Modern Physics

EXERCISES

ELEMENTRY

Q.1 (4)

$$p = \frac{hv}{c} \Rightarrow v = \frac{pc}{h} = \frac{3.3\times10^{-29}\times3\times10^{8}}{6.6\times10^{-34}}$$

$= 1.5 \times 10^{13}$ Hz

Q.2 (1)

Q.3 (2)

$$p = \frac{E}{c} = \frac{hv}{c} \Rightarrow v = \frac{pc}{h}$$

Q.4 (4)

$E \propto \frac{1}{\lambda}$; also $\lambda_{infrared} > \lambda_{visible}$ so $E_{infrared} > E_{visible}$

Q.5 (3)
According to Einstein's photoelectric equation

Q.6 (3)

$$K_{max} = \frac{hc}{\lambda} - W_0 = \frac{6.4\times10^{-34}\times3\times10^{8}}{6400\times10^{-10}} - 1.6\times10^{-19}$$

$= 1.4 \times 10^{-19}$ J

Q.7 (3)

Energy of incident light $E(eV) = \frac{12375}{3320} = 3.72$ eV

(332 nm = 3320 Å)
According to the relation $E = W_0 + eV_0$

$$\Rightarrow V_0 = \frac{(E - W_0)}{e} = \frac{3.72eV - 1.07eV}{e} = 2.65 \text{ Volt.}$$

Q.8 (4)
Intensity $\propto$ (No. of photons) $\propto$ (No. of photoelectrons)

Q.9 (2)

Stopping potential $V_0 = \frac{hc}{e}\left[\frac{1}{\lambda} - \frac{1}{\lambda_0}\right]$. As λ decreases

so V_0 increases.

Q.10 (1)
Intensity increases means more photons of same energy will emit more electrons of same energy, hence only photoelectric current increases

Q.11 (2)
$K_{max} = (|V_s|)eV \Rightarrow |V_s| = 4V$

Q.12 (3)
According to de-Broglie hypothesis.

Q.13 (2)

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mE}}, \quad \lambda \propto \frac{h}{\sqrt{E}} \quad \text{(h and m = constant)}$$

Q.14 (1)

$$\frac{1}{2}mv^2 = E \Rightarrow mv = \sqrt{2mE} \;;\; \therefore \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$$

Q.15 (1)

By using $\lambda = \frac{h}{\sqrt{2mE}}$ $E = 10^{-32}$ J = Constant for both particles.

Hence $\lambda \propto \frac{h}{\sqrt{m}}$ Since $m_p > m_e$ so $\lambda_p < \lambda_e$.

Q.16 (1)

$$\lambda_{neutron} \propto \frac{1}{\sqrt{T}} \Rightarrow \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{T_2}{T_1}}$$

$$\Rightarrow \frac{\lambda_1}{\lambda_2} = \sqrt{\frac{(273+927)}{(273+27)}} = \sqrt{\frac{1200}{300}} = 2 \Rightarrow \lambda_2 = \frac{\lambda}{2}$$

Q.17 (2)
Balmer series lies in the visible region.

Q.18 (4)

$$2E - E = \frac{hc}{\lambda} \Rightarrow E = \frac{hc}{\lambda}$$

$$\frac{4E}{3} - E = \frac{hc}{\lambda} \Rightarrow \frac{E}{3} = \frac{hc}{\lambda'} \;\therefore\; \frac{\lambda'}{\lambda} = 3 \Rightarrow \lambda' = 3\lambda$$

Q.19 (3)

$$mvr = \frac{nh}{2\pi}, \text{ for } n = 1 \text{ it is } \frac{h}{2\pi}$$

Q.20 (4)

By using

$$N_E = \frac{n(n-1)}{2} \Rightarrow N_E = \frac{4(4-1)}{2} = 6$$

Q.21 (4)

$r \propto n^2$. For ground state n =1 and for first excited state n = 2.

Q.22 (3)

The voltage applied across the X-ray tube is of the range of 10 kV – 80 kV.

Q.23 (4)

The production of X-rays is an atomic property whereas the production of γ-rays is a nuclear property

Q.24 (3)

Q.25 (3)

Q.26 (3)

$$v \propto (Z-b)^2 \Rightarrow v = a(Z-b)^2$$

Z = atomic number of element (a, b are constant).

Q.27 (1)

Mosley's law is $f = a(Z-b)^2$

Q.28 (3)

$$\lambda \propto \frac{1}{(Z-1)^2} \Rightarrow \frac{\lambda_2}{\lambda_1} = \left(\frac{Z_1-1}{Z_2-1}\right)^2$$

$$\Rightarrow \frac{\lambda_2}{1} = \left(\frac{43-1}{29-1}\right)^2 = \left(\frac{42}{28}\right)^2 \Rightarrow l_2 = \frac{9}{4}\lambda$$

JEE-MAIN
OBJECTIVE QUESTIONS

Q.1 (3)

$$E = \frac{12400(\text{ eV})}{(\lambda \text{ in Å})}$$

$$\text{No. of Photon} = \frac{IAt\lambda}{hc}$$

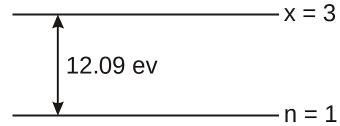
$$\text{No. of Photon} = \frac{Pt\lambda}{hc} = \frac{E\lambda}{hc}$$

if E is constant no. of photon is $\propto$ l

Q.2 (1)

$hf = 1.7 + 10.4 = 12.1\,\text{eV} = \text{energy}$

in H-atom



Q.3 (4)

Frequency of light does not change with medium.

Q.4 (3)

Einstein's formula $k_{max\,1} = eV_1 + f$

if frequency is doubled, $k_{max\,2} = ev_2 + f > 2\,K_{max\,1}$

Q.5 (1)

The number of photo electron depends on the number of photons

$$\text{Number of photon} = \frac{I}{hc/\lambda} = \frac{\lambda \cdot I}{hc}\ \mu\ l$$

$$\text{Ratio of no. of photo electrons} = \frac{\lambda_A}{\lambda_B}$$

Q.6 (1)

A Photon can interact with only a single electron.

Q.7 (2)

$$C = l \cdot n = \frac{h}{p} \cdot \frac{E}{h} = \frac{E}{p}$$

Q.8 (1)

Applying $p = \frac{h}{\lambda}$ and $E = \frac{hc}{\lambda}$

If l decreases E and p increases.

Q.9 (1)

$$2\phi = \phi + K_1 \quad \Rightarrow \quad K_1 = \phi = \frac{1}{2}mv_1^2$$

$$5\phi = \phi + K_2 \quad \Rightarrow \quad K_2 = 4\phi = \frac{1}{2}mv_2^2$$

$$v_1 : v_2 = 1:2$$

Q.10 (2)

no. of Photons $\propto$ I

I -, no. of photon e^- ejection -

Q.11 (4)

$$\frac{h}{\lambda} = 10^{12}h$$

Q.12 (B)

The electrons will get accelerated in the electric field. Hence, kinetic energy will increase.

Q.13 (2)

Since frequency of light solurce is double, the energy carried by each photon will be doubled.

Hence intensity will be doubled even if number of photons remains constant. Hence saturation current is constant. Since frequency is doubled, maximum KE increases but it is not doubled.

Q.14 (D)

As the distance of the source doubles, the photons falling on the photon cell becomes $\frac{1}{4}$th. Hence, number of photoelectrons will also become $\frac{1}{4}$th.

Q.15 (2)

The threshold frequency for Al must be greater as it has higher work function.

Q.16 (D)

Radiation force

$$= \frac{I}{C} \times \text{Area} = \frac{I}{C} \cdot \frac{1}{2} \cdot 2R \cdot H = \frac{IRH}{C}$$

Q.17 (B)

The radiation pressure

$$P = \frac{F}{A} = \left(\frac{2h}{\lambda}\right) \frac{N}{A} = 2\frac{I}{C}$$

if reflected completely. It is independent of wavelength. It will depend on the nature of the surface and the intensity of light.

Q.18 (3)

$$hf = \phi + ev_S$$

Q.19 (2)

$$\text{No. of Photons} = \frac{10^{-3}}{\frac{12400}{5000} \times 1.6 \times 10^{-13}} = 0.25 \times 10^{16}$$

$$\text{No. of } e^- \text{ reaching} = \frac{0.16 \times 10^{-6}}{1.6 \times 10^{-19}} = 10^{+12}$$

$$\% = \frac{10^{12}}{0.25 \times 10^{16}} \times 100 = 0.04\%$$

Q.20 (B)

Emission of photo electron is independent of external factor. It depends only on the nature of the material and wavelength of incident light

Q.21 (1)

Experimental obervation.

Q.22 (B)

$$\frac{hC}{\lambda} = \phi + eV \qquad \text{....(i)}$$

$$\frac{hC}{2\lambda} = \phi + \frac{eV}{3} \qquad \text{....(ii)}$$

$3 \cdot II - I$

$$\Rightarrow \left(\frac{3}{2} - 1\right)\frac{hc}{\lambda} = 2\phi \qquad \Rightarrow \phi = \frac{hc}{4\lambda}$$

$\therefore \quad \lambda_{th} = 4\lambda$

Q.23 (C)

Depends on ϕ not on Intensity

Q.24 (4)

As distance $\uparrow$ses.

$I \downarrow$ ses.

$\therefore \quad i \downarrow$

$$I = \frac{P}{4\pi r^2}$$

Q.25 (2)

Stopping potential = maximum kinetic energy of e = 4V.

Q.26 (C)

If v_1, v_2, v_3 are in A.P. then

$$\frac{hc}{\lambda_1} = \phi + eV_1 \qquad \text{....(1)}$$

$$\frac{hc}{\lambda_2} = \phi + eV_2 \qquad \text{....(2)}$$

$$\frac{hc}{\lambda_3} = \phi + eV_3 \qquad \text{....(3)}$$

After solving (1), (2) and (3) we get

$$\lambda_2 = \frac{2\lambda_1 \lambda_3}{\lambda_1 + \lambda_3} \text{ which are in H.P.}$$

Q.27 (B)

KE_{max} = 2ev

E_{photon} = 5ev

f_0 = 5ev - 2ev = 3ev

Now no current when

$E_{photon} = 6ev$
i.e. $KE_{max} < 3ev$
$eV_{max} < 3ev$
$V_{max} < 3ev/e = 3V$

$\because \quad \phi = 3eV$

$\therefore \quad K.E._{max} = 3eV$ in Second case

Q.28 (1)
Greater work function means greater cut off frequency.
Slope Remains same
$f_y > f_x$
Intercept of y > Intercept of x
and must be parallel to each

Q.29 (2)
Diameter is same so light falling will be same so photoelectric current will be same.

Q.30 (1)
The energy of x–ray is more that of U.V. light. Hence, the K.E. of emitted photoelectron is more and hence stopping potential required is also more.

Q.31 (4)

$$l_d = \frac{h}{mv}$$

E_l = energy of photon = $\frac{hc}{\lambda}$ and energy of $e^- = \frac{p^2}{2m}$

$$= \frac{hv}{2\lambda}$$

The required ratio = $\dfrac{\frac{hv}{2\lambda}}{\frac{hc}{\lambda}} = \frac{1}{4}$.

Q.32 (3)

K.E. of neutron $E = \frac{3}{2}kT$

$$\lambda_d = \frac{h}{p} = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2m \times \frac{3}{2}kT}}\ ;\ \lambda_2 = \lambda . \sqrt{\frac{(927+273)}{27+273}}$$

$= 2\lambda$.

Q.33 (4)

$$\lambda = \frac{h}{P} = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2meV}}$$

Q.34 (3)
They have same K.E.

$$\lambda = \frac{h}{\sqrt{2m\,K.E.}}$$

$m_p > m_e$ and $q_p = q_e$

$\lambda_p < \lambda_e$ as $\lambda \propto \frac{1}{\sqrt{m}}$

Q.35 (1)

$$KE = 100 + 50 = 150\,eV$$

$$v = 150\,volt$$

$$\lambda = \sqrt{\frac{150}{V}}$$

$$\lambda = 1\,\overset{0}{A}$$

Q.36 (2)

$$r = a_0\frac{n^2}{Z} = a_0 . \frac{2^2}{4} = a_0$$

Q.37 (3)
$E_n(Li^{2+}) = E_1(H)$

$\Rightarrow \; -13.6\,\frac{3^2}{n^2} = -13.6 \times \frac{1}{1}$

$\Rightarrow \; n = 3$

Q.38 (B)
ΔE = ionization energy
$= 13.6 \times z^2$ eV
$\Delta E_A > \Delta E_B \Rightarrow Z_A > Z_B$

$$L = \frac{nh}{2\pi}$$

$\therefore \; L_A = L_B$

E = energy of the orbit $E \propto -\frac{Z^2}{n^2}$

$E_A < E_B$

$u \propto \frac{Z}{n}$

$\therefore \; u_A > u_B$

$r\ a\ \frac{n^2}{Z}$

$\therefore \; r_A < r_B$.

Q.39 (2)

$$L = mvr = \frac{nh}{2\pi}$$

$$\Rightarrow \quad n = 3$$

$$K.E. = -T.E. = 13.6 \times \frac{1}{9}$$

$$= 1.51 ev$$

Q.40 (4)

$r \propto n^2$

$\therefore r_{10} = 10^2 \times 1.06$ Å $= 106$ Å.

Q.41 (3)

$$\Delta E = Rcz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = \frac{hc}{\lambda}$$

$C \longrightarrow$ *Shortest*

$D \longrightarrow$ *longest*

Q.42 (C)

$$\frac{mv^2}{a_0} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{e^2}{a_0^2} \Rightarrow v = \frac{e}{\sqrt{4\pi \epsilon_0 a_0 m}}.$$

Q.43 (2)

Since speed reduces to half, KE reduced to

$\frac{1}{4}$ th $\Rightarrow$ n = 2

$$mvr = \frac{nh}{2\pi}$$

$$mv_0 r = 1.\frac{h}{2\pi} \quad \text{..........I}$$

$$m\frac{v_0}{2} r` = 2 \cdot \frac{h}{2\pi} \quad \text{.........II}$$

from I and II

$r' = 4r$

Q.44 (1)

According to the Bohr model

P.E. = – 2 K.E. = 2 T. E.

$\Rightarrow$ K.E. = – T.E.

$$\text{Where T.E.} = \frac{-me^4}{8\epsilon_0^2 n^2h^2}$$

$$K.E. = -\frac{-me^4}{8\epsilon_0^2 n^2h^2} \Rightarrow \frac{K.E.}{T.E.} = -1$$

Q.45 (4)

12.1 = E(n = 3) – E (n = 1)

10.2 = E(n = 2) – E (n = 1)

1.9 = E(n = 3) – E (n = 2)

At least two atoms must be enveloped as there connot be two transition from same level from same atom.

Q.46 (4)

All the transition energies in option(A),(B) and (C) are greater than corresponding to n = 4 to n = 3. Hence, option (D).

Q.47 (3)

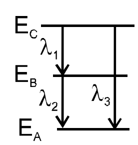
12.1 eV radiation will excite a hydrogen atom in ground state to n = 3

state number of possible transition = ${}^nC_2 = {}^3C_2 = 3$.

Q.48 (B)

$E_C - E_A = (E_C - E_A) + (E_B - E_A)$

$$\Rightarrow \frac{hc}{\lambda_3} = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$$



$$\Rightarrow \lambda_3 = \frac{\lambda_1\lambda_2}{\lambda_1 + \lambda_2}.$$

Q.49 (3)

$$I.E. = \frac{2.18 \times 10^{-18}}{n^2} = \frac{2.18 \times 10^{-18}}{9}$$

$= 2.42 \times 10^{-19}$ J

Q.50 (A)

$$\frac{((n+1)-3)((n+1)-3+1)}{2} = 10$$

(n-2) (n+1) = 20

$n^2 - 3n - 18 = 0$

n = 6

Q.51 (4)

$$0.529\left[(n-1)^2 - n^2\right] = 0.529(n-1)^2$$

$$\Rightarrow \quad 2n + 1 = n^2 + 1 - 2n$$

$$\Rightarrow \quad n = 0, 4$$

Q.52 (D)

$$a = \frac{v^2}{R} \propto \frac{z^2/n^2 . z}{n^2} \propto \frac{z^3}{n^4} \propto \frac{1}{n^4}$$

$\therefore\ 16:81$

Q.53 (B)

$$f = \frac{\omega}{2\pi} \propto \frac{v}{r} \propto \frac{z/n}{n^2/z} \propto \frac{z^2}{n^3} \propto \frac{1}{n^3}$$

As per queestion

$$f_1 = \frac{1}{27} f_2$$

$$\frac{1}{n_1^3} \propto \frac{1}{27} \times \frac{1}{n_2^3}$$

n = $3n_2$

Q.54 (1)

$$\frac{1}{\lambda_1} = R\left(\frac{1}{4} - \frac{1}{9}\right) \Rightarrow l_1 = \frac{4 \times 9}{5R}$$

similarly $\frac{1}{\lambda_2} = R\left(\frac{1}{4} - \frac{1}{4^2}\right) \Rightarrow l_2 = \frac{16}{3R} = \frac{16}{3} \times$

$$\frac{5\lambda}{4 \times 9} = \frac{20}{27}\lambda$$

Q.55 (3)

$$E = 13.6\left(\frac{Z^2}{n^2}\right)$$

$$D\,E_H = \frac{13.6(1)^2}{(1)^2} - \frac{13.6(1)^2}{(2)^2} = 10.2 \text{ eV} = hn$$

$$DE_{Li} = \frac{13.6(3)^2}{(1)^2} - \frac{13.6(3)^2}{(2)^2} = 91.80 \text{ eV} = h\,(9\,n)$$

Q.56 (C)

$r_0 = a_0 = 0.529\,A^0$

$r_n = a_0 n^2$

Q.57 (3)

n - 1 = 5

n = 6

No. of briught lines = $\frac{n(n-1)}{2} = \frac{6 \times 5}{2} = 15$

Q.58 (3)

$P = \frac{E}{C}$ $n_1 = 1$, $n_2 = 5$

$$= \frac{\left(\frac{13.6}{1^2} - \frac{13.6}{5^2}\right)}{3 \times 10^8} \times 1.6 \times 10^{-19}$$

$$= \frac{13.056}{3} \times 1.6 \times 10^{-27}$$

mv = 6.96×10^{-27}

v = 4.2 m/s

Q.59 (4)

$$\Delta E = Rcz^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right) = \frac{hc}{\lambda}$$

$$\frac{1}{\lambda} \propto z^2$$

For $z = 3$ $\quad Li^{+2}$

λ will be minimum

Q.60 (C)

$$r \propto \frac{n^2}{z}$$

$$f \propto \frac{1}{n^2} \quad \& \quad T \propto n^3$$

$$\frac{T_1}{T_2} = \frac{n_1^3}{n_2^3} = \frac{1}{2^3}$$

$\therefore\ 1:8$

Q.61 (B)

Total no. of oribits are (n+1)

No. of spectral lines = $\frac{n(n+1)}{2}$

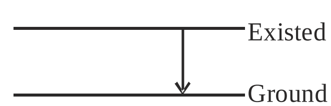
It is the sum of n natural nos.

So no of different spectrum lines = 1+2+3+....+ n

n^{th} Emitted state means (n+1)

Q.62 (1)

$\because$ T.E. = P.E. + K.E.



$\Delta E \uparrow$

So both P.E. & K.E. $\downarrow$

So both P.E. & K.E. $\downarrow$

Q.63 (2)

$r = 0.529 \times \frac{n^2}{Z}$

$0.529 \times \frac{2^2}{2}$

$r = 1.06\,A^0$

Q.64 (1)
E = -3.4 ev (for n = 2)

———— n = 2

angular momentum = $\frac{2h}{2\pi} = \frac{h}{\pi}$

Q.65 (1)
In ultra violet region lyman series is present

Q.66 **(A)**
10 eV electron cannot excite a hydrogen atom Hence collision is elastic.

Q.67 (A)

$\because$ If K.E.<13.6ev

$\Delta E = \{0, 10.2, 12.09 .... 13.6\text{ev}\}$

Collision must be elastic

Q.68 (A)
The contineous x-ray comes out because the striking electron lose its kinetic energy

Q.69 (C)
The cut off wavelength depends on the accelerating potential difference which is unchanged. Hence, the wavelength will remain unchanged.

Q.70 (C)

0.1 to $10\,\overset{0}{A}$ (x-ray range)

Q.71 (D)
When freqency is increased energy increases
i.e. penetrating power increases

Q.72 (C)

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

Since the momenta of the two particles are equal, λ are same.

Q.73 (C)
K_α : transition from $2 \rightarrow 1$
Similarly for $K_\beta : 3 \rightarrow 1$, $K_\gamma : 4 \rightarrow 1$; L_α 0: $3 \rightarrow 2$: $M_\alpha : 4 \rightarrow 3$
Now we can compare energy and λ .

Q.74 (B)
The characteristic x-rays are obtained due to the transition of electron from inner orbits.

Q.75 (C)

$\because \quad \Delta E = \frac{hc}{\lambda} \quad \Rightarrow \quad \lambda = \frac{hc}{\Delta E}$

$\lambda_p < \lambda_q$

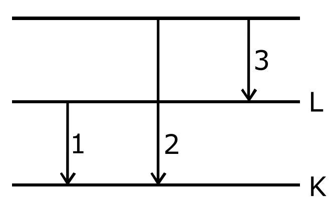
$\Delta E_P < \Delta E_Q$

$\because \quad \Delta E_{K\alpha} < \Delta E_{K\beta}$

So $\quad Q \longrightarrow K_\alpha$

$\quad P \longrightarrow K_\beta$

Q.76 (C)



$E_1 + E_3 = E_2$
$h\nu_{k\alpha} + h\nu_{L\alpha} = h\nu_{k\beta}$
$\nu_{k\beta} = \nu_{k\alpha} + \nu_{L\alpha}$

Q.77 (B)
When ever the energy of photon is doubled then work function increases must more than by 2 times.

JEE-ADVANCED
OBJECTIVE QUESTIONS

Q.1 (D)

$$\frac{hc}{\lambda}=\phi+K$$

$$\Rightarrow \quad \frac{4hc}{3\lambda}=\frac{4\phi}{3}+\frac{4K}{3} \quad ....(1)$$

$$\frac{4hc}{3\lambda}=\phi+K' \quad \Rightarrow \quad \frac{4hc}{3\lambda}=\phi+K' \text{ ......(2)}$$

equation (2) - equation (1)

$$K'-\frac{4}{3}K-\frac{4\phi}{3}+\phi=0$$

$$K'=\frac{4}{3}K+\frac{\phi}{3}>\frac{4K}{3}$$

Q.2 (C)

$$\frac{hc}{\lambda_1}=\phi+K_1 \quad \Rightarrow \frac{2hc}{\lambda_1}=2\phi+2K_1 \quad ....(1)$$

$$\frac{2hc}{\lambda_1}=\phi+K_2 \quad \Rightarrow \frac{2hc}{\lambda_1}=\phi+K_2 \quad ....(2)$$

Now eq.(1) – eq.(2)

$$\phi+2K_1-K_2=0$$

$$K_2=\phi+2K_1$$

$$\frac{K_2}{2}=\frac{\phi}{2}+K_1 \quad \Rightarrow \therefore K_1<\frac{K_2}{2}$$

Q.3 (C)

$$\text{no. of Photons}=\frac{\text{Total Energy}}{\text{Energy of one Photon}}$$

so no effect on current

$$KE_{\max}=h\nu-\phi$$

$$2(KE)_{\max}=2h\nu-2\phi \quad ....(i)$$

$$(KE)_{\max}=2h\nu-\phi \quad ....(ii)$$

$$(ii)-(i)$$

$$(K.E.)_{\max}=\phi>0$$

Q.4 (D)

f = 4ev

$K.E._{max}$ = E - f

eV_0 = (13.6-4) eV

V_0 = 9.6 V

for zero photo current

V_{anode} must be > V_s

$\Rightarrow$ V_{anode} = 10 V

Q.5 (C)

$P = P_- + P_+$

$= 200 \times (6.25 \times 10^{18} + 3.125 \times 10^{18}) \times 1.6 \times 10^{-19}$ W

= 300 W.

Q.6 (C)

$$V-0=\frac{eV_1}{f_1-f_0}(f-f_0)$$

$$f=\frac{eV_1 f_0}{f_0-f_1} \quad \text{or} \quad \phi=f_0 h$$

KE_{max} = E - f

$= hf_1 - hf_0$

Q.7 (B)

$$\text{Energy of a Photon}=\frac{1240}{200}=6.2\text{ev}$$

KE_{max} 6.2 - 4.5 = 1.7eV

Collector plate will attract it & the potential 2V increase KE by 2eV

So max KE = 3.7 eV

Q.8 (D)

When the source is 3 times farther, number of photons falling on the surface becomes $\frac{1}{9}$ th but the frequency remains same. Hence stopping potential will be same i.e. 0.6V and saturation current become $\frac{1}{9}\times 18$ mA = 2mA.

Q.9 (B)

$$I=\frac{nhc}{\lambda At}=\frac{nh\nu}{At}$$

I reamains same but n changes and increases n decreases

$\Rightarrow$ Photo current decreases

Q.10 (D)

Some of the energy of photon will be absorbed by the electron. Hence, energy of the photon will reduce correspendingly wavelength will increase and frequency decreases.

Q.11 (C)

Q.12 (B)

$$l = \frac{h}{p}$$

Hence, higher the momentum, smaller the wavelength.

Q.13 (B)

$$T.E. = -13.6\frac{Z^2}{n^2} \qquad -3.4 = -13.6\frac{1}{n^2}$$

$$n^2 = \frac{13.6}{3.4} = 4 \quad n = 2$$

$$P^2 = 2m \times 3.4(ev) = 2 \times 9.1 \times 10^{-31} \times 3.4 \times 1.6 \times 10^{-13}$$

$$P = 10^{-24}$$

$$\lambda = \frac{h}{p} = \frac{6.67 \times 10^{-34}}{10^{-24}} \quad \lambda = 6.6 \times 10^{-10}\, m$$

Q.14 (D)

The atom will absorb photon whose energy is equal to the energy gap between two energy levels of the atom.

Q.15 (A)

$\Delta E(1 \text{ to } \infty) = \Delta E(1 \text{ to } 2) + \Delta E(2 \text{ to } \infty)$

$= \quad u_1 = u_2 + u_3$.

Q.16 (A)

$$\frac{K3q^2}{r^2} = \frac{mv^2}{r}$$

and $\quad mvr = \frac{nh}{2\pi}$

for $n = 1 \qquad r_{min} = \frac{3q^2}{2\varepsilon_0 h}$

Q.17 (A)

$$E_n = \frac{-mz^2e^4}{BE_0^2h^2n^2} \quad , \qquad V = \frac{Ze^2}{2E_0nh}$$

$$r = \frac{E_0h^2}{\pi mZe^2} \times \frac{n^2}{Z}$$

$$f = \frac{\omega}{2\pi} = \frac{r}{2\pi R} = \frac{2En}{nh}$$

Q.18 (C)

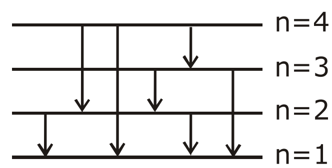
$$E_n = 13.6\ \frac{Z^2}{n^2}$$

$$\Delta E_H = \frac{13.6(1)^2}{(1)^2} - \frac{13.6(1)^2}{(2)^2} = 10.2\text{eV}$$

$$\Delta E_{He} = \frac{13.6(2)^2}{(1)^2} - \frac{13.6(2)^2}{(2)^2} = 40.8 \text{ eV}$$

Q.19 (C)

$$Six\ difference \rightarrow n = 4$$



Q.20 (D)

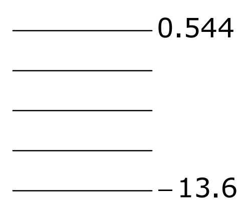
Energy required to remove the second e^-

$\therefore$ TE = (54.4 + 24.6) = 79.0 eV.

Q.21 (A)

$10 \rightarrow$ different wavelength

Means $\quad n = 5$



$$\frac{n(n-1)}{2} = 10$$

n = 5

$$\frac{1}{\lambda} = R\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\frac{1}{\lambda} = R\left(1 - \frac{1}{25}\right)$$

$$\lambda = \frac{25}{24} \times 932\text{A}^\circ = 95\text{nm}$$

Q.22 (C)

Q.23 (C)

$$\because \text{ P.E.} = \frac{\text{T.E.}}{2}$$

$$\therefore \text{ P.E.} = \frac{-13.6}{2} = -6.8\,\text{eV}$$

Q.24 (B)

$$f \propto \frac{1}{n^3}$$

$$r \propto n^2$$

$$L \propto n$$

$$frl = \frac{1}{n^3} \times n^2 \times n$$

= 1 Constant

Q.25 (A)

$$r \propto \frac{1}{m}$$

$$r = 0.529 \times \frac{n^2}{2} \times \frac{1}{207} = 2.56 \times 10^{-3}\,A^0$$

Q.26 (C)

The maximum kinetic energy avaiable for transition to potential energy/excitation energy is :

$$\frac{1}{2} \cdot \frac{m_\alpha m_H}{m_\alpha + m_H} \cdot (v_{rel})^2$$

$$= \frac{4m,m_H}{5m} .(v_a + v_H)^2 \quad = \frac{2m}{5} .(v_a^2 + v_H^2 + 2v_a v_H)$$

$$= \frac{2m}{5}\left[\frac{2.E_\alpha}{4m} + \frac{2E_4}{m} + 2.\sqrt{\frac{2E.\alpha}{4m} \cdot \frac{2E_H}{m}}\right] =$$

$$\frac{2}{5}\left[\frac{2.1}{2} + 2 \times 8.4 + 2 \times \sqrt{2.1 \times 8.4}\right]$$

= 10.5 eV > 10.2 eV

Hence, inelastic collision is possible.

Q.27 (C)

for largest warelength of Balmer series

n=3 to n=2

So Electron will jump from ground state to n=3

Energy Required = 13.6 - 1.51 = 12.1ev

Q.28 (D)

$$\lambda_{min} = \frac{hC}{E} = \frac{1.24 \times 10^4}{66 \times 10^3}\ \text{Å}$$

Since 0.01 nm is less than λ_{min}, it will be absent but 0.02 nm and longer wavelength will be present

Q.29 (A)

Q.30 (D)

$$\frac{K}{\lambda_1} = E_\infty - E_1 \Rightarrow \frac{K}{\lambda_2} = E_\infty - E_2$$

$$\frac{K}{\lambda_3} = E_2 - E_3 \Rightarrow \frac{1}{\lambda_1} - \frac{1}{\lambda_2} = \frac{1}{\lambda_3}$$

Q.31 (A)

$$\sqrt{v_{K_\alpha}} = K\,(Z - a) \times \sqrt{1 - \frac{1}{4}}$$

$$\sqrt{v_{K_\beta}} = K\,(z - a) \times \sqrt{1 - \frac{1}{9}}$$

$$\text{Ratio for } \frac{K_\beta}{K_\alpha} = \frac{\sqrt{\frac{8}{9}}}{\sqrt{\frac{3}{4}}} = \sqrt{\frac{32}{27}}$$

Q.32 (D)

$$hf = 13.6(Z - 1)^2 \cdot \left(1 - \frac{1}{4}\right)$$

$$= 13.6 \times \frac{3}{4}\,(31 - 1)^2$$

$$\Rightarrow\ = 13.6 \times \frac{3}{4}(51 - 1)^2$$

$$\Rightarrow \frac{f'}{f} = \frac{50^2}{30^2} \Rightarrow f' = \frac{25}{9}.f$$

Q.33 (D)

$$\frac{1}{\lambda} = R\,(Z - 1)^2 \times \left(1 - \frac{1}{4}\right)$$

$$\Rightarrow \frac{1875R}{4} = R\,(Z_1 - 1)^2\ \frac{3}{4} \Rightarrow Z_1 = 26$$

$$\text{and } 675\,R = R\,(Z_2 - 2)^2 \cdot \frac{3}{4} \Rightarrow Z_2 = 31$$

Hence number of elements = 4

Q.34 (C)

$$= \frac{12420}{0.021 \times 10} = 59142 \text{ eV} = 0.059 \text{ MeV} = 59 \text{ kV}$$

Q.35 (C)

$$\frac{1}{\lambda} = R(57)^2\left(1 - \frac{1}{4}\right) \quad ....(1)$$

$$\frac{1}{\lambda_2} = R(29)^2\left(1 - \frac{1}{4}\right) \quad ....(2)$$

From (1) and (2)

$$\lambda_2 = 4\lambda$$

JEE-ADVANCED

MCQ/COMPREHENSION/COLUMN MATCHING

Q.1 (A,C)

$$\phi + ev_0 = hv \quad v_0 = \frac{hv - \phi}{e}$$

i.e. v_0 depends on frequency of incident light and work function (emitter property)

Q.2 (B, C)
Photocurrent depends no. of photons following on collector-plate only.

Q.3 (A,B,C)

$K_{max} = E - W$
Therefore,
$T_A = 4.25 - W_A$ ......(i)
$T_B = (T_A - 1.50) = 4.70 - W_B$ ......(ii)
Equation (i) and (ii) gives,
$W_B - W_A = 1.95$ eV ......(iii)
de-Broglie wavelength is given by

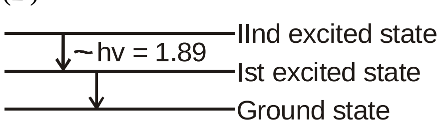
$$\lambda = \frac{h}{\sqrt{2Km}} \text{ or } \lambda \propto \frac{1}{\sqrt{K}} \quad K = \text{KE of elecron}$$

$$\therefore \quad \frac{\lambda_B}{\lambda_A} = \sqrt{\frac{K_A}{K_B}}$$

$$\text{or} \quad 2 = \sqrt{\frac{T_A}{T_A - 1.5}} \quad \text{or} \quad T_A = 2\text{eV}$$

From equation (i)
$W_A = 4.25 - T_A = 2.25$ eV
From equations (iii),
$W_B + 1.95$ eV $= (2.25 + 1.95)$ eV
or $W_B = 4.20$ eV.
$T_B = 4.70 - W_B = 4.70 - 4.20 = 0.50$ eV.

Q.4 (B)



$$Z = \frac{1.89}{10.2} = 0.185 = \frac{5}{27}$$

$$\frac{hc}{\lambda_1} = 1.89 \qquad \frac{hc}{\lambda_2} = 10.2$$

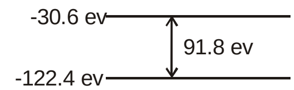
$$Now \quad \frac{\lambda_1}{\lambda_2} = \frac{10.2}{1.89} = 5.39$$

$$\lambda = \frac{h}{p} \quad P = \frac{h}{\lambda} \quad \Rightarrow \frac{P_2}{P_2} = \frac{\lambda_2}{\lambda_1} \; \frac{P_1}{P_2} = \frac{1.89}{10.2} = \frac{5}{27}$$

Q.5 (A,C,D)

$$122.4 = \frac{13.6 \times z^2}{1} \quad z^2 = 9 \quad z = 3$$

Its energy level are



If e^- have K.E. energy = 125 ev

then energy of average electron = 125 - 122.4 = 2.6ev

Q.6 (A,C,D)
If same energy released in y-direction then same of the incident wavelength is missing in A.
Ratio M.W. Infrared Visible Regions.

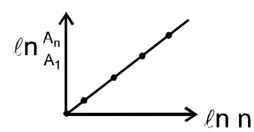
U.V. X-Ray $\xrightarrow{\lambda \downarrow f \uparrow}$

B will contain same visible and infrared light.

Q.7 (C,D)

$v \propto z$ and $r \propto \frac{1}{z}$.

Q.8 (A, B)
$A_n = pr^2 = p\,(r_0\,n^2)^2 = pr_0^2\,n^4$



$$\ln \frac{A_n}{A_1} = \ln (n^4) = 4 \ln n.$$

Q.9 (A,B)

$$A_n = \pi r_n^2 = 0.529 \times n^4 \qquad A_1 = \pi r_1^2 = 0.529 \times 1$$

$$\frac{A_n}{A_1} = n^4 \qquad ln \frac{A_n}{A_1} = 4 \ln n$$

Straight line passing though origin with slope 4.

Q.10 (A,C,D)

$$K = 2.55 \;\; n = 4(0.85) \qquad 10 \;\; n = 2(3.4) \;\; so \; \min$$

$$\frac{K}{2} = 13.6 - 0.85 \;\; = 12.75 \;\; \boxed{K = 25.5\,ev}$$

Q.11 (A,C)

$$If \qquad K < 20.4\,ev$$
$$\Delta E = \{0, 10.2ev, 12.09ev\}$$
$$\Delta E = \{0, 7ev,\}$$
$$loss = 0$$

so elastic collision
if (K.E.) > 20.4ev
then if loss = 0 then elastic & otherwise inelastic collision

Q.12 (A,D)
Minimum wavelength detreases.
$\therefore$ Intensity Increases.

Q.13 (A,B)

$\lambda_{min} = \frac{12400}{20000}$ $\lambda_{min} = 0.62\overset{0}{A}$ $\lambda_{min} = 62pm$

12 & 45 pm will be absent

Q.14 (A,D)
As the potential difference is increased, the kinetic energy is increased. The total energy of x-rays emitted
will also increase hence intensity will increase. Also the shorter wavelengths will also decrease.

Q.15 (A,B,C,D)
Photon exerts force due to change in momentum photon transfers its energy to the material. Photon transfers its energy to the material.
Since, it exerts force, hence imparts impulse also.

Q.16 (A,B,C,D)
(A) Minimum wavelength will correspond to maximum energy i.e.,from ∞ to k.

ΔE = 19.9 KeV

$\therefore$ $\lambda_{min} = \frac{1.24 \times 10^4}{19.9 \times 10^3}$Å = 0.62 Å = 62 pm.

(B) Energy of the characteristic x–rays will be less than corresponding to ∞ to k–shell, hence than 19.9 KeV.

Q.17 (B)

$$E = \frac{12400}{0.663} = 18700\,eV \quad Potential = 18.7\,KV$$

$$Kv = \frac{1227}{\sqrt{v}} = 0.01\overset{0}{A}$$

Q.18 (A,B,C)

Q.19 (D)
Electric field may increase or decrease the speed of electron

As $P = \frac{h}{\lambda}$ $\Rightarrow$ $mv = \frac{h}{\lambda}$

magnetic field will on change the speed of the particle.

so $\lambda_1 > \lambda_2$ or $\lambda_1 < \lambda_2$

Q.20 (B)

$\Delta E = \frac{12400}{4500Å}$

ΔE = 2.75 eV ....(1)

for photoelectric effect
$\Delta E > W_0$ (work function).

Q.21 (A)
$\Delta E = W_0 + E_k$
$(E_k) = \Delta E - W_0$
for maximum value of (E_k), W_0 should be minimum.
W_0 for lithium = 2.3 eV
$\therefore$ (E_k) = 2.75 – 2.3 = 0.45 eV.

Q.22 (C)
The maximum magnitude of stopping potential will be for metal of least work function.
$\therefore$ required stopping potential is

$V_s = \frac{hv - \phi_0}{e}$ = 0.45 volt.

Q.23 (D)
For Balmer series, $n_1 = 2$, $n_2 = 3,4,........$
(lower) (higher)
$\therefore$ In transition (VI), Photon of Balmer series is absorbed.

Q.24 (C)
In transition II
E_2 = – 3.4 eV, E_4 = – 0.85 eV
ΔE = 2.55 eV

$\Delta E = \frac{hc}{\lambda} \Rightarrow \lambda = \frac{hc}{\Delta E}$

λ = 487 nm.

Q.25 (D)
Wavelength of radiation = 103 nm = 1030 Å

$\therefore$ $\Delta E = \frac{12400}{1030Å} \simeq 12.0$ eV

So difference of energy should be 12.0 eV (approx)
Hence $n_1 = 1$ and $n_2 = 3$
(–13.6)eV (–1.51)eV
$\therefore$ Transition is V.

Q.26 (A) r, (B) s, (C) p (D) q
Saturation photo current is directly proportional to intensity.
$K_{max} = h\upsilon - \phi$
Stopping voltage is independent of intensity.

Q.27 (A) r (B) q,s (C) p (D) q,s

$E \propto \frac{1}{n^2}$, $V \propto \frac{1}{n}$ and $r \propto n^2$

(A) $Epr \propto \frac{1}{n^2} \times \frac{1}{n} \times n^2$ or $Epr \propto \frac{1}{n}$

(B) $\frac{p}{E} \propto \frac{1}{n} \times n^2$ or $\frac{p}{E} \propto n$

(C) $Er \propto \frac{1}{n^2} \times n^2$ or Er is independent of n

(D) $Pr \propto \frac{1}{n} \times n^2$ or $pr \propto n$

Q.28 (A) p,r (b) q,s (C) q,s (D) p,r

(A) Frequency of orbiting electron $v_n \propto \frac{z^2}{n^3}$

$f = \frac{v}{2\pi r}$.

(B) angular momentum of orbiting electron $L = \frac{nh}{2\pi}$.

(C) Magnetic moment of orbiting electron $\propto$ n.

$M = i \times \pi R^2 = \frac{e}{T}\pi R^2$

(D) Average current due to orbiting of electron $i \propto \frac{z^2}{n^3}$.

NUMERICAL VALUE BASED

Q.1 [n = 5]

Total energy of radiation

$$E = \frac{hc}{\lambda_1} + \frac{hc}{\lambda_2}$$

$$13.6 \times 4 \times \left(1 - \frac{1}{n^2}\right) = \left(\frac{1240}{108.5} + \frac{1240}{30.4}\right) \text{ eV}$$

$$1 - \frac{1}{n^2} = \frac{1}{13.6 \times 4} \times 52.22$$

n = 5.

Q.2 [4]

Paschen series $\frac{1}{\lambda} = 1.097 \times 10^7 \left(\frac{1}{9} - \frac{1}{n^2}\right) \le 10^6$

$$\frac{1}{9} - \frac{1}{n^2} \le \frac{1}{10.97}$$

$$\frac{1}{n^2} \ge \frac{1.97}{9 \times 10.97}$$

$$\frac{9 \times 1097}{197} \ge n^2$$

$$n \le \sqrt{\frac{1097}{197}} \approx 7$$

$\Rightarrow$ n = 3 $\to$ 4 , 3 $\to$ 5, 3 $\to$ 6, 3 $\to$ 7 $\Rightarrow$ 4 lines

Q.3 [n = 3, 3 : 1]

$(E_H)_n = (E_H)_1$

$$\Rightarrow 13.6 \times \frac{(3)^2}{n^2} = 13.6 \times \frac{1^2}{1^2}$$

$\Rightarrow$ n = 3

$$r = \left(0.0529 \times \frac{n^2}{z}\right) \text{Å}$$

$$\Rightarrow \frac{r_{Li}}{r_H} = \left(\frac{n_{Li}}{n_H}\right)^2 \times \frac{z_H}{z_{Li}} = \left(\frac{3}{1}\right)^2 \times \left(\frac{1}{3}\right) = \frac{3}{1} = 3$$

Q.4 [87 pm, 217 pm]

$E = E_1 + E_2$

$$\Rightarrow 20{,}000 = \frac{12400}{\lambda + 1.3} + \frac{12400}{\lambda}$$

$$\Rightarrow 1.61 = \frac{1}{\lambda + 1.3} + \frac{1}{\lambda}$$

$$\Rightarrow 1.61 = \frac{2\lambda + 1.3}{\lambda^2 + 1.3\lambda}$$

$\Rightarrow 1.61\,\lambda^2 + 0.093\,\lambda - 1.3 = 0$

$\Rightarrow \lambda = 0.87$ Å $\Rightarrow \lambda_1 = 87$ pm

$\lambda_2 = 217$ pm

Q5 [6210 eV]

$$-\frac{hc}{\lambda_{L_\alpha}} = -\frac{hc}{\lambda_{K_\beta}} + \frac{hc}{\lambda_{K_\alpha}}$$

$$\Rightarrow \frac{1}{\lambda_{L_\alpha}} = \frac{1}{\lambda_{K_\beta}} - \frac{1}{\lambda_{K_\alpha}} = \frac{1}{1} - \frac{1}{2} = \frac{1}{2} \Rightarrow \lambda_{L_\alpha} = 2\text{Å}$$

$$\therefore \Delta E = \frac{hc}{\lambda_{L_\alpha}} = \frac{12420}{2} = 6210 \text{ eV}$$

Q.6 [n = 6, Z = 3]

$$10.2 + 17 = 13.6\ Z^2 \left[\frac{1}{2^2} - \frac{1}{n^2}\right]$$

$$\Rightarrow 27.2 = 13.6\ Z^2 \left[\frac{1}{4} - \frac{1}{n^2}\right] \Rightarrow 2 = Z^2 \left[\frac{1}{4} - \frac{1}{n^2}\right] \quad \text{...(i)}$$

$$4.25 + 5.95 = 13.6\ Z^2 \left[\frac{1}{3^2} - \frac{1}{n^2}\right]$$

$$10.2 = 13.6\ Z^2 \left[\frac{1}{9} - \frac{1}{n^2}\right] \Rightarrow$$

$$\frac{3}{4} = Z^2\left[\frac{1}{9} - \frac{1}{n^2}\right] \quad \text{...(ii)}$$

$$\frac{(i)}{(ii)} \Rightarrow \frac{8}{3} = \left[\frac{n^2-4}{4n^2}\right]\left[\frac{9n^2}{n^2-9}\right] \Rightarrow \frac{n^2-4}{n^2-9} = \frac{32}{27}$$

$$\Rightarrow n = \sqrt{\frac{180}{5}} = 6 \qquad z = 3$$

Q.7 [(a) 2000 Å, 1500 Å,]
[(b) Assume energy of level 1 to be zero]

------------------E_4 = 7.75 eV
------------------E_3 = 7.35 eV
------------------E_2 = 6.2 eV
------------------E_1 = 0 eV

[(c) 8.27 volt]

$$\lambda = \frac{1500\,p^2}{p^2-1} = \frac{1500}{1-1/p^2}$$

(a) $$\lambda_{max} = \frac{1500}{1-1/2^2} = \frac{4}{3} \times 1500\ \text{Å} = 2000\ \text{Å}$$

$$\lambda_{min} = \frac{1500}{1-\frac{1}{\infty^2}} = 1500\ \text{Å}.$$

(b) $$\lambda_{2\to1} = \frac{1500}{1-\frac{1}{4}} = 2000\ \text{Å}$$

$$\Delta E_{2\to1} = \frac{hc}{\lambda} = \frac{12400}{2000}\ \text{eV} = 6.2\ \text{eV}$$

$$\lambda_{3\to1} = \frac{1500}{1-\frac{1}{9}} = \frac{9}{8} \times 1500\ \text{Å}$$

$$\Delta E_{3\to1} = \frac{12400}{\frac{9}{8}\times1500}\ \text{eV} = 7.35\ \text{eV}$$

$$\Delta E_{4\to1} = \frac{12400}{\frac{16}{15}\times1500}\ \text{eV} = 7.75\ \text{eV}.$$

Assume energy of level 1 to be zero

------------------E_4 = 7.75 eV
------------------E_3 = 7.35 eV
------------------E_2 = 6.2 eV
------------------E_1 = 0 eV

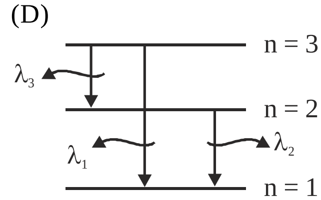
(c) Ionization energy

$$E = (\infty - 1) = \frac{12400}{1500}\ \text{eV} = 8.27\ \text{eV}$$

The ionization potential = 8.27 eV.

KVPY
PREVIOUS YEAR'S

Q.1 (D)



$$\frac{hc}{\lambda_1} = \frac{hc}{\lambda_2} + \frac{hc}{\lambda_3}$$

$$\frac{1}{\lambda_1} = \frac{1}{\lambda_2} + \frac{1}{\lambda_3}$$

Q.2 (B)
Collision of e^- lead to excitation of molecules
so Collision is inelastic
$\therefore$ K' < K and loss of kinetic energy go for excitation of molecules. Momentum remain conserved during collision.

$$\vec{P} = \vec{P'}$$

Q.3 (C)
Size of the nucleus is completely to the atom

Q.4 (A)

K = 3 – 2.3 = 0.7eV, $\quad S = \frac{K}{eE}$ and E = V/d

Q.5 (B)

$$2.6 = 13.6\ z^2\left[\frac{1}{n^2} - \frac{1}{4^2}\right]$$

$$\frac{2.6}{13.6\times 4}=2^2\left[\frac{1}{n^2}-\frac{1}{4^2}\right]$$

$$\frac{2.6}{13.6\times 4}=\frac{1}{n^2}-\frac{1}{16}$$

n = 3 now Energy

$$E=\frac{13.6Z^2}{n^2}eV$$

$$-\frac{13.6\times 4}{9}=-6eV$$

Q.6 (B)

$$V=\frac{h\nu}{e}-\phi$$

Hence from graph ϕ = 2eV

$$\frac{h}{e}=\text{slope}=\frac{6}{1.6\times 10^{15}}$$

$$h=\frac{6\times 1.6\times 10^{-19}}{1.6\times 10^{15}}=6.0\times 10^{-34}$$

Q.7 (D)

Q.8 (C)

Intensity of light at 1.8 m $=\dfrac{P}{4\pi(1.8)^2}$

$$I\Rightarrow\frac{160}{4\times\pi\times(1.8)^2}$$

Photon flux = Number of photon per unit area.

$$\Rightarrow\frac{I}{\frac{hc}{\lambda}}\Rightarrow\frac{I\lambda}{hc}$$

$$\Rightarrow\frac{160\times 6200\times 10^{-10}}{4\times\pi\times(1.8)^2\times 6.63\times 10^{-34}\times 3\times 10^8}$$

$$\Rightarrow 1.22\times 10^{19}$$

Q.9 (B)

$KE_{max} = e \times V_{retarding}$
= e × 0.6
= 0.6 eV
Photon energy = hv = E
When frequency increase by 10% energy of photon also increases by 10%
New energy = E’ = 1.1 E
New $KE_{max.} = e \times V_{retarding} = e \times 0.9 = 0.9$ eV
Einstein photoelectric equation
$hf = KE_{max} + \phi$
$E = 0.6 + \phi$ ....(1)
$1.1 E = 0.9 + \phi$ ....(2)

$$1.1=\frac{0.9+\phi}{0.6+\phi}$$

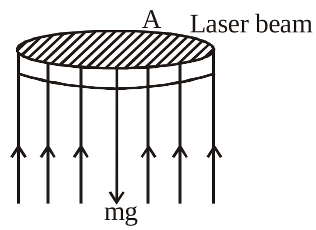
$$1.1\phi+0.66=0.9+\phi$$

$$0.1\,\phi=0.24$$

$$\phi = 2.4\text{ eV}$$

Q.10 (D)

Power of light = P



Force acting on Al disc = $\dfrac{2P}{C}$

$$=\frac{2\times 1.5\times 10^3}{3.0\times 10^8}$$

$= 10^{-5}$
Force acting on Al disc = mg
10^{-5} m × 10
m = 10^{-6} kg

Q.11 (B)

$$\frac{1}{\lambda_1}=R\left[\frac{1}{2^2}-\frac{1}{3^2}\right]$$

$$\frac{1}{\lambda_1}=R\left[\frac{1}{4}-\frac{1}{9}\right]$$

$$\frac{1}{\lambda_1}=R\left[\frac{5}{36}\right]$$

$$\frac{1}{\lambda_1}=R\left[\frac{1}{9}-\frac{1}{25}\right]$$

$$\frac{1}{\lambda_2}=R\left[\frac{16}{9\times 25}\right]$$

From (1) & (2)

$$\frac{\lambda_2}{\lambda_1}=\frac{5}{36}\div\frac{16}{9\times 25}$$

$$\lambda_2=\frac{5}{36}\times\frac{9\times 25}{16}=\frac{125}{64}\lambda_1$$

Q.12 (D)

From Bohr postulates

$$\frac{kze^2}{r^2}=\frac{mv^2}{r} \qquad ...(i)$$

$$mvr = \frac{nh}{2\pi} \qquad ...(ii)$$

$$\Rightarrow v = \frac{e^2}{2\varepsilon_0 h}\frac{z}{n}$$

$$r = \frac{nh}{2\pi mv}$$

$$r = \frac{nh}{2\pi m\left(\frac{e^2}{2\varepsilon_0 h}\right)\left(\frac{z}{n}\right)}$$

$$r = \left(\frac{\varepsilon_0 h^2}{\pi me^2}\right)\left(\frac{n^2}{z}\right)$$

$$r = r_0\frac{n^2}{z}$$

Because the medium of permittivity $\varepsilon = 13\,\varepsilon_0$ effective mass $m = 0.07\ m_e$

$$r = \frac{13r_0}{0.07}\frac{n^2}{z}$$

At ground state (n = 1, assuming like H atom, z = 1)

$$r = \frac{13}{0.07}(0.53)\,\text{Å} \Rightarrow r \approx 100\text{Å}$$

Q.13 (B)

Debroglie wavelength of electron

$$\lambda = \frac{h}{\sqrt{2mK}} \qquad \text{Kinetic energy } K = qV$$

$$\lambda \propto \frac{1}{\sqrt{V}}$$

Potential becomes four time so wavelength becomes half.

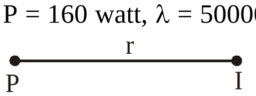
Fringe width (β) = $\frac{\lambda D}{d}$

$\beta \propto \lambda$

Fringe width becomes half.

Q.14 (D)

P = 160 watt, λ = 50000Å



$$I = \frac{P}{4\pi r^2}$$

$$nh\nu = \frac{P}{4\pi r^2}$$

$$\Rightarrow n = \frac{P}{4\pi r^2(h\nu)} \text{ (n=no. of photons per sec per m}^2\text{)}$$

$$n = \frac{P\lambda}{4\pi r^2 hc}$$

$n = 10^{20}\ m^{-2}\ s^{-1}$

Q.15 (C)

Energy of photon $= E = \frac{hc}{\lambda}$

Momentum of photon = $P\frac{h}{\lambda}$

$E = PC \qquad \therefore \frac{E}{P} = C = 3\times10^8\ m/s$

Q.16 (D)

$$R = \frac{mv}{qB}$$

$$V = \frac{qBR}{m} = \frac{eBR}{m_e}$$

$$\frac{hc}{\lambda} - \phi = KE_{max}\ (\text{Einstein photo electric equation})$$

$$\phi = \frac{hc}{\lambda} - KE_{max}$$

$$= \frac{hc}{\lambda} - \frac{1}{2}m_e\left(\frac{eBR}{m_e}\right)^2$$

$$= \frac{hc}{\lambda} - 2m_e\left(\frac{eBR}{2m_e}\right)^2$$

Q.17 (D)

Continuous X Ray is inverse of photoelectric effect

Q.18 (B)

When e^- collide with atom which is massive in comparison to e^-. Max possible loss of KE = KE of e^- (initial KE) = E if this E is less than min excitation energy then collision is elastic

$\therefore$ E < 10.2 eV (Minimum excitation energy)

Q.19 (A)

$$mvr = n\frac{h}{2\pi}$$

$v = r\omega$

$$mr^2\omega = n\frac{h}{2\pi}$$

$$r = \sqrt{\frac{nh^2}{2\pi m\omega}}$$

$$r = \sqrt{n}\sqrt{\frac{h^2}{2\pi m\omega}}$$

$$r = \sqrt{n}.a$$

Q.20 (A)

$r \propto \frac{1}{z}$ and $r \propto z$

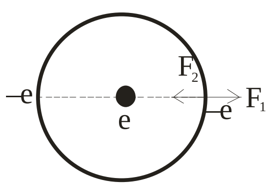
$$\therefore \text{ According } \left(\frac{v^2}{z}\right) \propto z^2 \times \frac{1}{(1/z)} = z^3$$

$$\frac{a_H}{a_{H\in}} = \left(\frac{z_H}{z_{He}}\right)^3 = \left(\frac{1}{2}\right)^3 = \frac{1}{8}$$

Q.21 **(B)**

$$mvr = n\frac{h}{2\pi}$$

and $\frac{mv^2}{r} = \frac{ke^2}{r^2} - \frac{mv^2}{(2r)^2}$



$$\frac{mv^2}{r} = \frac{3}{4}\frac{ke^2}{r^2} \Rightarrow mv^2 r = \frac{3}{4}ke^2 \quad ....(2)$$

Solving (1) + (2)

$$r = \frac{4\pi\varepsilon_0 h^2}{me^2} \times \frac{4}{3}$$

$$r = \frac{4}{3}a_B$$

Q.22 (B)

$$\frac{1}{2}\left(\frac{m.4m}{m+4m}\right)v^2 = \frac{1}{4\pi\varepsilon_0}\frac{2e^2}{r}$$

$$r = \frac{5e^2}{4\pi\varepsilon_0 mv^2}$$

Q.23 (A)

$$\frac{1}{\lambda} - Rz^2\left|\frac{1}{m^2} - \frac{1}{n^2}\right|; n = 2, m = 1$$

Q.24 (D)

For standing wave $n\frac{\lambda}{2} = L$

so $P = \frac{h}{\lambda} = n\frac{h}{2L}$

So Energy $F = \frac{P^2}{2m_e} = \frac{n^2h^2}{8m_eL^2} = n^2\alpha$

For ground state E = α = u_0

For first excited state E = 2^2 α = $4u_0$

= u_0 + 3α

For second excited sate E = 3^2 α = 9α

= u_0 + 8α

Q.25 (C)

$hv' = hv + mgh$

$$m = \frac{hv}{c^2}$$

$$\Rightarrow \frac{v' - v}{v} = \frac{gh}{c^2} = 1.12 \times 10^{-13}$$

Q.26 (A)

$$E_n = \frac{-me^4}{8\varepsilon_0^2 n^2 h^3} = \frac{-Rhc}{n^2}$$

For munoic atom $R = \frac{me^4}{8\varepsilon_0^2 h^3 C}$

$$\frac{1}{\lambda} = 200R\left(\frac{1}{2^2} - \frac{1}{n^2}\right)$$

Wavelength λ for corresponding balmer series will be $\frac{1}{200}$ times that of hydrogen atom will be in range of x-rays

Q.27 (B)

If electron orbits positive sphere in place of point particle the ground energy remains the same. Hence ground state energy is – 13.6 eV.

Q.28 **(C)**

$$\phi = \frac{12431}{3320} = 3.74 \text{ eV}$$

$$\varepsilon = \frac{hc}{\lambda} = \frac{12431}{2900} = 4.28 \text{ eV}$$

$(KE)_{max}$ = 4.28 – 3.74 = 0.54 eV

Initially sphere is negatively charged so e^- will go easily then potential becomes O. After that as e^- will leave the potential will increase till it reaches the stopping potential value, V_0

$eV_0 = 0.54$ eV

$V_0 = 0.54$ V

Q.29 (D)

$$F_e = \frac{mv^2}{r} \Rightarrow \frac{mv^2}{r} = \frac{k(Ze)(e)}{r^2}$$

$$\frac{1}{2}mv^2 = \frac{KZe^2}{2r} \text{.....(i) (Kinetic energy)}$$

$$\text{Potential energy} = \frac{Kq_1q_2}{r} = \frac{K(Ze)(-e)}{r} \quad \text{....(ii)}$$

$$\text{Total energy} = KE + PE = -\frac{Kze^2}{2r} = -\frac{E_0}{n}$$

$\therefore \quad r \propto n$

$$\text{As kinetic energy} = \frac{KZe^2}{2r} \Rightarrow KE \propto \frac{1}{n}$$

$$\text{or } v^2 \propto \frac{1}{n} \Rightarrow v^2 \propto \frac{1}{\sqrt{n}}$$

$L = mvr$

$$L \propto \frac{1}{\sqrt{n}}(n) \propto \sqrt{n}$$

$$L \propto \sqrt{n}$$

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Q.1 (1)

$$13.6 \times \left(1 - \frac{1}{4}\right) = \frac{1240}{\lambda(\text{nm})}$$

$$\lambda = \frac{4 \times 1240}{13.6 \times 3} \text{ nm} = 121.5 \text{ nm}$$

Q. 2 [5]

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

$$\frac{hc}{\lambda} = \frac{m^2v^2}{2m}$$

$$\frac{hc}{\lambda} = \frac{p^2}{2m}.$$

$$\frac{hc}{\lambda} = \frac{h^2}{\lambda^2(2m)}$$

$$m = \frac{h}{2c\lambda} = \frac{h}{2(3 \times 10^8)(10 \times 10^{-10})}$$

$$m = \frac{5h}{3}$$

Q.3 (1)

$$\frac{1}{\lambda_1} = R\left[1 - \frac{1}{(4)^2}\right], \text{ Lyman,}$$

$$\frac{1}{\lambda_1} = R\left[\frac{1}{9} - \frac{1}{(4)^2}\right], \text{ Paschen}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{\left(\frac{1}{9} - \frac{1}{16}\right)}{\left(1 - \frac{1}{16}\right)} = \frac{\frac{7}{9 \times 16}}{\frac{15}{16}}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{7}{9 \times 15} = \frac{7}{135}$$

Q.4 (1)

$$E_1 = -\frac{13.6 \text{ eV}}{1^2} = -13.6 \text{ eV}$$

$$E_5 = -\frac{13.6 \text{ eV}}{25} = -0.54 \text{ eV}$$

$E_5 - E_1 = 13.6 - 0.54 = 13.06$ eV

$$\text{recoil speed} = \frac{p_{\text{photon}}}{m_H} = \frac{(E_{\text{photon}}/c)}{m_H} = \frac{(\Delta E / c)}{m_H} = \frac{\Delta E}{cm_H}$$

$$\text{recoil speed} = \frac{13.06 \text{ eV}}{3 \times 10^8 \times 1.6 \times 10^{-27}}$$

$$= \frac{13.06 \times 1.6 \times 10^{-19}}{3 \times 1.6 \times 10^{-19}} = 4.35 \text{ m/sec}$$

Q.5 (1)

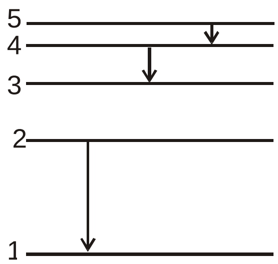
$$\text{Speed} \propto \frac{Z}{n}$$

$$\text{frequency of oscillation} \propto \frac{Z^3}{n^3}$$

$$\text{coulombic force of attraction} \propto \frac{Z^3}{n^4}$$

$$\text{Kinetic Energy} \propto \frac{Z^2}{n^2}$$

Q.6 (1)



$\Delta E = hf$

f is more for transitions from n = 2 to n = 1

Q.7 (1)

A $\rightarrow$ Series limit of laymen
B $\rightarrow$ 3rd line of Balmer
C $\rightarrow$ 2rd line of paschan

Q.8 (1)

$$\lambda_{min} = \frac{\lambda c}{ev} = \frac{1240nm - ev}{1.24 \times 10^6}$$

$$\lambda_{min} = 10^{-3}\ nm$$

Q.9 (2)

$$\lambda = \frac{h}{\sqrt{2m(qV)}}$$

$$\frac{\lambda_p}{\lambda_\alpha} = \sqrt{\frac{M_\alpha q_\alpha}{M_p q_P}} = 2\sqrt{2}$$

Q.10 (1)

$$\lambda = \frac{h}{mv}$$

$$\frac{\lambda_e}{\lambda_p} = \frac{m_p}{m_e} = 1836$$

Q.11 (2)

$$\frac{hc}{\lambda} = \phi + eVs.$$

$$\frac{1240}{491} = \phi + 0.71$$

$$\frac{1240}{\lambda} = \phi + 1.43$$

$$1240\left(\frac{1}{\lambda} - \frac{1}{491}\right) = 0.72$$

$$\lambda = 382\ nm$$

Q.12 [1]

Case–1.

$$2\phi - \phi = \frac{1}{2}mv^2{}_1 \quad .....(i)$$

Case–2

$$10\phi - \phi = \frac{1}{2}mv^2{}_2 \quad .....(ii)$$

Dividing (i) and (ii)

$$\frac{\phi}{9\phi} = \frac{v_1^2}{v_2^1}$$

$$\frac{1}{3} = \frac{v_1}{v_2}$$

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

x = 1a
y = 3a
If a = 1(assume)
Then
x = 1
y = 3

Q.13 **(3)**

Statement-I $\lambda = \frac{h}{p}$

Statement-II $p = \frac{h}{\lambda}$ and $E = \frac{hc}{\lambda}$

Q.14 (1)

$$\frac{h}{m_\alpha v_\alpha} = \frac{h}{m_p v_p}$$

$$\Rightarrow \frac{u_\alpha}{u_p} - \frac{m_p}{m_\alpha} = \frac{1}{4}$$

Q.15 **(4)**

Stopping potential changes linearly with Stopping potential changes linearly with frequency of incident radiation.

Q.16 **(4)**

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mK}} = \frac{h}{\sqrt{2mqV}}$$

$$\frac{\lambda_1}{\lambda_2} = \sqrt{\frac{m_2}{m_1}}$$

$$\frac{\lambda_e}{\lambda_p} = \sqrt{\frac{m_p}{m_e}} = \sqrt{1831.4} = 42.79$$

Q.17 (2)

$$l = \frac{h}{\sqrt{2mE}}$$

$$l_2 = \frac{hc}{E}$$

$$\frac{\lambda_1}{\lambda_2} = \frac{1}{c}\left(\frac{E}{2m}\right)^{1/2}$$

Q.18 [25]

$$F = \frac{IA}{C}$$

$$I = \frac{FC}{A} = \frac{2.5\times10^{-6}\times3\times10^{8}}{30} = 25\ W/cm^2$$

Q.19 (1)

$$(1)\ \frac{1}{2}mv_1^2 = hf_1 - \phi$$

$$\frac{1}{2}mv_2^2 = hf_2 - \phi$$

$$v_1^2 - v_2^2 = \frac{2h}{m}(f_1 - f_2)$$

Q.20 (4)

$$l = \frac{h}{p}$$

$$\frac{\lambda_p}{\lambda_e} = \frac{p_e}{p_p} = \frac{m_e v_e}{m_p v_p}$$

$$2 = \frac{m_e}{m_p}\left(\frac{v_e}{4v_e}\right)$$

$$\therefore\ m_p = \frac{m_e}{8}$$ **Ans. (4)**

Q.21 [15]

For 1st line

$$\frac{1}{\lambda_1} = Rz^2\left(\frac{1}{2^2} - \frac{1}{3^2}\right)$$

$$\frac{1}{\lambda_1} = Rz^2\,\frac{5}{36} \qquad .....(i)$$

For 3rd line

$$\frac{1}{\lambda_1} = Rz^2\left(\frac{1}{2^2} - \frac{1}{5^2}\right)$$

$$\frac{1}{\lambda_3} = Rz^2\,\frac{21}{100} \qquad .....(ii)$$

(ii) + (i)

$$\frac{\lambda_1}{\lambda_3} = \frac{21}{100}\times\frac{36}{5} = 1.512 = 15.12\times10^{-1}$$

$x \approx 15$

Q.22 (2)

We know velocity of electron in n^{th} shell of hydrogen atom is given by

$$v = \frac{2\pi kZe^2}{nh}$$

$$\therefore\ v \propto \frac{1}{n}$$

Q.23 (2)

Energy of H-atom is $E = -13.6\ Z^2/n^2$

for H-atom Z = 1 & for ground state, n = 1

$$\Rightarrow\ E = -13.6\ X\ \frac{1^2}{1^2} = -13.6\ eV$$

Now for carbon atom (single ionised), Z = 6

$$E = -13.6\ \frac{Z^2}{n^2} = -13.6 \qquad \text{(given)}$$

$$-13.6\ \frac{6^2}{n^2} = -13.6$$

n = 6

Q.24 (3)

$U = U_0 r^4$

$$F = \frac{dU}{dr} = 4U_0 r^3$$

$$\because\ F_c = F$$

$$\frac{mv^2}{r} = 4v_0 r^3$$

$mv^2 = 4v_0 r^4$

$v^2 \propto r^4$

$v \propto r^2$

Now

$$mvr = \frac{nh}{2\pi}$$

$r^3 \propto n$

$r \propto n^{1/3}$

So

a = 3

Q.25 (2)

$E \propto \frac{1}{r}$ $\quad r \propto \frac{1}{m}$

$E \propto m$

$$\text{Ionization potential} = 13.6 \text{ X } \frac{(\text{Mass}_\mu)\text{eV}}{(\text{Mass}_e)}$$

= 13.6 X 207 e V = 2815.2 eV

Q.26 (1)

Every part (dl) of the wire is pulled by force i(dl)B acting perpendicular to current & magnetic field giving it a shape of circle.

Q.27 (4)

(4) Conceptual

Q.28 **[4]**

Q.29 (3)

Q.30 (3)

Q.31 (4)

Q.32 (3)

Q.33 [125]

Q.34 (2)

Q.35 (3)

Q.36 [910]

Q.37 (2)

Q.38 **(4)**

Q.39 (112)

Q.40 (1)

De-Broglie wavelength

$$\lambda = \frac{h}{mv} = \frac{h}{\sqrt{2mE}}$$

Where E is kinetic energy

$$E = \frac{3kT}{2} \text{ for gas}$$

$$\lambda = \frac{h}{\sqrt{3mkT}} = \frac{6.6\times10^{-34}}{\sqrt{3\times9\times10^{-31}\times1.38\times10^{-23}\times300}}$$

$\lambda = 6.26 \times 10^{-9}$ m = 6.26 nm

Q.41 (2)

Q.42 (2)

Q.43 (1)

$$KE_{max} = eV_S = \frac{hc}{\lambda} - \phi$$

$$\Rightarrow eV_S = \frac{1240}{280} - 2.5 = 1.93\text{eV}$$

$$\rightarrow V_{S_1} = 1.93\text{V ... (i)}$$

$$\rightarrow V_{S_2} = \frac{1240}{400} - 2.5 = 0.6\text{eV}$$

$$\Rightarrow V_{S_2} = 0.6\text{V ... (ii)}$$

$$\Delta V = V_{S_1} - V_{S_2} = 1.93 - 0.6 = 1.33\text{V}$$

Option (1)

Q.44 (1)

Q.45 (3)

$$\Delta x.\Delta p \geq \frac{h}{4\pi}$$

$$\Delta x = \frac{h}{4\pi m \Delta v} \qquad v = \sqrt{\frac{3KT}{m}}$$

$$\frac{\Delta x_e}{\Delta x_p} = \sqrt{\frac{m_p}{m_e}}$$

Q.46 (3)

For every large distance P.E. = 0

& Total energy = 2.6 + 0 = 2.6 eV

Finally in first excited state of H atom total energy = –3.4 eV

Loss in total energy = 2.6 – (3.4)

= 6eV

It is emitted as photon

$$\lambda = \frac{1240}{6} = 206\,\text{nm}$$

$$f = \frac{3\times10^8}{206\times10^{-9}} = 1.45 \times 10^{15} \text{ Hz}$$

$= 1.45 \times 10^9$ Hz

Q.47 (4)

Q.48 (2)

Q.49 (4)

$$nf_1 = k\left(\frac{1}{1} - \frac{1}{3^2}\right)$$

$$nf_2 = k\left(1-\frac{1}{2^2}\right)$$

$$\frac{f_1}{f_2} = \frac{8/9}{3/4} \Rightarrow f_2 = 2.46\times10^{15}$$

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Q.1 (C)

$$\left[\sqrt{\frac{Ne^2}{m\varepsilon_0}}\right] = \sqrt{\frac{\frac{1}{L^3}\times Q^2}{M\times\frac{Q^2}{L^2\times F}}} = \frac{1}{T}$$

So only (C) is dimensionally correct

Q.2 (B)
For resonance

$$\omega = \omega_p = \sqrt{\frac{Ne^2}{m\varepsilon_0}} = \sqrt{\frac{4\times10^{27}\times(1.6\times10^{-19})^2}{10^{-30}\times10^{-11}}}$$

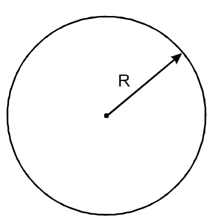
$\omega = 3.2 \times 10^{15}$

$$f = \frac{\omega}{2\pi} = \frac{3.2\times10^{15}}{2\times3.14} \approx \frac{1}{2}\times10^{15}$$

$$\lambda = \frac{c}{f} = \frac{3\times10^8}{\frac{1}{2}\times10^{15}} \quad \lambda \approx 600 \text{ nm}$$

Q.3 [7]
R = 1 cm
f = 4.7 eV

$$\frac{hc}{\lambda} = \phi + eV$$



$$\frac{1240(ev)(nm)}{200(nm)} = 4.7\text{ (eV)} + eV$$

$$\frac{1240}{200}e = 4.7e + eV$$

$6.2 - 4.7 = V$ $\therefore$ V = 1.5 volt

$$\frac{1}{4\pi\epsilon_0}\frac{Q}{R} = 1.5$$

$$(9\times10^9)\frac{Ne}{\frac{1}{100}} = 1.5$$

$$9\times10^{11}\ Ne = 1.5\ ;\ N = \frac{1.5}{9\times10^{11}\times1.6\times10^{-19}}$$

$$= \frac{15}{16}\times\frac{1}{9}\times10^8 = \frac{5}{3\times16}\times10^8 = \frac{50}{48}\times10^7$$

$\therefore$ Z = 7

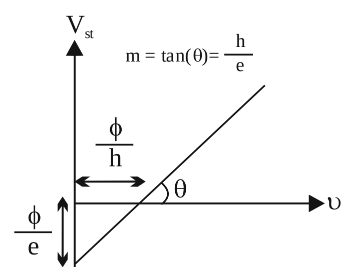
Q.4 (B)
Change in momentum

$$= \frac{\text{power}\times\text{total time}}{\text{speed of light}} = \frac{P\times t}{c}$$

1.0×10^{-17} kg × m/s

Q.5 [1]

$$KE_{max} = h\nu - \phi$$



$$eV_{st} = h\nu - \phi$$

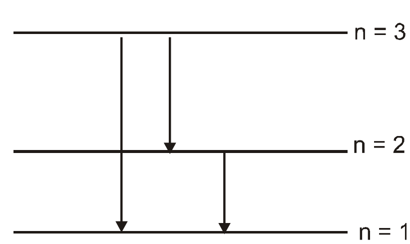
$$V_{st} = \left(\frac{h}{e}\right)\nu - \frac{\phi}{e}$$

y = m x + C

So slope will be $\left(\frac{h}{e}\right)$, and it will be same for both the metals.
So ratio of the slopes = 1

Q.6 (A, C)
$R_n = 4.5\ a_0$

$$L = mvr = \frac{3h}{2\pi} \quad [\text{as } n = 3,\ z = 2]$$



$$\frac{1}{\lambda} = Rz^2\left(\frac{1}{n_f^2} - \frac{1}{n_1^2}\right)$$

$$\frac{1}{\lambda_{3\to1}} = R4\left[\frac{1}{1}-\frac{1}{9}\right] = 4R\frac{8}{9} \Rightarrow \lambda_{3\to1} = \frac{9}{32R}$$

$$\frac{1}{\lambda_{2\to1}} = R4\left[\frac{1}{1}-\frac{1}{4}\right] = \frac{3}{4}4R \Rightarrow \lambda_{2\to1} = \frac{1}{3R}$$

$$\frac{1}{\lambda_{3\to2}} = R4\left[\frac{1}{4}-\frac{1}{9}\right] = \frac{5}{36}4R \Rightarrow \lambda_{3\to2} = \frac{9}{5R}$$

Q.7 (B)

Using Mosley's law, for K_α line : $\sqrt{\upsilon}$ = a (z – b)
where b = 1

$$\upsilon \propto \frac{1}{\lambda} \therefore \frac{\sqrt{\frac{1}{\lambda_{cu}}}}{\sqrt{\frac{1}{\lambda_{mo}}}} = \frac{a(29-1)}{a(42-1)}$$

$$\Rightarrow \frac{\lambda_{cu}}{\lambda_{mo}} = \frac{41\times 41}{28\times 28} = \frac{1681}{784} = 2.144$$

Q.8 (A)

248 nm ≡ 1240 / 248 ev = 5 ev
310nm ≡ 1240 / 310 ev = 4 ev

$$\frac{K.E_1}{K.E_2} = \frac{4}{1} = \frac{5ev-W}{4ev-W} \Rightarrow 16 - 4W = S - W$$

$\Rightarrow$ 11 = 3 W $\Rightarrow$ W = $\frac{11}{3}$ = 3.67 ev ≅ 3.7 ev

Q.9 (B)

$$ev_0 = hc\left[\frac{1}{\lambda}-\frac{1}{\lambda_0}\right]$$

$$e \times 2 = hc\left[\frac{1}{(0.3)\,\mu m}-\frac{1}{\lambda_0}\right]$$

(i)

$$e \times 1 = hc\left[\frac{1}{(0.4)\,\mu m}-\frac{1}{\lambda_0}\right]$$

(ii)

$$e \times 0.4 = hc\left[\frac{1}{(0.5)\,\mu m}-\frac{1}{\lambda_0}\right]$$

(iii)
By solving (i) & (ii)

$h = 6.4\times 10^{-34}\,Js$
Hence, (B)

Q.10 (A,B,D)

$$\because r = K\frac{n^2}{z}$$

$$\therefore \frac{\Delta r}{r} = \frac{\frac{K}{z}\left\{n^2-(n-1)^2\right\}}{K\frac{n^2}{z}} = \frac{(2n-1)}{n^2}z \simeq \frac{2}{n}$$

$$\because E = -K\frac{z^2}{n^2}$$

$$\therefore \frac{\Delta E}{E} = \frac{Kz^2\left\{\frac{1}{(n-1)^2}-\frac{1}{n^2}\right\}}{\frac{Kz^2}{2^2}} \propto \frac{1}{n}$$

$$\because L = \frac{nh}{2\pi}$$

$$\therefore \frac{\Delta L}{L} = \frac{\left\{n-(n-1)\right\}\frac{h}{2\pi}}{\frac{nh}{2\pi}}$$

Q.11 [N = 1, 2 or 3]

Q.12 (A)

$$\frac{hc}{\lambda_{ph}} = \phi + K_{C,\max} = \phi + K_{A,\max} - eV$$

$$\Rightarrow \frac{hc}{\lambda_{ph}} = \phi + K_{C,\max} = \phi + \frac{h^2}{2m\lambda_e^2} - eV$$

For $V \gg \frac{\phi}{e}$,

$\phi \ll eV$ and $\frac{hc}{\lambda_{ph}} \ll eV$

$$\therefore \quad \frac{h^2}{2m\lambda_e^2} = eV$$

When V is made four times λ_e is halved.

Q.13 [5]

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

$$\frac{v_i}{v_f} = \frac{-\frac{27.2}{n_f^2}}{-\frac{27.2}{n_i^2}} = \frac{1}{6.25}$$

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

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

Q.14 (A)

$$\frac{hc}{\lambda} = \phi_0 + KE_{max}$$

$$KE = \frac{P^2}{2m_e} = \frac{h^2}{2m_e\lambda_d^2}$$

$$\frac{hc}{\lambda} = \phi_0 + \frac{h^2}{2m_e\lambda_d^2}$$

$$-\frac{hc}{\lambda^2}d\lambda = 0 + \frac{h^2}{2m_e}\frac{(-2)}{\lambda_d^3}d\lambda_d$$

$$\frac{d\lambda_d}{d\lambda} = \frac{2m_e\lambda_d^3}{h^2 \times \lambda^2}\cdot hc$$

$$\frac{d\lambda_d}{d\lambda} \propto \frac{\lambda_d^3}{\lambda^2}$$

Q.15 [24]

Power = nhν   n = number of photons per second

Since KE = 0, $h\nu = \phi$

200 = n[6.25 × 1.6 × 19^{-19} Joule]

$$n = \frac{200}{1.6\times10^{-19}\times6.25}$$

As photon is just above threshold frequency KE_{max} is zero and they are accelrated by potential difference of 500V.

$KE_f = q\Delta V$

$$\frac{P^2}{2m} = q\Delta V \Rightarrow P = \sqrt{2mq\Delta V}$$

Since efficiency is 100%, number of electrons = number of photons per second

As photon is completely absorbed force exerted = nmv

$$= \frac{200}{6.25\times1.6\times10^{-19}}\times\sqrt{2\left(9\times10^{-31}\right)\times1.6\times10^{-19}\times500}$$

$$= \frac{3\times200\times10^{-25}\times\sqrt{1600}}{6.25\times1.6\times10^{-19}} = \frac{2\times40}{6.25\times1.6}\times10^{-4}\times3 = 24$$

Q.16 [3]

$$\Delta E_{2-1} = 13.6\times z^2\left(1-\frac{1}{4}\right) = 13.6\times Z^2\left(\frac{3}{4}\right)$$

$$\Delta E_{3-2} = 13.6\times z^2\left[\frac{1}{4}-\frac{1}{9}\right] = 13.6\times z^2\left(\frac{5}{36}\right)$$

$$\Delta E_{2-1} = \Delta E_{3-2} + 74.8$$

$$13.6\times z^2\left(\frac{3}{4}\right) = 13.6\times z^2\left(\frac{5}{36}\right) + 74.8$$

$$13.6\times z^2\left(\frac{3}{4}-\frac{5}{36}\right) = 74.8$$

$$z^2 = 9$$

$$z = +3$$

Q.17 (B, C)

$$\frac{hc}{\lambda_a} = 13.6\left[\frac{1}{1^2}-\frac{1}{4^2}\right] \quad ....(i)$$

$$\frac{hc}{\lambda_e} = 13.6\left[\frac{1}{m^2}-\frac{1}{4^2}\right] \quad ....(ii)$$

(ii) / (i), we get

$$\frac{\lambda_a}{\lambda_e} = \left[\frac{\frac{1}{m^2}-\frac{1}{16}}{1-\frac{1}{16}}\right] = \frac{1}{5}$$

$$\Rightarrow \frac{1}{m^2}-\frac{1}{16} = \frac{15}{16}\times\frac{1}{6}$$

$$\Rightarrow \frac{1}{m^2}-\frac{1}{16} = \frac{3}{16}$$

$$\Rightarrow \frac{1}{m^2} = \frac{3}{16}+\frac{1}{16}$$

$\Rightarrow$ m = 2

from (ii)

$$\frac{hc}{\lambda_e} = 13.6\left[\frac{1}{2^2}-\frac{1}{4^2}\right] = 13.6\times\frac{3}{16}ev$$

$$\Rightarrow \lambda_e = \frac{1242\times16}{13.6\times3}nm$$

$$\Rightarrow \lambda_e \approx 487.05 \text{ nm}$$

we have $KE_a \propto \frac{z^2}{n^2}$

$$\Rightarrow \frac{KE_2}{KE_1} = \frac{1}{4}$$

$$\Delta P_a = \frac{h}{\lambda_a}$$

$$\Delta P_e = \frac{h}{\lambda_e}$$

$$\Rightarrow \frac{\Delta P_a}{\Delta P_e} = \frac{\lambda_e}{\lambda_a}$$

Q.18 [1.00]

Let momentum of one photon is p and after reflection velocity of the mirror is v.

conservation of linear momentum

$$Np\hat{i} = -Np\hat{i} + mv\hat{i}$$

$$mv\hat{i} = 2pN\hat{i}$$

$mv = 2Np$ ....(i)

since v is velocity of mirror (spring mass system) at mean position,

$v = A\Omega$

Where A is maximum deflection of mirror from mean position. (A = 1 μm) and Ω is angular frequency of mirror spring system,

momentum of 1 photon, $p = \frac{h}{\lambda}$

$mv = 2\ Np$ .....(i)

$mA\Omega = 2N\frac{h}{\lambda}$

$N = \frac{m\Omega}{h} \times \frac{\lambda A}{2}$

given, $\frac{m\Omega}{h} \times \frac{10^{24}}{4\pi} m^{-2}$

$\lambda = 8\pi \times 10^{-6}$ m

$N = \frac{10^{24}}{4\pi} \times \frac{8\pi \times 10^{-6} \times 10^{-6}}{2}$

$N = 10^{12} = x \times 10^{12}$

Q.19 (B,C)

U=Fr

[Using U=Potential energy and v=velocity, to avoid confusion between their symbols]

$\Rightarrow$ Force $= \frac{-dU}{dr} = -F$

$\Rightarrow$ Magnitude of force =Constant =F

$\Rightarrow F = \frac{mv^2}{R}$ ....(1)

$\Rightarrow mvR = \frac{nh}{2\pi}$ .....(2)

$\Rightarrow F = \frac{m}{R} \times \frac{n^2h^2}{4\pi^2} \times \frac{1}{m^2R^2}$

$\Rightarrow R = \left(\frac{n^2h^2}{4\pi^2 mF}\right)^{1/3}$ ...(3)

$\Rightarrow v = \frac{nh}{2\pi mR}$

$\Rightarrow v = \frac{nh}{2\pi m}\left(\frac{4\pi^2 mF}{n^2h^2}\right)^{1/3}$

$\Rightarrow v = \frac{n^{1/3}h^{1/3}F^{1/3}}{2^{1/3}\pi^{1/3}m^{2/3}}$ ....(4)

(B) is correct

$\Rightarrow E = \frac{1}{2}mv^2 + U$

$= \frac{1}{2}mv^2 + FR$

$\Rightarrow E = \frac{1}{2}m\left(\frac{n^{2/3}h^{2/3}F^{2/3}}{2^{2/3}\pi^{2/3}m^{4/3}}\right) + F \times \left(\frac{n^2h^2}{4\pi^2 mF}\right)^{1/3}$

$\Rightarrow E = \left(\frac{n^2h^2F^2}{4\pi^2 m}\right)^{1/3}\left[\frac{1}{2}+1\right]$

$= \frac{3}{2}\left(\frac{n^2h^2F^2}{4\pi^2 m}\right)^{1/3}$

Q.20 (A, C)

$\lambda_{min} = \frac{hc}{eV}$

$\Rightarrow \lambda_{min} \alpha \frac{1}{V} \Rightarrow (\lambda_{min})_{new} = \frac{(\lambda_{min})_{old}}{2}$

$\because I = \frac{dN}{dt} \times \frac{hc}{\lambda}$

$\because \frac{dN}{dt}$ decreases

Hence I decreases

Q.21 (AD)

Q.22 [6]

Nuclear Physics

EXERCISES

ELEMENTRY

Q.1 (1)

Radius of $O_5^{189} = r_0\ A_{O5}^{1/3}$

Radius of that nucleus $= \frac{1}{3} \times r_0 \left(A_{O_5}\right)^{\frac{1}{3}} = r_0 \left(\frac{189}{27}\right)^{\frac{1}{3}} =$ $r_0\ 7^{1/3}$

$\therefore$ **A for that nucleus = 7**

Q.2 (4)

Q.3 (3)
Nucleus does not contains electron.

Q.4 (3)
Nuclear force do not exist when seperation is greater than 1 fermi.

Q.5 (1)
B.E.= Δmc^2 = [2(1.0087 + 1.0073(– 4.0015] = 28.4 MeV

Q.6 (2)
$Q = 4\ (x_2 - x_1)$

Q.7 (2)

Q.8 (1)
${}_{92}U^{235} + {}_0n^1 \rightarrow {}_{38}Sr^{90} + {}_{54}Xe^{143} + 3{}_0n^1$

Q.9 (4)
${}_6C^{11} \rightarrow {}_5B^{11} + \beta^+ + \gamma$ because $\beta^+ = {}_1e^0$

Q.10 (1)

$$N = \frac{N_0}{2^4} = \frac{N_0}{16},$$

$$\%\ \text{amount remaining} = \frac{N \times 100}{N_0} = \frac{N_0}{16} \times \frac{100}{N_0} = 6.25\%$$

Q.11 (2)

$$\frac{dN}{dt} = \lambda N \Rightarrow \frac{dN}{N} = \lambda dt = \frac{0.693}{t_{1/2}} dt = \frac{0.693}{1.4 \times 10^{10}} \times 1$$

$= 4.95 \times 10^{-11}$

Q.12 **(3)**

$$T_{avg.} = \frac{1}{\lambda} \Rightarrow T_{1/2} = \frac{\ln 2}{\lambda} < T_{avg.}$$

So more than half the nuclei decay.

Q.13 (3)
β-rays emitted from nucleus and they carry negative charge.

Q.14 (2)

Q.15 (4)

By using $A = A_0 \left(\frac{1}{2}\right)^{1/T_{1/2}} \Rightarrow \frac{A}{A_0} = \left(\frac{1}{2}\right)^{9/3} = \frac{1}{8}$

Q.16 (3)

Q.17 (3)

Q.18 (1)
Total mass of reactants = (2.0141) × 2 = 4.0282 amu
Total mass of products = 4.0024 amu
Mass defect = 4.0282 amu – 4.0024 amu = 0.0258 amu
$\therefore$ Energy released E = 931 × 0.0258 = 24 MeV

JEE-MAIN
OBJECTIVE QUESTIONS

Q.1 (4)

Q.2 (4) the binding energy per nucleon in a nucleus varies in a way that depends on the actual value of A.

Q.3 (4)
It is the sum of the kinetic energy of all the nucleons in the nucleus

Q.4 (1)
$Q = (2BE_{He} - BE_{Li})$
$= (2 \times 7.06 \times 4 - 5.60 \times 7)$ Mev
= 17.28 Mev.

Q.5 (1)

Let ${}_5^{10}B$ and ${}_5^{11}B$ be in the ratio m:n .

Average atomic weight

$$10.81 = \frac{m \times 10 + n \times 11}{m + n}$$

$$\Rightarrow \frac{m}{n} = \frac{0.19}{0.81} = \frac{19}{81}$$

Q.6 (3)

1 a.m.u. = $\frac{1}{12}$ [mass of one ${}_6c^{12}$]

For $C \Rightarrow A = 12$

Q.7 (2)
Energy = BE of Products – BE of Reactants
(8.2 × 110 + 8.2 × 90) – 7.4 × 200 = 160 MeV

Q.8 (2)

$^{A}X + {}^{A}X \rightarrow {}^{2A}Y$

$E_2 - 2E_1 = Q$

Q.9 (3)

$$\begin{array}{ccc} 3B & \rightarrow & A + e \\ \downarrow & & \downarrow \\ E_b & & E_a \end{array}$$

$e = E_a - 3E_b \Rightarrow 3E_b = E_a - e$

Q.10 (3)
BE/ Nucleon $\Rightarrow$

${}_2^4He \Rightarrow \frac{28}{4} = 7\,MeV$

${}_3^7Li \Rightarrow \frac{52}{7} = 7.4\,MeV$

${}_6^{12}C \Rightarrow \frac{90}{12} = 7.5\,MeV$

${}_7^{14}N \Rightarrow \frac{98}{14} = 7\,MeV$

Elements with more BE/nucleon is more stable.

Q.11 (4)
The gamma photon corresponding to the energy difference will be captured so that energy on reactant and product side is equal.
(939 + 940 - 1876) = 3 MeV (Captures)

Q.12 (2)

$K.E_\alpha = \frac{A\,50\,Mev}{(A+4)}$ = 48 MeV

0.96 × 50 MeV = 48 MeV
A = 100

Q.13 (D)

Q.14 (3)
Energy released
= [(80 × 7) + (120 × 8)] – [200 × 6.5]
= 220 MeV **Ans.**

Q.15 (2)

${}_2^4He + {}_7^{14}N \rightarrow {}_8^{17}O + {}_1^1H$

Q.16 (2)

$n \rightarrow p + e^- + \bar{\upsilon}$

Q.17 (3)

${}_{88}^{226}R_a \rightarrow {}_{82}^{206}P_b + x\alpha + y\beta$
226 = 206 + 4x
x = 5

Q.18 (D)

${}_{92}U^{235} + n \longrightarrow {}_{54}Xe^{139} + {}_{38}Y^{94} + 3n$

Q.19 (4)
Energy of γ photon
= Difference in energies of α particles = 0.4 MeV

Q.20 **(3)**

$T_{avg.} = \frac{1}{\lambda} \Rightarrow T_{1/2} = \frac{\ln 2}{\lambda} < T_{avg.}$

So more than half the nuclei decay.

Q.21 (2)
64 = 2^6

After 6 half lives activity will become = $\frac{1}{64}$

Hence required time = 6 × 2h **= 12h.**

Q.22 (D)

No. of nucleus of P, $N_P = \frac{m}{10} \times N_A$

No. of nucleus of Q, $N_Q = \frac{m}{20} \times N_A$

No. of Isotope P after 20 days, $N_P' = \frac{N_P}{4}$

Let no. of Isotope Q after 20 days be N_Q'

$$\therefore \frac{N_P' \times \frac{10}{N_A}}{N_Q' \times \frac{20}{N_A}} = \frac{1}{4} \text{ (given)}$$

$N_Q' = \mathbf{2} \times N_P' = \frac{N_P}{2} = \mathbf{N_Q}$

Thus no change in number of Q. Hence its half life is infinity.

Q.23 (1)

The weight will not change appreciably as the process is b - decay.

Q.24 (4)

Q.25 (3)

$A = \lambda N$

$A_1 = \frac{0.693}{2} N_0 e^{-\frac{0.693}{2}t}$

$A_2 = \frac{0.693}{4} N_0\, e^{\frac{-0.693}{4}t}$ $\frac{A_1}{A_2} = 2e^{\frac{0.693}{4}t - \frac{0.693}{2}t}$

$= 2e^{\frac{-0.693}{2}}$

Q.26 (3)

$N_1 = N_0 e^{-\lambda t}$

$= N_0 e^{-1} = \frac{N_0}{e}$

Q.27 (2)

$0.9N_0 = N_0 e^{-\lambda t}$

N = $N_0 e^{-2\lambda t}$ N = $N_0\, 0.9 \times 0.9$

N = 0.81 N_0

Q.28 (4)

$R_1 = R_0 e^{-\lambda t_1}$

$R_2 = R_0 e^{-\lambda t_2}$ $\frac{R_2}{R_1} = e^{-\lambda(t_2 - t_1)}$

Q.29 (1)

$\lambda_1 : \lambda_2 = 1 : 2$

$\lambda_1 A_0 = \lambda_2 B_0$ $A_0 = 2B_0$

Q.30 (3)

$A_1 = A_0 e^{-\lambda t_1}$ $A_2 = A_0 e^{-\lambda t_2}$

$A_2 = A_1 e^{(t_1 - t_2)\lambda}$ Þ $A_2 = A_1\, e^{\frac{(t_1 - t_2)}{T}}$

Q.31 (1)

$f_1 = 1 - e^{-\lambda \frac{1}{\lambda}} = 0.634$

$f_2 = 1 - e^{-\lambda \frac{Ln2}{\lambda}} = 1 - e^{ln2^{-1}}$

$= \left(1 - \frac{1}{2}\right) = \frac{1}{2}$

Q.32 (B)

$R_1 = \lambda N_o e^{-\lambda T_1}$

$R_2 = \lambda N_o e^{-\lambda T_2}$

Atoms decayed N_1-N_2

$= \frac{R_1 - R_2}{\lambda} = R_1 - R_2$

Q.33 (1)

As there is no further disintegration of product hence decay constant is Zero.

Q.34 (2)

Initial = N_o

Total decayed in 10 years

$\frac{N_o}{2} + \frac{N_o}{2^2} = \frac{3}{4} N_o$

Prob $= \frac{\frac{3}{4}N_o}{N_o}$ Prob = 75%

Q.35 (1)

Prob of decay by $\lambda_1 \Rightarrow \frac{dN_1}{N_1} = \lambda_1 t$

$\lambda_2 \Rightarrow \frac{dN_2}{N_2} = \lambda_2 t$

$\text{Total Prob} = \frac{dN}{N} = \lambda dt$

$\lambda dt = \lambda_1 dt + \lambda_2 dt$

$\lambda = \lambda_1 + \lambda_2$

Q.36 (4)

N = N_0 (1-e^{-lt})

Q.37 (3)

No effect of concentration on activity.

Q.38 (2)

$\text{time} = \frac{3200 \times 10^3}{2000}$

$1600 \rightarrow 1600$ sec.

Remaining after two half time

$$\frac{N_o}{4} = \frac{10^8}{4} = 25 \times 10^6$$

Q.39 (1)

(1) no of moles of $_1H^2$ consumed

$$= \frac{1\text{MW} \times (24 \times 3600)\text{sec/day}}{(20\,\text{MeV} \times 6.023 \times 10^{23})} = 0.05$$

$\therefore$ m = 0.1 g

Q.40 (3)

(3) The energy released per unit mass is more in fusion and that per atom is more in fission.

Q.41 (4)

(4)

Fusion reaction is possible at high temperature because kinetic energy is high enough to overcome repulsion between nuclei.

Q.42 (3)

Q = (BE_x + BE_y – Be_u)

= (2 × 117 × 8.5 – 236 × 7.6) MeV = 195 MeV » **200 MeV.**

Q.43 (2)

Two smaller nuclei combining to form a larger nucleus is called a Fusion reaction.

Q.44 (4)

No. of nuclear spliting per second is

$$N = \frac{100\text{MW}}{200\text{MeV}} = \frac{100}{200 \times 1.6 \times 10^{-19}}\ S^{-1}$$

No. of neutrons Liberated = $\frac{100}{200} \times \frac{1}{1.6 \times 10^{-19}} \times$ 2.5 S^{-1}

$$= \frac{125}{16} \times \mathbf{10^{18}\ S^{-1}}$$

JEE-ADVANCED OBJECTIVE QUESTIONS

Q.1 (A)

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

$$\text{In}\ \frac{R}{R_0} = \frac{1}{3}\ln A$$

It is similar to y = mx.

Q.2 (B)

Nuclear force is charge independent

Q.3 (A)

$$R = \frac{mv}{2B}$$

$$R_p = \frac{m_P v}{eb}$$

$$R_{235_U} = \frac{m_{235_U}.v}{eB}$$

$\Delta x = 2 \times \frac{3M_P v}{2B}$ = 6 × 10 mm = **60 mm.**

Q.4 (A)

We know that

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

Surface area $\Rightarrow \pi R^2$

$$= \pi(R_o A^{1/3})^2 = \pi R_0^2 A^{2/3}$$

Q.5 (A)

$$C^{13} \rightarrow C^{12} + n$$

BE of reactants = 7.5 × 13 = 97.50

BE of products = 7.68 × 12 = 92.16

Energy Required = $(BE)_R$– $(BE)_P$

= 97.50 - 92.16 = 5.34 MeV

Q.6 (C)

As a proton is lighter than a neutron, proton can not be converted into neutron without providing energy from outside. Reverse is possible. The weak interaction force is responsible in both the processes (i) conversion of p to n and (ii) conversion of n to p.

Q.7 (C)

$$(BE)_W = 7.5 \times 120 = 900$$

$$(BE)_x = 8.0 \times 90 = 720$$

$$(BE)_y = 8.5 \times 60 = 510$$

$$(BE)_Z = 3.0 \times 5.0 = 150$$

To release energy $\Rightarrow (BE)_{Products} > (BE)_{Reactants}$

Q.8 (A)

(A) When a β^--particle is emitted from a nucleus, a proton increases and a neutron decreases. Hence the neutron-proton ratio is decreased

Q.9 (C)

The decay law will remain same even in the train. The velocities of the α-particle and the recoiling nucleus will be same on the ground and in the train with respect to train.

Q.10 (B)

$${}_{92}U^{238} \rightarrow {}_{82}Pb^{206} + x\ {}_{2}He^{4} + y\ {}_{-1}e^{0} + Q$$

A = 206 + 4x = 238

4x = 32 ⇒ x = 8

2x - y + 82 = 98 ⇒ 2x - y = 10

16 - y = 10 ⇒ y = 6

Q.11 (D)

(A) The emitted β- particles may have varying energy.

(B) e^- or e^+ does not exists inside the nucleus.

(C) $\bar{\nu}$ does carry momentum.

(D) In β-decay mass number does not change.

Q.12 (C)

The total number of nucleons will be $A-4$ and the number of neutrons will be $A-Z-3$.

Q.13 (B)

Each β-decay (β^--decay) increases z by 1 with no change in A and each α-decay decreases z by 2 and A by 4. Hence

$${}^{234}_{88}Ra \longrightarrow {}^{234-8}_{88+3-2}X + 3\beta^- + 2\alpha$$

Hence ${}^{226}_{89}X$

Q.14 (B)

$A = A_{0]}\, e^{-\lambda t}$

$\ell n\, A = \ell n\, A_0 - \lambda t$

ℓn A versus t is a linearly decreasing graph with slope depending to λ. As λ does not change, slope remains same.

Q.15 (C)

No. of atoms of A after 2hrs. = $\frac{N_0}{4}$

No of atoms of B after 2hrs. = $\frac{N_0}{2}$

$$\frac{(dN/dt)_A}{(dN/dt)_B} = \frac{\lambda_A N_A}{\lambda_B N_B} = \frac{(T_{1/2})_B . N_A}{(T_{1/2})_A . N_B} = \frac{2}{1} \times \frac{1}{2} = \mathbf{1}$$

Q.16 (B)

$$A_P = A_Q\, e^{-\lambda t} \quad = A_Q\, e^{-\frac{1}{T}t} \therefore t = T\, \ell n \frac{A_Q}{A_P}$$

Q.17 (C)

$$A_1 = A_0 e^{-\lambda t}$$

$$A_2 = 2A_0 e^{-\lambda(t-t^1)}$$

$$\frac{A_1}{A_2} = \frac{1}{2} e^{-\lambda t^1} \quad \log\frac{2A_1}{A_2} = -\lambda t^1$$

$$t' = \frac{T}{\log_2}\left|\log\frac{A_2}{A_1}\right|$$

Q.18 (B)

$$\frac{A_0}{\sqrt{3}} = A_0 e^{-\lambda 1} \quad A' = A_0 e^{-\lambda 4}$$

$$A' = \frac{A_0}{9}$$

Q.19 (B)

Give $t_{1/2} = 1620\,\text{yr} \quad t_{1/2} = \frac{0.693}{\lambda}$

$$\lambda = \frac{0.693}{1620 \times 365 \times 24 \times 60 \times 60}$$

No of mols (n) = $\frac{\text{mass}}{\text{At.wt}} = \frac{5}{223}$

$N_0 = n \times N_A = 6.023 \times 10^{23}$

At t = 5hr = 5 × 3600

$N(t) = N_0\, e^{-\lambda t} \Rightarrow N(t) = 3.23 \times 10^{15}$

Q.20 (C)

$$\xrightarrow{R} A \xrightarrow{\lambda} B$$

$\frac{dN}{dt} = R - \lambda N$ N = be the number of at any time t

$$\int_0^N \frac{dN}{R-\lambda N} = \int_0^N dt$$

$$N = \frac{R(1-e^{-\lambda t})}{\lambda}$$

$$2(1-e^{-\lambda t}) = 1 \quad e^{-\lambda t} = \frac{1}{2}$$

$$\frac{t}{2}=\ln 2 \quad t=2 \times 0.693=1.386$$

Q.21 (D)

(D)$n=\lambda N$

$$=\quad \lambda=\frac{n}{N}$$

$$\therefore \quad t_{1/2}=\frac{0.69}{\lambda}=\frac{0.69\ N}{n}$$

Q.22 (C)

$$\frac{-dN_1'}{dt}=\lambda_1 N_1'$$

$$\frac{-dN_2'}{dt}=\lambda_2 N_2'$$

$$\frac{-dN}{dt}=\frac{-dN_1'}{dt}+\left(\frac{-dN_2'}{dt}\right)$$

$$=\lambda_1 N_1'+\lambda_2 N_2' = \lambda_1 N_1' e^{-\lambda_1 t}+\lambda_2 N_2' e^{-\lambda_2 t}$$

Q.23 (C)

$$\text{Probability} = \frac{\text{favourable}}{\text{Total}}$$

Surviving Nucleus after 6 half lives in $\frac{N_o}{2^6}$

Total $\frac{N_o}{2^5}$

$$\text{Prob} = \frac{N_o}{2^6}/\frac{N_o}{2^5}=\frac{1}{2}$$

Q.24 (B)

Let sample is x' x $\rightarrow$ Y

2% 14%

$$x \rightarrow \frac{2x'}{100}\, y \rightarrow \frac{14x'}{100} \qquad \lambda=\frac{\ln 2}{45}$$

$$\text{Total}=\frac{16x'}{100}$$

Hence from formula $N = N_0\, e^{-\lambda t}$

$$\frac{2}{100}x'=\frac{16x'}{100}e^{-\lambda t}=2^{-3}$$

$$\lambda t=3\ln 2=45 x 3=135$$

Q.25 (C)

$$\xrightarrow{1000} A \xrightarrow{\lambda} B$$

$$\frac{dN}{dt}=R-\lambda N=0 \quad R=\lambda N$$

$$1000=\frac{1}{40\times 60}N$$

$$N=24\times 10^5$$

Q.26 (C)

At t = 0

$$N_o=20\times 10^5 \qquad N=N_o\frac{R}{\lambda}(1-e^{-\lambda t})$$

Q.27 (B)

One fission = 200 MeV

Power = 200 x $10^6 \times 1.6$ x 10^{-19}

= 10^3J/S

1.5 x 10^{-19} J = 1eV.

Fission / sec = x

X × 3.2 × 10^{-11} = 10^3

x = 0.3125 × 10^{14}

x = 3.125 × 10^{13} .

$$\frac{1\times 10^3}{200\times 10^6\times 1.6\times 10^{-19}}$$

= 3.125 × 10^{13}

Q.28 (C)

Total energy radiated by star is 10^{16}J/s

energy from one fission is of the order of 10^6 x 1.6x 10^{-19}J

No of reactions per sec= $10^{16} \times 10^{13}$ / 1.6

= 10^{29} / 1.6

No of deutrons used/sec = 3 × 10^{29} / 1.6

Time to use 10^{40} deutrons = 10^{29} t

t = 10^{40} /$10^{29} \cong 10^{11}$

order about 10^{12} sec.

JEE-ADVANCED

MCQ/COMPREHENSION/COLUMN MATCHING

Q.1 (C,D)

As the number of protons increases, Coulomb repulsive force among protons increases. To compensate, number of neutrons which are neutral is increased.

Q.2 (A,C)

Initially

$$A=m_p+m_n$$

$A = \frac{m_p}{m_n} = 1$

$\frac{(B.E.)_1}{A_1} > \frac{(B.E.)_2}{A_2}$

A_1 is lesser initially then

$A_2 \uparrow \quad (B.E.)_2 \downarrow$

Q.3 (B,C)

$AB \rightarrow r \downarrow PE \uparrow$ due to electrostatic repulsion.

BC $\rightarrow$ nuclear force dominate & nuclear forces are always attractive in nature.

Q.4 (C)

$m_1^1 = 10 \times m_p + (20-10)m_n$

$m_1^1 = 10m_p + 10m_n = 10(m_p + m_n)$ &

$m_2^1 = 20m_p + (40-20)m_n$

$m_2^1 = 20(m_p + m_n)$

$m_2^1 = 2m_1^1$

$M_{observed} < M_{expected}$

But observed relation $m_2 < 2m_1$

Q.5 (A,D)

Rest mass $\Rightarrow$ $E = mc^2$

Stable nucleus has to release energy.

A $\Rightarrow$ B+C

$E_1 < E_2 + E_3$.

$m_1 < (m_2+m_3)$

Q.6 (A,B,D)

(A) ${}_zX^A \rightarrow {}_{z-2}Y^{A-4} + {}_2He^4 + Q_1$

(B) ${}_zX^A \rightarrow {}_{z-1}Y^A + {}_{+1}e^0 + Q_2$

(C) ${}_zX^A \rightarrow {}_{z+1}Y^A + {}_{-1}e^0 + Q_3$

(D) ${}_zX^A \rightarrow {}_zY^A + {}_z\gamma^0 + Q_4$

Q.7 (A, C, D)

${}_7N^{14} + n \rightarrow {}_3Li^7 + 4p + 4n$

$\rightarrow {}_3Li^7 + 2\alpha$

$\rightarrow {}_3Li^7 + \alpha + 4p + 2\beta^-$

Q.8 (A, C)

Given, $\lambda = 0.173$

$T_{1/2} = \frac{\ln 2}{\lambda} = \frac{0.693}{0.173} \cong 4$

Also $N_0 - N = N_0\, e^{-\lambda t}$

Fort = $\frac{1}{0.173}$ year :

$N_0 - N = \frac{N_0}{e} = 0.37\, N_0$

Q.9 (B,D)

excess neutrons = α active and β^- active

excess proton = β^+ active

Q.10 (A,B,C)

${}_ZX^A \rightarrow {}_{Z+1}Y^A + {}_+\beta^0 + E$

KE of β particle can not exceed E.

$T_e = \frac{my}{m_e + m_y} Q < Q$

N/2 ratio becomes $\frac{N-1}{Z+1}$

Q.11 (A,B,C)

Free neutron does not exist in nature hence it breaks into proton and electron but free proton is possible.

Q.12 (C,D)

The nucleus agter gamma decay remains neutral as no change in proton and neutron take place. Gamma photons carry only energy with them. In K capture also the neutrality of nucleus do not get altered.

Q.13 (A, D)

$\left|\frac{dN}{dt}\right| = \lambda N = \frac{\ln 2}{T_{1/2}} \times \frac{1 \times 6.02 \times 10^{23}}{238}$

$\Rightarrow T_{\frac{1}{2}} = \frac{\ln 2 \times 6.023 \times 10^{23}}{238 \times 1.24 \times 10^4}$ = **4.5×10^9 yrs.**

The activity = number of disintegration per second = 1.24×10^4 dps

Q.14 (A,C)

Given

$\lambda = 0.173 (\text{year})^{-1}$

$t_{1/2} = \frac{0.693}{0.173} \quad N = N_0 e^{-0.173 \times \frac{1}{0.173}}$

(A) $N = \frac{N_0}{e} \Rightarrow N = 0.63\, N_0$

Q.15 (B)

(A) Since energy will be released X will not be at rest.

(B) Generally daughter nucleus is in excited state.

(C) If X has kinetic energy, ^{232}Th will also have kinetic energy to conserve the momentum

(D) The Q value

$Q = (m_u - m_{Th} - m_x).C^2$

Q.16 (D)

Initially uranium atom is at rest, so after decay both nuclei have equal momentum,

and $K = \frac{P^2}{2m}$, Here X is light so it has more kinetic energy

Q.17 (D)

$Q = \Delta m.C^2$

$= (m_u - m_{Th} - m_x).C^2$

$= (236.045562 - 232.038054 - 4.002603) \times 1.5 \times 10^{-10}$ J

$= 7.4 \times 10^{-13}$ J.

Q.18 (A) p,q,r,s (B) p,q,r,s (C) p,q,r,s, (D) p,q,r,s

(A) Energy is released in all the four processes. Hence mass will decrease

(B) Since energy is released, Binding energy per nucleon will increase.

(C) Mass number conserves in all the processes.

(D) Total charge also conserves in all the processes.

Q.19 (A) q,r,s, (B) q,r,s (C) q,r,s (D) p,q,r,s

(A) In the given spontaneous radioactive decay, the number of protons remain constant and all conservation principles are obeyed.

(B) In fusion reaction of two hydrogen nuclei a proton is decreased as positron shall be emitted in the reaction. All the three conservation principles are obeyed.

(C) In the given fission reaction the number of protons remain constant and all conservation principles are obeyed.

(D) In beta negative decay, a neutron transforms into a proton within the nucleus and the electron is ejected out.

Q.20 (A)

Informative

The radionuclide ^{56}Mn is being produced in a cyclotron at a constant rate P by bombarding a maganese target with deutrons. ^{56}Mn has a half life of 2.5 hours and the target contains large number of only the stable maganese isotope ^{55}Mn. The reaction that produces ^{56}Mn is :

$^{55}\text{Mn} + d \rightarrow {}^{56}\text{Mn} + p$

After being bombarded for a long time, the activity of ^{56}Mn becomes constant equal to 13.86×10^{10} s^{-1}. (Use ℓn2 = 0.693; Avogadro No = 6×10^{23}; atomic weight ^{56}Mn = 56 gm/mole)

NUMERICAL VALUE BASED

Q.1 [0154]

$$P = 700 \times 10^3 \times 1.6 \times 10^{-19} \times \frac{dN}{dt} = 10 \times 10^{-3}$$

$$\frac{dN}{dt} = \frac{10^{-2}}{10^{-14}} \times \frac{1}{7\times16} = \frac{10^{12}}{11.2} = \lambda N_0$$

$$\lambda = \frac{ln\ 2}{14\times86400}$$

$$\Rightarrow \quad N_0 = \frac{14\times86400\times10^{12}}{11.2\,ln2} = 154 \times 10^{15}$$

Q.2 [0003]

	A	B
t = 0	N_0	N_0
t_0 = 3 days	2N	N

$2N = N_0\ (0.5)\ t_0/\tau_1$

$N = N_0\ (0.5) t_0/\tau_2$

$$2 = (0.5)\ t_0 \left(\frac{1}{\tau_1} - \frac{1}{\tau_2}\right)$$

$$\Rightarrow 0.5^{-1} = (0.5) \left(\frac{3}{\tau_1} - 2\right)$$

$$\Rightarrow -1 = \frac{3}{\tau_1} - 2 \quad \therefore \tau_1 = 3 \text{ days}$$

Q.3 [1880 keV]

$$\text{Energy available} = \frac{1}{2}\mu v_{rel}^2. = \text{Q value.}$$

$$= \frac{1}{2} \times \frac{7\times1}{7+1} \times v_{rel}^2 = \text{Q value.}$$

$$\Rightarrow \frac{1}{2} \times v_{rel}^2 = Q \times \frac{8}{7}$$

$$K_i = 1645 \times \frac{8}{7} = 1880 \text{ keV}$$

Q.4 [0001 kg]

Evaporations and reaction has rate similar to first order reaction rate

Hence

$$\frac{1}{t_{1/2}} = \frac{1}{\left(t_{1/2}\right)_{evoparation}} + \frac{1}{\left(t_{1/2}\right)_{suction}} \quad \Rightarrow$$

$$\frac{1}{t_{1/2}} = 6 \text{ hrs}$$

Hence water left = $\frac{16}{2^4} = 1\text{kg}$

Q.5 [5]

$$P = \frac{dQ}{dt} = (eV\eta)\frac{dN}{dt}$$

$$\frac{dN}{dt} = \frac{P}{eV\eta} = \frac{3136}{(1.6\times10^{-19})(40\times10^{3})(0.98)}$$

$$= 5 \times 10^{17}$$

KVPY
PREVIOUS YEAR'S

Q.1 (A)

$$Pb^{214}_{82} \xrightarrow[2e^- + {}_2He^4]{} {}^{210}_{82}X$$

$82 \rightarrow$ Proton
$210 - 82 = 128$ Neutron

Q.2 (A)

$$\tau_B = \frac{\tau_{A/2}.3\tau_A}{\tau_{A/2} + 3\tau_A}$$

$$\frac{\tau_B}{\tau_A} = \frac{3}{7}$$

Q.3 (A)
In radioactive equilibrium
rate of decay of X = rate of decay of Y

$$\lambda_x N_x = \lambda_y N_y, \ \frac{N_x}{T_x} = \frac{N_y}{T_y}$$

Q.4 (B)
P I² R

$$\frac{\Delta P}{P} = \frac{2\Delta I}{I} = 6\%$$

Q.5 (A)

Q.6 (B)

$$\text{avg life} = \frac{\int t dN_1 + t dN_2}{2N_0}$$

where $dN_1 = \lambda N_0 e^{-\lambda t}\, dt$

$$dN_2 = \frac{\lambda}{3} N_0 e^{-\frac{\lambda}{3}t} dt$$

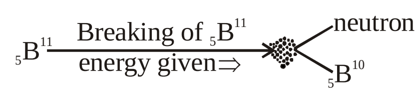
$$\text{avg. life} = \frac{\int_0^\infty t(\lambda N_0 e^{-\lambda t} dt + \frac{\lambda}{3} N_0 e^{-\frac{\lambda}{3}t} dt}{2N_0}$$

Intergrating we got

$$\text{avg life} = \frac{2}{\lambda} \approx \frac{2.10}{\lambda}$$

Q.7 (B)
Very thin foil can be made only of highly malleable material.

Q.8 (A)



formation of ${}_5B^{10}$ will release energy $\Rightarrow E_2$
E_1 = Binding energy of ${}_5B^{11}$ $\Rightarrow 7.5 \times 11$ MeV
= 82.5 MeV
E_2 = Binding energy of ${}_5B^{10}$ = 8.0 × 10
= 80 MeV
Energy given = $E_1 - E_2$
= 82.5 – 80 = 2.5 MeV

Q.9 (D)

$$KE = \frac{1}{2}mv^2$$

$$0.05\times1.6\times10^{-19} = \frac{1}{2}\times1.6\times10^{-26}\times v^2$$

$$0.05\times2\times10^{7} = v^2$$

$$10^6 = v^2$$

v = 1000 m/sec
time taken to travel a distance of 1 m is

$$\frac{1}{v} \Rightarrow \frac{1}{1000} = 0.001\,\text{sec}$$

Half life of radioactive material = 6.9 sec

$$T_{1/2} = \frac{0.693}{\lambda}$$

$$\lambda = \frac{0.693}{6.9} \Rightarrow 0.1$$

fraction of particle decay in 0.001 sec or

$$\frac{1}{1000}\text{ sec} = 1 - e^{-\lambda t}$$

$\Rightarrow 1-e^{-0.1\times\frac{1}{1000}}$

$\Rightarrow 1-e^{-\frac{1}{10000}}$

$\Rightarrow 0.0001$

Q.10 (D)
From the nucleus of metal atom.
in nucleus

$$n \rightarrow P + \underset{\substack{\uparrow \\ \text{Beta}}}{e^-} + \bar{\nu}_{\text{antinutrino}}$$

Q.11 (B)

$${}^{12}_{6}C \rightarrow {}^{11}_{5}B + \beta^{\oplus} + \nu + 0.96\,\text{MeV}$$

$$M = \frac{M_0}{2^n} \Rightarrow M = \frac{1\mu g}{2^2}$$

[Half life=t_0; n = $t/t_0 \Rightarrow n = \frac{2t_0}{1} \Rightarrow n = 2$]

M = 0.25 μg (remained)
Carbon used $\Rightarrow M_0 - M$
$\Rightarrow 0.75\ \mu g$

Number of moles = $\left(\frac{0.75\times10^{-6}}{12}\right)$

Number of reaction $= \frac{0.75\times10^{-6}}{12}\times 6.023\times10^{23}$

Energy from reaction = $0.376\times10^{17}\times 0.96\,\text{MeV}$
$= 0.36\times10^{17}$
$= 3.6\times10^{16}$ MeV
$\approx 4\times10^{16}$ MeV

Energy from annihilation = $2\,m_0c^2\,(0.376\times10^{17})$

$$\approx 1.02\left(0.376\times10^{17}\right)\text{MeV}$$

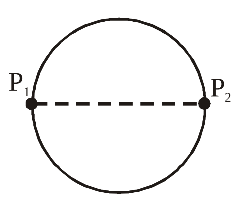
$$\approx 4\times10^{16}\ \text{MeV}$$

Total energy = $E_{\text{reaction}} + E_{\text{annihilation}}$

$E_T \approx 8\times10^{16}$ MeV

Q.12 (A)
$r = r_0 A^{1/3}$ $r_0 = 1.3\times10^{-15}$

$$F = \frac{1}{4\pi\varepsilon_0}\times\frac{q_1q_2}{r^2}$$



$$F = \frac{9\times10^9\times1.6\times10^{-19}\times1.6\times10^{-19}}{r_0^{\,2}A^{2/3}}$$

$$F = \frac{9\times10^9\times1.6\times10^{-19}\times1.6\times10^{-19}}{(1.3)^2\times10^{-30}\times(206)^{2/3}}$$

$$= \frac{23.04\times10^{39}\times10^{-38}}{(1.69)\times34.81}$$

$$= \frac{23.04\times10}{1.69\times34.81}$$

= 3.91 Newton
$= 0.039\times10^2$ **Ans.** (A)

Q.13 (A)

Q.14 (B)
$R = R_0e^{-\lambda t}$
$\text{In}R = \lambda t + \text{In}R_0$
comparing we get (B)

Q.15 **(C)**
Density of nucleus is

$$\frac{M}{V} = \frac{A.m_P}{\frac{4}{3}\pi R^3} = \frac{Am_P}{\frac{4}{3}\pi r_0^3 A}$$

$$= \frac{3m_P}{4\pi r_0^3} = \text{constant}$$

Q.16 **(A)**
Initial energy of nucleus

$$= E_i = \frac{kz^2e^2}{R}$$

by volume conservation, new radius of daughter nuclei

$$\frac{4}{3}\pi R^3 = \frac{4}{3}\pi r^3.2$$

$$r = \frac{R}{(2)^{1/3}}$$

now, total energy $= E_f = 2k\dfrac{\left(\frac{ze}{2}\right)^2}{r}$

$$= \frac{2kz^2e^2}{4R}2^{1/3} = \frac{0.63kz^2e^2}{R}$$

Hence the change in energy

$$= \frac{kz^2e^2}{R}[1-0.63]$$

$$= 0.37\frac{kz^2e^2}{R}$$

Q.17 (B)
In case I energy of all electrons will be same but in case II energy of electrons will be different.

JEE-MAIN
PREVIOUS YEAR'S

Q.1 [8]

$$T_x = \frac{T_Y}{2}$$

$$\frac{1}{\lambda_X} = \frac{1}{2\lambda_Y}$$

$\lambda_X = 2\lambda_Y$
$t = 3T_Y$

$$N_X = N_1e^{-\lambda_x x 3T_Y} = N_1e^{-2\lambda_y x 3T_Y}$$

$$N_Y = N_2e^{-\lambda_Y x 3T_Y}$$

$\because N_X = N_Y$

$$N_1e^{-2\lambda_Y x 3 x \frac{\ell n2}{\lambda_Y}} = N_2e^{-\lambda_Y x \frac{3\ell n2}{\lambda_Y}}$$

$$N_1e^{-6\,\ell n2} = N_2e^{-3\,\ell n2}$$

$$\frac{N_1}{N_2} = e^{3\,\ell n2} = 8$$

Q.2 (1)
$A = A_0\, e^{-\lambda t_1}$ (Radio active decay law)

$\frac{A}{5} = A_0\, e^{-\lambda t_2}$(Radio active decay law)

By above equations

$$\frac{A}{5} = Ae^{-\lambda(t2-t1)}$$

$$\ell n\, 5 = \lambda\, (t_2 - t_1)$$

$$\frac{1}{\lambda} = \frac{t_2 - t_1}{\ell n5}$$

Q.3 **(2)**
$A = \lambda N$

$$N = nN_A \qquad \left(t_{1/2} = \frac{\ln 2}{\lambda} \Rightarrow \lambda = \frac{\ln 2}{t_{1/2}}\right)$$

$$N = \left(\frac{1.5\times10^{-3}}{198}\right)N_A$$

$$A = \left(\frac{\ln 2}{t_{1/2}}\right)N$$

$$= \frac{0.693}{2.7\times24\times60\times60}\times\frac{1.5\times10^{-3}}{198}\times6\times10^{23}\text{ dps}$$

$=1350.30\times10^{10}$ Bq

1 Curie = 3.7×10^{10} Bq

$$A = \frac{1350.30\times10^{10}}{3.7\times10^{10}}\text{Curie} = 364.94\,\text{Ci}$$

Q.4 **(2)**

$$N_1 = N_0e^{-\lambda t_1}$$

$$\frac{N_1}{N_0} = e^{-\lambda t_1}$$

$$0.67 = e^{-\lambda t_1}$$

$\ln(0.67) = -\lambda t_1$ ....(i)

$$N_2 = N_0e^{-\lambda t_2}$$

$$\frac{N_2}{N_0} = e^{-\lambda t_2}$$

$$0.33 = e^{-\lambda t_2}$$

$\ln(0.33) = -\lambda t_2$ ....(ii)

So

$\ln(0.67) - \ln(0.33) = \lambda t_2 - \lambda t_1$

$$\lambda(t_2 - t_1) = \ln\left(\frac{0.67}{0.33}\right)$$

$$\lambda\,(t_2 - t_1) \approx \ln 2$$

$$t_1 - t_2 \approx \frac{\ln 2}{\lambda} = t_{1/2}$$

Half life = $t_{1/2}$ = 20 minutes.

Q.5 **(3)**

$$\lambda_{eq} = \lambda_1 + \lambda_2$$

$$\frac{1}{T_{1/2}} = \frac{1}{T_{1/2}^{(1)}} + \frac{1}{T_{1/2}^{(2)}}$$

$$T_{1/2} = \frac{T_{1/2}^{(1)}T_{1/2}^{(2)}}{T_{1/2}^{(1)} + T_{1/2}^{(2)}}$$

Q.6 **(2)**
It is possible only inside the nucleus and not otherwise.

Q.7 **(4)**

Q.8 **(4)**

Q.9 **[20]**

Q.10 **(4)**

Q.11 **(4)**

Q.12 (4)

Q.13 (4)

Q.14 [10]

Q.15 [27]

Q.16 [150]

Q.17 (3)

Q.18 (2)

Q.19 [10]

Q.20 (2)

$(t_{1/2})_x = (\tau)_y$

$\Rightarrow \frac{\ell n2}{\lambda_x} = \frac{1}{\lambda_y} \Rightarrow \lambda_x = 0.693\ \lambda_y$

Also initially $N_x = N_y = N_0$

Activity $A = \lambda N$

As $\lambda_x < \lambda_y \Rightarrow A_x < A_y$

$\Rightarrow$ y will decay faster than x

Option (2)

Q.21 [15]

Q.22 (3)

Q.23 (2)

Q.24 (2)

JEE-ADVANCED PREVIOUS YEAR'S

Q.1 [1]

$N = N_0\ e^{-\lambda t}$

$$\frac{dN}{dt} = 10^{10} = N_0\ (\lambda)\ e^{-10^{-9}t}$$

at (t = 0)

$10^{10} = N_0\ 10^{-9}$

$N_0 = 10^{19}$

mass of sample $= N_0\ 10^{-25}$

$= N_0$ (mass of the atom

$= 10^{-6}$ kgm

$= 10^{-6} \times 10^{3}$ gm

$= 10^{-3}$ gm

$= 1$ mg

Q.2 [7]

+120 e r = 10 fm +e

$$\frac{(9\times10^9)(120e)(e)}{10\times10^{-15}} = \frac{p^2}{2m}$$

$$\lambda = \frac{h}{p}\ \therefore\ p^2 = \frac{h^2}{\lambda^2}$$

$$2\left(\frac{5}{3}\times10^{-27}\right)10^{15}(9\times10^9)(12)e^2 = \frac{h^2}{2m\lambda^2}$$

$(120)\ (3)10^{-27+15+9}\ \lambda^2 = (4.2)^2 \times 10^{-30}$

$$\lambda^2 = \frac{4.2\times4.2\times10^{-30}}{360\times10^{-3}} = \frac{42\times42}{360}\times10^{-29}$$

$= 7^2 \times 10^{-30}$ $\lambda = 7\times10^{-15}$ m = 7 fm

Q.3 **(C)**

KE_{max} of β^-

$Q = 0.8 \times 10^6$ eV

$$KE_P + KE_{\beta^-} + KE_{\bar{\nu}} = Q$$

KE_p is almost zero

When $KE_{\beta^-} = 0$

then $KE_{\bar{\nu}} = Q - KE_P$

$\cong Q$

Q.4 **(D)**

$$0 \le KE_{\beta^-} \le Q - KE_P - KE_{\bar{\nu}}$$

$$0 \le KE_{\beta^-} < Q$$

Q.5 [4]

$$\lambda = \frac{0.693}{1386} = 5 \times 10^{-4}$$

Number decayed = $N_0 - N(t)$

% age Decayed = $\dfrac{N_0 - N(t)}{N_0} \times 100$

$= (1 - e^{-\lambda t}) \times 100$

$\approx \lambda t \times 100$

$= 5 \times 10^{-4} \times 80 \times 100 = 4$

Q.6 **(C)**

(p) In α decay mass number decreses by 4 and atomic number decreases by 2.

(q) In β^+ decay mass number remains unchanged while atomic number decreases by 1.

(r) In Fission, parent nucleus breaks into allmost two equal fragments.

(s) In proton emission both mass number and atomic number decreases by 1.

Comprehenison (Q.7 to Q.8)

Q.7 **(C)**

(A) $3^{Li^7} \rightarrow_2 He^4 +_1 H^3$

$\Delta m = [M_{Li} - M_{He} - M_{H^3}]$

= [6.01513 – 4.002603 – 3.016050]

= – 1.003523u

Δm is negative so reaction is not possible.

(B) $84^{Po^{210}} \rightarrow 83^{Bi^{209}} + 1^{P^1}$

Δm is negative so reaction is not possible.

(C) $1^{H^2} \rightarrow 2^{He^4} + 3^{Li^6}$

Δm is Positive so reaction is possible.

(D) $30^{Zn^{70}} + 34^{Se^{82}} \rightarrow 64^{Gd^{152}}$

Δm is Positive so reaction is not possible.

Q.8 (A)

$84^{Po^{210}} + 2^{He^4} \rightarrow 82^{Pb^{206}}$

$\Delta m = [M_{PO} - M_{He} - M_{Pb}] = 0.008421$ u

Q = 0.008421×932 MeV = 5422 KeV

$K_\alpha = \dfrac{210}{214} \times 5422 \text{KeV}$

= 5320 KeV

Q.9 [9]

= 0.014 × 931.5 – 4.041 = 9

As $M_\beta << M_B$

$\therefore K_e \simeq (Q - E)$

$= (12.014 - 12)c^2 - E$

$= 0.014 \times 931.5 - 4.041 = 9$

Q.10 **(C)**

$$\Delta m_N c^2 - \Delta m_O c^2 = \frac{3}{5}\frac{e^2}{4\pi\varepsilon_0 R}\left[Z_O(Z_O - 1) - Z_N(Z_N - 1)\right]$$

$\Rightarrow R = 3.42\, fm$

Hence, (C)

Q.11 (C)

$2^n = 64 \qquad \Rightarrow n = 6$

$\therefore t = nT = 108\ days$ Hence, (C)

Q.12 [5]

$I^{131} \xrightarrow[T_{1/2}=8\text{Days}]{} xe^{131} + \beta$

$A_0 = 2.4 \times 10^5$ Bq $= \lambda N_o$

Let the volume is V,

t = 0	$A_o = \lambda N_o$
t = 11.5 Hrs	$A = \lambda N$

$$115 = \lambda\left(\frac{N}{V} \times 2.5\right)$$

$$115 = \frac{\lambda}{V} \times 2.5 \times \left(N_o e^{-\lambda t}\right)$$

$$115 = \frac{(N_o\lambda)}{V} \times (2.5) \times e^{-\frac{\ln 2}{8\text{day}}(11.5\text{Hr})}$$

$$115 = \frac{(2.4 \times 10^5)}{V} \times (2.5) \times e^{-1/24}$$

$$V = \frac{2.4 \times 10^5}{115} \times 2.5\left[1 - \frac{1}{24}\right] = \frac{2.4 \times 10^5}{115} \times 2.5\left[\frac{23}{24}\right]$$

$$= \frac{10^5 \times 23 \times 25}{115 \times 10^2} = 5 \times 10^3 \text{ml} = 5 \text{liter}$$

Q.13 (A, C)

$^{232}_{90}Th$ is converting into $^{212}_{82}Pb$

Change in mass number (A) = 20

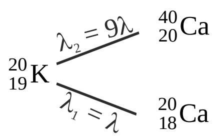
$\therefore$ no. of a particle = $\frac{20}{4} = 5$

Due to 5 α particle, z will change by 10 unit.

Since given change is 8, therefore no. of β particle is 2

Q.14 (A)

Parallel radioactive decay



$\lambda = \lambda_1 + \lambda_2 = 5 \times 10^{-10}$ per year

$N = N_0e^{-\lambda t}$

$N_0 - N = N_{stable}$

$N = N_{radioactive}$

$$\frac{N_0}{N} - 1 = 99$$

$$\frac{N_0}{N} = 100$$

$$\frac{N}{N_0} = e^{-\lambda t} = \frac{1}{100}$$

$\Rightarrow \lambda t = 2\, ln10$

= 4.6

$t = 9.2 \times 10^9$ years

Q.15 [135.00]

$Ra^{226} \rightarrow Rn^{222} + \alpha$

Q = (226.005 – 222 – 4) 931 MeV

= 4.655 MeV

$$K_\alpha = \frac{A-4}{A}(Q - E_\gamma)$$

$$4.44 \text{ MeV} = \frac{222}{226}(Q - E_\gamma)$$

$$Q - E_\gamma = (4.44)\left(\frac{226}{222}\right)\text{MeV}$$

$E_\gamma = 4.655 - 4.520$

= .135 MeV

= 135 KeV

Q.16 (D)

Out of 1000 nuclei of Q 60% may go α-decay

$\Rightarrow$ 600 nuclei may have α-decay

$$\lambda = \frac{\ln 2}{t_{1/2}} = \frac{\ln 2}{20}$$

t = 1 hour = 60 minutes

Using

$N = N_0e^{-\lambda t}$

$$= 600 \times e^{-\frac{\ln 2}{20} \times 60}$$

N = 75

$\Rightarrow$ 75 Nuclei are left after one hour

So, No. of nuclei decayed

= 600 – 75 = 525

Q.17 (ACD)

EXERCISES

OBJECTIVE QUESTIONS

Q.1 **(2)**

Q.2 **(2)**

Q.3 **(1)**

Q.4 **(1)**

Q.5 (3)

$\boxed{\alpha < 1}$ → in case of current gain in comman base amplifer.

Q.6 **(1)**

Q.7 **(3)**

Q.8 **(1)**

Q.9 **(2)**

Q.10 **(2)**

Q.11 **(1)**

Q.12 **(2)**

Q.13 (3)
Peak value = 2 – 07 = 1.3 V

Q.14 **(1)**

Q.15 (1)

Q.16 (3)

Q.17 (2)

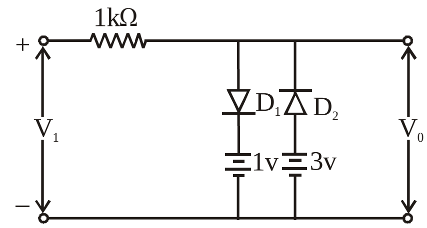
Q.18 (3)
When lattice constant decreases width of conduction band and valance band increases while band gape decreases.

Q.19 (1)

Q.20 (3)

KVPY
PREVIOUS YEAR'S

Q.1 (A)



$V_0 = V_i$ when no current flow through 1 kQ /
for negative values of V_i

i from D_1 = 0 (always)

i from D_2 = 0 upto 3V
So from 0 to –3V $V_i = V_0$
from –3 to –4V
$V_0 = -3V$
For positive values of V_i

i from D_1 = 0 upto 1V

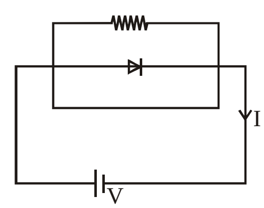
i from D_2 = 0 (always)
Hence 0 to 1V
$V_i = V_0$
1 to 4 V
V_0 = 1 volt
Correct graph is (A)

Q.2 (A)
Break down voltage is proportional to width of depletion region.

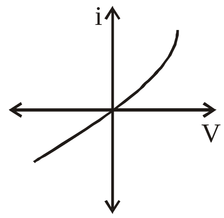
$\therefore$ When width reduce to 1 μm thus become $\frac{1}{20}$ times

then break down voltage also become $\frac{1}{20}$ times thus it become 5 volt. So Zener diode can used for voltage regulation of 5 volt.

Q.3 (A)



When V is positive in forward bias the potential drop on diode is low. When V is negative current will pass through the resister as V = IR . (in diode current almost zero because of reverse bias diode)



Q.4 **(A)**

V_0 can only have two values either +10 or –10

$\therefore$ Only (A) is possible

Q.5 **(A)**

Generally we want the electron to cross energy gaps in material A.

Not in material-B because its just covering.

And E_g in the A should not be very small otherwise there will be huge heat loss because of large difference in E_g and energy of incident photon

JEE-MAIN
PREVIOUS YEAR'S QUESTIONS

Q.1 **(2)**

$\overline{(A+B)}$ = NOR gate

When both inputs of NAND gate are connected, it behaves as NOT gate.

$\Rightarrow$ OR + NOT = NOR.

Q.2 **(1)**

$$y = \overline{\left(\overline{A\cdot\overline{A\cdot B}}\right)\cdot\left(\overline{B\cdot\overline{A\cdot B}}\right)}$$

$$= \left(\overline{\overline{A\cdot\overline{A\cdot B}}}\right)\cdot\left(\overline{\overline{B\cdot\overline{A\cdot B}}}\right)$$

$$= A\cdot\left(\overline{A}+\overline{B}\right)+B\cdot\left(\overline{A}+\overline{B}\right)$$

$$= A\cdot\overline{A} + A\cdot\overline{B} + B\cdot\overline{A} + B\cdot\overline{B}$$

$$y = 0 + A\cdot\overline{B} + B\cdot\overline{A} + 0$$

Q.3 **(3)**

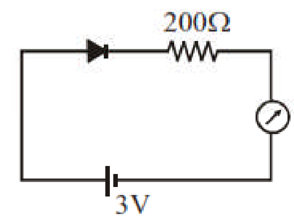
Q.4 **(1)**

Q.5 **(2, 4)**

Q.6 **(2)**

In common emitter amplifier circuit input and out put voltage are out of phase. When input voltage is increased then i_b is increased, i_c also increases so voltage drop across R_c is increased. However increase in voltage across R_C is in opposite sense.

Q.7 (2)



Silicon diode is in forward bias.

Hence across diode potential barrier

$\Delta V = 0.7$ volts

$$I = \frac{V-\Delta V}{R} = \frac{3-0.7}{200} = \frac{2.3}{200} = 11.5 \text{ mA}$$

Q.8 (2)

$I = \frac{6}{300} = 0.002$ (D_2 is in reverse bias)

Q.9 (1)

When switched on :

$V_{CE} = 0$

$V_{CC} - R_{C|C} = 0$

$$i_C = \frac{V_{CC}}{R_C} = 5\times10^{-3}\text{A}$$

$I_C = Bi_B$

$\Rightarrow i_B = 25\ \mu A$

$\Rightarrow V_{BB} = i_B R_B - V_{BE} = 0$

$\Rightarrow V_{BB} = V_{BE} + i_B R_B = 3.5$ V

Q.10 (3)

$$Y = A.\overline{AB} + AB.\overline{B}$$

$$= A.\left(\overline{A}+\overline{B}\right)+\left(AB\right).\overline{B}$$

$$= A\overline{B}+0$$

Q.11 (3)

$$R = \overline{P+Q} = \overline{\left(\overline{x}+y\right)+\left(\overline{x\overline{y}}\right)}$$

$$= \left(\overline{\overline{x}+y}\right)\cdot\left(x\overline{y}\right) = \left(x\cdot\overline{y}\right)\cdot\left(x\overline{y}\right) = x\overline{y}$$

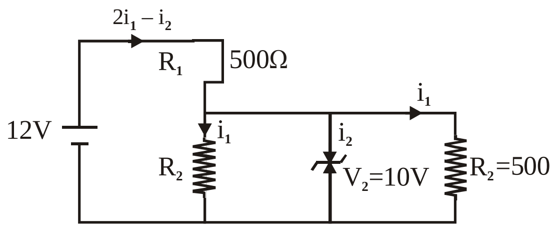
Q.12 (1)

$12 - 500(2i_1 + i_2) - 10 = 0$

$$\Rightarrow 2i_1 + i_2 = \frac{2}{500} = \frac{1}{250}$$

$< i_1$ when zenor has break down.

So, $i_2 = 0$.



Q.13 (4)

$V_{o_i} = 12 - 0.3 = 11.7\,V$

$V_{o_f} = 12 - 0.7 = 11.3\,V$

$\Rightarrow \Delta V_0 = -0.4\,V$

Q.14 **(3)**

Use $I = neAv_d$ and $\mu = \frac{v_d}{E}$

Q.15 (1)

$i_{10k} = \frac{50}{10k} 5mA$

$i_{5k} = \frac{120-50}{5k} = 14mA$

$i_2 = (14 - 5)$ mA = 9mA

Q.16 (1)

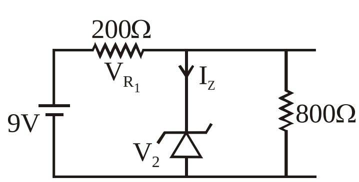
Method 1

Truth table can be formed as

A	B	Equivalent
0	0	0
0	1	1
1	0	1
1	1	1

Hence the Equivalent is "OR" gate

Q.17 (3)



$9 = V_Z + V_{R_1}$

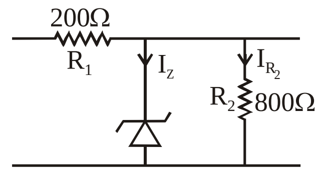
$V_Z = 5.6$ V

$V_{R_1} = 9 - 5.6$

$V_{R_1} = 3.4$

$I_{R_1} = \frac{V_{R_1}}{R} = \frac{3.4}{200}$

$I_{R_1} = 17$ mA



$V_Z = V_{R_2} = I_{R_2}(R_2)$

$\frac{5.6}{800} = I_{R_2}$

$I_{R_2} = 7$ mA

$I_z = (17 - 7)$ mA = 10 mA

Q.18 (2)

At $V_B = 8V$

$i_L = \frac{6\times10^{-3}}{4} = 1.5\times10^{-3}A$

$i_R = \frac{8-6\times10^{-3}}{1} = 2 \times 10^{-3}$ A

$\therefore i_{\text{zener diode}} = i_R - i_{\text{load}}$
$= 0.5 \times 10^{-3}$ A

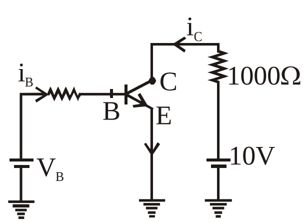
At $V_B = 16$ V

$i_L = 1.5 \times 10^{-3}A$

$i_R = \frac{(16-6)\times10^{-3}}{1} = 10\times10^{-3}$ A

$\therefore i_{\text{zener diode}} = i_R - i_L = 8.5 \times 10^{-3}$ A

Q.19 (3)



At saturation state, V_{CE} becomes zero

$\Rightarrow i_C = \frac{10V}{1000\Omega} = 10mA$

now current gain factor $\beta = \frac{i_C}{i_B}$

$\Rightarrow i_B = \frac{10mA}{250} = 40\mu A$

Q.20 (4)

$T = \frac{30\,\text{sec}}{20}$

$\Delta T = \frac{1}{20}$ sec.

L = 55 cm

ΔL = 1 mm = 0.1 cm

$$g = \frac{4\pi^2 L}{T^2}$$

percentage error in g is

$$\frac{\Delta g}{g}\times 100\% = \left(\frac{\Delta L}{L}+\frac{2\Delta T}{T}\right)100\%$$

$$= \left(\frac{0.1}{55}+\frac{2\left(\frac{1}{20}\right)}{\frac{30}{20}}\right)100\% = 6.8$$

Q.21 (4)

input current = 15×10^{-6}

output current = 3×10^{-3}

resistance output = 1000

$V_{input} = 10 \times 10^{-3}$

Now $V_{input} = r_{input} \times i_{input}$

$10 \times 10^{-3} = r_{input} \times 15 \times 10^{-6}$

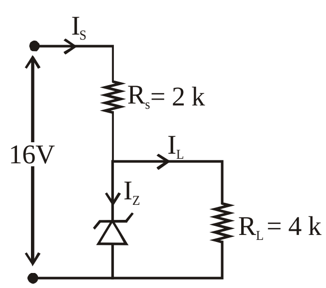
$$r_{input} = \frac{2000}{3} = 0.67 K\Omega$$

$$\text{voltage gain } = \frac{V_{output}}{V_{input}} = \frac{1000\times 3\times 10^{-3}}{10\times 10^{-3}} = 300$$

Option (4)

Q.22 (2)

Maximum current will flow from zener if input voltage is maximum



When zener diode works in breakdown state. Voltage across the zener will remain same

$\therefore V_{across\,4k\Omega} = 6V$

$$\therefore \text{ Current through } 4K\Omega = \frac{6}{4000}A = \frac{6}{4}mA$$

Since input voltage = 16V

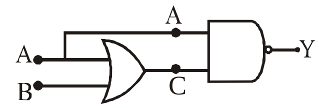
= Potential difference across $2K\Omega$ = 10V

$$\therefore \text{ Current through } 2k\Omega = \frac{10}{2000} = 5mA$$

= Current through zener diode

= $(I_S - I_L)$ = 3.5 mA

Q.23 (1)



$C = A + B$ and $y = \overline{A.C}$

A	B	$C = (A+B)$	A.C.	$y = \overline{A.C}$
0	0	0	0	1
0	1	1	0	1
1	0	1	1	0
1	1	1	1	0

Q.24 (3)

$$V_{gain} = \left(\frac{\Delta I_C}{\Delta I_B}\right)\frac{R_{out}}{R_{in}} \qquad = \left(\frac{5\times 10^{-3}}{100\times 10^{-6}}\right)\times 10^3$$

$$= \frac{1}{20}\times 10^6 = 5\times 10^4$$

$$= P_{gain} = \left(\frac{\Delta I_C}{\Delta I_b}\right)\left(V_{gain}\right) = \left(\frac{5\times 10^{-3}}{100\times 10^{-6}}\right)\left(5\times 10^4\right)$$

= 2.5×10^6

Q.25 (4)

$A_v \times \beta = P_{gain}$

$$60 = 10\log_{10}\left(\frac{P}{P_0}\right)$$

$$P = 10^6 = \beta^2 \times \frac{R_{out}}{R_{in}} = \beta^2 \times \frac{10^4}{100}$$

$\beta^2 = 10^4$

$\beta = 100$

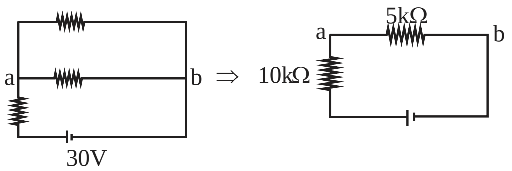
Q.26 (4)

A logic gate is reversible if we can recover input date from the output

e.g. NOT

Q.27 (3)

Diode is in forward bias, so it will behave as simple wire so,



So, $V_{ab} = \dfrac{30}{5+10} \times 5 = 10V$

Q.28 (2)

First part of figure shown is OR gate and second part of figure shown is NOT gate.

So, Y_P = OR + NOT = NOR gate

$Y = \overline{A + B} = \overline{A}.\overline{B}$

Q.29 (2)

$Y = \overline{\overline{AB} \bullet A}$

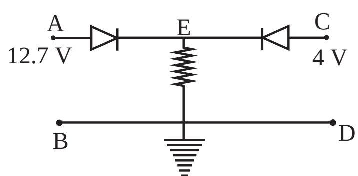
$= \overline{\overline{AB}} + \overline{A}$

$= AB + \overline{A}$

$= 0 + 0$

$= 0$

Q.30 [12]



Let $V_B = 0$

Right diode is reversed biased and left diode is forward biased

$\therefore\ V_E = 12.7 - 0.7 = 12$ Volt

Q.31 (2)

Both diodes are in reverse biased

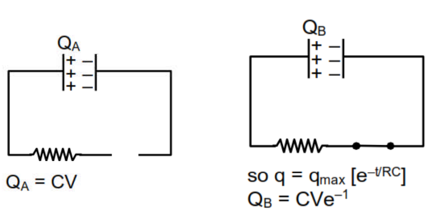
$I = \dfrac{9}{3} = \dfrac{3}{10} A = 0.3A$

Q.32 (2)

Maximum charge on capacitor = 5 CV

(a) is reverse biased and (b) is forward biased

for case (a)



Q. 33 [40]

$i = \dfrac{(12-8)}{(200+200)} A = \dfrac{4}{400} = 10^{-2} A$

Power loss in each = (4) (10^{-2}) W = 40 mW

Q.34 (2)

Truth Table

A	B	W = A.B	X = A+B	Y = W.X	Z = W+Y
1	0	1	1	0	0
0	0	1	0	0	0
1	1	0	1	0	1
0	1	1	1	1	0

Q.35 (1)

$\overline{\left(\overline{A} + \overline{B} + \overline{C}\right)} = A.B.C$

$\Rightarrow$ AND gate

Q.36 (3)

Zener diode works in reverse bias and potential drop across it remains constant.

Q.37 (3)

Voltage across RL increases up to 4 V, then one of the zener diode will blow. So, option (3) is correct.

Q.38 [150]

$\beta_{ac} = \dfrac{\Delta I_C}{\Delta I_B}$

ΔI_C = (4.5 – 3) mA

ΔI_n = (30 – 20) μA = 10μA

$\beta_{ac} = \dfrac{1500}{10} = 150$

Q.39 (None)

$Y = \overline{\overline{A} \cdot \overline{B}} = \overline{\overline{A}} + \overline{\overline{B}} = A + B$

Truth Table

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

Q.40 (1)

Since silicon diode is used so 0.7 volt is drop cross it. Only D_1 will conduct so current through cell

$I = \dfrac{5 - 0.7}{10}$

I = 0.43

Q.41 (1)

$Y = \overline{A\overline{B} + \overline{A}B}$

$Y = \overline{A\overline{B}} \cdot \overline{\overline{A}B}$

$Y = (\overline{A} + B) \cdot (A + \overline{B})$

$Y = \overline{A} \cdot A + \overline{A}\,\overline{B} + A \cdot B + B\overline{B}$

$Y = AB + \overline{A}\,\overline{B}$

Q.42 (1)
Transformer → Step up – Step down
Rectifier → AC to DC
Filter → Ripple is removed
Stabiliser → For any input, output would be same

Q.43 (2)
The variation of the fermi level obeys two conditions.
→ The mass action law
→ The neutrality equation

Q.44 (4)

$\lambda = \frac{1242}{1.9}$ nm = 654 nm, Red..

Q.45 (1)

$i = \frac{6}{300} = \frac{1}{50}$ A

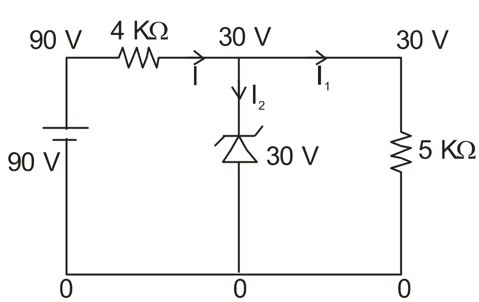
$= \frac{1000}{50}$ mA

= 20 mA

Q.46 (3)

$y = \overline{\overline{A} + B} = A\overline{B}$

Q.47 [9]



$I = \frac{90 - 30}{4} = 15\text{mA}$

$I_1 = \frac{30}{5K\Omega} = 6\text{mA}$

$I_2 = 15\text{mA} - 6\text{mA} = 9\text{mA}$
Ans. = 9

Q.48 (4)
It is heavily dopped and work in reverse biased so depletion layer thickness is more.

Q.49 (3)
$\Delta I_E = 4$
$\Delta I_C = 3.5$

$\alpha = \frac{\Delta I_C}{\Delta I_E} = \left(\frac{3.5}{4}\right) = \left(\frac{7}{8}\right)$

$\beta = \frac{\alpha}{1 - \alpha} = \frac{\frac{7}{8}}{1 - \frac{7}{8}} = 7$

Q.50 (1)
Zener diode breakdown

$\Rightarrow i = \frac{5}{2 \times 10^{-3}} = 2.5 \times 10^{-3}$

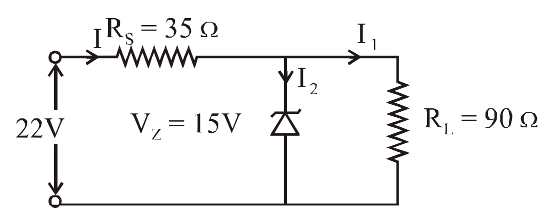
$x \times 10^{-4} = 2.5 \times 10^{-3}$
$x = 2.5\text{mA}$

Q.51 (3)

$y = \overline{A + B} = \overline{AB}$
which is equivalent to (3) option

Q.52 (2)
Theoretically

Q.53 **[5]**



Voltage across $R_S = 22 - 15 = 7V$

Current through $R_S = I = \frac{7}{35} = \frac{1}{5}$ A

Current through $90\Omega = I_2 = \frac{15}{90} = \frac{1}{6}$ A

Current through zener = $\frac{1}{5}-\frac{1}{6}=\frac{1}{30}$ A

Power through zener diode

P = VI

$P\times\frac{1}{30}=0.5$ watt

P = 5 × 10^{-1} watt

Q.54 **(1)**

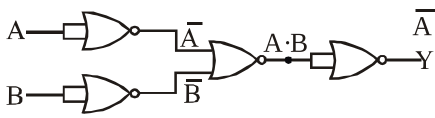
Truth table for the given logic gate :

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

The truth table is similar to that of a NOR gate.

Q.55 **(2)**

By De Morgan's theorem, we have



$\overline{A\cdot B}$ = NAND

Q.56 **(4)**

(4) Conceptual

Q.57 **[100]**

$$10^6=\beta^2\times\frac{R_0}{R_i}$$

$$10^6=\beta^2\times\frac{10^4}{10^2}$$

β2 =104 ⇒β =100

Q.58 **(4)**

$$\alpha=\frac{I_C}{I_E},\beta=\frac{I_C}{I_B}$$

IE = IB + IC

$$\alpha=\frac{I_C}{I_B+I_C}=\frac{1}{\frac{I_B}{I_C}+1}$$

$$\alpha=\frac{1}{\frac{1}{\beta}+1}$$

$$\alpha=\frac{\beta}{1+\beta}$$

Q.59 **[200]**

$$\beta=\frac{\Delta I_C}{\Delta I_B}=\frac{2\times10^{-3}}{10\times10^{-6}}$$

$$\beta=\frac{1}{5}\times10^3$$

β = 2 × 102

β = 200

Q.60 [25]

Q.61 [192]

Q.62 **(1)**

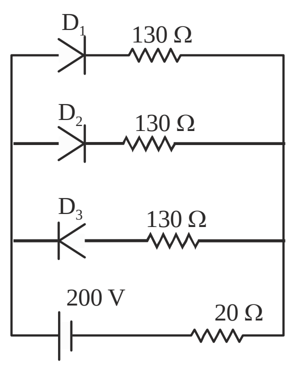
Q.63 (2)

Q.64 [5]

Q.65 [25]

Q.66 (2)

Q.67 (3)



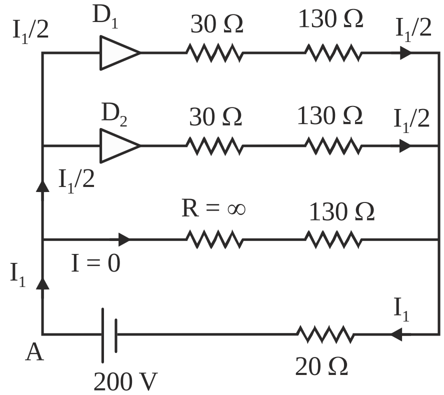
As per diagram,

Diode D_1 & D_2 are in forward bias i.e. R = 30Ω

where diode D_3 is in reverse bias i.e. R = infinite

⇒ Equivalent circuit will be

Applying KVL starting from point A



$$-\left(\frac{I_1}{2}\right)\times 30-\left(\frac{I_1}{2}\right)\times 130 - I_1 \times 20 + 200 = 0$$

$\Rightarrow -100\, I_1 + 200 = 0$

$I_1 = 2$

Option (3)

Q.68 [20]

Q.69 (2)

Q.70 [120]

Q.71 (4)

Q.72 (3)

A	B	X	Y	Z
1	1	0	0	0
1	0	0	1	0
0	1	1	0	0
0	0	1	1	1

Option (3)

Q.73 (2)

VA = 5V $\Rightarrow$ A = 1

VA = 0 V $\Rightarrow$ A = 0

VB = 5 V $\Rightarrow$ B = 1

VB = 0 V $\Rightarrow$ B = 0

If A = B = 0, there is no potential anywhere here V_0 = 0

If A = 1, B = 0, Diode D_1 is forward biased, here V_0 = 5V

If A = 0, B = 1, Diode D_2 is forward biased hence V_0 = 5V

If A = 1, B = 1, Both diodes are forward biased hence V_0 = 5V

Truth table for I^{st}

A	B	Output
0	0	0
0	1	1
1	0	1
1	1	1

$\therefore$ Given circuit is OR gate

For II^{nd} circuit

V_B = 5V, A = 1

V_B = 0V, A = 0

When A = 0, E – B junction is unbiased there is no current through it

$\therefore$ V_0 = 1

When A = 1, E–B junction is forward biased

V_0 = 0

$\therefore$ Hence this circuit is not gate.

Q.74 (3)

Q.75 **(1)**

Q.76 (4)

Q.77 [5]

EXERCISES

OBJECTIVE QUESTIONS

Q.1 (3)

Q.2 (4)

Q.3 (1)

Q.4 (4)

Q.5 (1)

Q.6 (2)

Q.7 (4)

Q.8 (1)

Q.9 (3)

Q.10 (1)

Q.11 (3)

Q.12 (3)

Q.13 (4)

Q.14 (3)

Q.15 (1)

Q.16 (2)

Q.17 (3)

Q.18 (1)

Q.19 (1)

Q.20 (4)

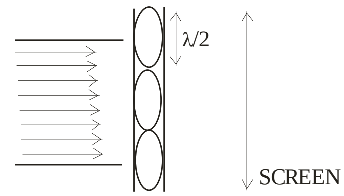
KVPY
PREVIOUS YEAR'S

Q.1 (A)

$v = \nu \lambda$

$\Rightarrow \lambda = \dfrac{1500}{0.5\times10^6} = 3000 \times 10^{-6}$

$\lambda = 3$ mm



Intensity veary according to graph 'A'

Q.2 **(B)**

Time period between two flashes $= \dfrac{1}{f}$

Distance travelled by laser in this interval

$\dfrac{c}{f} = \dfrac{3\times10^8}{10^9} = 0.3\text{m} = 30\text{cm}$

So this is the maximum distance between two detectors, so that they can see the same pulse simultaneously.

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Q.1 **(1)**

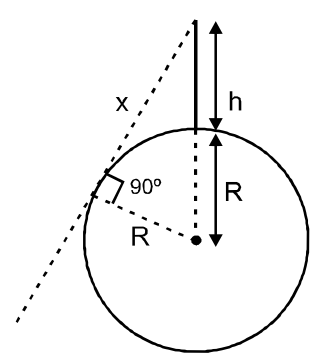
Low frequencies cannot be transmitted to long distances. Therefore, they are super imposed on a high frequency carrier signal by a process known as modulation.

Speed of electro–magnetic waves will not change due to modulation. So time lag between transmission and reception of the information signale.

Q.2 **(1)**

$r = R + h \cong R$

$x = \sqrt{(R+h)^2 - R^2}$

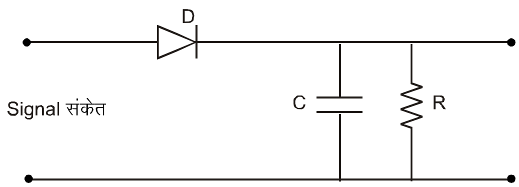


$= \sqrt{h^2 + 2hR}$

$x^2 = 25000 + 2.\ 500\ 6.4\ 100000$

$= 25000 + (64 \times 100000000)$
$= 10^4\ (640025)$
$x^2 \cong 10^4.640000$
$x = 8 \times 10^4$ m
$= 80$ km.

Q.3 **(2)**



$\tau = RC = 100 \times 10^3 \times 250 \times 10^{-12}$ sec
$= 2.5 \times 10^7 \times 10^{-12}$ sec $= 2.5 \times 10^{-5}$ sec
The higher frequency which can be detected with tolerable distortion is

$$f = \frac{1}{2\pi m_a RC} = \frac{1}{2\pi \times 0.6 \times 2.5 \times 10^{-5}}\text{Hz} = \frac{100 \times 10^4}{25 \times 1.2\pi}\text{Hz} = \frac{4}{1.2\pi} \times 10^{-4}\ \text{Hz} = 10.61\ \text{KHz}$$

This condition is obtained by applying the condition that rate of decay of capacitor voltage must be equal or less then the rate of decay modulated singnal voltage for proper detection of mdoulated signal.

Q.4 **(1)**

Q.5 (3)
Refer NCERT Page No. 526
Three frequencies are contained
$\omega_m + \omega_c$, $\omega_c - \omega_m$ & ω_c

Q.6 **(2)**
Since the carrier frequency is distributed as band width frequency, so
10% of 10 GHz = n × 5 kHz
where n = no of channels

$$\frac{10}{100} \times 10 \times 10^9 = n \times 5 \times 10^3$$

$n = 2 \times 10^5$ telephonic channels

Q.7 (3)
Analysis of graph says
(1) Amplitude varies as 8 – 10 V or 9 ± 1
(2) Two time period 100 μs (signal wave) and 8 μs (carrier wave)

Hence signal is $\left[9 \pm 1\sin\left(\frac{2\pi t}{T_1}\right)\right]\sin\left(\frac{2\pi t}{T_2}\right) = 9 \pm 1\sin$

$(2\pi \times 10^4 t)\ \sin 2.5\pi \times 10^5 t$

Q.8 (4)
The interval between two carrier frequencies should be at least two times of AM frequency.

Q.9 (3)

$$f = \frac{c}{\lambda} = \frac{3 \times 10^8}{8 \times 10^{-7}} = \frac{3}{8} \times 10^{15}\ \text{Hz}$$

$$\therefore\ n = \frac{(0.01)f}{6 \times 10^6} = \frac{\frac{3}{8} \times 10^{13}}{6 \times 10^6} = \frac{1}{16} \times 10^7 = 6.25 \times 10^5$$

Q.10 (3)
$A_C = 100$
$A_C + A_m = 160$
$A_C - A_m = 40$
$A_C = 100$, $A_m = 60$

$$\mu = \frac{A_m}{A_C} = 0.6$$

Q.11 (3)
Covering range of transition power = $\sqrt{2hR}$
To double the range make height 4 times.

Q.12 (3)
$f_{so} = f_c \pm f_m$

$$= \frac{\omega_c \pm \omega_m}{2\pi} = \frac{(5.5 \pm 0.22) \times 10^5}{2 \times \frac{22}{7}} = 89.25,\ 85.75$$

Q.13 (1)

$$D = \sqrt{2h_T R} + \sqrt{2h_R R}$$

Q.14 (3)
The physical size of antenna of reciver and transmitter both inversely proportional to carrier frequency.

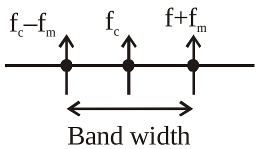
Q.15 (4)
To minimise attenuation, wavelength of carrier waves is close to 1500 nm

Q.16 (3)
Range $= \sqrt{2Rh_T} + \sqrt{2Rh_R}$
$50 \times 10^3 =$

$$\sqrt{2 \times 6400 \times 10^3 \times h_T} + \sqrt{2 \times 6400 \times 10^3 \times 70}$$

by solving $h_T = 32$ m

Q.17 (2)



Q.18 (4)
f_m = 100 MHz = 10^8Hz, $(V_m)_0$ = 100V
f_c = 300 GHz , $(V_c)_0$ = 400V

Modulaton Index = $\frac{(V_m)_0}{(V_c)_0} = \frac{100}{400} = \frac{1}{4} = 0.25$

Upper band frequency (UBF) = $f_c + f_m$
Lower band frequency (LBF) = $f_c – f_m$
$\therefore$ UBF – LBF = $2f_m = 2 \times 10^8$ Hz

Q.19 (1)

Modulation index is given by $m = \frac{A_m}{A_c} = \frac{2}{4} = 0.5$

& (a) carrier wave frequency is given by
$= 2\pi f_c = 2\times10^4\pi$
f_c = 1 kHz
(b) modulating wave frequency (f_m)
= $2\pi\ f_m$ = 2000 π
$\Rightarrow f_m$ = 1 kHz
lower side band frequency $\Rightarrow f_c – f_m$
$\Rightarrow$ 10 kHz – 1 kHz = 9 kHz

Q.20 (None)
$A_{max} = A_C(1 + \mu) = 8V$
$A_{min} = A_C(1 – \mu) = 2V$

Q.21 (2)
Theory based

Q.22 (1)
Theoretical

Q.23 (1)

Using theory $\lambda = \frac{c}{f_c}$

Q.24 [33]

$$u = \frac{A_{max} - A_{min}}{A_{max} + A_{min}}$$

$$= \frac{16-8}{16+8} = \frac{8}{24} = \frac{1}{3}$$

= 0.33 = $33 \times 10^{–2}$
x = 33

Q.25 (1)
Theorwtical information based

Q.26 [25]

$$m\% = \frac{A_M}{A_C} \times 100 = \frac{20}{80} \times 100 = 25\%$$

Q.27 **(2)**
D = $2\sqrt{2Rh}$

$$h = \frac{D^2}{8R} = \frac{45^2}{8\times6400}\text{km} \cong 39.55\,\text{m}$$

Q.28 **[1206]**
d = $\sqrt{2Rh}$
A = πd^2
A = $\pi 2Rh$

$$= 3.14 \times 2 \times 6400 \times \frac{30}{1000}$$

A = 1205.76 km^2
A $\simeq$ 1206 km^2

Q.29 **(4)**
(4) Band width = 2 f_m
$\omega_m = 1.57 \times 10^8 = 2\pi f_m$

$$BW = 2f_m = \frac{10^8}{2}\text{ Hz} = 50\text{ MHz}$$

Q.30 **(1)**
Order of atmosphere stratification from bottom Troposphere, stratosphere, Mesosphre, Thermosphere
(a) $\rightarrow$ (iv)
(b) $\rightarrow$ (iii)
(c) $\rightarrow$ (ii)
(d) $\rightarrow$ (i)

Q.31 **[50]**
Range = $\sqrt{2Rh}$
Range (i) = $\sqrt{2Rh}$
Range (ii) = $\sqrt{2Rh} + \sqrt{2Rh'}$
where h = 20 m & h' = 5m

$$\text{Ans} = \frac{\sqrt{2Rh'}}{\sqrt{2Rh}}\times100\% = \frac{\sqrt{5}}{\sqrt{20}}\times100\% = 50\%$$

Q.32 **[40]**

Q.33 **(1)**

Q.34 (1)

Q.35 [1]

Q.36 [1]

Q.37 [3]

Q.38 [1]

Q.39 (2)

Q.40 (4)

Q.41 **[64]**

Q.42 [500]

Singnal bandwidth = 2 fm

=12 kHz

$$\therefore N = \frac{6MNZ}{12kHZ} = \frac{6\times10^{6}}{12\times10^{3}} = 500$$

Q.43 [224]

Q.44 [2]

Q.45 [200]

$A_{max} = A_C + A_m = 250 + 150 = 400$

$A_{min} = A_C - A_m = 250 - 150 = 100$

$$\frac{A_{min}}{A_{max}} = \frac{100}{400} = \frac{1}{4} = \frac{50}{200}$$

x = 200

EXERCISES

OBJECTIVE QUESTIONS

Q.1 4)
Q.2 (4).
Q.3 (4)
Q.4 (1)
Q.5 (1)
Q.6 (1)
Q.7 (3)
Q.8 (4)
Q.9 (3)
Q.10 (1)
Q.11 (1)
Q.12 (3)
Q.13 (4)
Q.14 (1)
Q.15 (2)
Q.16 (1)
Q.17 (3)
Q.18 (2)
Q.19 (2)

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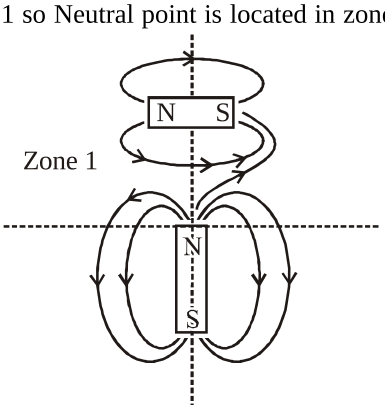
Q.1 (A)
Magnetic filed lines are in opposite direction in zone 1 so Neutral point is located in zone 1.



Q.2 (A)
Diamagnetic material move from high magnetic field to low magnetic field so this material are likely to accumulate over the region such as A as here magnetic field is minimum.

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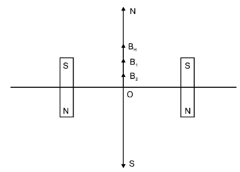
PREVIOUS YEAR'S

Q.1 (2)
$B_{net} = B_1 + B_2 + B_H$



$$B_{net} = \frac{\mu_0}{4\pi}\frac{(M_1 + M_2)}{r^3} + B_H$$

$$= \frac{10^{-7}(1.2+1)}{(0.1)^3} + 3.6 \times 10^{-5} = 2.56 \times 10^{-4} \text{ Wb/m}^2$$

Ans. (2)

Q.2 (3)
For electromagnet and transformer, the coercivity should be low to reduce energy loss.

Q.3 (3)

$$T = 2\pi\sqrt{\frac{I}{MB}}$$

$I = 7.5 \times 10^{-6}$ kg-m^2
$M = 6.7 \times 10^{-2}$ Am^2
By substituting value in the formula

$$T = 2\pi\sqrt{\frac{7.5\times10^{-6}}{6.7\times10^{-2}\times0.01}}$$

$\Rightarrow T = 0.665$ sec
For 10 oscillations, time taken will be
Time = 10 T = 6.65 sec

Q.4 (4)

$$\chi = \frac{I}{H}$$

$$I = \frac{\text{Magnetic moment}}{\text{Volume}}$$

$$I = \frac{20\times10^{-6}}{10^{-6}} = 20 N/m^2$$

$$\chi = \frac{20}{60\times10^3} = \frac{1}{3}\times10^{-3}$$

$= 0.33 \times 10^{-3} = 3.3 \times 10^{-4}$

Q.5 (4)
$\tau = F \times 0.06 = 1.8 \times 0.12 \times 18 \times 10^{-6}$
$F = 6.48 \times 10^{-5}$

Q.6 **(2)**
$B = \mu_0 H$; $\mu_0 ni = \mu_0 H$

$$\frac{100}{0.2}\times5.2 = H$$

H = 2600 A/m

Q.7 (BONUS)

Work done by external agent = $U_f - U_i$

$$U_i = -MB\cos\left(\frac{1}{8}\right)$$

$$U_f = MB\cos\left(\frac{1}{8}\right)$$

$$W = 2MB\cos\left(\frac{1}{8}\right) \qquad = 0.0198 \text{ J}$$

None of the option is correct.

Q.8 (1)

For paramagnetic materials, magnetic susceptibility,

$$\chi \propto \frac{1}{T}$$

$$\Rightarrow \frac{\chi_1}{\chi_2} = \frac{T_2}{T_1}$$

$$\Rightarrow \chi_2 = \frac{T_1}{T_2} \times \chi_1 = \frac{350}{300} \times 2.8 \times 10^{-4} = 3.267 \times 10^{-4}$$

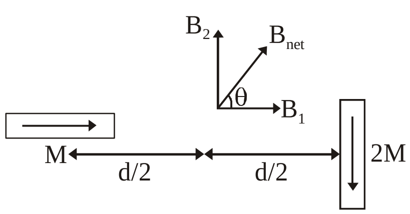
Q.9 (1)

$$\because \; T = 2\pi\sqrt{\frac{I}{\mu B}}$$

$$\frac{T_h}{T_c} = \sqrt{\frac{I_h}{I_c} \times \frac{\mu_c}{\mu_h}} = \sqrt{2 \times \frac{1}{2}} = 1$$

$$T_h = T_c$$

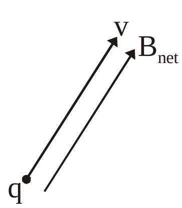
Q.10 (4)



$$B_1 = 2\left(\frac{\mu_0}{4\pi}\right)\frac{M}{(d/2)^3}; \quad B_2 = \left(\frac{\mu_0}{4\pi}\right)\frac{2M}{(d/2)^3}$$

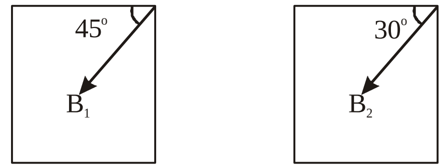
$B_1 = B_2$

$\Rightarrow$ B_{net} is at 45° ($\theta = 45°$)



velocity of charge and B_{net} are parallel so by $\vec{F} = q(\vec{v} \times \vec{B})$, force on charge particle is zero.

Q.11 (3)



$$f_1 = \frac{1}{2\pi}\sqrt{\frac{\mu B_1 \cos 45^\circ}{I}} \qquad f_2 = \frac{1}{2\pi}\sqrt{\frac{\mu B_2 \cos 30^\circ}{I}}$$

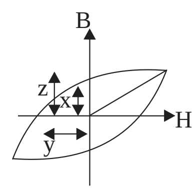
$$\frac{f_1}{f_2} = \sqrt{\frac{B_1 \cos 45^\circ}{B_2 \cos 30^\circ}} \qquad \therefore \frac{B_1}{B_2} = 0.7$$

Q.12 (1)

x = retentivity

y = coercivity

z = saturation magnetization



Q.13 (2)

Option (2) is correct as permanent magnet should have high coercivity & retentivity.

Q.14 (4)

Magnetic field inside perfectly diamagnetic material remains zero.

Q.15 (2)

$$M \propto \frac{B}{T}$$

$$\Rightarrow \frac{M_2}{M_1} = \frac{B_2}{B_1} \times \frac{T_1}{T_2}$$

$$\Rightarrow \frac{x}{6} = \frac{0.3}{0.4} \times \frac{4}{24}$$

$\Rightarrow$ x = 0.75 A/m

Q.16 (3)

$\tau = MB\sin\theta$

$0.018 = M \times 0.06 \times 0.5$

$\Rightarrow M = 0.6 \text{ Am}^2$

$W = U_f - U_i$

$= MB(\cos\theta_1 - \cos\theta_f)$

$= 0.06 \times 0.06 (1 - (-1))$

$= 7.2 \times 10^{-2}$ J

Q.17 (1)

$M = \chi H$

Magnetic moment = MV

$H = ni$

Q.18 (1)

Theoretical

Q.19 **(1)**

Statement (C) is correct because, the magnetic field outside the toroid is zero and they form closed loops inside the toroid itself.

Statement (E) is correct because we know that super conductors are materials inside which the net magnetic field is always zero and they are perfect diamagnetic.

$\mu_r = 1 + \chi$

$\chi = -1$

$\mu_r = 0$

For superconductors.

Q.20 (2)
Q.21 (2)
Q.22 (1)
Q.23 [22]
Q.24 [8]
Q.25 (4)
Q.26 (1)
Q.27 [3]

Electromagnetic Waves

EXERCISES

OBJECTIVE QUESTIONS

Q.1. (1, 2)

Since $i_d = E_0 \frac{d\phi_E}{dt}$

$i_d \rightarrow$ displacement current
$\phi_E \rightarrow$ flux of electric field
Therefore displacement current flows in dielectric of a capacitor when electric field between plates changes. That is possible while increasing or decreasing the potential difference across capacitors plates.

Q.2 (4)

Free electrons (ie at rest) will experiences force in the direction of electric field ie $\left(\vec{F} = q\vec{E}\right)$. Hence it moves along direction of electirc field.

Q.3 **(4)**
Speed of electromagnetic wave is same for all frequency.

Q.4 (2)
According to einstine photoelectric theory when electromagnetic wave is incident on a metal surface it transfer energy and momentum. Hence p ≠ 0, E ≠ 0.

Q.5 (1)
Ampere's circuital law,

$\oint B.dl = \mu_0 i_{in}$ where in is current enclosed in the bounded curve surface. This is conduction current. Which is actually consider due to flow of charge.

Q.6 **(1)**

$i_d = E_0 \frac{d\phi_E}{dt}$, displacement current is contineous when electric field is changing in circuit.

Q.7 (2)

When capacitor is fully charged the potential across it becomes constant and conduction current in circuit become zero.

Q.8 **(1)**
Along the wire field is maximum.

Q.9 **(1)**
Visible light lies in a range of 10^{15} Hz.

Q.10 **(4)**
Magnetic field due to changing capacitor.

$$B = \frac{\mu_0 ir}{2\pi R^2} \quad r \le R$$

$$B = \frac{\mu_0 i}{2\pi R} \quad r = R$$

where r is radius of loop.

Q.11 (3)

$\vec{C} = \vec{E} \times \vec{B}$

Direction of C 1 to $\vec{E} \times \vec{B}$

Q.12 **(3)**

$$B = \frac{\mu_0 i_D}{2\pi r} \quad r > R$$

Q.13 (2)
$n = 2 \times 10^{10}\ H_z$
$E_0 = 48\ Vm^{-1}$

$$\lambda = \frac{c}{n} = \frac{3\times10^8}{2\times10^{10}} = 1.5\times10^{-2}\,m$$

Q.14 (4)
$E_0 = 9 \times 10^3$
$B_0 = ?$

$$B_0 = \frac{E_0}{C} = \frac{9\times10^3}{3\times10^8} = 3\times10^{-5}\,T$$

Q.15 **(1)**

$$\frac{dE}{dt} = 10^{10}\ v/m^{-s}$$

Q.16 (2)

$I_d = 1A$

$C = 1uF$

$$\frac{dv}{dt} = \frac{1}{c}\frac{dq}{dt} = \frac{1}{c}id = \frac{1\times10^6}{1} = 10^6\ V/s$$

Q.17 (4)

P = 800 watt

$E_0 = 4$

$$I = \frac{P_0}{4\pi R^2} = \frac{1}{2}\varepsilon_0 E_2^0 C$$

$$\frac{2P_0}{4\pi c\varepsilon_0 R^2} = E_0^2$$

$$\frac{2\times800\times9\times10}{3\times10\times16} = E_0^2$$

$300 \times 10 = E_0$

$E_0 = 54.77$ V/m

Q.18 **(2)**

$$B = \frac{E_0}{C} = \frac{54.77}{3\times10^8} = 1.83\times10^{-7}T$$

Q.19 (1)

$$E = 50\sin(wt - kx)$$

$$U_{av} = \frac{1}{2}\varepsilon_0 E^2$$

$$= \frac{1}{2}\times8.85\times10^{-12}\times25\times10^2$$

$= 1.1 \times 10^{-8}\ J/m^3$

Q.20 (4)

$$E_Z = 100\cos\left(6\times10^8 t + 4x\right)$$

$$\text{speed} = v = \frac{6\times10^8}{4} = \frac{3}{2}\times10^8 = 1.5\times10^8$$

$$\text{Dielectric constant} = \frac{C}{V} = 2$$

KVPY PREVIOUS YEAR'S

Q.1 (A)

Absorbs infrared radiation thus it absorbs longer wave-length of EMwave spectrum while transmitting shorter wavelength.

Q.2 (B)

VIBG | YOR

400 nm | 700 nm

Absorbed Refelected

therefore seen

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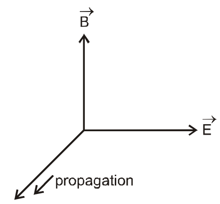
Q.1 (2)



Q.2 **(2)**

$$\vec{E} = \vec{B}\times\vec{C}$$

$|\vec{E}| = |\vec{B}|.|\vec{C}| = 20 \times 10^{-9} \times 3 \times 10^8 = 6$ V/m.

Q.3 **(3)**

Both the energy densities are equal.

Q.4 **(4)**

Option 4 Is Correct

Q.5 (4)

Intensity of EM wave is given by

$$I = \frac{\text{Power}}{\text{Area}} = \frac{1}{2}\varepsilon_0 E_0^2 C$$

$$= \frac{27\times10^{-3}}{10\times10^{-6}} = \frac{1}{2}\times9\times10^{-2}\times E^2\times3\times10^8$$

$E = \sqrt{2}\times10^3$ kV / m

= 1.4 kV/m

Q.6 (3)

$$\frac{E_i}{B_i} = C \qquad ...(1)$$

$$\frac{E_f}{B_f} = \frac{c}{n} \qquad ...(2)$$

$$\Rightarrow \frac{E_i B_f}{E_f B_i} = \frac{1}{n}$$

$$\Rightarrow \frac{E_i}{E_f} = \frac{1}{n}\frac{B_i}{B_f}$$

$$\left(\because n = \frac{1}{\sqrt{\mu_0 e_r}}\right)$$

$$\frac{1}{\sqrt{n}} : \sqrt{n}$$

Q.7 (2)

E = CB

Q.8 (2)

$$\vec{E} = 10\hat{j}\cos(6x + 8z - 10ct)$$

$$B_o = \frac{E_o}{C} = \frac{10}{C}$$

W = 10 C

$$\because \quad \hat{E} \times \hat{B} = \hat{C}$$

$$\begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ 0 & 1 & 0 \\ B_x & B_y & B_z \end{vmatrix} = \frac{6\hat{i} + 8\hat{j}}{10}$$

$$\Rightarrow B_z\hat{i} - 0\hat{j} - B_x\hat{k} = \frac{3}{5}\hat{i} + \frac{4}{5}\hat{j}$$

$$B_z = \frac{3}{5}, B_y = 0, B_z = \frac{4}{5}$$

$$\therefore \quad \vec{B} = \frac{1}{C}\left(-8\hat{i} + 6\hat{k}\right) \cos\,(6x + 8z + 10ct)$$

Q.9 **(2)**

$$\frac{E}{B} = C$$

Q.10 (4)

$$B = \frac{E}{C}$$

$$\Rightarrow U_E = \frac{1}{2}\varepsilon_0 E^2$$

$$U_B = \frac{B^2}{2\mu_0} = \frac{E^2}{2\mu_0 C^2} = \frac{E^2}{2\mu_0}(\mu_0\varepsilon_0) = U_E$$

Q.11 (3)

The direction of propogation of an EM wave is direction $\vec{E} \times \vec{B}$.

$$\hat{i} = \hat{j} \times \hat{B}$$

$$\Rightarrow \hat{B} = \hat{k}$$

$$C = \frac{E}{B} \Rightarrow B = \frac{E}{C} = \frac{6}{3 \times 10^8}$$

$B = 2 \times 10^{-8}$ T along z-direction.

Q.12 (4)

If we use that direction of light propagation will be along $\vec{E} \times \vec{B}$. Then (4) option is correct Detailed solution is as following .

magnitude of E = CB

$$E = 3 \times 10^8 \times 1.6 \times 10^{-6} \times \sqrt{5}$$

$$E = 4.8 \times 10^2 \sqrt{5}$$

$\vec{E}$ and $\vec{B}$ are perpendicular to each other

$$\Rightarrow \vec{E}.\vec{B} = 0$$

$\Rightarrow$ either direction of $\vec{E}$ is $\hat{i} - 2\hat{j}$ or $-\hat{i} + 2\hat{j}$ from given option

Also wave propagation direction is parallel to $\vec{E} \times \vec{B}$ which is $-\hat{k}$

$\Rightarrow$ $\vec{E}$ is along $\left(-\hat{i} + 2\hat{j}\right)$

Q.13 (4)

Maximum Electric field E = (B) (c)

$$\vec{E}_0 = \left(3 \times 10^{-5}\right)c\left(-\hat{j}\right)$$

$$\vec{E}_1 = \left(2 \times 10^{-6}\right)c\left(-\hat{i}\right)$$

Maximum force

$$\vec{F}_{net} = q\vec{E} = qc\left(-3 \times 10^{-5}\hat{j} - 2 \times 10^{-6}\hat{i}\right)$$

$$\vec{F}_{0\,max} = 10^{-4} \times 3 \times 10^8 \sqrt{\left(3 \times 10^{-5}\right)^2 + \left(2 \times 10^{-6}\right)^2}$$

= 0.9 N

$$F_{rms} = \frac{F}{\sqrt{2}} = 0.6\text{N} \quad \text{(approx)}$$

Q.14 (3)

Magnetic field when electromagnetic wave propagated in +z direction

$$B = B_0 \sin(kz - \omega t)$$

where

$$B_0 = \frac{60}{3 \times 10^8} = 2 \times 10^{-7}$$

$$k = \frac{2\pi}{\lambda} = 0.5 \times 10^3$$

$$\omega = 2\pi f = 1.5 \times 10^{11}$$

Q.15 (3)

$$\vec{E} = E_0\hat{n}\sin\left(\omega t + (6y - 8z)\right)$$

$$= E_0\hat{n}\sin\left(\omega t + \vec{k}.\vec{r}\right)$$

wher $\vec{r} = x\hat{i} + y\hat{j} + z\hat{k}$

and $\vec{k}.\vec{r} = 6y - 8z$

$$\Rightarrow \vec{k} = 6\hat{j} - 8\hat{k}$$

direction of propagation

$$\hat{s} = -\hat{k} = \left(\frac{-3\hat{j} + 4\hat{k}}{5}\right)$$

Q.16 (2)

$\because \vec{E}\times\vec{B} \parallel \vec{v}$

Given that wave is propagating along positive z-axis and $\vec{E}$ along positive x-axis. Hence $\vec{B}$ along y-axis.
From
Maxwell equation

$\vec{V}\times\vec{E} = -\frac{\partial B}{\partial t}$

i.e. $\frac{\partial E}{\partial Z} = -\frac{\partial B}{dt}$ and $B_0 = \frac{E_0}{C}$

Q.17 (4)

$\frac{E_0}{B_0} = C$ (speed of light in vacuum)

$E_0 = B_0C = 3 \times 10^{-8} \times 3 \times 10^8$
$= 9$ N/C
So $E = 9\sin(1.6 \times 10^3 x + 48 \times 10^{10} t)$

Q.18 (2)

$\frac{E}{B} = c$

$E = B \times c$
$= 15$ N/c

Q.19 (1)
Magnetic field vectors associated with this electromagneetic wave are given by

$\vec{B}_1 = \frac{E_0}{c}\hat{k}\cos(kx - \omega t)$ & $\vec{B}_2 = \frac{E_0}{c}\hat{i}\cos(ky - \omega t)$

$\vec{F} = q\vec{E} + q(\vec{V}\times\vec{B})$

$= q(\vec{E}_1 + \vec{E}_2) + q(\vec{V}\times(\vec{B}_1 + \vec{B}_2))$

by putting the value of $\vec{E}_1, \vec{E}_2, \vec{B}_1$ & $\vec{B}_2$
The net Lorentz force on the charged particle is

$\vec{F} = qE_0[0.8\cos(kx - \omega t)\hat{i} + \cos(kx - \omega t)\hat{j} + 0.2\cos(ky - wt)\hat{k}]$

at t = 0 and at x = y = 0

$\vec{F} = qE_0[0.8\hat{i} + \hat{j} + 0.2\hat{k}]$

Q.20 (3)

EM wave is in direction $\rightarrow \frac{\hat{i}+\hat{j}}{\sqrt{2}}$

Electric field is in direction $\rightarrow \hat{k}$

$\vec{E}\times\vec{B} \rightarrow$ direction of propagation of EM wave

Q.21 (3)

$\hat{C} = \hat{E}\times\hat{B}$

$= \hat{k}\times\frac{(\hat{i}-\hat{j})}{\sqrt{2}}$

$= \frac{(\hat{i}-\hat{j})}{\sqrt{2}}$

Q.22 (4)

$\frac{B^2}{2\mu_0} = 1.02\times10^{-8}$

$\Rightarrow B^2 = (1.02 \times 10^{-8}) \times 2\mu_0$

Also, $\frac{1}{\sqrt{\mu_0\varepsilon_0}} = C \Rightarrow \mu_0 = \frac{1}{C^2\varepsilon_0}$

$\Rightarrow B^2 = (1.02 \times 10^{-8})\, 2 \times \frac{4\pi\times9\times10^9}{9\times10^{16}}$

Q.23 (2)

$\vec{E}\times\vec{B} \parallel \vec{C}$ -

Hence $\vec{B}$ should be in $\hat{k}$ direction.

Also , $E_0 = B_0C$, $C = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$

$\Rightarrow \vec{B} = E_0\sqrt{\mu_0\varepsilon_0}\cos(kx)\hat{k}$

Q.24 (3)

$\vec{E}\times\vec{B}$ is along $\vec{C}$

$\hat{E}\times\hat{B} = \hat{C}$

$\Rightarrow \vec{B} = \frac{E_0}{c}(-\hat{x}+\hat{y})\sin(kz - \omega t)$

Q.25 (3)
Theoretical

Q.26 (3)

$\vec{B} = 1.2 \times 10^{-7}\sin(0.5 \times 10^3 x + 1.5 \times 10^{11}t)\hat{k}$] T.

Wave is travelling along –x axis and $\vec{B}$ is along + z axis.

$E_0 = cB_0 = 36\frac{V}{m}$

$\vec{E}$ must be along – y axis

Q.27 [10]
Since Resonance,

$\omega_r = \frac{1}{\sqrt{LC}}$

$\therefore \quad 2\pi f = \frac{1}{\sqrt{LC}}$

$\therefore \quad 4\pi^2 \frac{c^2}{\lambda^2} = \frac{1}{LC}$

$\therefore \quad 4\pi^2 \times \frac{9\times10^8\times10^8}{960\times960} = \frac{1}{L\times2.56\times10^{-6}}$

$L = \frac{375\times960}{10^{-6}\times4\times\pi^2\times9\times10^{16}} = \frac{10^3}{10^{10}}$

$= 10^{-7}H = 10\times10^{-8}$

Q.28 (1)

$f = 5\times10^8$ Hz

EM wave is travelling towards $+\hat{j}$

$\vec{B} = 8.0\times10^{-8}\hat{z}T$

$\vec{E} = \vec{B}\times\vec{C} = (8\times10^{-8}\hat{z})\times(3\times10^8\hat{y})$

$-24\hat{x}V/m$

Q.29 (4)

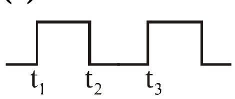
Length of Antena = 25m = $\frac{\lambda}{4}$

$\Rightarrow \boxed{\lambda = 100m}$

Q30 (1)

In EMW, Average energy density due to electric (U_e) and magnetic (U_m) fields is same.

Q31 (3)



For $t_1 - t_2$ Charging graph

$t_1 - t_3$ Discharging graph

Q.32 (6)

$J_c = \frac{E}{\rho} = \frac{V}{\rho d} = \frac{V_0\sin(2\pi ft)}{\rho d}$

$J_d = \frac{I_d}{A}$

$= \frac{1}{A}\frac{dq}{dt} = \frac{C}{A}\frac{dV_c}{dt} = \frac{\varepsilon}{d}\frac{dV_c}{dt}$

$= \frac{80\varepsilon_0}{d}\frac{d}{dt}\left[V_0\sin(2\pi ft)\right]$

$= \frac{80\varepsilon_0}{d}V_0(2\pi f)\left[\cos(2\pi ft)\right]$

Now, according to question

$J_c = 10^x \times J_d$

$\frac{V_0\sin(2\pi ft)}{\rho d} = 10^x\times\frac{80\varepsilon_0}{d}V_0(2\pi f)\cos(2\pi ft)$

$\tan(2\pi ft) = 10^x \times 80\varepsilon_0 \times 2\pi f \times \rho$

$\tan(2\pi ft) = \frac{10^x\times80\times f\times\rho}{2k}$

$\tan\left(2\pi\times900\times\frac{1}{800}\right) = \frac{10^x\times80\times9\times10^2\times0.25}{2\times9\times10^9}$

$\tan\left(\frac{9\pi}{4}\right) = \frac{10^x}{10^6}$

$1 = \frac{10^x}{10^6}$

$10^6 = 10^x$

$x = 6$

Q.33 (3)

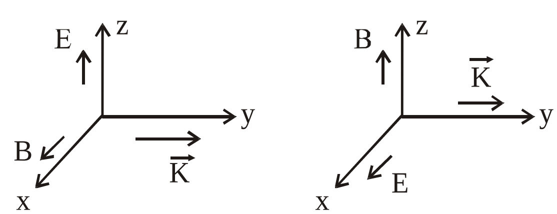
$E = BC = 6$

(Dir. of wave) $\parallel \left(\vec{E}\times\vec{B}\right)$

$\hat{i} = \hat{j}\times\hat{k}$

$\vec{E} = 6\hat{j}$ V/m

Q.34 (3)



Q.35 **(3)**
Q.36 (4)
Q.37 (4)
Q.38 [354]
Q.39 [500]
Q.40 (3)
Q.41 (1)

Speed of wave = $\frac{2\times10^{10}}{200} = 10^8 m/s$

Refractive index = $\frac{3\times10^8}{10^8} = 3$

Now refractive index = $\sqrt{\varepsilon_r\mu_r}$

$3 = \sqrt{\varepsilon_r(1)}$

$\Rightarrow \varepsilon_r = 9$