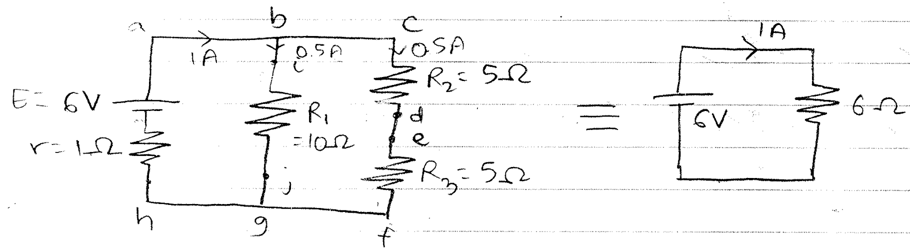
Class-XII

Physics(042)

SECTION - E

34.



a) Points having the same potential are:

i) a, b, c, i

ii) h, g, f, j

iii) d, e

b) $R_{eff} = 6\Omega \Rightarrow I_{tot} = 1A$

Current splits equally between arms bg and cf

$\therefore I_{bg} = 0.5\,A$

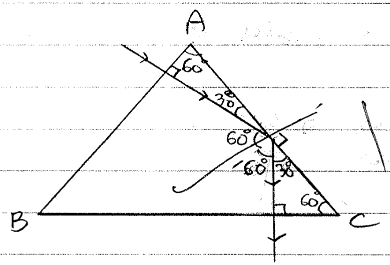
c) $I_{cp} = 0.5\,A = I_3$

$\therefore V_3 = I_3 R_3 = 0.5 \times 5 = 2.5\,V$

The potential difference across resistor R_3 is $\underline{2.5\,V}$

35. $\mu = 2.41$, $i_c = 24.5$

a)



($60° > 24.5°$
$\Rightarrow$ Total internal
reflection occurs)

b) $V = \dfrac{c}{\mu} = \dfrac{3 \times 10^8}{2.41} \simeq \underline{1.245 \times 10^8\,m/s}$

$\log 3 = 0.4771$

$\log 2.41 = 0.382$

$0.4771 - 0.382 = 0.095$

$241\overline{)300}$ = 1.24...
241
590
482
1080
964
160

c) Total internal reflection is the phenomenon in which a ray of light, moving from an optically denser to an optically rarer medium, and incident on the interface of the two media at an angle greater than the critical angle for the pair of media, is reflected back into the same medium entirely.

The two conditions necessary for its occurrence are:

- The ray of light should be moving from a denser medium to a rarer medium.
- The angle of incidence should be greater than the critical angle.

$i > i_c$, where $\sin i_c = \frac{\mu_{rarer}}{\mu_{denser}} \Rightarrow i_c = \sin^{-1}\frac{\mu_r}{\mu_d}$

SECTION - D:

31. a) (i) (1)

INTERFERENCE PATTERN	DIFFRACTION PATTERN
The intensity of the bright fringes is the same for all the maxima.	• The intensity of the bright fringes decreases as the distance from the central maxima increases.
• The ~~cen~~ fringe width of the centl maxima is equal to that of the other maxima/ bright fringes.	• The width of the central maxima is twice that of the secondary maxima.

(2) $\beta = \frac{\lambda D}{d} \Rightarrow \beta \propto \lambda, \ \beta \propto D, \ \beta \propto \frac{1}{d}$

Fringe width in Young's Double Slit Experiment depends on :

- The distance between the two slits, and the distance between the slits and screen.
- The wavelength of light used.

(ii) $d = 100\lambda$

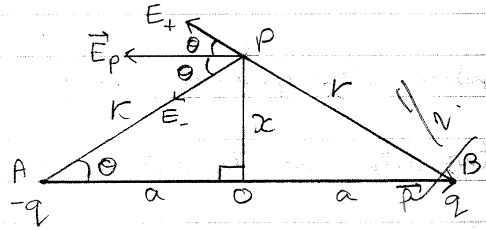
(1) $\theta = \frac{\lambda}{d} = \frac{\lambda}{100\lambda} = \frac{1}{100}$ rad $\left(\because \begin{array}{l} \text{Central maxima} - \theta = 0 \\ \text{First maximum} - \theta = \frac{\lambda}{d} \end{array} \right)$

(2) $D = 50$ cm

Distance between the maxima $= \theta \times D = \frac{1}{100} \times 50$ cm

$= 0.5$ cm or $\underline{5 \text{ mm}}$

32.b)(i)



Consider an electric dipole of dipole moment $\vec{p}$, ~~separated~~ consisting of 2 charges q and -q separated by a distance 2a.

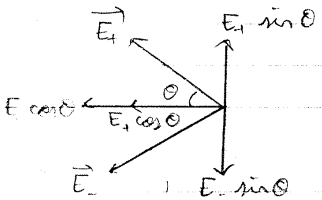
The equitorial ~~line~~ plane is the perpendicular bisector of the dipole.

Consider a point P on the equitorial plane, at a distance x from the midpoint of the dipole O.

$\vec{E}_p = \vec{E}_+ + \vec{E}_-$

$E_+ = E_- = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{r^2}$

Resolving $\vec{E}_+$ and $\vec{E}_-$ into their rectangular components:



The vertical components cancel out, leaving only the horizontal components.

~~$E = E_+ + E_-$~~ $E = E_+ \cos\theta + E_- \cos\theta$

$E_+ = E_- \Rightarrow E = 2E_+ \cos\theta$

From ΔPAO, $\cos\theta = \frac{a}{r}$

$$\therefore E = 2 \times \frac{1}{4\pi\varepsilon_0} \frac{q}{r^2} \times \frac{a}{r} = \frac{(q \cdot 2a)}{4\pi\varepsilon_0 r^3}$$

$p =$ Charge $\times$ distance $= q \times 2a$

Also, from ΔPAO, $r = \sqrt{a^2+x^2}$

$$\therefore E = \frac{p}{4\pi\varepsilon_0 \left(\sqrt{a^2+x^2}\right)^3}$$

$$E = \frac{p}{4\pi\varepsilon_0 (a^2+x^2)^{3/2}}$$

$$\vec{E} = \frac{-\vec{p}}{4\pi\varepsilon_0 (a^2+x^2)^{3/2}}$$

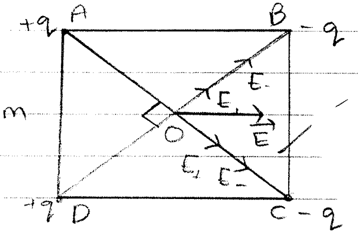
(ii) For a far off point, $x >> a \Rightarrow E = \dfrac{p}{4\pi\varepsilon_0 x^3} \Rightarrow E \propto \dfrac{1}{x^3}$

Distance is halved, i.e, $x \rightarrow \dfrac{x}{2}$

$E - 1/x^3$
$E' - 1/(x/2)^3 = 8/x^3$ $\Rightarrow E' = \dfrac{8}{\cancel{x^3}} \times E \times \cancel{x^3} \Rightarrow E' = 8E$

Electric field will be 8 times its initial value

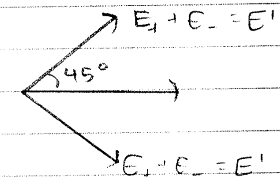
(iii)



$S = \sqrt{2}\,m \Rightarrow AC = BD = \sqrt{2+2} = 2m$

$\therefore AO = BO = CO = DO = 1m$

$E_A = E_B = E_C = E_D = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q}{r^2} = \dfrac{q}{4\pi\varepsilon_0}$



$E' = E_+ + E_- = \frac{2q}{4\pi\varepsilon_0}$

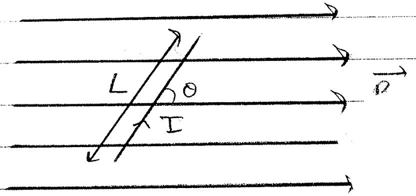
$$E = \sqrt{E'^2 + E'^2 + 2E'^2\cos 90^\circ} = E'\sqrt{2} = \frac{2\sqrt{2}\,q}{4\pi\varepsilon_0}$$

Thus E at O is $\frac{2\sqrt{2}\,q}{4\pi\varepsilon_0}$ or $\frac{\sqrt{2}\,q}{2\pi\varepsilon_0}$ in the direction $\overrightarrow{AB}$

$p = q\cdot 2 \Rightarrow q = \frac{p}{2}$

$\therefore E_0 = \frac{\sqrt{2}\,p}{4\pi\varepsilon_0}$ in $\overrightarrow{AB}$ direction

33. b) (i)



Consider a straight conductor of length L ~~carry~~ carrying current I, placed in a magnetic field $\vec{B}$ at an angle θ to the field.

Let $\vec{f}$ be the force on a single electron.

$\vec{f}_e = -e(\vec{v}_d \times \vec{B})$ (Lorentz force, where e is magnitude of charge of the electron)

$= e(-\vec{v}_d \times \vec{B})$

Summing up the forces on all the electrons, considering N free electrons in the conductor,

$\vec{F} = Ne(-\vec{v}_d \times \vec{B}) = Nev_d(-\hat{v}_d \times \vec{B})$, where $\hat{v}_d$ is the unit vector in the direction of $\vec{v}_d$

$v_d = \frac{I}{neA} \Rightarrow I = neAv_d$, where n is the ~~number~~ free electron density $n = \frac{N}{V}$

$\vec{F} = (nV)ev_d(-\hat{v}_d \times \vec{B}) \Rightarrow \vec{F} = nA\cancel{L}ev_d(-\hat{v}_d \times \vec{B})$

$\vec{F} = IL(-\hat{v}_d \times \vec{B})$ $(\because neAv_d = I)$

$\vec{L}$, is the direction of current, is opposite to $\vec{V_d}$.

$\Rightarrow \hat{L} = -\hat{V_d}$

$\therefore \vec{F} = IL(\hat{L} \times \vec{B})$

$\Rightarrow \vec{F} = I(\vec{L} \times \vec{B})$ ($L\hat{L} = \vec{L}$) , $F = ILB \sin\theta$

→ The rule used to find the the direction of the force is <u>Fleming's Left Hand Rule</u>.

The rule states that "When the thumb, index finger and middle finger of the left hand are stretched such that they are mutually perpendicular, the ~~index~~ middle finger points in the direction of current, the index finger in the direction of the magnetic field, and the thumb in the direction of the force exerted on the current carrying conductor".

→ $F = ILB \sin\theta$

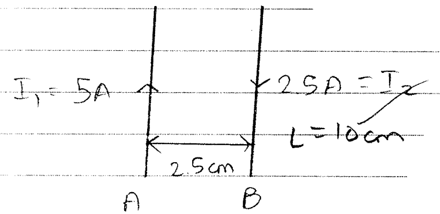
(1) Force is maximum when the conductor is <u>perpendicular</u> to the direction of magnetic field.

$\theta = 90^\circ \Rightarrow \sin\theta = 1 \Rightarrow F = ILB$

(2) Force is minimum when the conductor is <u>parallel</u> to the direction of magnetic field.

$\theta = 0^\circ \Rightarrow \sin\theta = 0^\circ \Rightarrow F = 0$

(ii)



$$|\vec{F}| = BIL = \frac{\mu_0 I_1}{2\pi r} \times I_2 \times L = \frac{\cancel{4}^{2}\cancel{\pi} \times 10^{-7} \times 5 \times \cancel{2.5} \times \cancel{10^{-1}}^{10}}{\cancel{2\pi} \times \cancel{2.5} \times \cancel{10^{-2}}} = 10^{2} \times 10^{-7} = \underline{10^{-5}\,N}$$

SECTION - C

26. $V_m = 310V,\ f = 50Hz$

$\omega = 2\pi f \Rightarrow \omega = 2\pi \times 50 = 100\pi$ rad/s

$V = 310 \sin 100\pi t$ V

$C = 15\mu F$

(i) $X_C = \dfrac{1}{\omega C} = \dfrac{1}{100\pi \times 15 \times 10^{-6}} = \dfrac{10^4}{15\pi} = 212.3\,\Omega$

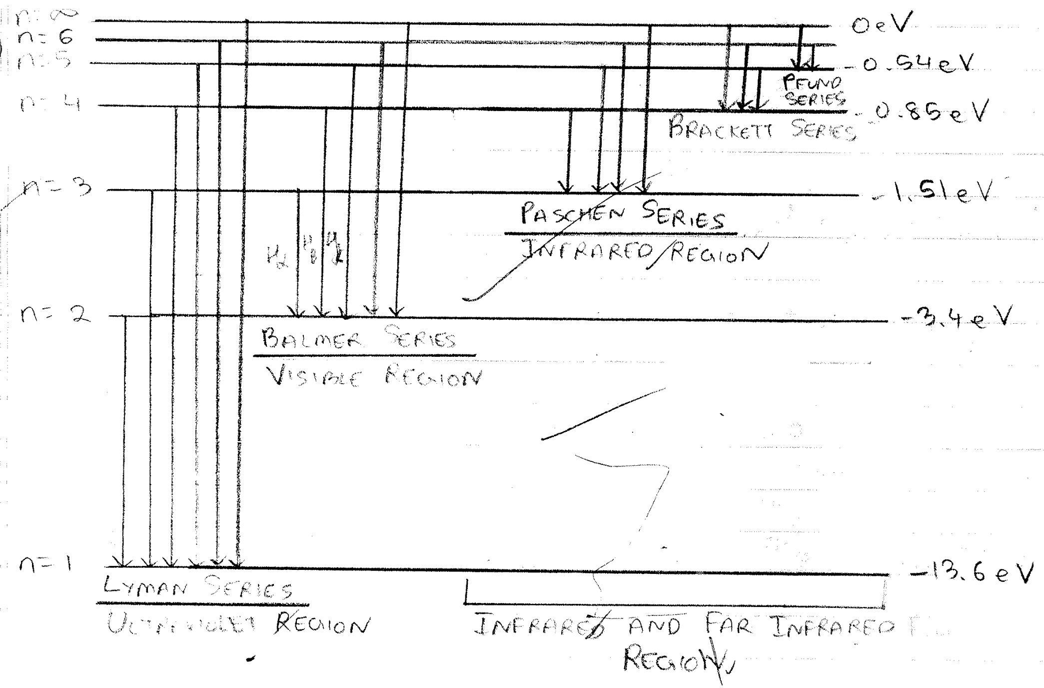
(ii) $I_m = \dfrac{V_m}{X_C} = \dfrac{310 \times 15\pi}{10^4} = \dfrac{465\pi}{1000}$ A $= 0.465\pi$ A $= 1.46$ A

→ Current in a capacitor leads the voltage by $\frac{\pi}{2}$

$I = 0.465\pi \sin(100\pi t + \frac{\pi}{2})$ A

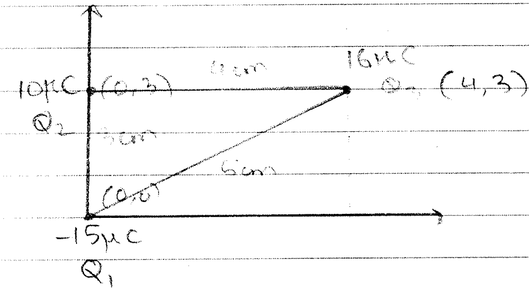
$I = \underline{0.465\pi \cos 100\pi t \ A}$ or ~~0.465 x 3.14 cos 314t~~ $\underline{1.46 \cos 314t \ A}$

27. a)



28.

Distances in cm



$$U = U_{Q_1Q_2} + U_{Q_2Q_3} + U_{Q_1Q_3}$$

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1q_2}{r_{12}} + \frac{q_2q_3}{r_{23}} + \frac{q_1q_3}{r_{13}}\right)$$

$$= \frac{1}{4\pi\varepsilon_0}\left(\frac{-15\times10^{-6}\times10\times10^{-6}}{3\times10^{-2}} + \frac{10\times10^{-6}\times16\times10^{-6}}{4\times10^{-2}} + \frac{-15\times10^{-6}\times16\times10^{-6}}{5\times10^{-2}}\right)$$

$$= \frac{9\times10^{9}\times10^{-12}}{10^{-2}}\left(-50+40-48\right)$$

$= 9 \times 10^{-1} \times -58 = \cancel{-52.2N} -52.2\ J$

$\therefore$ U of system $= -52.2\ J$

$\frac{1}{2}$

29.b) At resonance, I_m is maximum.

$I_m = \frac{V_m}{Z} \Rightarrow Z$ should be minimum

$Z = \sqrt{R^2 + (X_L - X_C)^2}$, Z will be minimum when $X_L = X_C$, i.e, $Z_{min} = R$

$\therefore X_L = X_C$

$L\omega_0 = \frac{1}{C\omega_0} \Rightarrow \omega_0^2 = \frac{1}{LC}$

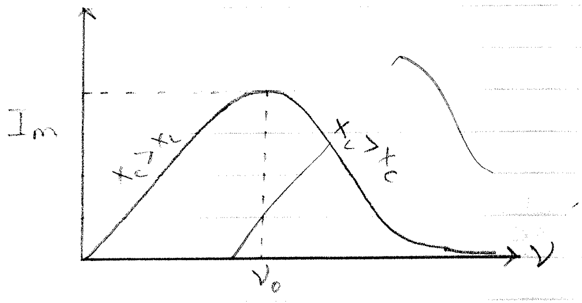
$\omega_0 = \frac{1}{\sqrt{LC}}$, where ω_0 is the resonant ~~fre~~ angular frequency

$\nu = \frac{\omega}{2\pi} \Rightarrow \nu_0 = \frac{1}{2\pi}\frac{1}{\sqrt{LC}} \Rightarrow \nu_0 = \frac{1}{2\pi\sqrt{LC}}$, where ν_0 is the resonant frequency

→ ν_0 (resonant frequency) depends on :

- Inductance of the inductor
- Capacitance of the capacitor

→



30. $\lambda_{db} = 1.2\,nm$, $KE \rightarrow 4\,KE$

$$\lambda_{db} = \frac{h}{p} = \frac{h}{\sqrt{2mKE}} \Rightarrow \lambda_{db} \propto \frac{1}{\sqrt{KE}}$$

$$\lambda - 1/\sqrt{KE}$$
$$\lambda' - 1/\sqrt{4KE} = 1/2\sqrt{KE} \Rightarrow \lambda' = \frac{1}{2\cancel{\sqrt{KE}}} \times \lambda \times \cancel{\sqrt{KE}} = \frac{\lambda}{2}$$

$$\therefore \lambda'_{db} = \frac{\lambda}{2} = \underline{0.6\,nm}$$

SECTION - B

19. $R_1 = 20\,cm$, ~~$R_2 = \frac{29}{87}$~~ $R_2 = 30\,cm$, $P = \frac{25}{6}\,D \Rightarrow f = \frac{6}{25}\,m = \frac{6}{\cancel{25}} \times \overset{4}{\cancel{100}}\,cm = 24\,cm$

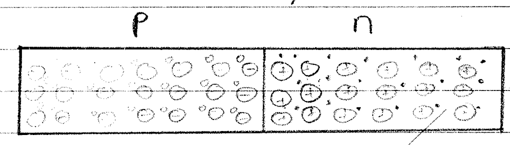
$$\frac{1}{f} = (\mu_g - 1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$ 4/N

$$\frac{1}{24} = (\mu_g - 1)\left(\frac{1}{20} + \frac{1}{30}\right) \Rightarrow \frac{1}{24} = (\mu_g - 1)\left(\frac{5}{60}\right)$$

$$\mu_g - 1 = \frac{\cancel{60}^{12}}{\cancel{5}} \times \frac{1}{24} = \frac{1}{2} \Rightarrow \mu_g = 1 + \frac{1}{2} = \frac{3}{2}$$

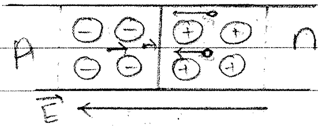
$\therefore$ The refractive index of the glass is $\frac{3}{2}$ or 1.5

20.

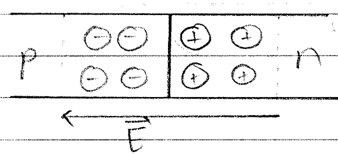


In a p-n junction the p-side has an excess of holes and the n-side has an excess of electrons. Due to this concentration gradient these majority charge carriers diffuse to the other side. The diffusing holes and electrons recombine at the junction, depleting the number of charge carriers near the junction as a result of the diffusion current.

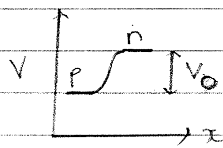
The immobile donor and acceptor ions remain, and create an electric field due to the absence of the majority charge carriers.



The electric field created is in the $n \to p$ direction. As a result, the minority charge carriers experience a force and move ~~to wa~~ towards the junction and recombine. This depletes all the charge carriers near the junction, creating a depletion region. This movement of the minority charges due to the electric field constitutes the drift current.



The electric field leads to the creation of a potential barrier, which makes it difficult for majority charge carriers to move to the other side of the junction.



21. $\vec{v} = (3\times10^5\,\hat{i})\ m/s$, $\vec{B} = \cancel{0.4\hat{i}} + (0.4\hat{i} + 0.3\hat{j})\ T$, $\frac{q}{m} = 4.8\times10^7\ C/kg$

$$\vec{F} = q(\vec{v}\times\vec{B}) \Rightarrow \vec{a} = \frac{\vec{F}}{m} = \frac{q}{m}(\vec{v}\times\vec{B})$$

$$\vec{a} = 4.8\times10^7\ \left((3\times10^5)\hat{i}\times(0.4\hat{i}+0.3\hat{j})\right)$$

$$= 4.8\times10^7\times3\times10^5\times0.3\ \hat{k} \quad (\because \hat{i}\times\hat{i}=0,\ \hat{i}\times\hat{j}=\hat{k})$$

$$\vec{a} = (4.32\times10^{12}\,\hat{k})\ m/s^2$$

$$\begin{array}{r} {}^{7}4.8 \\ 9 \\ \hline 43.2 \end{array}$$

22. $-1.51\,eV$ - $n=3$

$\downarrow$

$-3.4\,eV$ - $n=2$

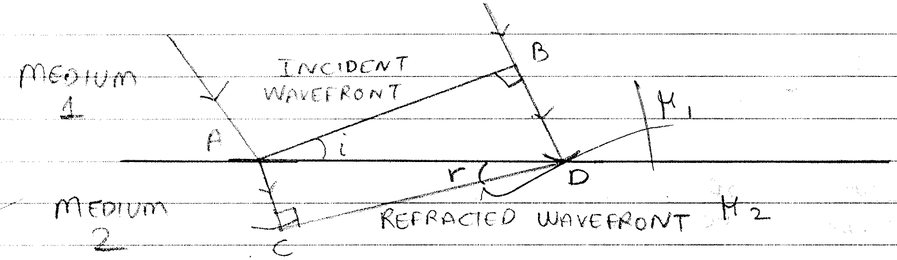
$$\frac{1}{\lambda} = R\left(\frac{1}{2^2}-\frac{1}{3^2}\right) = R\left(\frac{1}{4}-\frac{1}{9}\right) = \frac{5R}{36}$$

$$\lambda = \frac{36}{5} \times \frac{1}{R} = \frac{36}{5} \times 911\ \text{Å} = (7.2 \times 911)\ \text{Å}$$

$$\lambda = 6559.2\ \text{Å} = \underline{655.92\ \text{nm}}$$

$$\begin{array}{r} 911 \\ \times 72 \\ \hline 1822 \\ 63770 \\ \hline 6559.2 \end{array}$$

23.a)



By Huygen's principle, the new wavefront is the forward surface tangent/envelope of the secondary wavelets.

→ Let the refractive index in the first medium be μ_1 and that in the second medium be μ_2. The speed of light in the former is V_1, and in the latter is V_2.

The distances AC and BD are traversed in the same time t

$AC = V_2 t, \quad BD = V_1 t$

In ΔABD, $\sin i = \dfrac{BD}{AD}$

In ΔACD, $\sin r = \dfrac{AC}{AD}$

$$\frac{\sin i}{\sin r} = \frac{BD/AD}{AC/AD} = \frac{BD}{AC} = \frac{V_1 t}{V_2 t} = \frac{V_1}{V_2}$$

$$\frac{\sin i}{\sin r} = \frac{V_1}{V_2}$$

By definition, $\dfrac{\mu_2}{\mu_1} = \dfrac{v_1}{v_2}$ $\left(\because \mu_2 = \dfrac{c}{v_2}, \ \mu_1 = \dfrac{c}{v_1}\right)$

$$\therefore \frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1}$$

Hence Snell's Law is verified

24. a) ~~Microwaves~~

Use: ~~RADAR navigation systems~~

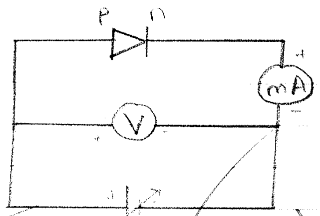
a) Infrared

Use: Remotes and switches
Cameras in mist / fog conditions

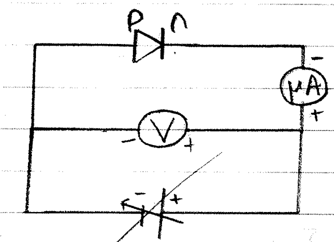
b) X-rays

Use: Diagnostic tool in medicine, studying crystal structure

25. b)



FORWARD BIAS



REVERSE BIAS

- VARIABLE BATTERY

V - VOLTMETER

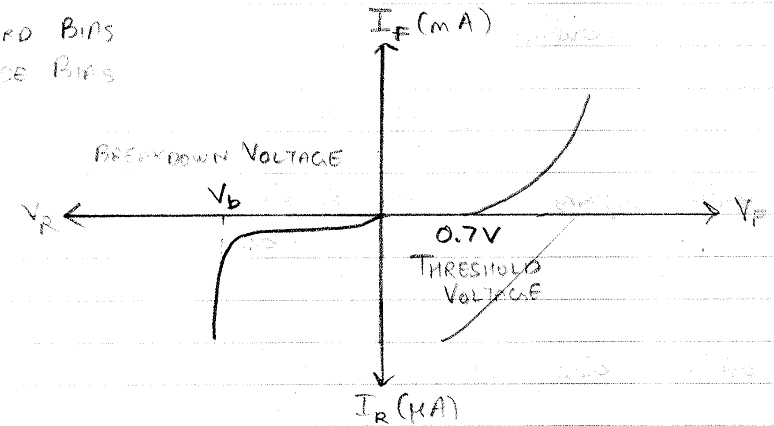
mA - MILLIAMMETER

μA - MICROAMMETER

- DIODE

These are the circuits used for studying a diode's V-I characteristic

F- FORWARD BIAS
R- REVERSE BIAS



SECTION - A

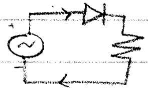
1. d) 0.01 eV

2. $J = \frac{I}{A}$, A increases $\Rightarrow$ J decreases, $J = nev_d \Rightarrow J \propto v_d \Rightarrow v_d$ decreases

$$\frac{I}{neA} = v_d \Rightarrow v_d \propto \frac{1}{A}$$

$\therefore$ a)

3. c)



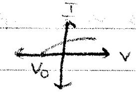
Current only passes in one direction (during +ve half cycle)
(-ve half cycle - no I)

4. $n=1 \rightarrow n=5$; $\frac{1}{\lambda} = R\left(\frac{1}{1^2} - \frac{1}{5^2}\right) = \frac{24}{25}R \Rightarrow \lambda = \frac{25}{24} \times 911\,\text{Å} = \frac{25}{24} \times 91.1\,\text{nm}$

d) 95nm

5 c) $\varepsilon_0 \frac{d\phi_E}{dt}$ $\left(\because \frac{d\phi_E}{dt} = \frac{1}{\varepsilon_0}\cdot\frac{dq}{dt} = \frac{I}{\varepsilon_0}\right)$

6. E_1 $h\nu = 7.5\,eV$, $KE = 4.5\,eV \Rightarrow \phi_0 = h\nu - KE = 3\,eV$



a) 3.0 eV

7. $e_{max} = NAB\omega = \cancel{40} \times \cancel{\pi} \times 64 \times \cancel{10^{-4}}^{\,10^{-1}} \times 3 \times 10^{-2} \times \frac{25}{\cancel{\pi}} = 192 \times 10^{-3} = 0.192\,V$

c) 0.19V

8. d) 1 : 1 (Nuclear density is a constant)

9. b) $\frac{\vec{F}}{8}$ $\left(\because E \propto \frac{1}{r^3} \text{ in short dipole}, \; r \to 2r \Rightarrow E \to \frac{E}{8} \right)$

10. $\frac{dN}{dt} = 3.3 \times 10^{19}$, $I = \frac{dq}{dt} = e\frac{dN}{dt} = 3.3 \times 10^{19} \times 1.6 \times 10^{-19} = 5.28\ A$

d) 5.3 A

11. b) it becomes a p-type semiconductor

12. a) repelled by both the poles

13. d) Diamond to air $(\mu_d > \mu_g > \mu_w > \mu_a)$, $\left(\sin i_c = \frac{\mu_r}{\mu_d} \Rightarrow i_c \downarrow, \frac{\mu_d}{\mu_r} \uparrow \right)$

14. c) less than g (Induced current creates a magnetic field opposing change in flux)

15 ~~$R = \frac{\rho A}{L} \Rightarrow R \alpha A \Rightarrow R \alpha r^2$~~ $R = \frac{\rho L}{A} \Rightarrow R \alpha \frac{1}{A} \Rightarrow R \alpha \frac{1}{r^2}$

c)

16. b) A & R are true but R is not the correct explanation of A.

17. ~~a) A is true but R is~~ d) A is false and R is also false (copper is diamagnetic and repels field lines)

18. a) A & R are true and R is the correct explanation of A.

— X —