CHAPTER - 18
MODERN PHYSICS

JEE MAIN - SECTION I

1. 4

$$\frac{1}{2}mv^2 = \frac{hc}{\lambda} - W$$

$$\frac{1}{2}mv'^2 = \frac{hc}{3\lambda/4} - W$$

$$\text{Dividing, } \left(\frac{v'}{v}\right)^2 = \frac{\frac{4hc}{3\lambda} - W}{\frac{hc}{\lambda} - W}$$

$$v' > v\sqrt{\frac{4}{3}}$$

Hence, the correct answer is (D).

2. 1

The stopping potential for curves a and b is same.

$\therefore\ f_a = f_b$

Also saturation current is proportional to intensity

$\therefore\ I_a < I_b$

3. 4

$$v = \sqrt{\frac{2qV}{m}}$$

Hence, the correct answer is (D).

4. 2 . Force acting on electron

$$F = ma$$

$$eE_0 = ma$$

$$a = \frac{eE_0}{m}$$

Velocity of electron after time t in x-direction,

$$v = v_0 + at$$

$$v = v_0 + \frac{eE_0}{m}t$$

$$\lambda = \frac{h}{mv} = \frac{h}{m\left[v_0 + \frac{eE_0}{m}t\right]} = \frac{h}{mv_0\left[1 + \frac{eE_0}{mv_0}t\right]}$$

$$= \frac{\lambda_0}{\left(1 + \frac{eE_0}{mv_0}t\right)}$$

5. 2 Let the velocities of the particles A and B just after the collision be v_1 and v_2, respectively.

Applying law of conservation of momentum,

$$mv = mv_1 + \left(\frac{m}{2}\right)v_2$$

or $$2v = 2v_1 + v_2 \qquad ...(i)$$

For the elastic collision the coefficient of restitution, $e = 1$

Thus,

$$e = \frac{v_2 - v_1}{v - 0} = 1$$

or, $\qquad v = v_2 - v_1 \qquad ...(ii)$

[$\because$ collision is elastic, $e = 1$]

Solving equations (i) and (ii)

$$v_1 = \frac{v}{3} \text{ and } v_2 = \frac{4v}{3}$$

The de Broglie wavelength of a particle is given by

$\lambda = \dfrac{h}{p}$

where p is the momentum of the particle

$$\therefore \qquad \frac{\lambda_A}{\lambda_B} = \frac{p_B}{p_A} = \frac{\frac{m}{2} \times \frac{4}{3} v}{m \times \frac{v}{3}} = \frac{\mathbf{2}}{\mathbf{1}}$$

Hence, the correct option is (b).

6. 2 Since we know that

$$N \propto \frac{1}{\sin^4\left(\frac{\phi}{2}\right)}$$

$$\Rightarrow \quad \frac{N_{60^\circ}}{N_{90^\circ}} = \frac{\sin^4\left(\frac{90^\circ}{2}\right)}{\sin^4\left(\frac{60^\circ}{2}\right)} = \frac{\sin^4(45^\circ)}{\sin^4(30^\circ)} = \frac{\left(\frac{1}{\sqrt{2}}\right)^4}{\left(\frac{1}{2}\right)^4} = 4$$

$$\Rightarrow \quad \frac{N_{60^\circ}}{N_{90^\circ}} = \frac{N_{60^\circ}}{55} = 4$$

$$\Rightarrow \quad N_{60^\circ} = 4(55) = 220$$

7. Force on mass m in conservative field is

$$F = -\frac{dU}{dr} = mb^2 r$$

For circular orbit of particle, we have

$$mb^2 r = \frac{mv^2}{r} \quad \ldots(1)$$

$\Rightarrow \quad v = br$

Also, by Bohr's Quantisation rule, we have

$$mvr = \frac{nh}{2\pi} \quad \ldots(2)$$

$$\Rightarrow \quad m(br)r = \frac{nh}{2\pi}$$

$$\Rightarrow \quad r = \sqrt{\frac{nh}{2\pi mb}}$$

8. 1

9. 4 Q= Binding energy of product- BInding energy of reactant

$$= 2(4\text{B.E. of He}) - (7 \times \text{B.E. of Li})$$

$$= 8 \times 7.06 - 7 \times 5.60 - 56.48 - 39.2 = 17.28\,\text{MeV}$$

10. 4 Mass converted into energy by relations

$$E = mc^2 = (1 \times 10^{-6}\,\text{kg})(3 \times 10^8)^2$$

$$= 10^{-6} \times 9 \times 10^{16}\,\text{J} = 9 \times 10^{10}\,\text{J}$$

SECTION II (NUMERICAL)

11. 6

12. 1 Equation of b+-decay of ${}_6C^{11}$; ${}_6C^{11} \longrightarrow {}_5B^{11} + {}_{+1}\beta^0 + \nu + Q$

Q-value of reaction = Δmc^2

$$= \left[m({}_6C^{11}) - 6m_e - m({}_5B^{11}) + 5m_e - m_e\right]c^2$$

$$= \left[m({}_6C^{11}) - m({}_5B^{11}) - 2m_e\right]c^2$$

$$= [11.011434 - 11.009305 - 2 \times 0.000548]uc^2$$

$$= [0.001033]\,uc^2 = 0.001033 \times 931.5\text{ MeV} = 0.962\text{ MeV}$$

13. $$PE = -\frac{27.2}{n^2}$$

$$\frac{V_f}{V_i} = \frac{-\frac{27.2}{n_f^2}}{-\frac{27.2}{n_i^2}} = \frac{1}{6.25}$$

$$6.25 = \frac{n_f^2}{n_i^2}$$

$$\frac{n_f}{n_i} = 2.5 = \frac{5}{2}$$

Hence smallest value of $n_f = 5$.

JEE ADVANCED LEVEL

14. B

$$W_{elec\,field} = KE_f - KE_i$$

$$-eEd = 0 - (h\nu - \phi)$$

$$eEd = hc/\lambda - \phi$$

$$\lambda_0 = hc/\phi = \frac{hc}{hc/\lambda - eEd} = \frac{1}{\frac{1}{\lambda} - \frac{eEd}{hc}}$$

15. C

$$\vec{V} = \vec{u} + \vec{a}t \qquad \lambda \to \lambda/2$$

$$\vec{V} = V_0\hat{j} + \frac{q_0E}{m}\hat{i}\,t_0 \qquad \text{when } V \to 2V$$

$$|\vec{V}| = \sqrt{V_0^2 + \left(\frac{q_0Et}{m}\right)^2}$$

$$4V_0^2 = V_0^2 + \left(q_0E/m\; t\right)^2$$

Solving $t_0 = \sqrt{3}\,\frac{mV_0}{q_0E}$

16. A

$r_n \propto n^2$ $\qquad r = \frac{\varepsilon_0 h}{\pi m e^2} \frac{n^2}{Z}$

$\frac{r_n}{r_1} = n^2$

$\log r_n/r_1 = \log n^2$

$\log \frac{r_n}{r_1} = 2 \log n$

$y = 2x$

St line

17. D
18. C
19. C
20. B

A mass no: of parent nuclei

$KE_\alpha = \frac{228}{232} Q$

21. D

Energy released = $BE_{pdts} - BE_{reactants}$

$Q = 4 \times 7 - 4 \times 1.1$

$= 28 - 4.4$

$= 23.6$ MeV

22. B,D

23. A,C

$$L = 3h/2\pi$$
$$n h/2\pi = 3h/2\pi$$
$$n = 3$$
$$r_n = 0.53\frac{n^2}{z}$$
$$4.5 \times \cancel{0.53} = \cancel{0.53}\, n^2/z$$
$$z = 2$$
$$\frac{1}{\lambda} = z^2 R\left(\frac{1}{n_f^2} - \frac{1}{n_i^2}\right)$$
$$\frac{1}{\lambda} = 4R\left(\frac{1}{n_f^2} - \frac{1}{9}\right)$$

24. C

when energy of photon is 15eV, 13.6eV is utilized as ionization energy and remaining energy converted into KE.

25. AC

$$(t_{1/2})_A = 1 \quad (t_{1/2})_B = 2$$
$$m_{0A} : m_{0B} = 3:4 \quad \lambda_A N_{0A} = 5$$
$$M_{0A} : M_B = 6:7$$
$$N = N_0\left(\frac{1}{2}\right)^{t/t_{1/2}}$$
$$\frac{m_A}{M_A} = \frac{m_{0A}}{M_A}\left(\frac{1}{2}\right)^{8/1}$$
$$\frac{m_B}{M_B} = \frac{m_{0B}}{M_B}\left(\frac{1}{2}\right)^{8/2}$$
$$\frac{m_A}{m_B} = \frac{m_{0A}}{m_{0B}}\left(\frac{1}{2}\right)^4 = \frac{3}{4} \times \frac{1}{16} = 3/64$$

$$A_B = \lambda_B N_B$$

$$A_B = \lambda_B N_{0B}\left(\frac{1}{2}\right)^{t/t_{1/2}}$$

$$A_B = \frac{0.693}{2}\,\frac{m_{0B}}{M_B}\left(\frac{1}{2}\right)^{8/2}$$

$$A_A = \frac{0.693}{1}\,\frac{m_{0A}}{M_A}\left(\frac{1}{2}\right)^{8/1}$$

$$\frac{A_B}{A_A} = \frac{1}{2} \times \frac{m_{0B}}{m_{0A}}\,\frac{M_A}{M_B} \times \frac{1}{\left(\frac{1}{2}\right)^4}$$

$$\frac{A_B}{A_A} = \frac{1}{\cancel{2}} \times \frac{\overset{2}{\cancel{4}}}{3} \times \frac{6}{7} \times 16$$

$$A_B = \frac{12\times 16}{21} \times 5 \times \left(\frac{1}{2}\right)^8$$

$$A_B = \frac{\overset{4}{\cancel{12}}\times\cancel{16}}{\underset{7}{\cancel{21}}} \times 5 \times \frac{1}{\cancel{2^4}\times 2^4}$$

$$= 5/28$$

26. A,B,C,D

27. 2

$$nh/2\pi = 3h/2\pi$$

$$n = 3$$

$$\lambda = \frac{h}{mv} = \frac{h}{\frac{nh}{2\pi r}} = \frac{2\pi r}{n} =$$

$$= \frac{2\pi}{\cancel{n}} \times 0.53\,\frac{n^{\cancel{2}}}{Z}$$

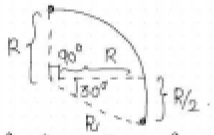
$$= 2\pi a_0\; 3/3$$

$$= 2\pi a_0$$

Ans(2)

28. 6

$E_{photon} = -0.85 - -3.4$
$= 2.55 eV$
$\phi = 1.83 eV$
$KE = 0.72 eV$



$18.2 \times 10^{-31} \times$
$0.72 \times 1.6 \times 10^{-19}$
21×10^{-50}

Angle $\theta = 120^\circ = 2\pi/3$ rad.
dist $= R \times \theta$
$= R \times 2\pi/3$
$= \frac{mv}{qB} \times 2\pi/3$
$= \frac{\sqrt{2mKE}}{qB} \times 2\pi/3$

$\frac{4.58 \times 10^{-25}}{1.6 \times 10^{-19} \times 1} \times \frac{2\pi}{3}$

6×10^{-6} m

29. 6

$N_1 - N_2 = \frac{R_1 - R_2}{\lambda} = \frac{R_1 - R_2}{\left(\frac{0.693}{t_{1/2}}\right)}$

30. 1

$\frac{R_1 - R_2}{\ln 2} T$

$n = 1$

31. a-p, b-p, c-p, d-s