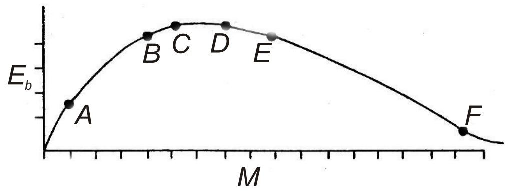
Nuclei

1. 

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 : **[AIEEE-2009]**

(i) $A + B \rightarrow C + \varepsilon$

(ii) $C \rightarrow A + B + \varepsilon$

(iii) $D + E \rightarrow F + \varepsilon$

(iv) $F \rightarrow D + E + \varepsilon$

where ε is the energy released? In which reactions is ε positive?

(1) (i) and (iii)

(2) (ii) and (iv)

(3) (ii) and (iii)

(4) (i) and (iv)

Directions : Question numbers 2 and 3 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. **[AIEEE-2010]**

2. The speed of daughter nuclei is

(1) $c\sqrt{\frac{\Delta m}{M + \Delta m}}$ (2) $c\frac{\Delta m}{M + \Delta m}$

(3) $c\sqrt{\frac{2\Delta m}{M}}$ (4) $c\sqrt{\frac{\Delta m}{M}}$

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

(1) $E_1 = 2\,E_2$ (2) $E_2 = 2\,E_1$

(3) $E_1 > E_2$ (4) $E_2 > E_1$

4. A radioactive nucleus (initial mass number A and atomic number Z) emits 3 α-particles and 2 positrons. The ratio of number of neutrons to that of protons in the final nucleus will be **[AIEEE-2010]**

(1) $\frac{A-Z-4}{Z-2}$ (2) $\frac{A-Z-8}{Z-4}$

(3) $\frac{A-Z-4}{Z-8}$ (4) $\frac{A-Z-12}{Z-4}$

5. Statement-1 : A nucleus having energy E_1 decays by β^- emission to daughter nucleus having energy E_2, but the β^- rays are emitted with a continuous energy spectrum having end point energy $E_1 - E_2$.

Statement-2 : To conserve energy and momentum in β-decay at least three particles must take part in the transformation. **[AIEEE-2011]**

(1) Statement-1 is correct, Statement-2 is correct and Statement-2 is the not correct explanation of Statement-1

(2) Statement-1 is incorrect, Statement-2 is correct

(3) Statement-1 is correct but Statement-2 is not correct

(4) Statement-1 and Statement-2 both are correct and Statement-2 is the correct explanation of Statement-1

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

(Mass of neutron = 1.6725×10^{-27} kg

Mass of proton = 1.6725×10^{-27} kg

Mass of electron = 9×10^{-31} kg) **[AIEEE-2012]**

(1) 7.10 MeV (2) 6.30 MeV

(3) 5.4 MeV (4) 0.73 MeV

7. 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 **[JEE (Main)-2016]**

(1) 4 : 1 (2) 1 : 4

(3) 5 : 4 (4) 1 : 16

8. 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 **[JEE (Main)-2017]**

(1) $t = \frac{T}{2}\frac{\log 2}{\log 1.3}$ (2) $t = T\frac{\log 1.3}{\log 2}$

(3) $t = T\log(1.3)$ (4) $t = \frac{T}{\log(1.3)}$

9. A sample of radioactive material A, that has an activity of 10 mCi(1 Ci = 3.7×10^{10} decays/s), 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 would then be respectively:

[JEE (Main)-2019]

(1) 10 day and 40 days

(2) 20 day and 5 days

(3) 20 day and 10 days

(4) 5 day and 10 days

10. 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 ln2, the half-life of B is **[JEE (Main)-2019]**

(1) 4 ln2 (2) $\frac{\ln 2}{2}$

(3) $\frac{\ln 2}{4}$ (4) 2 ln2

11. 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 **[JEE (Main)-2019]**

(1) 400 (2) 360

(3) 150 (4) 200

12. Consider the nuclear fission

$Ne^{20} \rightarrow 2He^4 + C^{12}$

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

[JEE (Main)-2019]

(1) Energy of 9.72 MeV will be supplied

(2) 8.3 MeV energy will be released

(3) Energy of 3.6 MeV will be released

(4) Energy of 11.9 MeV has to be supplied

13. In a radioactive decay chain, the initial nucleus is $^{232}_{90}Th$. At the end there are 6 α-particles and particles which are emitted. If the end nucleus is $^{A}_{Z}X$, A and Z are given by **[JEE (Main)-2019]**

(1) $A = 200$; $Z = 81$

(2) $A = 202$; $Z = 80$

(3) $A = 208$; $Z = 80$

(4) $A = 208$; $Z = 82$

14. An alpha-particle of mass m suffers 1-dimensional elastic collision with a nucleus at rest of unknown mass. It is scattered directly backwards losing, 64% of its initial kinetic energy. The mass of the nucleus is: **[JEE (Main)-2019]**

(1) 1.5m (2) 3.5m

(3) 4m (4) 2m

15. A nucleus A, with a finite de-Broglie wavelength λ_A, undergoes spontaneous fission into two nuclei B and C of equal mass. B flies in the same direction as that of A, while C flies in the opposite direction with a velocity equal to half of that of B. The de-Broglie wavelength λ_B and λ_C of B and C are respectively: **[JEE (Main)-2019]**

(1) $2\lambda_A, \lambda_A$ (2) $\lambda_A, \frac{\lambda_A}{2}$

(3) $\frac{\lambda_A}{2}, \lambda_A$ (4) $\lambda_A, 2\lambda_A$

16. The ratio of mass densities of nuclei ^{40}Ca and ^{16}O is close to : **[JEE (Main)-2019]**

(1) 0.1 (2) 1

(3) 2 (4) 5

17. 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 $1/e$ after a time : **[JEE (Main)-2019]**

(1) $\frac{1}{10\lambda}$ (2) $\frac{11}{10\lambda}$

(3) $\frac{1}{9\lambda}$ (4) $\frac{1}{11\lambda}$

18. 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 to become $\left(\frac{1}{e}\right)^2$ will be : **[JEE (Main)-2019]**

(1) $\frac{1}{2\lambda}$ (2) $\frac{1}{4\lambda}$

(3) $\frac{1}{\lambda}$ (4) $\frac{2}{\lambda}$

19. 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 : **[JEE (Main)-2019]**

(1) 9 : 8 (2) 3 : 8

(3) 8 : 1 (4) 1 : 8

20. The activity of a radioactive sample falls from 700 s^{-1} to 500 s^{-1} in 30 minutes. Its half life is close to **[JEE (Main)-2020]**

(1) 66 min

(2) 52 min

(3) 62 min

(4) 72 min

21. In a reactor, 2 kg of $_{92}U^{235}$ fuel is fully used up in 30 days. The energy released per fission is 200 MeV. Given that the Avogadro number, $N = 6.023 \times 10^{26}$ per kilo mole and 1 eV = 1.6×10^{-19} J. The power output of the reactor is close to **[JEE (Main)-2020]**

(1) 125 MW

(2) 35 MW

(3) 60 MW

(4) 54 MW

22. In a radioactive material, fraction of active material remaining after time t is 9/16. The fraction that was remaining after $t/2$ is **[JEE (Main)-2020]**

(1) $\frac{3}{4}$ (2) $\frac{4}{5}$

(3) $\frac{3}{5}$ (4) $\frac{7}{8}$

23. The radius R of a nucleus of mass number A can be estimated by the formula $R = (1.3 \times 10^{-15})A^{1/3}$ m. It follows that the mass density of a nucleus is of the order of ($M_{prot.} \cong M_{neut.} \simeq 1.67 \times 10^{-27}$ kg) **[JEE (Main)-2020]**

(1) 10^{24} kg m^{-3} (2) 10^{10} kg m^{-3}

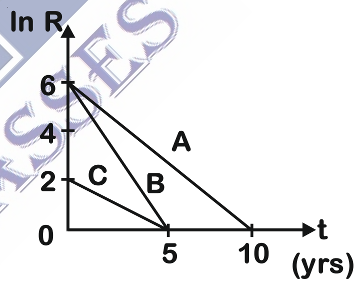
(3) 10^{17} kg m^{-3} (4) 10^{3} kg m^{-3}

24. Find the binding energy per nucleon for $^{120}_{50}Sn$. Mass of proton m_p = 1.00783 U, mass of neutron m_n = 1.00867 U and mass of tin nucleus m_{Sn} = 119.902199 U. (take 1U = 931 MeV) **[JEE (Main)-2020]**

(1) 9.0 MeV (2) 8.5 MeV

(3) 8.0 MeV (4) 7.5 MeV

25. Activities of three radioactive substances A, B and C are represented by the curves A, B and C, in the figure. Then their half-lives $T_{\frac{1}{2}}(A):T_{\frac{1}{2}}(B):T_{\frac{1}{2}}(C)$ are in the ratio **[JEE (Main)-2020]**



(1) 2 : 1 : 3 (2) 4 : 3 : 1

(3) 2 : 1 : 1 (4) 3 : 2 : 1

26. A physical quantity z depends on four observables a, b, c and d, as $z = \frac{a^2 b^{\frac{2}{3}}}{\sqrt{c}\, d^3}$. The percentages of error in the measurement of a, b, c and d are 2%, 1.5%, 4% and 2.5% respectively. The percentage of error in z is **[JEE (Main)-2020]**

(1) 13.5% (2) 14.5%

(3) 16.5% (4) 12.25%

27. A radioactive nucleus decays by two different processes. The half life for the first process is 10 s and that for the second is 100 s. The effective half life of the nucleus is close to **[JEE (Main)-2020]**

(1) 12 s (2) 9 s

(3) 55 s (4) 6 s

28. You are given that Mass of ${}^{7}_{3}\text{Li} = 7.0160\text{ u}$, Mass of ${}^{4}_{2}\text{He} = 4.0026\text{ u}$ and Mass of ${}^{1}_{1}\text{H} = 1.0079\text{ u}$.

When 20 g of ${}^{7}_{3}\text{Li}$ is converted into ${}^{4}_{2}\text{He}$ by proton capture, the energy liberated, (in kWh), is

[Mass of nucleon = 1 GeV/c^2] **[JEE (Main)-2020]**

(1) 1.33×10^6 (2) 4.5×10^5

(3) 8×10^6 (4) 6.82×10^5

29. Given the masses of various atomic particles $m_p = 1.0072$ u, $m_n = 1.0087$ u, $m_e = 0.000548$ u, $m_{\bar{\nu}} = 0$, $m_d = 2.0141\text{ u}$, where $p \equiv$ proton, $n \equiv$ neutron, $e \equiv$ electron, $\bar{\nu} \equiv$ antineutrino and $d \equiv$ deuteron. Which of the following process is allowed by momentum and energy conservation?

[JEE (Main)-2020]

(1) $n + n \rightarrow$ deuterium atom

(electron bound to the nucleus)

(2) $n + p \rightarrow d + \gamma$

(3) $p \rightarrow n + e^{+} + \bar{\nu}$

(4) $e^{+} + e^{-} \rightarrow \gamma$

30. A particle of mass 200 MeV/c^2 collides with a hydrogen atom at rest. Soon after the collision the particle comes to rest, and the atom recoils and goes to its first excited state. The initial kinetic energy of the particle (in eV) is $\frac{N}{4}$. The value of N is

(Given the mass of the hydrogen atom to be 1 GeV/c^2)______. **[JEE (Main)-2020]**

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