DPP – 1 (Nuclear Physics)

Video Solution on Website:- https://physicsaholics.com/home/courseDetails/88

Video Solution on YouTube:- https://youtu.be/JDpgtnmqww4

Written Solution on Website:- https://physicsaholics.com/note/notesDetalis/28

Q 1. The graph of $\log\left(\frac{R}{R_0}\right)$ versus log A (R = radius of a nucleus and A = mass number) is -

(a) a circle (b) an ellipse

(c) a parabola (d) a straight line

Q 2. The range of nuclear forces is about -

(a) 2×10^{-10}m

(b) 1.5×10^{-20} m

(c) 7.2×10^{-4} m

(d) 1.4×10^{-15} m

Q 3. A star initially has 10^{40} deuterons. It produces energy via the processes ${}_1H^2 + {}_1H^2 \rightarrow {}_1H^3 + p$ and ${}_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + n$. 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: [The mass of the nuclei are as follows $M(H^2) = 2.014$amu ; $M(n) = 1.008$ amu;$M(p) = 1.008$ amu; $M(He^4) = 4.001$ amu.]

(a) 10^6 s (b) 10^8s (c) 10^{12} s (d) 10^{16} s

Q 4. Let m_p be the mass of proton, m_n the mass of neutron. M_1 the mass of ${}^{20}_{10}Ne$ nucleus and M_2 the mass of ${}^{40}_{20}Ca$ nucleus. Then:

(a) $M_2 = 2 M_1$

(b) $M_2 > 2 M_1$

(c) $M_2 < 2 M_1$

(d) $M_1 < 10(m_n + m_p)$

Q 5. When an electron and positron with equal speeds in opposite direction annihilate each other, they cannot produce just one gamma ray, because that will violate law of–

(a) conservation of charge

(b) conservation of energy

(c) conservation of momentum

(d) conservation of nucleon number

Q 6. The heavier nuclie tend to have larger N/Z ratio because–

(a) a neutron is heavier than a proton

(b) a neutron is an unstable particle

(c) a neutron does not exert electric repulsion

(d) coulomb forces have longer range compared to the nuclear forces

Q 7. A proton moving with velocity v_0 moves towards a proton initially at rest and free to move. Find the distance of closest approach.

(a) $\frac{e^2}{2\pi\varepsilon_0 m v_0^2}$ (b) $\frac{e^2}{4\pi\varepsilon_0 m v_0^2}$

(c) $\frac{e^2}{\pi\varepsilon_0 m v_0^2}$ (d) None of these

Q 8. In the fusion reaction, ${}_1^2H + {}_1^2H \rightarrow {}_2^3He + {}_0^1n$ The masses of deutrons, helium and neutron expressed in amu are 2.015, 3.017 and 1.009 respectively. If 1 kg of deuterium undergoes complete fusion. Find the amount of total energy release, 1 amu = 931 MeV/C^2

(a) 6×10^{13} J (b) 5.6×10^{13} J

(c) 9×10^{13} J (d) 0.9×10^{13} J

Q 9. Nuclear radius of ${}_8O^{16}$ is 3 fermi. The nuclear radius of ${}_{82}Pb^{205}$ is

(a) 5.02 fermi (b) 5.02 fermi

(c) 7.02 fermi (d) 9.02 fermi

Q 10. In a star, three alpha particles join in succession to form ${}_6C^{12}$ nucleus. How much energy is evolved in this reaction? Take mass ${}_6C^{12}$ = 12 amu and that of alpha particle = 4.002603 amu

(a) 15 MeV (b) 18 MeV

(c) 7.27 MeV (d) 2.917 MeV

Q 11. Mass defect of an atom refers to -

(a) packing fraction of the atom

(b) increase in mass over total mass of its constituents to bind the atoms

(c) mass annihilated to produce energy to bind the nucleons

(d) error in the measurement of atomic masses

Q 12. The binding energy of deuteron is 2.2 MeV and that of ${}_2^4He$ is 28 MeV. If two deuterons are fused to form one ${}_2^4He$then the energy released is -

(a) 25.8 MeV (b) 23.6 MeV

(c) 19.2 MeV (d) 30.2 MeV

Q 13. For nuclei with A > 100, mark the incorrect statement -

(a) the binding energy per nucleon decreases on the average as A increases

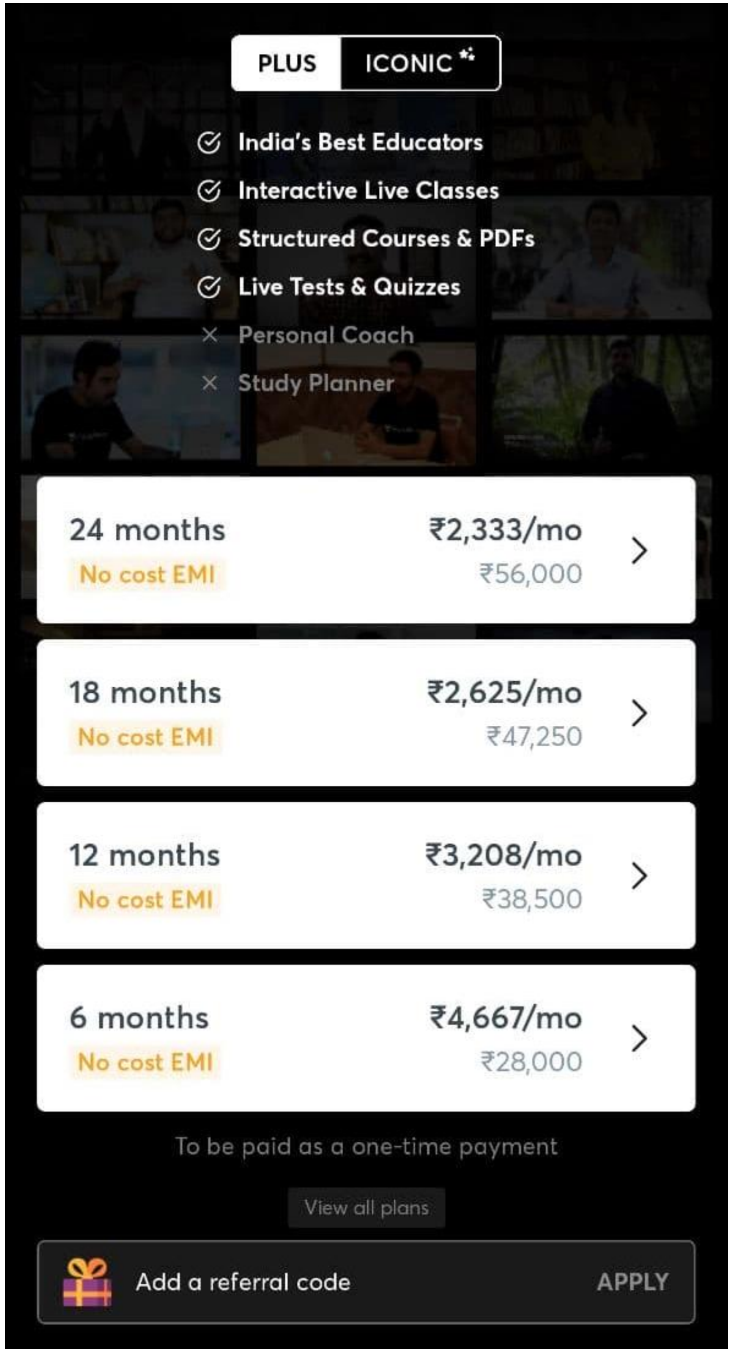
(b) if the nucleus breaks into two roughly equal parts, energy is released

(c) if two nuclei fuse to form a bigger nucleus energy is released

(d)the nucleus with Z > 83 are generally unstable

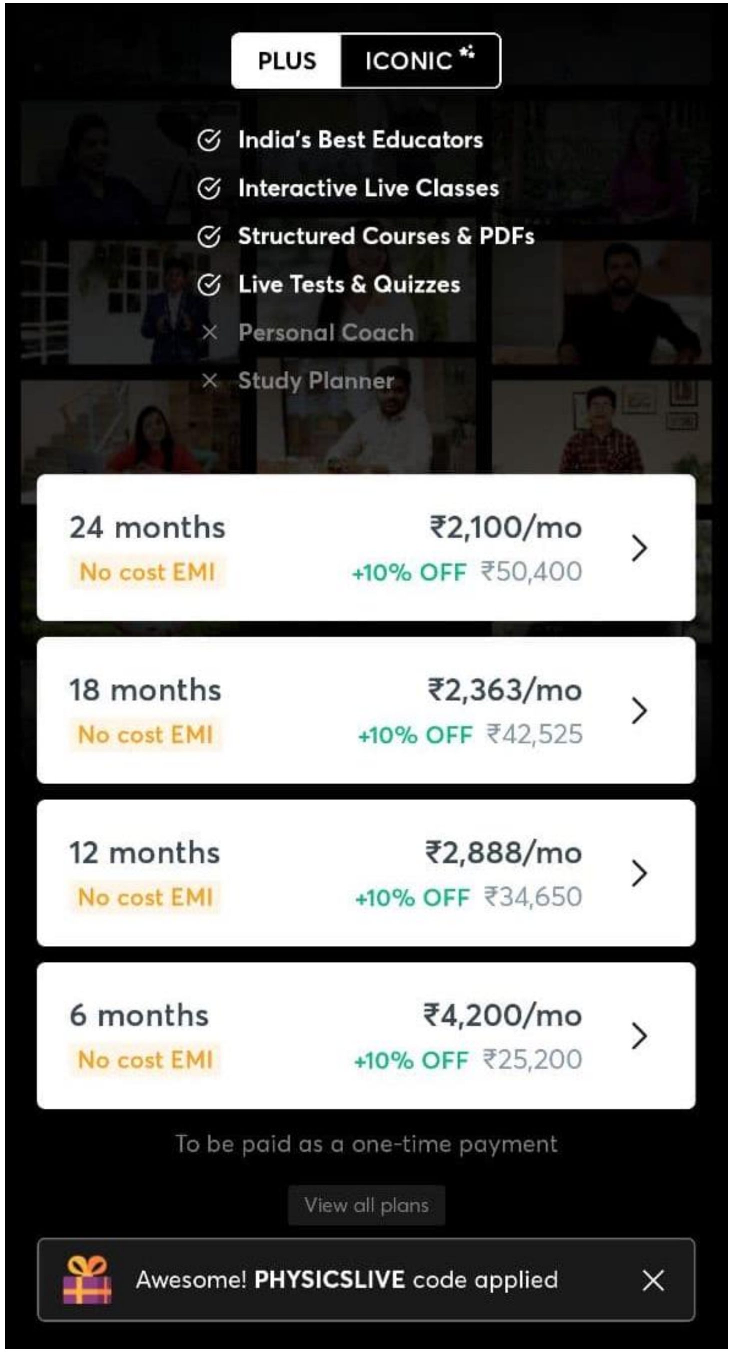
Answer Key

Q.1 d	Q.2 d	Q.3 c	Q.4 c,d	Q.5 c
Q.6 c,d	Q.7 c	Q.8 c	Q.9 c	Q.10 c
Q.11 c	Q.12 b	Q.13 c		



PHYSICSLIVE

Use code PHYSICSLIVE to get 10% OFF on Unacademy PLUS.



JEE Main & Advanced, NSEP, INPhO, IPhO
Physics DPP - Solution

DPP – 1 Nuclear Physics : Distance of closest approach, Nuclear density, Mass defect & Binding Energy

By Physicsaholics Team

Q1) The graph of $\log\left(\frac{R}{R_0}\right)$ versus log A (R = radius of a nucleus and A = mass number) is -

$$R = R_0 A^{1/3}$$

$$\frac{R}{R_0} = A^{1/3}$$

$$\underbrace{\log\left(\frac{R}{R_0}\right)}_{y} = \frac{1}{3}\underbrace{\log A}_{x}$$

(a) a circle

(b) an ellipse

(c) a parabola

$$y = \frac{1}{3}x$$

(d) a straight line ✓

Q2) The range of nuclear forces is about -

(a) 2×10^{-10}m

(b) 1.5×10^{-20} m

(c) 7.2×10^{-4} m

(d) 1.4×10^{-15} m

$931 \times .025$

$46\,55$

$186\,2\times$ 23.275

Q3) A star initially has 10^{40} deuterons. It produces energy via the processes ${}_1H^2 + {}_1H^2 \rightarrow {}_1H^3 + p$ and ${}_1H^2 + {}_1H^3 \rightarrow {}_2He^4 + n$. 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: The mass of the nuclei are as follows $M(H^2) = 2.014$ amu ; $M(n) = 1.008$ amu; $M(p) = 1.008$ amu; $M(He^4) = 4.001$ amu.

$${}_1H^2 + {}_1H^2 \longrightarrow {}_1H^3 + p$$

$${}_1H^2 + {}_1H^3 \longrightarrow {}_2He^4 + n$$

$$3\ {}_1H^2 \longrightarrow {}_2He^4 + p + n$$

energy released per ${}_1H^2 = \frac{23.275 \text{ MeV}}{3} = 7.758 \text{ MeV}$

no of ${}_1H^2$ consumed/sec $= \frac{10^{16}}{7.758 \times 10^6 \times 1.6 \times 10^{-19}}$

(a) 10^6 s (b) 10^8 s (c) 10^{12} s (d) 10^{16} s

Q value $= [3 \times 2.014 - 4.001 - 1.008 - 1.008]\, 931$ MeV

$= [6.042 - 6.017]\, 931$ MeV

$= .025 \times 931$ MeV $= 23.275$ MeV

$T = \frac{10^{40} \times 7.8 \times 1.6 \times 10^{-13}}{10^{16}}$

$= 7.8 \times 1.6 \times 10^{11}$ sec

$\simeq 10^{12}$

Q4) Let m_p be the mass of proton, m_n the mass of neutron. M_1 the mass of $^{20}_{10}Ne$ nucleus and M_2 the mass of $^{40}_{20}Ca$ nucleus. Then:

(a) $M_2 = 2M_1$

(b) $M_2 > 2M_1$

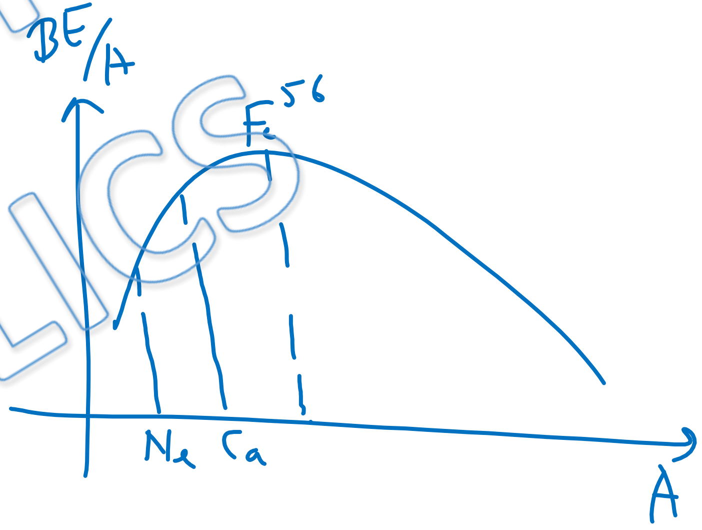
(c) $M_2 < 2M_1$ ✓

(d) $M_1 < 10(m_n + m_p)$

M_2: 20p 20n — high BE/A, high $\Delta m/A$

$2M_1$: 20p 20n — low BE/A, low $\Delta m/A$

$M_2 < 2M_1$



$BE = [\text{mass of Protons} + \text{mass of neutrons} - M]c^2$

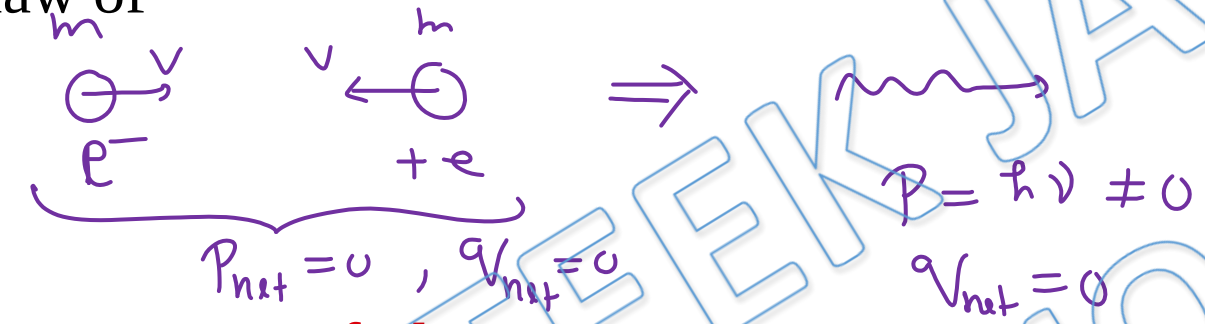
$\Rightarrow M = \text{mass of protons} + \text{mass of neutrons} - BE/c^2$

$M_1 = 10m_p + 10m_n - 20B_1/c^2$ (B = BE/A) & $M_2 = 20m_p + 20m_n - 40B_2/c^2$

$2M_1 = 20m_p + 20m_n - 40B_1/c^2$

Since $B_2 > B_1$, $M_2 < 2M_1$

Q5) When an electron and positron with equal speeds in opposite direction annihilate each other, they cannot produce just one gamma ray, because that will violate law of–



(a) conservation of charge

(b) conservation of energy

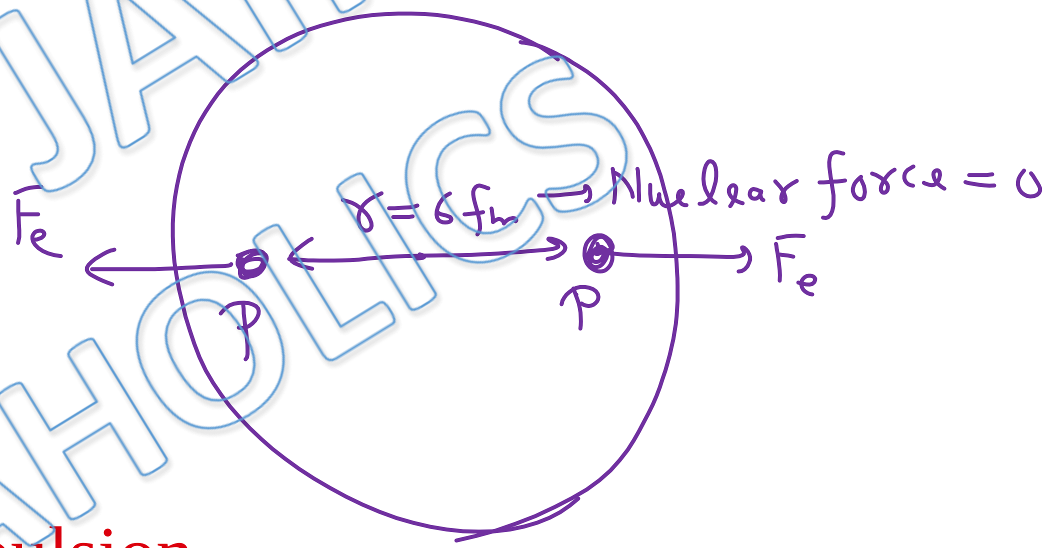
(c) conservation of momentum

(d) conservation of nucleon number

Q6) The heavier nuclie tend to have larger N/Z ratio because–

$R = R_0 A^{1/3}$

high $A \Rightarrow$ high R



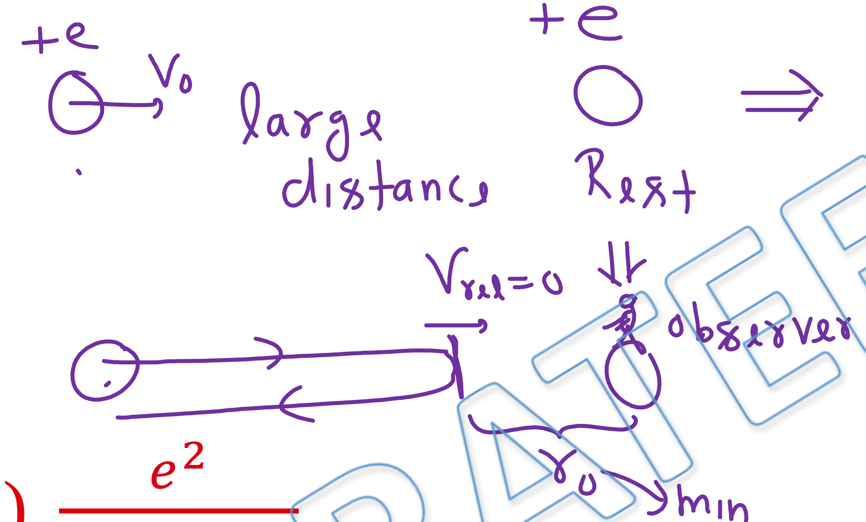
(a) a neutron is heavier than a proton

(b) a neutron is an unstable particle

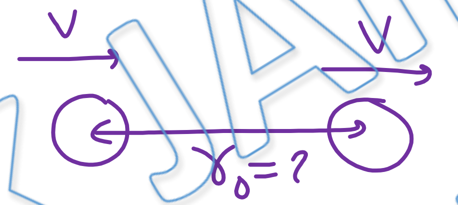
(c) a neutron does not exert electric repulsion

(d) coulomb forces have longer range compared to the nuclear forces

Q7) A proton moving with velocity v_0 moves towards a proton initially at rest and free to move. Find the distance of closest approach.



$\Rightarrow$



at min distance $V_{rel} = 0$

$\Rightarrow V_1 = V_2 = V$

by Conservation of momentum

$mV_0 = 2mV \quad -(1)$

$V = V_0/2$

by COME

$\frac{1}{2}mV_0^2 + 0 = \frac{1}{2}mV^2 \times 2 + \frac{e^2}{4\pi\epsilon_0 r_0}$

$\frac{1}{2}mV_0^2 = \frac{mV_0^2}{4} + \frac{e^2}{4\pi\epsilon_0 r_0}$

$\frac{1}{4}mV_0^2 = \frac{e^2}{4\pi\epsilon_0 r_0}$

(a) $\frac{e^2}{2\pi\varepsilon_0 m v_0^2}$

(b) $\frac{e^2}{4\pi\varepsilon_0 m v_0^2}$

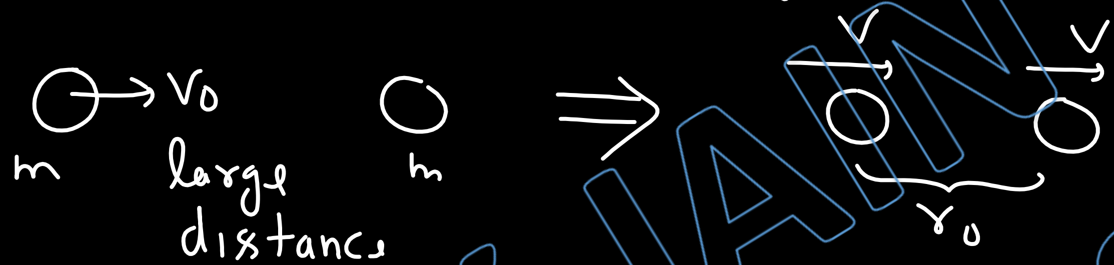
(c) $\frac{e^2}{\pi\varepsilon_0 m v_0^2}$ ✓

(d) None of these

Ans. c

KE of two particle system w r t CM $= \frac{1}{2}\mu V_{rel}^2$

where $\mu = \frac{m_1 m_2}{m_1 + m_2}$



Here CM is inertial frame Since V_{cm} = Constant.

by Conservation of mechanical energy w r t cm frame →

$$KE_i + PE_i = KE_f + PE_f$$

$$\Rightarrow \frac{1}{2} \times \left(\frac{m}{2}\right) V_0^2 + 0 = \frac{1}{2}\left(\frac{m}{2}\right)(0)^2 + \frac{e^2}{4\pi\epsilon_0 r_0}$$

$$\Rightarrow \frac{1}{4} m V_0^2 = \frac{e^2}{4\pi\epsilon_0 r_0}$$

$$\Rightarrow r_0 = \frac{e^2}{\pi\epsilon_0 m V_0^2}$$

Q8) In the fusion reaction, ${}^{2}_{1}H + {}^{2}_{1}H \rightarrow {}^{3}_{2}He + {}^{1}_{0}n$ The masses of deutrons, helium and neutron expressed in amu are 2.015, 3.017 and 1.009 respectively. If 1 kg of deuterium undergoes complete fusion. Find the amount of total energy release, 1 amu = 931 MeV/C^2

Q value = $[2 \times 2.015 - 3.017 - 1.009]$ 931 MeV = $[4.030 - 4.026]$ 931 MeV

= .004 × 931 MeV = 3.724 MeV

Energy released per deutron atom = $\frac{3.724}{2}$ MeV = 1.862 MeV

(a) 6×10^{13} J

(b) 5.6×10^{13} J

(c) 9×10^{13} J ✓

(d) 0.9×10^{13} J

Total no of ${}^{2}_{1}H$ atoms = $\left(\frac{1000\,g}{2\,g}\right) \times 6 \times 10^{23}$ atoms (= 3×10^{26})

Total energy released = $3 \times 10^{26} \times 1.862 \times 1.6 \times 10^{-13}$

= 9×10^{13}

Q9) Nuclear radius of ${}_{8}O^{16}$ is 3 fermi. The nuclear radius of ${}_{82}Pb^{205}$ is

$R = R_0 A^{1/3}$

$3f = R_0 (16)^{1/3}$

$R = R_0 (205)^{1/3}$

$4^3 = 64$

$5^3 = 125$

(a) 5.02 fermi (b) 5.02 fermi (c) 7.02 fermi (d) 9.02 fermi

$\frac{3f}{R} = \frac{(16)^{1/3}}{(205)^{1/3}}$

$R = 3f \left(\frac{205}{16}\right)^{1/3} = \frac{3f}{2} (102.5)^{1/3}$

$6f < R < 7.5f$ Since $64 < 102.5 < 125$

Q10) In a star, three alpha particles join in succession to form $_6C^{12}$ nucleus. How much energy is evolved in this reaction? Take mass $_6C^{12}$ = 12 amu and that of alpha particle = 4.002603 amu

$$3\ {}_2He^4 \longrightarrow {}_6C^{12}.$$

$$Q\ value = (3 \times 4.002603 - 12)\,931\ MeV$$

$$= (12.007809 - 12)\,931\ MeV = .007809 \times 931\ MeV$$

(a) 15 MeV

(b) 18 MeV

(c) 7.27 MeV ✓

(d) 2.917 MeV

Q11) Mass defect of an atom refers to -

(a) packing fraction of the atom

(b) increase in mass over total mass of its constituents to bind the atoms

(c) mass annihilated to produce energy to bind the nucleons

(d) error in the measurement of atomic masses

Q12) The binding energy of deuteron is 2.2 MeV and that of $^{4}_{2}He$ is 28 MeV. If two deuterons are fused to form one $^{4}_{2}He$ then the energy released is -

Q Value = BE of Products − BE of reactants

$= 28\,MeV - 2.2 \times 2$

$= (28 - 4.4)\,MeV = 23.6\,MeV$

(a) 25.8 MeV

(b) 23.6 MeV

(c) 19.2 MeV

(d) 30.2 MeV

Q13) For nuclei with A > 100, mark the incorrect statement -

(a) the binding energy per nucleon decreases on the average as A increases

(b) if the nucleus breaks into two roughly equal parts, energy is released

(c) if two nuclei fuse to form a bigger nucleus energy is released

(d)the nucleus with Z > 83 are generally unstable

For Video Solution of this DPP, Click on below link

Video Solution on Website:- https://physicsaholics.com/home/courseDetails/88

Video Solution on YouTube:- https://youtu.be/JDpgtnmqww4

Written Solution on Website:- https://physicsaholics.com/note/notesDetalis/28

SUBSCRIBE

@Physicsaholics

@Physicsaholics_prateek

@NEET_Physics
@IITJEE_Physics

physicsaholics.com

Unacademy

CLICK

Chalo Niklo