PHYSICS - 042

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SECTION-A:

1. (C) 300%

2. (A) $\frac{L}{2}$

3. (A) Drift velocity.

4. (C) $\frac{m_1}{m_2} < \frac{q_1}{q_2}$

5. (A) Infrared region.

6. (D) decrease by 50% of it's initial value.

7. (C) depletion region.

8. (C) $1.5 \times 10^{-4}\ A\,m^2$

9. (C) 0 and 10.

$\cancel{100} = \frac{\cancel{\text{or}}\ l' - l}{\cancel{R}\ l} \times \cancel{100}$

$\cancel{R' - R = R}$

$l' - l = l \qquad R = \frac{\rho l}{A}$

$l' = 2l.$

$l' A' = l A \qquad R' = \frac{\rho 2 l \times 2}{A}$

$2\cancel{l} A' = \cancel{l} A$

$A' = \frac{A}{2} \qquad R' = \frac{4\rho l}{A} = 4R$

$\frac{R' - R}{R} \times 100 = \frac{4R - R}{R} \times 100$

$\frac{3\cancel{R}}{\cancel{R}} \times 100$

$\frac{\mu_0 N^2 A}{l} \qquad \mu_0 n^2 A l$

$\frac{\mu_0 N^2 A \cancel{l}}{\cancel{l}\ \cancel{A}\ l}$

$\frac{m_1 \cancel{v}}{q_1 \cancel{B}} < \frac{m_2 \cancel{v}}{q_2 \cancel{B}}$

$\frac{m_1}{q_1} < \frac{m_2}{q_2} \qquad \frac{m_1}{m_2} < \frac{q_1}{q_2}$

Space for writing Question Number

10. (B) $2\times10^{8}\ ms^{-1}$

11. (B) Only Mo will not show photoelectric emission.

12. (B) maximum kinetic energy of photoelectrons will remain the same.

13. (D) Both (A) and (R) are false.

14. (A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

15. (C) Assertion (A) is true and Reason (R) is false.

16. (D) Both Assertion (A) and Reason (R) are false.

$K' = 4K$ $\quad 300\times10^{-6}$

$K = \frac{p^2}{2m}$ $\quad 3\times10^{-4}$

3.75.

$p = \sqrt{2mK}$

$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}}$

$\lambda \propto \frac{1}{\sqrt{K}}$ $\quad \lambda' = \frac{h}{2\sqrt{2mK}} = \frac{\lambda}{2}$

$\frac{\frac{\lambda}{2}-\lambda}{\lambda}\times100 = \frac{-\frac{\lambda}{2}}{\lambda}\times100$

$\mu = NIA = 100\times3\times10^{-4}\times5\times10^{-3}$

$1.6\overline{)60}$ 3.75

48

120

$15\times10^{-3+2-4}$

$\frac{2V_0}{\pi}$ 112 1.5×10^{-4}

$\frac{2\times14\times7}{22}$ 11

$11\overline{)14}$ 1.2

11

30

22

-19

$\frac{E}{B} = \frac{3\times10^{8}}{1.5}$ 2

~~313×~~

331×10^{-9} $\quad \frac{6.6\times10^{-34}\times3\times10^{8}}{3.3\times10^{-7}}$ 2

$\frac{6\times10^{-19}}{}$

4

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SECTION-B:

17. (a) Huygen's principle states that:

- Each point on a wavefront is a source of secondary disturbance which emanate and ~~spread~~ out with the speed of the wave. These wavelets are called secondary wavelets.
- If we draw a common tangent to all the spheres, we get the position of the new wavefront at a later ~~to~~ time.

Huygen stated the amplitude of the forward wave is maximum and backwave is zero since energy cannot travel backwards, to the source, ~~and~~ in order to justify the absence of a backwave on a spherical wavefront.

18. $n_i = 5 \times 10^{8}\ m^{-3}$

~~n_e~~ After doping, $n_e = 4 \times 10^{12}\ m^{-3}$

Space for writing Question Number

$$n_h = \frac{n_i^2}{n_e}$$

$$= \frac{5 \times 5 \times 10^{16}}{4 \times 10^{12}}$$

$$n_h = 6.25 \times 10^4 \ m^{-3}.$$

∴ new value of the hole concentration = $6.25 \times 10^4 \ m^{-3}$.

$\because n_e >> n_h$, it is a pentavalent impurity.

The type of semiconductor is n-type semiconductor.

19. $m = -2$ (Magnification). $R = -16$ cm

$\frac{-v}{u} = +2$ $\therefore f = \frac{R}{2} = \frac{-16}{2} = -8$ cm.

$v = 2u$

Using the mirror formula: $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$$\begin{array}{r} 6.25 \\ 5\overline{)95} \\ -24 \\ \hline 10 \\ 8 \\ \hline 20 \end{array}$$

$$\frac{-1}{24} - \frac{1}{12}$$

$$\frac{-1-2}{24}$$

$$\frac{-3}{24}$$

6

Space for writing Question Number

$$\frac{1}{2u} + \frac{1}{u} = \frac{-1}{8}$$

$$\frac{1}{2u} + \frac{2}{2u} = \frac{-1}{8}$$

$$\frac{3}{2u} = \frac{-1}{8}$$

$$-\frac{3}{2} \times \overset{4}{8} = u$$

$$u = -12 \text{ cm}.$$

∴ The object is placed at a distance of 12 cm from the ~~mir~~ pole of the mirror.

20. To prove: density of nuclear matter is same for all nuclei.

Proof: Consider a nucleus of mass number A and Radius R.

∴ Radius of the nucleus is related to A, as $R = R_0 A^{1/3}$ where R_0 is a constant.

Space for writing Question Number

$$\text{Density} = \frac{\text{Mass}}{\text{Volume}}$$

Mass of given nucleus $= m_n A$, where m_n is mass of individual nucleon and is a constant for all matter.

$$\text{Volume} = \frac{4}{3}\pi R^3 = \frac{4}{3} \times \pi \times R_0^3 A$$

$$\therefore \text{Density} = \frac{m_n \cancel{A}}{\frac{4}{3}\pi R_0^3 \cancel{A}} = \frac{3m_n}{4\pi R_0^3}, \text{ which is a constant.}$$

∴ Density of nuclear matter is same for all nuclei.

21. Given: $q = 10^{-6}\,C$

$2a = 10 \times 10^{-2}\,m = 10^{-1}\,m.$

$E = 100\,N/C.$

$p = 2aq = 10^{-1} \times 10^{-6} = \underline{10^{-7}\,C\,m.}$

8

Space for writing Question Number

$W = pE(\cos\theta_i - \cos\theta_f)$

Here $\theta_i = 0^\circ$ & $\theta_f = 180^\circ$

$W = pE(1 - (-1))$

$W = 2pE$

$W = 2 \times 10^{-7} \times 10^2$

$W = 2 \times 10^{-5}$ J

$\therefore$ 2×10^{-5} J of work has to be done in ~~rotating~~ turning the dipole from a position of stable equilibrium to the position of unstable equilibrium.

SECTION-C :

~~22 (b) (i) $\epsilon = d\phi$ $\phi = B \cdot A$~~

Space for writing Question Number

22. (a) (i) Let $\vec{B}_1$ and $\vec{B}_3$ be net magnetic field at a point on conductors ① due to ~~wires B 2~~ long parallel conductors ② and ③.

$\vec{B}_2 = \frac{\mu_0 I}{2\pi d} \hat{k}$ (out of the plane of the paper).

$\vec{B}_3 = \frac{\mu_0}{2\pi} \times \frac{3I}{2d} (-\hat{k})$ (into the plane of the paper).

~~B_I~~ net magnetic field : $\vec{B}_{net}$ at a point on conductor ①.

$$\vec{B}_{net} = \left[-\frac{3\mu_0 I}{4\pi d} + \frac{2\mu_0 I}{4\pi d} \right] \hat{k}$$

$$\boxed{\vec{B}_{net} = -\frac{\mu_0 I}{4\pi d} \hat{k}}$$ (direction : into the plane of the paper).

(ii) ~~Let~~ Let $\vec{F}_1$ be the net magnetic force acting on unit length of the conductor ① due to conductors ② and ③.

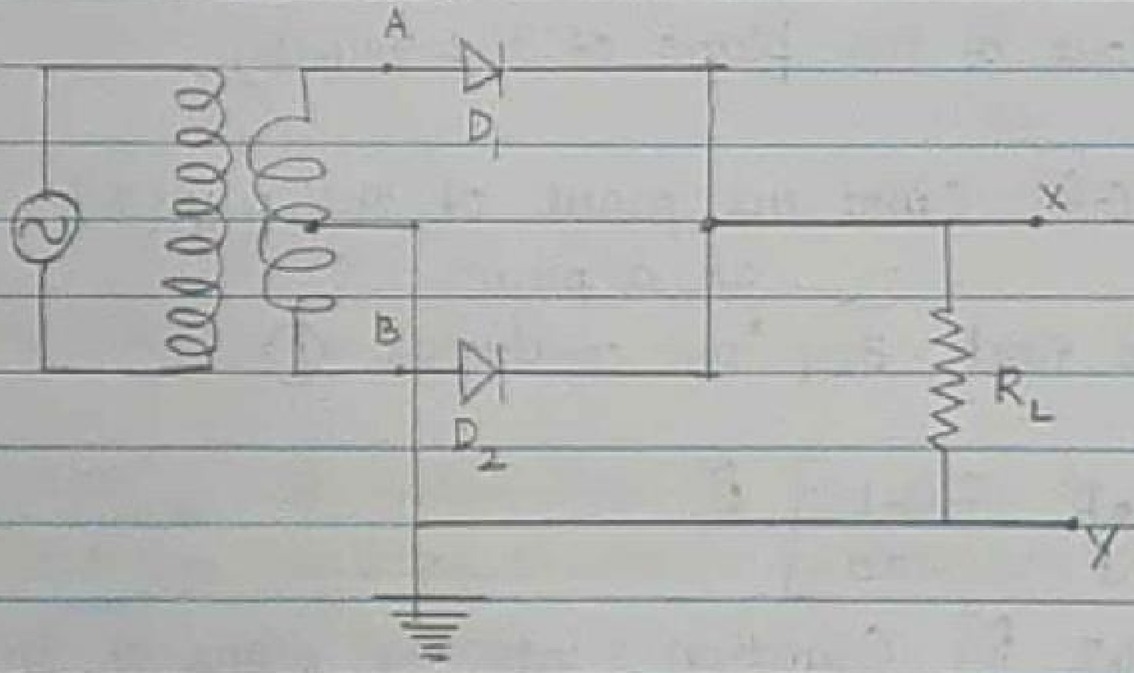
$$\vec{F}_1 = \frac{\vec{B}_{net}\, l \sin\theta}{l} = \frac{\mu_0 I}{4\pi d} \times 2I \times (1) = -\frac{2\mu_0 I^2}{4\pi d} \hat{j}$$

10

Space for writing Question Number

∴ Net magnetic force on conductor (1) per unit length is $\frac{\mu_0 I^2}{2\pi d}\hat{j}$, (away from both the wires)

23.



~~When~~ A rectifier uses the property of the p-n junction diode to conducts only when it is forward biased.

Each Diode conducts for only half the AC cycle.

When potential at A is greater, than potential at B, only diode D_1 conducts. This is because only diode D_1 is forward

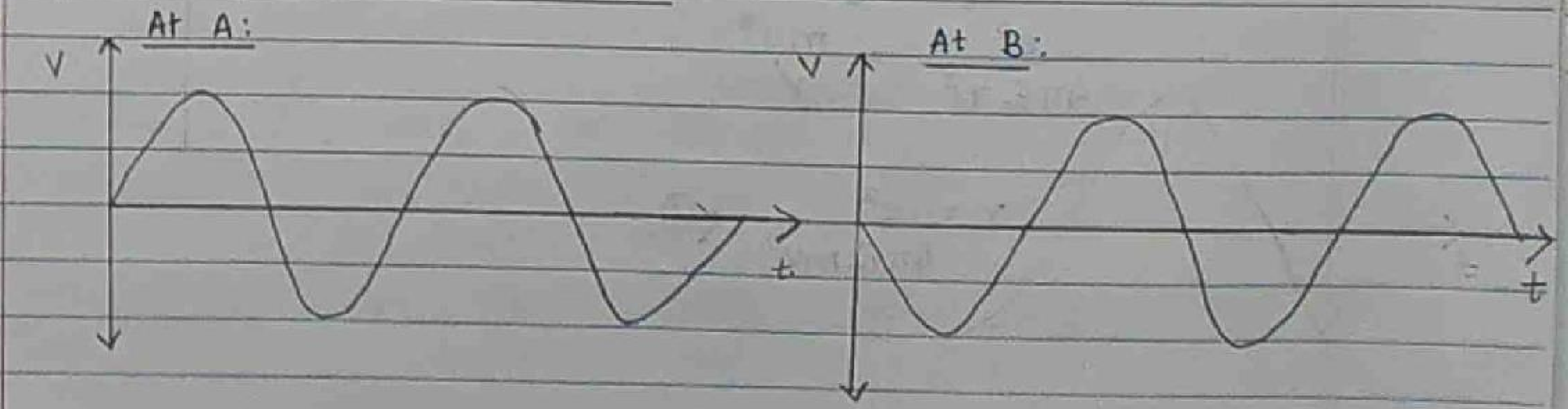
biased, and B being at a negative potential, diode D_2 is reverse biased.

Thus only diode D_1 conducts during the positive half of the cycle.

During the second half, when B is at positive potential with respect to A, the Diode D_2 is forward biased, while diode D_1 is ~~not~~ reverse biased and hence only diode D_2 conducts.

The voltage obtained is still in the form of pulses, however, it is limited to one-direction only and hence it is said to be rectified.

Input waveforms at A and B:



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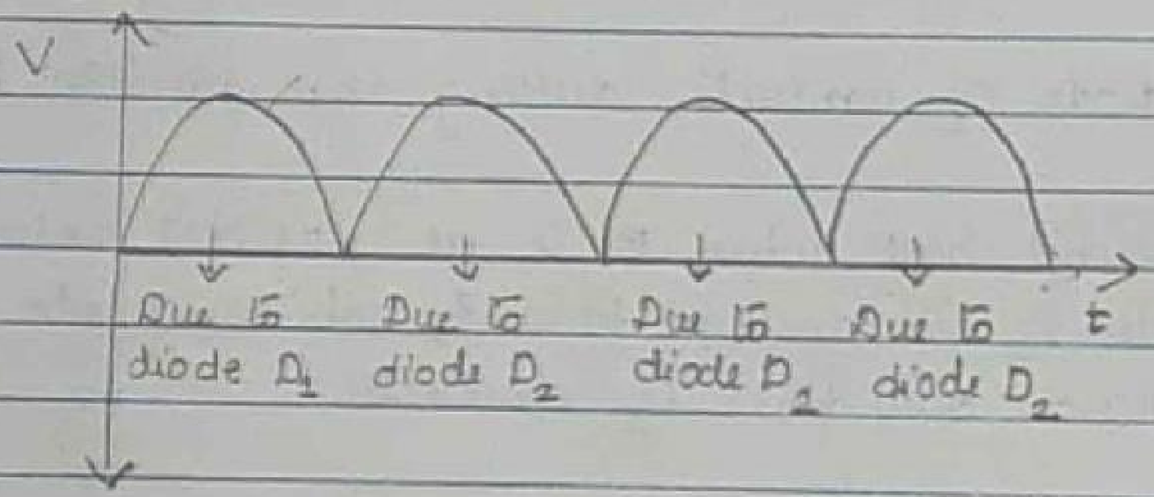
Output waveform (across R_L)



24. (a) The centripetal force is provided by the electrostatic force of attraction.

$$\therefore F_e = F_c$$

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

$$r = \frac{e^2}{4\pi\varepsilon_0 mv^2} \quad -(1)$$

Space for writing Question Number

According to Bohr's second postulate:

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

For innermost orbit, $n = 1$.

$$\therefore v = \frac{nh}{2\pi mr} = \frac{h}{2\pi mr} \quad -①$$

Inserting value of v from ① in ②:

$$r = \frac{e^2}{4\pi\varepsilon_0 m \left(\frac{h}{2\pi mr}\right)^2}$$

$$r = \frac{e^2}{4\pi\varepsilon_0} \times \frac{1}{m} \times \frac{4\pi^2 m^2 r^2}{h^2}$$

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

$$r = \left(\frac{h}{2\pi}\right)^2 \times \frac{4\pi\varepsilon_0}{me^2} \quad -③$$

Space for writing Question Number

~~∴ r = 0.529 Å~~

Substituting the values in ③.

$$r = \left(\frac{6.626 \times 10^{-34}}{2 \times 3.14}\right)^2 \times \frac{1}{(1.6 \times 10^{-19})^2 \times 9 \times 10^9 \times 9.1 \times 10^{-31}}$$

$$\therefore \boxed{r = 0.529\ \text{Å}}$$

24. (b) $$v = \frac{h}{2\pi m r} = \frac{6.626 \times 10^{-34}}{2 \times 3.14 \times 9.1 \times 10^{-31} \times 5.29 \times 10^{-11}}$$

$$v = \frac{6.626 \times 10^{-34}}{302.31292 \times 10^{-42}}$$

$$= \frac{6.626 \times 10^{-34}}{3.02313 \times 10^{-40}}$$

$$\boxed{v = 2.19 \times 10^6\ m/s}$$

2.8
5.29
× 91
529
476 10
48139

48.139
× 2
96278
× 3.14
385112
962780
2888340
302.31292

2.19
302) 6.62
604
580
302
2780

Space for writing Question Number

25. (a) The de Broglie relation relates the wave nature of matter ie. (wavelength) to the particle nature of matter ie momentum using the ~~plan~~ Planck's constant.

- It shows us that matter waves also exist.
- It shows us that matter has both particle and wave nature.

h

The de Broglie's relation is as specified below:

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

(b) $\phi_0 = 0$ (Work Function).

$\therefore K_{max} = h\nu$ ($\because \phi_0 = 0$), where K is the kinetic energy of emitted electrons.

$\therefore K = \frac{hc}{\lambda}$ — ①

Also, $K = \frac{p^2}{2m}$ — ②

From ① & ②: $\frac{hc}{\lambda} = \frac{p^2}{2m} \Rightarrow p^2 = \frac{2mhc}{\lambda} \Rightarrow p = \sqrt{\frac{2mhc}{\lambda}}$

Space for writing Question Number

de Broglie

Let λ_e be the wavelength of emitted electrons.

According to de Broglie's relation:

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

$$\lambda_e = \frac{h}{\sqrt{2mhc}} \times \sqrt{\lambda}$$

$$\lambda_e = \sqrt{\frac{h\lambda}{2mhc}}$$

∴ ~~We Debro~~

∴ de Broglie's wavelength of emitted electrons = $\sqrt{\frac{\lambda h}{2mc}}$

Space for writing Question Number

or waves

26. • Microwaves are electromagnetic radiations that lie second in the electromagnetic spectrum, arranged in order of increasing frequency. They have a wavelength of 0.1m to 10^{-3}m. They are detected by point contact diodes.

• Their frequencies lie in the range of 10^9 to 10^{11} Hz.

• They are produced in Klystron ~~not~~ valves or Magnetron ~~valves~~ valves and in vacuum tubes. (Acceleration of charges).

• USES:

1. Microwaves are used in microwave ovens to warm food. The frequency of microwave is so selected that it matches the frequency of water molecules, so that transfer of kinetic energy, can take place efficiently. Thus food containing water molecules can be easily heated.

2. They are used in RADAR systems.

Space for writing Question Number

· They are used to study the internal structure of an atom.

27. (a) $\Delta Q = I\Delta t$

∴ Total charge that passed through the loop = Area under the given graph.

$$\therefore \Delta Q = \frac{1}{2} \times 0.3 \times \overset{0.3}{\cancel{0.6}}$$

$$= 3 \times 3 \times 10^{-2} \text{ C}$$

$$\therefore \underline{\Delta Q = 9 \times 10^{-2} \text{ C}}$$

$\therefore \underline{9 \times 10^{-2}\ C}$ of charge passed through the loop.

(b) Change in magnetic flux $\Delta\phi$ is related to ΔQ as:

$$\Delta Q = \frac{\Delta\phi}{R}$$

$$\Delta\phi = \Delta Q \times R$$

$$= 9 \times 10^{-2} \times 4$$

Space for writing Question Number

$\Delta\phi = 36 \times 10^{-2}$ Wb.

$\therefore$ $\underline{\Delta\phi = 0.36 \text{ Wb}}$

Change in magnetic flux = $\underline{0.36 \text{ Wb}}$.

27.

(C) ~~B A~~ $\because$ The loop is removed entirely, $\Delta\phi = \phi_i$.

$\therefore$ $\phi_i = 0.36$.

$\phi_i = BA \cos\theta$.

$\because$ $\vec{B}$ and $\vec{A}$ are along the same line. ie $\theta = 0$.

$\phi_i = B.A$

$0.36 = B \times 5 \times 10^{-4}$

$\frac{0.36 \times 2 \times 10^4}{5 \times 2} = B$

$\underline{B = 7.2 \times 10^2 \text{ T}}$

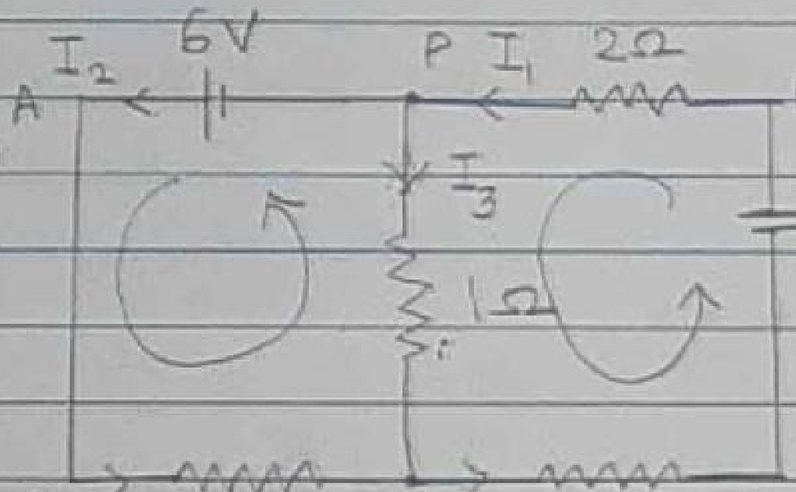
28. (a) ~~Law of~~ Kirchoff's Voltage Law or Loop Rule is based on law of conservation of energy.

Kirchoff's Current Law or ~~Vt~~ Junction Rule is based on law of conservation of charge.

20

Space for writing Question Number

28. (b)



Applying junction rule at P:

$$I_1 = I_2 + I_3 \quad -①$$

$$I_2 = I_1 - I_3 \quad -③$$

Applying ~~Volta~~ loop rule

To loop BPQCB:

$$2I_1 + I_3 + 3I_1 = 9$$

$$5I_1 + I_3 = 9 \quad -②$$

Applying loop rule to loop ~~PA~~ ADQPA

$$3I_2 - I_3 = 6 \quad -①$$

① + ②:

$$5I_1 + I_3 = 9$$

$$3I_2 - I_3 = 6$$

$$5I_1 + 3I_2 = 15$$

Substituting ③ in ①

$$3(I_1 - I_3) - I_3 = 6$$

Space for writing Question Number

$3I_1 - 3I_3 - I_3 = 6$

$3I_1 - 4I_3 = 6 \quad -(4)$

~~Mutli~~ Multiplying (2) by 4: $20I_1 + 4I_3 = 36 \quad -(5)$

(4) + (5):

$$\begin{array}{r} 3I_1 - 4I_3 = 6 \\ +\ 20I_1 + 4I_3 = 36 \\ \hline 23I_1 = 42 \end{array}$$

$$I_1 = \frac{42}{23} \text{ A.}$$

$3I_1 - 4I_3 = 6$

$3 \times \frac{42}{23} - 4I_3 = 6$

$\frac{126}{23} - \frac{138}{23} = 4I_3$

$-\frac{12}{23} = 4I_3$

4

42	23
× 3	× 6
126	138
	126
	12

Space for writing Question Number

$\therefore I_3 = \frac{-3}{23}$ A

The minus sign indicates direction of current is opposite to what we assumed.

$\therefore I_3 = \frac{3}{23}$ A from Q to P.

Current through the 1 Ω resistor is $\frac{3}{23}$ A from Q to P.

SECTION - D :

29. (i) (B) real, virtual

In case of normal adjustment : (D) real, real.

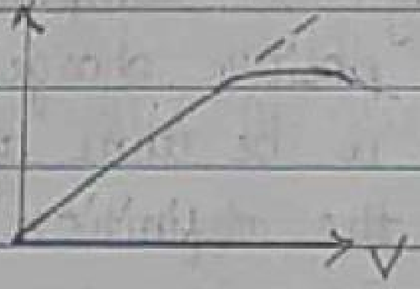
2 (ii) (D) apertures of objective lens.

(iii) (C) The distance between two lenses is more than ($f_o + f_e$)

Space for writing Question Number

(iv) (a) (A) 84 cm.

(iv) (b) (D) 20.

30. (i) (c) 

(ii) (c) equal to the sum of error in voltmeter reading and error in ammeter reading.

(iii) (B) readings in both voltmeter and ammeter increase.

~~(iv) (D) $V_1 = V_2 = V_3$~~

(iv) (a) (B) $V_2 > V_3 > V_1$.

(b) (C) $E_2 > E_3 > E_1$.

Space for writing Question Number

SECTION-F :

31. (a) (i) (I) If the electric field were not normal to the equipotential surface, it would have some tangential component along the surface. Hence to move a unit positive charge along the surface, some work would have to be done against the ~~charge~~ field, which contradicts the definition of equipotential surface, ie ~~the~~ no work is to be done to move a charge along it as all points, are ~~on~~ at the same potential.
on it

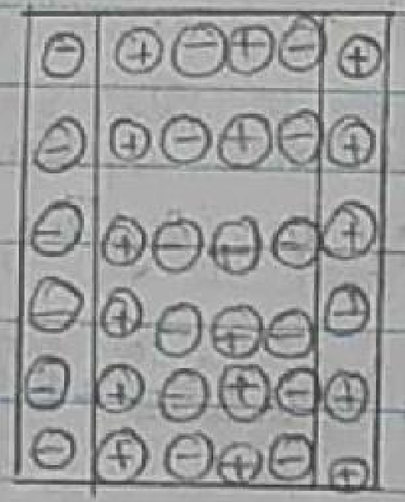
(II) This is because the electric field induces a dipole moment in the dielectric along the field. Hence, an electric field develops, against the external electric field in the dielectric.

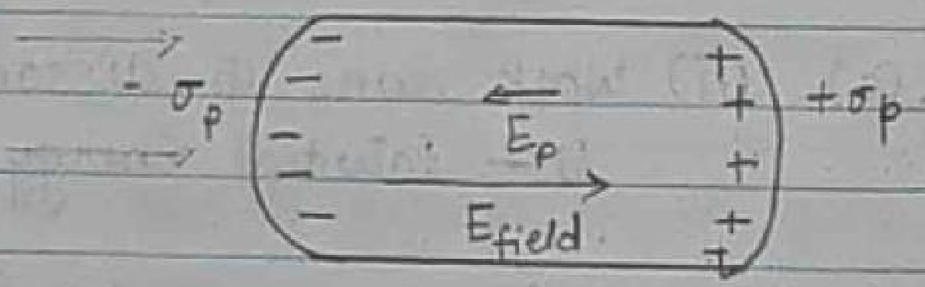
In polar molecules, the alignment happens due to the torque experienced by the individual dipoles when placed in an electric field.

Space for writing Question Number

In non-polar molecules, it happens due to the stretching of ~~e di~~ molecules and their positive and negative centres displace.

Thus, the net electric field inside the dielectric reduces, and hence is less than that outside it. It doesn't completely reduce to zero, as in conductors due to the absence of free charges.





(III) $Q = CV$

where $C = \frac{A\epsilon_0}{d}$

$\therefore Q = \frac{A\epsilon_0 V}{d}$

Space for writing Question Number

∴ For a charged parallel plate capacitor.

$$V = \frac{Qd}{A\varepsilon_0}$$

For a constant charge and the same plate placed in vacuum

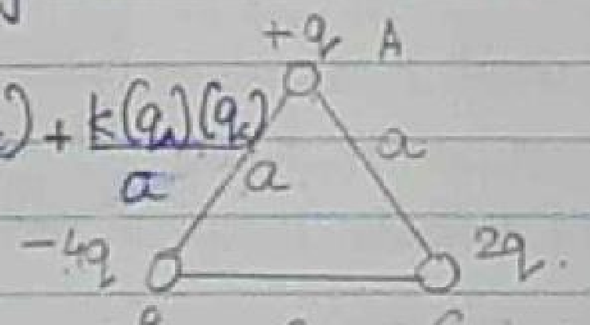
$$V \propto d$$

∴ V decreases as distance between the plates decreases. (or plates are brought closer).

9. (a) (i) Work done to dissociate the system of charges = -U

U – Potential Energy of the system

∴ ~~$U = \frac{2kq^2}{a}$~~ $U = \frac{k(q_A)(q_B)}{a} + \frac{k(q_B)(q_C)}{a} + \frac{k(q_A)(q_C)}{a}$



~~Potential at A = $\frac{1}{4\pi\varepsilon_0}\frac{q}{}$~~

$$U = \frac{k(2q)(-4q)}{a} + \frac{k(-4q)(q)}{a} + \frac{k(q)(2q)}{a}$$

32.

$$U = \frac{-8kq^2}{a} + \frac{2kq^2}{a} - \frac{4kq^2}{a}$$

$$U = \frac{(-12+2)\,kq^2}{a}$$

$$U = \frac{-10\,kq^2}{a}$$

∴ Work done to dissociate the charges $= \frac{10kq^2}{a} = \frac{10\,q^2}{4\pi\varepsilon_0 a}$
(~~ext~~ by external field).

32. (b) A wavefront is ~~a~~ the locus of all points in a given medium that oscillate in the same phase.
A ray ~~is the di~~ depicts the direction in which light energy propagates. It is perpendicular to the wavefront

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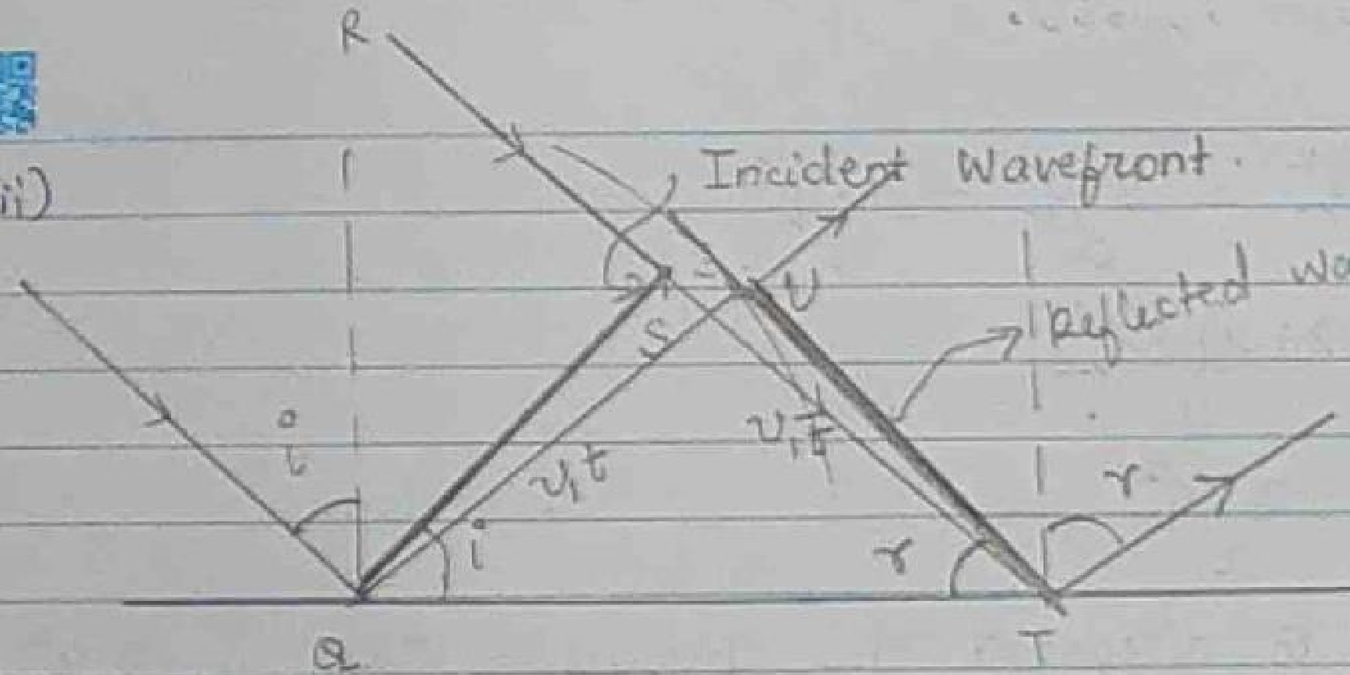
32. (b) (ii)



~~All~~ All points of the wavefront are in the same medium. Thus, they cover same distance

$QU = ST = v_1 t$ (since each point of the wavefront covers some distance in same amount of time).

In $\triangle STQ$ and $\triangle UQT$

$QT = TQ$ (common side).

$\angle TSQ = \angle QUT$ ($90°$ - ray is perpendicular to wavefront).

$QU = ST$ (from Huygen's principle).

$\therefore \triangle STQ \sim \triangle UQT$ (RHS congruence).

$\therefore \angle SQT = \angle UTQ$ (CPCT - corresponding parts of congruent triangles).

$\Rightarrow \angle i = \angle r$.

∴ First law of reflection is proved ; Angle of incidence is equal to angle of reflection.

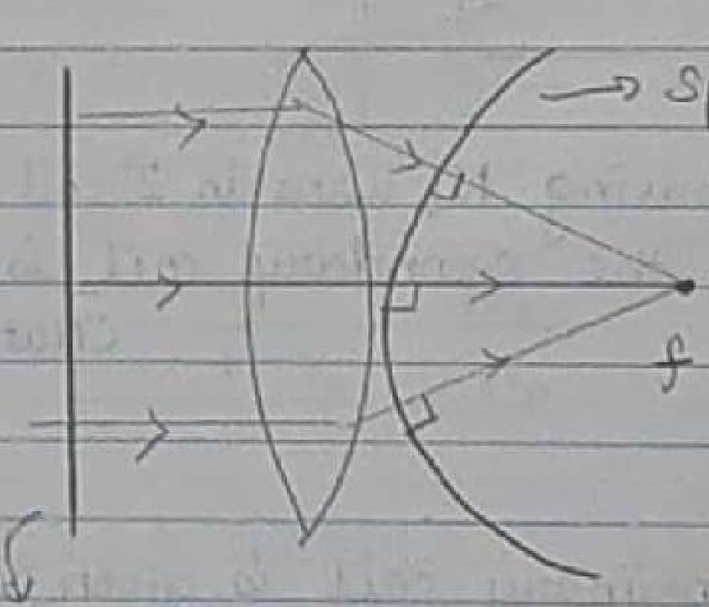
Space for writing Question Number

32. (b)
(iii)

The incident ray, normal and ~~ref~~ reflected ray at the point of incidence ~~are~~ all lie in the same plane, Thus incident wavefront and ~~refract~~ reflected are perpendicular, Thus proving 2nd law of reflection.

32. (b)

(iii)



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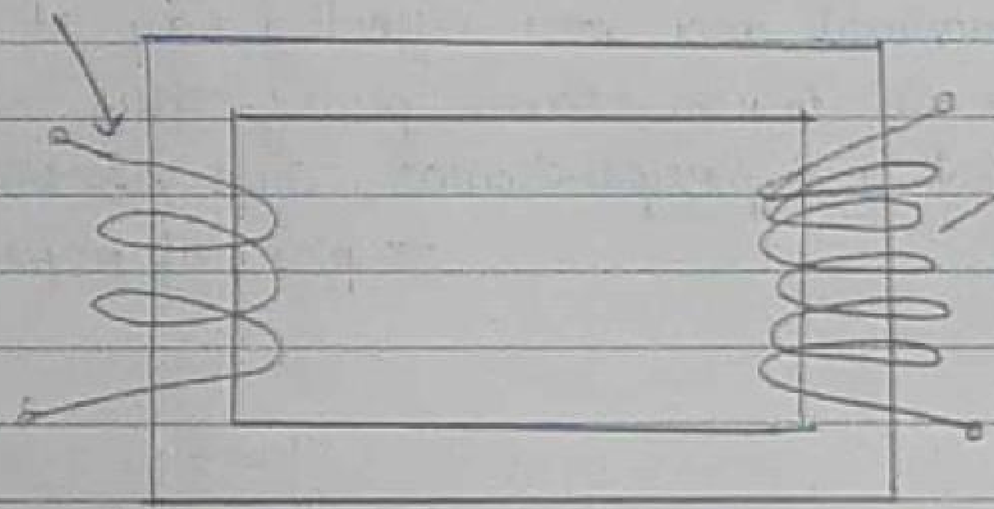
(b) a) primary coil



Consider a transformer having N_s turns in 2° coil and N_p turns in 1° coil.

The EMF induced ~~in~~ in the secondary coil is given as:

(Mutual induction).

$$\mathcal{E}_s = -N_s \frac{d\phi}{dt}$$

The EMF induced in the primary coil is given as:

(Self - induction).

$$\mathcal{E}_p = -N_p \frac{d\phi}{dt}$$

~~$\mathcal{E}_s = V_s$~~

$\mathcal{E}_p = V_p$, because the primary resistance is considered to be negligible else the primary current will become infinite.

Then to a good approximation $\mathcal{E}_s = V_s$, if secondary current is negligible ~~and~~ or circuit is open.

$\therefore \quad V_s = -N_s \frac{d\phi}{dt}$ -① and $V_p = -N_p \frac{d\phi}{dt}$ -②

from ① & ②:

$$\frac{V_s}{V_p} = \frac{N_s}{N_p} \qquad \therefore \boxed{\frac{V_s}{V_p} = \frac{N_s}{N_p}.}$$

(ii) ~~I_s~~ $V_p I_p = 3300$

$$I_p = \frac{3300}{220} \quad \frac{30}{2}$$

$$I_p = 15\,A$$

(I) $\therefore$ Current in the primary is 15 A.

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33. (b) (II) $\frac{V_s}{V_p} = \frac{N_s}{N_p}$

$V_s = \frac{N_s}{N_p} \times V_p$

$= \frac{5000}{100} \times 220$

$= 11000\ V$

∴ Output voltage = 11000 V

2026