	17. 1	18. 7	19. 8	20. 6
21. 4	22. 4	23. 24	24. 180	25. 560
26. 1.23	27. 1	28. 2000	29. 1539	30. 68

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1. B	2. C	3. A	4. A	5. B	6. C	7. D	8. D	9. A	10. C
11. A	12. C	13. B	14. D	15. A	16. A	17. A	18. B	19. B	20. D
21. C	22. C	23. C	24. D	25. A					

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Single Correct Choice Type Problems

1. B	2. C	3. C	4. A	5. A	6. A	7. B	8. C	9. D	10. B
11. A	12. D	13. C	14. A	15. D	16. C	17. D	18. C	19. A	20. B
21. B	22. C	23. D	24. D	25. A	26. B	27. C	28. B	29. B	30. A
31. D	32. C	33. C	34. C	35. B					

Multiple Correct Choice Type Problems

1. A, C	2. B, D	3. C, D	4. A, D	5. B, D
6. C, D	7. B, C			

Comprehension Type Questions

1. B	2. C	3. C	4. A	5. C	6. D	7. D	8. A	9. B
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Matrix Match/Column Match Type Questions

1. $A \rightarrow (p, q)$	$B \rightarrow (p, r)$	$C \rightarrow (p, s)$	$D \rightarrow (p, q, r)$
2. $A \rightarrow (r)$ OR (r, t)	$B \rightarrow (p, s)$	$C \rightarrow (q, t)$	$D \rightarrow (r)$
3. $A \rightarrow (q)$	$B \rightarrow (p)$	$C \rightarrow (s)$	$D \rightarrow (r)$
4. $A \rightarrow (p, r)$	$B \rightarrow (p, q, s)$	$C \rightarrow (p)$	$D \rightarrow (q)$

Integer/Numerical Answer Type Questions

1. 135	2. 5	3. 9	4. 2	5. 3
6. 4	7. 1	8. 8		