Solution

CET25P13 NUCLEI

Class 12 - Physics

1.

(b) M(N, Z) = $NM_n + ZM_p - \frac{B}{c^2}$

Explanation: From the above problem,

B.E. = $[ZM_p + (A - Z)M_n - M(N, Z)]c^2$

$\therefore$ M(N, Z) = $ZM_p + NM_n - B/c^2$

2.

(d) $A^{\frac{1}{3}}$

Explanation: The average radius of a nucleus with A nucleons is

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

where, $R_0 = 1.2 \times 10^{-15}$ m

The volume of the nucleus is directly proportional to the total number of nucleons.

3.

(c) decrease

Explanation: ${}_0^1n \rightarrow {}_1^1\text{H} + {}_{-1}^{0}e + \bar{v}$

When an electron is emitted from the nucleus, a neutron changes into a proton. Hence neutron-proton ratio decreases.

4. **(a)** 18 and 8

Explanation: ${}_7^{15}\text{X} + {}_2^4\text{He} \rightarrow {}_1^1\text{H} + {}_Z^A\text{Y}$

By conservation of mass

A + 1 = 15 + 4 $\Rightarrow$ A = 18

By conservation of charge,

Z + 1 = 7 + 2 $\Rightarrow$ Z = 8

5.

(b) 3%

Explanation: $\frac{N}{N_0} = \frac{1}{2^5} = \frac{1}{32}$

$\therefore N = \frac{N_0}{32}$, where $N_0 =$ initial amount

$\%N = \frac{N_0}{32} \times 100 = 3.125\%$

6.

(c) liquid droplet theory

Explanation: Nuclear fission is best explained by liquid drop model of the nucleus.

7.

(d) Positive

Explanation: The nucleus, that dense central core of the atom, contains both protons and neutrons. Electrons are outside the nucleus in energy levels. Protons have a positive charge, neutrons have no charge, and electrons have a negative charge.

8. **(a)** 1 : 3

Explanation: Since $\frac{R_1}{R_2} = \left[\frac{A_1}{A_2}\right]^{\frac{1}{3}}$

= $\left[\frac{1}{27}\right]^{\frac{1}{3}}$

= $\frac{1}{3}$.

9.

(b) ${}_8O^{16} + {}_0n^1 \rightarrow {}_7N^{14} + 3\ {}_1H^1 + 2\ {}_{-1}\beta^0$

This reaction is not balanced properly.

Explanation: $_8O^{16} + {_0n^1} \rightarrow {_7N^{14}} + 3\ {_1H^1} + 2\ {_{-1}\beta^0}$

10. **(a)** Uranium - 236

Explanation: U - 236 has a larger delayed neutron fraction.

11.

(d) $\frac{(1-A)^2}{(1+A)^2}$

Explanation: $v_1 = \frac{(m_1-m_2)u_1}{m_1+m_2} = \frac{(1-A)u_1}{1+A}$

or $\frac{v_1}{u_1} = \frac{1-A}{1+A}$

$\frac{\text{Final K.E.}}{\text{Initial K.E.}} = \frac{\frac{1}{2}m_1v_1^2}{\frac{1}{2}m_1u_1^2}$

$= \left(\frac{v_1}{u_1}\right)^2 = \frac{(1-A)^2}{(1+A)^2}$

12.

(b) 11, 12, 0

Explanation: In $^{23}_{11}Na$ nucleus,

Number of protons = Z = 11

Number of neutrons = A - Z =23 -11 = 12.

Number of electrons = 0.

13.

(c) Y > X

Explanation: Nuclear force is greater than Coulomb force.

14.

(b) $A^{1/3}$

Explanation: R = $R_0A^{1/3}$

15.

(b) 10^{17} kg/m^3

Explanation: Mass per unit volume of nucleus is called nuclear density

Nuclear density is the density of the nucleus of an atom, averaging about 2.3 $\times 10^{17}$ kg/m^3

Hence order of magnitude of density is 10^{17} kg/m^3

16.

(d) They are always attractive.

Explanation: They are always attractive.

17. **(a)** 23.6 MeV

Explanation: $^2_1\text{H} + {^2_1\text{H}} \rightarrow {^4_2\text{He}} + Q$

$Q = \text{ B.E. } \left(^4_2\text{ He}\right) - 2 \times \text{ B. } E\left(^2_1H\right)$

= 28 - 2 $\times$ 2.2

= 23.6 MeV

18. **(a)** 1

Explanation: 1

19.

(d) chain reaction of neutrons and $_{92}U^{235}$

Explanation: In an atomic bomb, the energy is released due to the chain reaction of neutrons and $_{92}U^{235}$ nuclei.

20. **(a)** 0.51 MeV

Explanation: E = mc^2

$= \frac{9.1\times10^{-31}\times9\times10^{16}}{1.6\times10^{-19}}$

= 0.51 MeV

21. **(a)** 4×10^{-5} kg

Explanation: E = 10^6kWh $= 10^6 \times 3.6 \times 10^6$ J $= 3.6 \times 10^{12}$ J

$\Delta m = \frac{E}{c^2} = \frac{931 \times 1.6 \times 10^{-13}}{(3 \times 10^8)^2}$

$= 1.66 \times 10^{-27}$ kg

22.

(c) a proton

Explanation: Protons and neutrons have the same mass, which is much larger than the mass of an electron. Protons and electrons have an electrical charge. This electrical charge is the same size for both, but protons are positive and electrons are negative. Neutrons have no electrical charge; they are neutral.

23.

(d) 28.4 MeV

Explanation: $\triangle$m = 2(1.0073 + 1.0087) - 4.0015 = 0.0305u

B.E. = $\triangle mc^2$

B.E. = (0.0305 u)c^2

$B.E = (0.0305u) \times 931 MeV/u$

B.E. = 28.4 MeV

24.

(d) 9×10^{10} joule

Explanation: E = $\Delta mc^2 = 1 \times 10^{-6} \times (3 \times 10^8)^2$ J $= 9 \times 10^{10}$ J

25.

(c) Neutrons

Explanation: Chemical properties are changed by addition or removal of electrons or protons. Neutrons are neutral particles. So they don't alter chemical properties.

26.

(d) Z protons and A - Z neutrons

Explanation: In the nucleus, $_ZX^A$, Z denotes the number of protons while A denotes the sum of protons and neutrons. Hence, the number of protons in the given nucleus = Z and the number of neutrons is = A - Z

27. **(a)** (8 M_p + 9 M_n - M_o) c^2

Explanation: The nucleus of the isotope $_8O^{17}$ of the oxygen contains 8 protons and 17 - 8 i.e. 9 neutrons. The binding energy of a nucleus is the energy equivalent to the difference of mass of the constituent nucleons and the mass of nucleus.

28. **(a)** 11 protons and 13 neutrons

Explanation: atomic no = No. of protons

Charge No. = 11 = No. of protons

Mass no. = No. of protons + No of neutrons

24 = 11 + No. of neutrons

No. of neutrons = 13

29. **(a)** an alpha particle

Explanation: Alpha decay is the decay of uranium $^{238}U_{92}$ to thorium $^{234}Th_{90}$ with the emission of a helium nucleus $^4He_2$.

$^{238}_{92}U \rightarrow ^{234}_{90}Th + ^4_2He$

30.

(d) M < [N - M_n + Z - M_p]

Explanation: The mass of a nucleus is less than the sum of the masses of its constituent nucleons.

31.

(c) $\frac{4}{3}$

Explanation: $\frac{r_1}{r_2} = \left(\frac{A_1}{A_2}\right)^{1/3} = \left(\frac{64}{27}\right)^{1/3} = \frac{4}{3}$

32.

(b) less than the total mass of neutrons and protons.

Explanation: Since, the mass depends upon energy. Also, ground state energy is lesser than first excited energy therefore the mass of nucleus would be less than the mass of neutrons and protons.

33.

(c) Z protons and A -Z neutrons

Explanation: A nucleus $\,_{z}^{A}X$ has Z protons and (A-Z) neutrons.

34.

(c) 17.6 eV

Explanation: ${}_1^2\mathrm{H}+{}_1^3\mathrm{H}\longrightarrow{}_2^4\mathrm{He}+{}_0^1n+Q$

$Q=\left[m\left({}_1^2\mathrm{H}\right)+m\left({}_1^3\mathrm{H}\right)-m\left({}_2^4\mathrm{He}\right)-m\left({}_0^1n\right)\right]c^2$

= [2.014102 + 3.016050 - 4.002603 -1.008665]

= 931.5 MeV

= 0.018884 $\times$ 931.5 MeV

= 17.6 MeV

35. **(a)** neutron

Explanation: 4 + A = A + 3 + A' = 1

2 + Z = Z + 2 + Z' = 0

Hence ${}_0^1M$ is a neutron.

36. **(a)** ${}_{Z-2}^{A-4}Y$

Explanation: Alpha particle has mass number 4 and atomic number 2. Thus, A decreases to A - 4 and Z decreases to Z - 2. Thus, ${}_{Z-2}^{A-4}Y$

37.

(b) 1.862 MeV

Explanation: 1.862 MeV

38.

(c) neutron

Explanation: ${}_1^2\mathrm{H}+{}_1^2\mathrm{H}\longrightarrow{}_2^3\mathrm{He}+{}_0^1n$

39. **(a)** 12 h

Explanation: For safe level,

$\frac{N}{N_0}=\left(\frac{1}{2}\right)^n=\frac{1}{64}\Rightarrow n=6$

$\therefore t=nT_{1/2}=6\times 2\text{ h}=12\text{ h}$

40. **(a)** c - a - b

Explanation: Q = B.E. (${}_2^4\mathrm{He}+{}_0^1n$) - B.E. (${}_1^2\mathrm{H}+{}_1^3\mathrm{H}$)

= c + 0 - (a + b) = c - a - b

41.

(c) Both nuclear fusion and nuclear fission

Explanation: Hydrogen bomb combines both nuclear fission and nuclear fusion to produce a powerful blast. The first stage of a hydrogen bomb involves a fission explosion. The explosion, in turn, leads to a second stage - fusion.

42. **(a)** $\frac{5}{3}\mathrm{R}$

Explanation: $\frac{5}{3}\mathrm{R}$

43.

(c) Electron

Explanation: Anti-particle will have same characteristic because of its conjugate particle due to which they have closest mass.

44.

(d) uranium-235

Explanation: A neutron, slow or fast, can cause fission U-235 nuclei.

45.

(d) both charge and mass number

Explanation: During a nuclear reaction, the mass of reactants may be more than products. The lost mass is converted into an enormous amount of energy. Charge is conserved as total charge before and after the reaction always remain the same in nuclear reaction.

46.

(b) 931 MeV

Explanation: E = mc^2

$E = \frac{[(1.66\times10^{-27})\times(9\times10^{16})]}{1.6\times10^{-19}}$

E = 931 MeV

47.

(b) M = M_{proton} + $M_{electron}$ - $\frac{BE}{c^2}$(BE = 13.6 eV)

Explanation: During the formation of H-atom, some mass of nucleons converts into energy by E = mc^2 this energy is used to bind the nucleons along with the nucleus. So the mass of atom becomes slightly less than the sum of actual masses of nucleons and electrons.

The effective mass of H atom is given by M = M_p + M_e - $\frac{BE}{c^2}$ ($\frac{B}{c^2}$ is binding energy)

B.E. (B) of H atoms is 13.6 eV per atom.

48.

(d) neutrons are electrically neutral entities

Explanation: Neutrons have no electrical charge and contribute only the mass of the nucleus. Each proton has a positive charge equal in strength to the negative charge carried by an electron.

49.

(d) Its atomic number and its actual mass remain unchanged

Explanation: Photon are chargeless and massless species . So atomic and mass no remains the same.

50.

(c) The helium nucleus has more kinetic energy than the thorium nucleus.

Explanation: ${}^{238}_{92}\mathrm{U} \rightarrow {}^{214}_{90}\mathrm{Th} + {}^{4}_{2}\mathrm{He}$

By conservation of linear momentum,

$p_f = p_i = 0$

$\therefore p_{\mathrm{He}} - p_{\mathrm{Th}} = 0 \Rightarrow p_{\mathrm{He}} = p_{\mathrm{Th}}$

$\Rightarrow K_{\mathrm{He}} > K_{\mathrm{Th}}$

51. **(a)** (C)

Explanation: The mass of a nucleus is sometimes equal to its atomic number. For example, for ${}^{1}_{1}\mathrm{H}$ nucleus, A = Z = 1.

52.

(d) ${}^{56}_{26}\mathrm{Fe}$

Explanation: The binding energy per nucleon is maximum for ${}^{56}_{26}\mathrm{Fe}$ (about 8.8 MeV/nucleon).

53.

(d) directly proportional to the mass number

Explanation: The volume of the nucleus is directly proportional to the total number of nucleons. As the average radius of a nucleus with A nucleons is given by $R = \mathrm{R}_0 A^{\frac{1}{3}}$, where $R_0 = 1.2 \times 10^{-15}$ m. So, we can say that the average volume of the nucleus is directly proportional to no. of nucleons.

54.

(b) 3 : 2

Explanation: $\frac{R_1}{R_2} = \left(\frac{A_1}{A_2}\right)^{\frac{1}{3}} = \left(\frac{216}{64}\right)^{\frac{1}{3}} = \frac{6}{4}$ = 3 : 2

55.

(c) ${}^{10}_{5}$ B

Explanation: ${}^{A}_{Z}X + {}^{1}_{0}n \rightarrow {}^{7}_{3}Li + {}^{4}_{2}Fe$

A = 11 - 1 = 10

Z = 5 - 0 = 5

$\therefore$ X is ${}^{10}_{5}$ B.

56.

(c) (D)

Explanation: The nucleus $_{92}U^{235}$ has 234 - 92 = 142 neutrons. It has highest neutron to proton ratio (142 : 92).

It has highest neutron to proton ratio (142 : 92)

57.

(d) All of these

Explanation: In nuclear reactions momentum, the sum of mass and energy and charges are conserved.
During a nuclear reaction, the mass of reactants may be more than products. The lost mass is converted into an enormous amount of energy. According to the conservation of mass and energy law, the total quantity of matter and energy remains constant in an isolated system.
Charges are conserved as total charge before and after the nuclear reaction remains same.

58.

(d) 200 MeV

Explanation: Energy released
= B.E. (X) + B.E. (Y)- B.E. (U)
= 8.5 $\times$ 117 + 8.5 $\times$ 117 - 236 $\times$ 7.6
= 994.5 + 994.5 - 1793.6
= 195.4 MeV $\approx$ 200 MeV

59.

(b) 58.3 MW

Explanation: Mass used in 30 days = 2 kg = 2000 g
Mass used up per second (m)
$= \frac{2000}{30\times 24\times 60\times 60} = \frac{1}{36\times 36}$
No. of atoms in 235 g of $^{235}_{92}\mathrm{U} = 6.023 \times 10^{23}$
No. of atoms in $\frac{1}{36\times 36}$ g of $^{235}_{92}U$
$= \frac{6.023\times 10^{23}}{235\times 36\times 36} = 1.977 \times 10^{18}$
This is the number of nuclei undergoing fission per second. Now energy released per fission = 185 MeV
Total energy released per second
= 1.977 $\times$ 10^{18} $\times$ 185 MeV
= 1.977 $\times$ 10^{18} $\times$ 185 $\times$ 1.6 $\times$ 10^{-13} J = 5.85 $\times$ 10^{7} J
Power output
= 5.85 $\times$ 10^{7} Js^{-1} = 5.85 $\times$ 10^{7} W = 58.5 MW

60.

(d) $4(x_2 - x_1)$

Explanation: B.E. of reacting nuclei = 2 $\times$ 2 $\times$ 1 = $4x_1$

B.E. of product nucleus = $4x_2$

Energy released,
Q = B.E. of product nucleus - B.E. of reacting nuclei
= $4(x_2 - x_1)$

61.

(d) Nuclear fusion of lighter elements in the sun.

Explanation: In this reaction two light nuclei are combined against proton-proton repulsion which requires temp. of order 10^7 or 10^8 Kelvin. This high temp. is possible only inside the core of stars like sun.

62.

(d) π-meson
Explanation: π-meson

63.

(c) $_{n}X^{m-4}$

Explanation: ${}_{n}^{m}X \xrightarrow{\alpha-decay} {}_{n-2}^{m-4}X \xrightarrow{2\beta-decay} {}_{n}^{m-4}X$

64.

(d) change for α and β radioactivity but not for γ-radioactivity

Explanation: β - Particles carry one unit of a negative charge, and α-particle carries 2 units of positive charge, and Y-particle carries no charge. So the electronic energy level of the atom changes in emission of α and β particle, but not in γ decay.

65.

(b) 23.6 MeV

Explanation: 23.6 MeV

66.

(b) 6 : 10

Explanation: $\frac{r\left(\frac{27}{13}\text{Al}\right)}{r\left(\frac{125}{52}\text{Te}\right)} = \left(\frac{27}{125}\right)^{1/3} = \frac{3}{5} = \frac{6}{10}$

67.

(b) 2×10^{-9} g/hr

Explanation: Efficiency = $\frac{\text{Output power}}{\text{Input power}}$

$\frac{20}{100} = \frac{10\text{ W}}{\text{Input power}}$

Input power = 10×5 = 50 W = 50 Js^{-1}

$\Delta m = \frac{E}{c^2} = \frac{50}{\left(3\times10^8\right)^2}\text{ kg s}^{-1}$

$= \frac{50\times3600\times10^3}{\left(3\times10^8\right)^2}\text{ g/h}$

$= 2\times10^{-9}\text{ g/h}$

68.

(b) $\frac{5}{3}R_{\text{Al}}$

Explanation: $R \propto A^{1/3}$

$\therefore \frac{R_{\text{Te}}}{R_{\text{Al}}} = \left(\frac{125}{27}\right)^{1/3} = \frac{5}{3}$

$R_{\text{Te}} = \frac{5}{3}R_{\text{Al}}$

69.

(c) 19 : 81

Explanation: Suppose natural boron has x% of ${}_{5}^{10}\text{B}$ isotope and (100 - x)% of isotope. Then

$\frac{10\times x+11(100-x)}{100}$ = 10.81

or x = 19%

$\therefore {}_{5}^{10}B : {}_{5}^{11}B$ = 19 : 81

70.

(d) Mass defect of the nucleus

Explanation: Mass defect of the nucleus

71.

(d) proportional to the cube root of its mass number

Explanation: Experimental measurements show that volume of a nucleus is proportional to its mass number A. If R be the radius of the nucleus assumed to be spherical, then its volume, $\left(\frac{4}{3}\pi R^3\right) \propto A$

or $R \propto A^{1/3}$ or R = $R_0A^{1/3}$

Where, R_0 is an empirical constant whose value is found to be 1.1×10^{15}m

72.

(b) constant

Explanation: The mass density of a nucleus is independent of its mass number.

73.

(d) fusion

Explanation: At very high temperature in the interior of the sun, protons fuse together to form helium nuclei, liberating a huge amount of energy.

74.

(b) 10^{18}

Explanation: 200 MeV = $200 \times 1.6 \times 10^{-13} = 3.2 \times 10^{-11}$ J

Energy required = P $\times$ t = 20 $\times$ 10^6 $\times$ 1 = 2 $\times$ 10^7

Number of neutrons emitted for 32 $\times$ 10^{-11} J of energy = 1.6

$\therefore$ Number of neutrons emitted for 2 $\times$ 10^7 J of energy

$= \frac{1.6}{32 \times 10^{-11}} \times 2 \times 10^7 = 10^{18}$

75.

(b) neutrons and protons

Explanation: The consistents of atomic nuclei are neutrons and protons.