MOCK PHYSICS | SUBJECTIVE TEST

CLASS – XII | SET – 1 | Solutions

(SECTION – A)

1.(C)	**6.(D)**	**11.(C)**
2.(D)	**7.(A)**	**12.(B)**
3.(D)	**8.(D)**	**13.(A)**
4.(B)	**9.(C)**	**14.(A)**
5.(A)	**10.(D)**	**15.(C)**
		16.(B)

(SECTION – B)

17. $\phi_0 = 5.63\text{eV} = 5.63\times 1.6\times 10^{-19}$ J

$v = 1.6\times 10^{15}\ Hz$

$K.E. = hv - \phi_0 = \dfrac{hc}{\lambda}$

$$\lambda = \frac{hc}{hv-\phi_0} = \frac{6.63\times 10^{-34}\times 3\times 10^{8}}{6.63\times 10^{-34}\times 1.6\times 10^{15} - 5.63\times} = \frac{19.89\times 10^{-26}}{1.6\times 10^{-19}\left(6.63-5.63\right)}$$

$$= \frac{19.89\times 10^{-26}}{1.6\times 10^{-19}} = 12.4\times 10^{-7}\ m$$

18. Net $I = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\phi$

Since, $I_1 = I_2 = I$

Net $I = I + I + 2I\cos\phi$

$$= 2I(1+\cos\phi) = 2I\left(2\cos^2\frac{\phi}{2}\right)$$

For path difference $\dfrac{\lambda}{4}$, phase difference is $\dfrac{\pi}{2}$

Net $I = 2I$

OR

$\lambda_1 = 4\times 10^{-7}\, m \lambda_2 = 6\times 10^{-7}\, m$

Distance at which dark fringe is observed $x = \left(n+\dfrac{1}{2}\right)\dfrac{\lambda D}{d}$

First Dark fringe for

$$\lambda_1 d_1 = \frac{1}{2}\frac{4\times 10^{-7}}{10^{-2}}m = 2\times 10^{-5}\, m$$

First Dark fringe for

$$\lambda_2 d_2 = \frac{1}{2}\frac{6\times 10^{-7}}{10^{-2}}m = 3\times 10^{-5}\, m$$

First dark fringe will be the distance where both dark fringes will coincide i.e. LCM of d_1 and d_2 i.e.,

$2\times 10^{-5}\, m\times 3\times 10^{-5}\, m = 6\times 10^{-5}\, m$

19. **(a)** As pitch (p) = $\dfrac{2Jmv\cos\theta}{q\theta}$

Or, $p = \dfrac{2\times 3.14\times 1.7\times 10^{-27}\times 2\times 10^{5}\cos 30^\circ}{1.6\times 10^{-19}\times 1.5} m$

Or, $P = 7.7\times 10^{-3} m$

(b) As, done by magnetic field is always zero $K.E. = 1/2mv^2\ 0.5M$

$K.E. = 3.4\times 10^{-17} J$

20. **Nuclear Fission:**

- Fission occurs in heavy nuclei (large mass numbers) that split into smaller nuclei.
- In the graph, nuclei with large mass numbers (e.g., uranium or thorium) are on the right-hand side (W).
- These nuclei are less stable because the binding energy per nucleon is lower than that of medium-sized nuclei.
- Answer: Nucleus W is most likely to undergo nuclear fission.
- Fusion occurs in light nuclei (small mass numbers) that combine to form heavier nuclei.
- In the graph, nuclei with small mass numbers (e.g., hydrogen or helium) are on the left-hand side (Z).
- These nuclei gain stability and release energy when fused into a nucleus with a higher binding energy per nucleon.
- Answer: Nucleus Z is most likely to undergo nuclear fusion.

21. **(I)** The direction of the magnetic field is perpendicular and inward into the plane.

(II) For a head-on collision to take place, the radius of the path of each ion should be equal to 0.5 *m*.

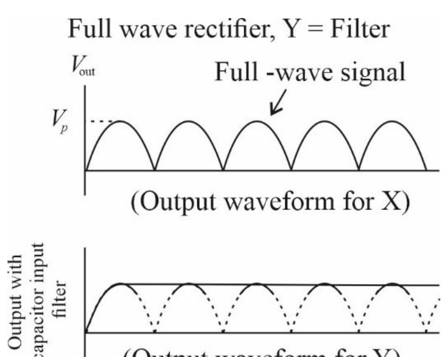
$r = \dfrac{mv}{qB} = 0.5m$

$B = \dfrac{mv}{qr} = \dfrac{4\times 10^{-26}\times 2.4\times 10^{5}}{4.8\times 10^{-19}\times 0.5}$

$B = 0.04T$

(SECTION – C)

22. **(i)**



- The device used is a rectifier.
- **Principle:** It uses the unidirectional conduction property of diodes, which allow current to flow only in one direction.

(ii)

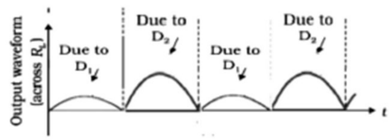
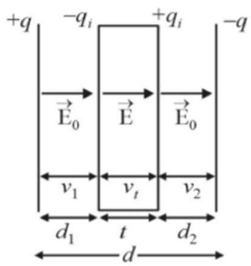


Figure : the output waveform of the circuit.

23.I. The capacitance of a parallel plate capacitor with dielectric slab ($t < d$)



$+q, -q$ = the charges on the capacitor plates

$+q_i, -q_i$ = Induced charges on the faces of the dielectric slab

$E_0 \rightarrow$ electric field intensity in air between the plates

$E \rightarrow$ the reduced value of electric field intensity inside the dielectric slab.

When a dielectric slab of thickness thickness $t < d$, d is introduced between the two plates of the capacitor the electric field reduces to E due to the polarisation of the dielectric. The potential difference between the two plates is given by

$V = V_i + V_t + V_2$

$V = E_0 d_1 + E_t + E_0 d_2$ … (1)

Here E is the reduced value of electric field intensity

$\vec{E} = \vec{E}_0 + \vec{E}_1$;. Here $\vec{E}_1$; is the electric field due to the induced charges $[+q_i \text{ and} - q_i]$

$$\boxed{E = \sqrt{E_o^2 + E_i^2 + 2E_0 E_1 \cos 180^\circ}}$$

$$= \sqrt{(E_0 - E_i)^2}$$

$E = E_0 - E$

Also, the dielectric constant K is given by

$K = \frac{E_0}{E}$ …(2)

$E_0 = \frac{\sigma}{\varepsilon_0} = \frac{q}{A\varepsilon_0}$ …(3)

From equations (1), (2) and (3)

$V = E_0 [d_1 + d_2] + \frac{E_0}{K} t$

$V = \frac{q}{A\varepsilon_0}\left[d - t + \frac{t}{K}\right]$ …(4)

The capacitance of the capacitor on the introduction of the dielectric slab is

$C = \frac{q}{V}$ …(5)

From (4) and (5)

$$C = \frac{\varepsilon_0 A}{d - t + \frac{t}{k}}$$

It $t = d$, then $C = K\frac{\varepsilon_0 A}{d} \Rightarrow C = KC_0$

Here $C_0 = \frac{\varepsilon_0 A}{d}$

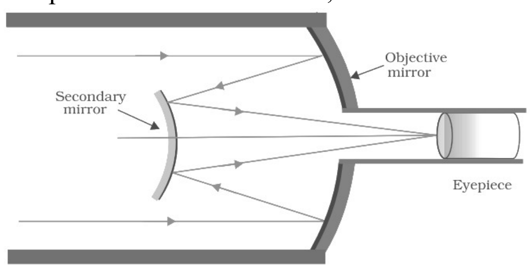
Since $K > 1$ therefor $C > C_0$

II. For a metallic slab K is infinitely large therefore $C = \frac{\varepsilon_0 a}{d - t}$

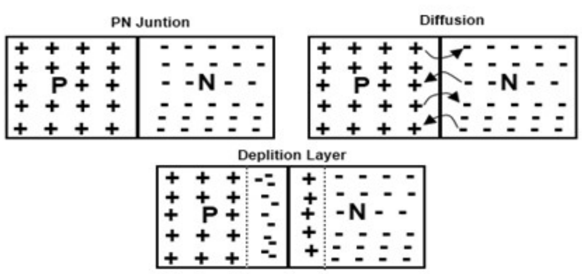
24. Advantages of reflecting telescope over a refracting telescope:

(i) A large aperture is not required to focus incoming light, hence it is easy to manufacture.

(ii) No spherical aberration exists, and thus a clear image is formed.



25. Barrier Potential: The electric field formed in the depletion region acts as a barrier. External energy must be applied to get the electrons to move across the barrier of the electric field. The potential difference required to move the electrons through the electric field is called the barrier potential. Barrier potential of a P-N junction depends on the type of semiconductor material, amount of doping and temperature. This is approximately 0.7V for silicon and 0.3 V for germanium.



- Forward Bias reduces the depletion region, allowing current flow.
- Reverse Bias widens the depletion region, restricting current flow.

26. Magnetic force $\left(qvB\sin\theta\right) =$ gravitational force (mg)

$$v = \frac{mg}{qBsin\theta}$$

For min. velocity $\sin\theta = 1$

$$v = \frac{mg}{qBsin\theta} = v = \frac{mg}{qB} = \frac{10^{-2} \times 9.8}{10^{-2} \times 2}\ m/s = 4.9\ m/s$$

$$v = 4.9\ m/s^2$$

As force is in upward direction so from Fleming's Left-hand rule, magnetic field will be along North to South.

27. (i) Since the light ray enters perpendicular to the face AB, the angle of incidence onface AC will be 45°.

(ii) In fig.2, the face AC of the prism is surrounded by a liquid so n =

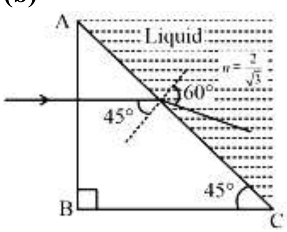
$$\frac{ng}{i}=\frac{\sqrt{2}}{\left(\frac{2}{3}\right)}=\frac{\sqrt{3}}{\sqrt{2}}$$

$$\sin\theta_C=\frac{1}{n}=\frac{\sqrt{2}}{\sqrt{3}}\theta_C=\sin^{-1}\left(\frac{\sqrt{2}}{\sqrt{3}}\right)=54.6°$$

Since the angle of incidence on the surface AC is 45°, which is less than the critical angle for the pair of media (glass and the liquid), the ray neither undergoes grazing along surface AC, nor does it suffer total internal reflection.

Instead it passes through the surface AC and undergoes refraction into the liquid.

(b)



Instead, it passes through the surface AC and undergoes refraction into the liquid.

For refracting interface AC, $n_1\sin_i=n_2\sin r$

$$n_1.\sin 45°=\left(\frac{2}{\sqrt{3}}\right)\sin r$$

$$\sin r=\frac{\sqrt{3}}{2}$$

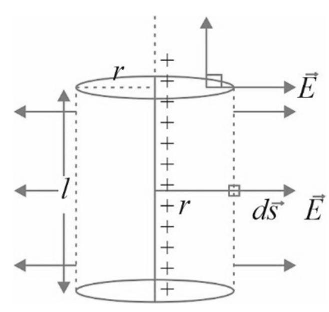
$\therefore \quad r=60°$

28. The Gauss law states that electric flux passing through any closed surface is equal to the charge enclosed by that surface divided by permittivity of vacuum. By symmetry, the magnitude of the electric field will be the same at all points on the curved surface of the cylinder and directed radially outward. E and ds are along the same direction. Now here we have the two surfaces, one curved and other the plane caps, First, the flux through the curved surface,

$$\oint\vec{E}\cdot d\vec{s}=\frac{q_{in}}{\varepsilon_0}$$

$$E(2\pi rl)=\lambda l/\varepsilon_0$$

$$E=\frac{\lambda}{2\pi r\varepsilon_0}$$



Now due to the plane caps,

The angle between $\vec{E}$ and $d\vec{s}$ is 90, so the flux through that part is zero

So, Total flux through the closed surface is,

$$E=\frac{\lambda}{2\pi r\varepsilon_0}$$

OR

(a) Electric flux is defined as the number of electric field lines passing through an area normal to the surface.

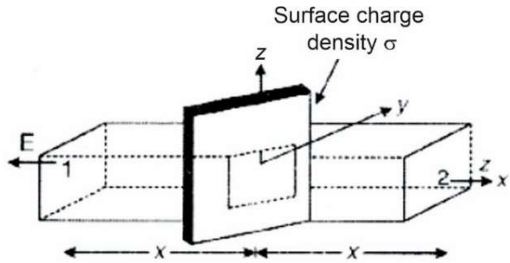
Alternatively.

The surface integral of the electric field is defined as the electric flux through a closed surface

$\phi = \oint \vec{E}.d\vec{s}$

Its SI unit is $N.m^2C^{-1}$ or $V - m$.

(b)



Outward flux through the Gaussian surface, is

$$2EA = \sigma A / \varepsilon_0$$

$$\therefore \quad E = \sigma / 2\varepsilon_0$$

Vectorically, $\vec{E} = \frac{\sigma}{2\varepsilon_0}\hat{n}$,

Where $\hat{n}$ is a unit vector normal to the plane away from it.

Hence, electric field is independent of the distance from the sheet.

(SECTION – D)

29. **(i)** **(B)**
(ii) **(C)**
(iii) **(B)**
(iv) **(C)**

OR

(D)

30. **(i)** **(D)**
(ii) **(C)**
(iii) **(A)**
(iv) **(B)**

OR

(A)

(SECTION – E)

31. **(a)** Ohm's law is valid and aplicable only till temperature remains constant.

(b) Devices like diodes (semiconductors) do not obey ohm's law because the I-V characteristic of a semiconductor is non-linear.

$I = \frac{\varepsilon}{R_0 + r}$ Where R_0 is resistance at room temperature 20°

$\Rightarrow R_0 = \frac{\varepsilon}{I} - 1$

OR $R_0 = \frac{100}{10} - 1 = R_0 = 9\Omega$

Now Final temperature is $320^\circ C$

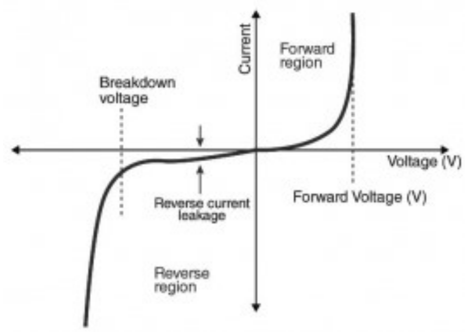
So, $R = R_0\left(1 + a\Delta T\right)$

$= 9\left(1 + 3.7\times10^{-4}\times300\right) = 100\text{hm}$

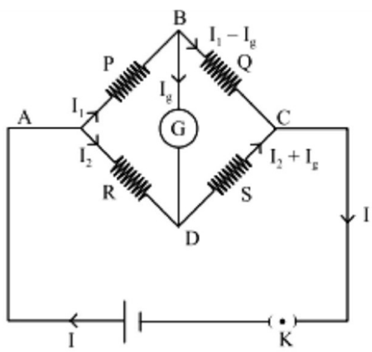
Power Consumed by cell $\left(P\right) = i^2 r$

$= \left(\frac{\varepsilon}{R + r}\right)^2 \times r$ Watt

$= \left(\frac{100}{11}\right)^2 = 82.64$



OR



Applying Kirchhoff's II law to mesh *ABDA*

$I_1P + I_gG - I_2R = 0$ …(1)

For the mesh *BCDB*

$\left(I_1 - I_g\right)Q + \left[-\left(I_2 + I_g\right)S\right] + \left[-I_gG\right] = 0$ …(2)

balanced, no current flows through the galvanometer

i.e. $I_g = 0$

$\therefore$ From equations (1) and (2) and (3)

$I_1P = I_2R$ …(3)

$I_1Q = I_2S$ …(4)

From equations (4) and (5)

$\frac{p}{Q} = \frac{R}{S}$

The sensitivity of a Wheatstone bridge is the amount of deflection in the attached galvanometer for very unit change in the unknown resistance.

A Wheatstone bridge is most sensitive when its four arms have resistances that are of the same order of magnitude. This means that all four resistors provide the same output resistance. A Wheatstone bridge is in a balanced state when its galvanomater shows zero deflection.

To increase the sensitivity of a wheatstone bridge, use higher resistor values, minimize standard resistor resistance, utilize a more sensitive galvanometer, increase the voltage supply, and ensure proper balancing.

32. **AC Generator:** It is a device used to convert mechanical energy into electrical energy.

Principle: It is based on the principle of electromagnetic induction. When a closed coil is rotated rapidly in a strong magnetic field, the magnetic flux linked with the coil changes continuously. Hence an emf is induced in the coil and a current-flows in it. In fact, the mechanical energy expended in rotating the coil appears as electrical energy in the coil.

1. **Armature:** It is a rectangular coil *ABCD* having a large number of turns of insulated copper wire wound on a soft-iron core. The use of soft-iron core increases the magnetic flux linked with the armature.
2. **Field Magnet:** It is a strong electromagnet having concave pole pieces *N* and *S*. The armature is rotated between these pole pieces about an axis perpendicular to the magnetic field.
3. **Slip Rings:** The leads from the armature coil *ABCD* are connected to two copper rings R_1 and R_2 called the 'slip rings'. These rings are concentric with the axis of the armature coil and rotate with it.
4. **Brushes:** These are two carbon pieces B_1 and B_2 called brushes, which remain stationary pressing against the slip rings R_1 and R_2, respectively. The brushes are connected to an external circuit.

Working Theory: When the coil *ABCD* is rotated inside the field, an emf is induced between its two ends. Let the plane of the coil be at right angles to the magnetic field at $t = 0$ and the angular speed of the rotation of the coil be ω. Then at time t, $0 = \omega t$. The magnetic flux linked with the coil at time t is: $\phi = nBA\cos\omega t$

Induced *e.m.f.* $e = \dfrac{-d\phi}{dt} = \dfrac{-d}{dt}[nBA\cos\omega t]$

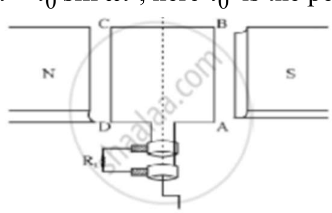
$\Rightarrow\ e = nBA\omega\sin\omega t$

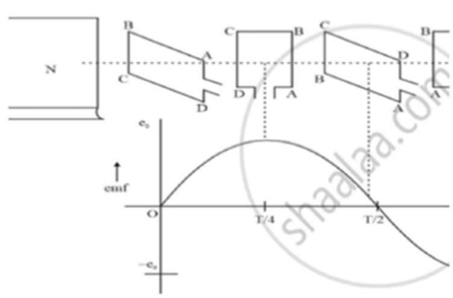
$e = e_0\sin\omega t$

Where $e_0 = nBA\omega$ is the peak value of emf.

The current in the external load is given by $i = \dfrac{e_0\sin\omega t}{R_L}$

$i = i_0\sin\omega t$, here i_0 is the peak value of the current.





In an ac generator, the source of electrical energy is the mechanical energy.

OR

(a) Transformer: A transformer is a device for converting a large alternating current at low voltage into a small alternating current at high voltage and vice-versa. If the voltage is stepped up and the current is decreased, the transformer is called step up transformer and if the voltage is lowered and the current is increased, the transformer is called step down transformer. Principle: It is based upon the principle of mutual inductance i.e. whenever magnetic flux linked with a coil is changed, an induced e.m.f. is produced in the neighbouring coil. Construction: A transformer consists of two coils of insulated wire containing different number of turns wound separately on a continuous soft iron core as shown in Fig. The coil to which the electric energy is fed is called the primary, whereas the coil from which the energy is drawn is called the secondary. The two coils of wire are close to each other but are not electrically connected. The entire magnetic flux coming out of one will practically remain in the iron core, and hence pass through the other coil. The soft iron core provides a good path for the magnetic lines of force and therefore, helps in making almost all of them pass through the secondary coil. Action: Alternating current is fed to the primary. The alternating current in the primary produces an alternating magnetic flux in the core which passes through the secondary coil. Since magnetic flux remains practically confined within the core, the magnetic flux linked with the secondary is almost the same as that passing through the primary. The changing magnetic flux produces an induced e.m.f. in the secondary and also gives rise to self-induced (back) e.m.f. in the primary. Consider the terminals of secondary coil to be open. Let N_p and N_s be the number of turns in the primary and secondary coils respectively. Let ϕ be the magnetic flux linked with the primary and the secondary at any instant. The induced e.m.f. in primary and secondary coils are given by

$$E_p = -N_p \frac{d\phi}{dt}$$

and $E_s = -N_s \frac{d\phi}{dt}$

Thus $\frac{E_s}{E_p} = \frac{N_s}{N_p}$ …(i)

The ratio of the number of turns in the secondary to that in the primary is called transformation ratio. If a step-up transformer, $N_s > N_p$, i.e., the transformation ratio is greater than 1 so that $E_s > E_p$.

Output current: Further, according to the law of conservation of energy whether device is possible which can give any net gain of energy. Therefore, assuming no energy losses in the transformer, the energy drawn from the secondary is equal to that fed into the primary. Or, in other words,

Power output = Power input

If I_p and I_s are the values of the currents in the primary and the secondary coils.

$$I_s E_s = I_p E_p$$

or $\frac{E_s}{E_p} = \frac{I_p}{I_s}$

Thus as the voltage in the secondary increases, the current proportionately falls and vice versa i.e., whatever we gain in voltage, we stand to lose that much in current.

The efficiency of transformer is defined as

$$\eta = \frac{\text{Output power}}{\text{Input power}}$$

(b) The sources of energy loss in a transformer are:

(i) Eddy current losses due to iron core.

(ii) flux leakage losses.

(iii) Copper losses due to heating up of copper wires.

(iv) Hysteresis losses due to magnetization and demagnetization of core.

(c) The law of conservation of energy cannot be violated at all. The fact that voltage and current get stepped" in opposite directions (one up, the other down) makes perfect sense when power is equal to voltage times current, and realize that transformers cannot produce power, only convert it. Any device that could output more power than it took in would violate the Law of Energy Conservation in physics, namely that energy cannot be created or destroyed, only converted. It makes a difference in number of turns. In a step-up transformer, the primary has lower number of turns than the secondary and vice versa in the case of step-down transformer.

33. **(a)** Angular magnification of a telescope is

$$m = \frac{f_0}{F_e} = \frac{15}{0.01} = 1500$$

(b) Let d be diameter of moon and r_0 be radius of lunar orbit.

Let d be the diameter of image of moon.

The angle subtended by the diameter of the moon is equal to the angle subtended by the image.

$$\frac{d}{r_0} = \frac{d}{f_0} \Rightarrow d = 13.74cm$$

OR

(a) Focal length of the objective lens $f_1 = 2cm$

Focal length of the eyepiece, $f_2 = 6.25cm$

Distance between the objective lens and the eyepiece, $d = 15cm$

Least distance of distinct vision, $d' = 25cm$

Image distance for the eyepiece, $V_2 = -25cm$

Object distance for the eyepiece = u_2

According to the lens formula

$$\frac{1}{f_2} = \frac{1}{v_2} - \frac{1}{u_2}$$

$$\frac{1}{6.25} = \frac{1}{-25} - \frac{1}{u_2}$$

$$u_2 = -5cm$$

Image distance for the objective lens

$$v_1 = d + u_2 = 15 - 5 = 10\,cm$$

According to the lens formula

$$\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u_1}$$

$$\frac{1}{2} = \frac{1}{10} - \frac{1}{u_1} = u_2 = -2.5\,cm$$

The magnifying power of a compound microscope is given by the relation:

$$\frac{v_1}{|u_1|}\left(\frac{d'}{|u_2|}\right) = 13.51$$

The magnifying power of a compound microscope is given by the relation

$$m = \frac{v_1}{|u_1|}\left(1 + \frac{d'}{f_2}\right)$$

$$m = \frac{10}{2.5}\left(1 + \frac{25}{6.25}\right) = 20$$

(b) The final image is formed at infinity image distance for the eyepiece $v_2 = \infty$.

According to the lens formula $\frac{1}{6.25} = \frac{1}{\infty} - \frac{1}{u_2}$

$u_2 = -6.25\,cm$

Image distance for the objective lens

$v_1 = d + u_2 = 10 - 6.25 = 8.75$

Object distance for the objective lens $= u_2$

According to the lens formula

$$\frac{1}{f_1} = \frac{1}{v_1} = \frac{1}{u_1}$$

$$\frac{1}{2} = \frac{1}{8.75} - \frac{1}{u_1}$$

$u_2 = -2.59cm$

MOCK PHYSICS | SUBJECTIVE TEST

CLASS – XII | SET – 2 | Solutions

(SECTION – A)

1.(D) electrons and holes

Explanation: N-type semiconductors have a larger electron concentration than hole concentration. The term n-type comes from the negative charge of the electron.

In n-type semiconductors, electrons are the majority carriers and holes are the minority carriers.

N-type semiconductors are created by doping an intrinsic semiconductor with donor impurities (or doping a p-type semiconductor as done in the making of CMOS chips). A common dopant for n-type silicon is phosphorus.

2.(A) 3 : 2

Explanation:

power dissipated in resistance $P = \frac{V^2}{R}$

As the resistor are connected in parallel to the battery, both have are potential

So, $P \propto \frac{1}{R}$

$$\frac{p_1}{p_2} = \frac{R_2}{R_1} = \frac{6}{4} = \frac{3}{2}$$

$$P_1 : P_2 = 3 : 2$$

3.(D) 2 *cm* upward

Explanation:

Shift $S = t\left(\frac{1-1}{\mu}\right)$

Substituting the given data we get,

$S = 6\left(\frac{1-1}{1.5}\right)$ or, $S = \left(\frac{1-2}{3}\right) = 2cm$ upward

4.(D) Water

Explanation:

As water is a diamagnetic substance.

5.(D) 2C

Explanation:

The capacitance C of a parallel plate capacitor is given by $C = \frac{\varepsilon_0 A}{d}$.

A metal plate of thickness $\frac{d}{2}$ when introduced between the plates reduces the distance between the plates to $\frac{d}{2}$. The effective capacitance becomes:

$$C_m = \frac{\varepsilon_0 A}{\frac{d}{2}} = \frac{2\varepsilon_0 A}{d} = 2C$$

6.(D) The needles become tangential to the ring.

Explanation:

The current carrying wire has a magnetic field around it and the lines of force are in the form of concentric circles with their centers on the wire. Magnetic force acts along the tangent to the circle i.e. along the direction of magnetic field.

7.(B) **Weber**

Explanation:

Weber

8.(A) 20 *cm*

Explanation:

$$r = q_m \times 2l \times B\sin\theta$$

$$\therefore 2l = \frac{r}{q_m \times B\sin\theta} = \frac{80\times10^{-7}}{2\times4\times10^{-5}\times\sin 30^\circ} = 0.20m = 20\,cm$$

9.(B) are longitudinal waves and require a medium to travel.

Explanation:

According to Huygens, light waves are longitudinal waves and require a material medium to travel. For this reason Huygens assumed the existence of a hypothetical medium called luminiferous aether.

10.(C) 6 cm

Explanation:

$$E = \frac{kQ}{3^2}$$

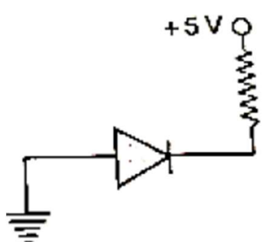
Equating these two equations, we get:

$$\frac{kQ}{x^2} = \frac{kQ}{3^2\times4}$$

In simplification, we get:

$$x^2 = 3^2\times4 = 6$$

11.(C)



Explanation:

The p-n junction is said to be reverse biased, when the positive terminal of the external battery in the circuit is connected to n-section and the negative terminal to p-section of the junction diode.

12.(D) 60°

Explanation:

60°

13.(C) A is true but R is false.

Explanation:

For an incident photon of given energy, velocity of photoelectron ejected from near the surface is larger than that coming from the interior of the metal because less energy is required to eject an electron from the surface than from the interior. The velocity of an ejected electron may not be zero.

14.(C) A is true but R is false.

Explanation:

Electric field for parallel plate capacitor in vacuum $= E = \frac{\sigma}{\varepsilon_0}$

Electric field in dielectric $E' = \frac{\sigma}{k\varepsilon_0}$

Since, the value of for Kerosene oil is greater than 1, then $E' < E$ and $V' < V$. Hence, the assertion is true. Dielectric constant of Kerosene oil is greater than 1. Hence, the reason is false.

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

Explanation:

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

16.(B) Both A and R are true but R is not the correct explanation of A.

Explanation:

The phase angle for the LCR circuit is given by $\tan\phi = \frac{X_L - X_C}{R} = \frac{\omega L - 1/\omega C}{R}$.

Where X_L, X_C are inductive reactance and capacitive reactance respectively when $X_L > X_C$ then $\tan\phi$ is positive i.e., ϕ is positive (between 0 and $\frac{p}{2}$). Hence emf leads the current. X_L

(SECTION – B)

17. Here $\lambda = 6.0\ mm = 6\times10^{-3}\ m$,

$E_0 = 33Vm^{-1}$

$$\omega = 2\pi\nu = \frac{2\pi c}{\lambda} = \frac{2\pi\times3\times10^8}{6\times10^{-3}} = \pi\times10^{11} rad\ s^{-1}$$

$$B_0 = \frac{E_0}{c} = \frac{33}{3\times10^8} = 1.1\times10^{-7}\ T$$

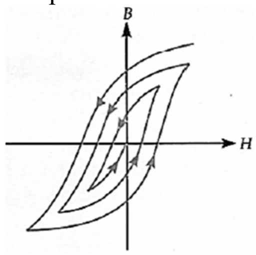
The equation for the electric field along y-axis can be written as

$$E = E_y = E_0 sin\omega\left(t - \frac{x}{c}\right) = 33 sin\pi\times10^{11}\left(t - \frac{x}{c}\right)Vm^{-1}$$

The equation for the magnetic field along z-axis can be written as

$$B = B_Z = B_0 sin\omega\left(t - \frac{x}{t}\right) = 1.1\times10^{-7} sin\pi\times10^{11}\left(t - \frac{x}{c}\right)\ tesla.$$

18. To demagnetise a sample, it is placed inside a solenoid carrying decreasing alternating current. The sample goes through several cycles of magnetisation under an alternating magnetising field of decreasing amplitude. Then the hysteresis loop becomes smaller and smaller until no residual magnetism is left in the sample.



19. Since $n_e > n_h$, the semiconductor is *n*-type. The conductivity of the semi-conductor is $e(n_e\mu_e + n_h\mu_h)$

$= 1.6\times10^{19}((8\times10^{13})(24000)+(4\times10^{13})(200))\,mho/cm = 0.32\,mho\,cm^{-1} = 320\ m\,mho\,cm^{-1}$

20. $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

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

$\frac{1}{\lambda_2} = R\left[\frac{1}{1^2} - \frac{1}{2^2}\right]$ …(ii)

$\frac{(2)}{(1)} = \frac{\lambda_1}{\lambda_2} = \frac{27}{5}$

21. Number of turns per unit length,

$n = \frac{5\times850}{1.0} = 4250\ m^{-1}$

i. $B = \mu_0 nI = 4\pi\times10^7\times4250\times5.0 = 2.67\times10^{-2}\ T$

ii. $\phi_B = BA = B\times\pi r^2$

$= 2.67\times10^{-2}\times3.14\times\left(1.5\times10^{-2}\right)^2 = 1.9\times10^{-5}\ Wb$

OR

In the first case $R = \frac{V}{I_g} - G$

$\therefore\ I_g = \frac{V}{R+G}$

Let R' be the required resistance to change the range from 0 to $\frac{V}{2}$. So, in the second case,

$I_g = \frac{V/2}{R'+G}$

$\therefore\ \frac{V}{R+G} = \frac{V/2}{R'+G}$

or $2R+2G = R+G$

Hence, $R' = \frac{R-G}{2}$

(SECTION – C)

22. Applying Kirchhoff's first law at the junction B, we get

$I_1 + I_2 + I_3 = 0$ ..(i)

Applying Kirchhoff's second law to the loop AE_1BE_2A, we have

$I_1\times1 - I_2\times2 = (10-4)I_1 - 2I_2 = 6$ ...(ii)

Similarly, from the closed-loop AE_2BE_3A, we have

$I_2 \times 2 - I_3 \times 1 = 4 - 13$ or $2I_2 - I_3 = -9$ ...(iii)

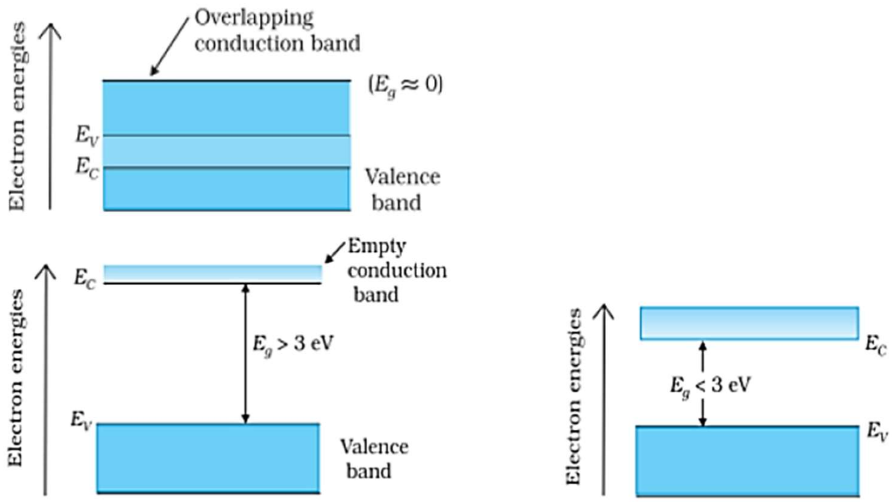
Solving equations (i), (ii) and (iii), we get

$I_1 = 0, I_2 = -3\ A, I_3 = 3A$

Thus, the current in the 10 V cell is zero. The current given by the 13 V cell to the circuit is 3 A, and the current taken by the 4 V cell from the circuit is 3 A.

As there is no current in the 10 V cell, so the potential difference across its ends is equal to its *e.m.f.* i.e., 10 V. Since all the three cells are in parallel, the potential difference across the terminals of each is 10 V.

23.



Conduction band determines electrical conductivity. As temperature of a semiconductor rises, the carrier concentration (electron-hole pair) increases due to breaking of covalent bonds and the conductivity of the semiconductor increases.

24. The frequency of ultraviolet radiations is more while that of red light is less than the threshold frequency for a zinc surface, so ultraviolet radiations can cause the emission of electrons and red light cannot.

From Einstein's photoelectric equation, K.E. of a photoelectron is

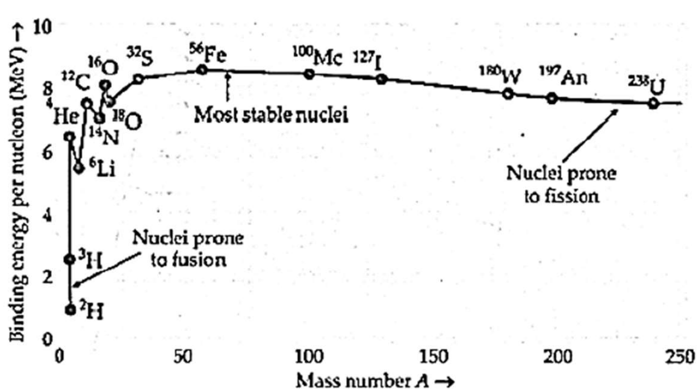
$$\frac{1}{2}mv^2 = hv - W_0 = hv - 0 = \frac{hc}{\lambda}$$

or $v = \sqrt{\dfrac{2hc}{m\lambda}}$

de Broglie wavelength of electrons,

$$\lambda_e = \frac{h}{mv} = \frac{h}{m}\sqrt{\frac{m\lambda}{2hc}} = \sqrt{\frac{h\lambda}{2mc}}$$

25.



Binding energy per nucleon as a function of mass number A. Two important conclusions from this graph are: Nuclear forces non-central and short ranged force.

Nuclear forces between proton-neutron and neutron-neutron are strong and attractive in nature.

Explanation of Nuclear Fission: When a heavy nucleus ($A \geq 235$ say) breaks into two lighter nuclei (nuclear fission), the binding energy per nucleon increases i.e., nucleons get more tightly bound. This implies that energy would be released in nuclear fission.

Explanation of Nuclear Fusion: When two very light nuclei ($A \leq 10$) join to form a heavy nucleus, the binding is energy per nucleon of fused heavier nucleus more than the binding energy per nucleon of lighter nuclei, so again energy would be released in nuclear fusion.

26. a. Now, $v = \frac{c}{n}\alpha$, where $\alpha = \frac{2\pi K e^2}{ch} = 0.0073$

$$v_1 = \frac{3\times 10^8}{1}\times 0.0073 = 2.19\times 10^6 \ m/s$$

$$v_2 = \frac{3\times 10^8}{3}\times 0.0073 = 1.095\times 10^6 \ m/s$$

$$v_3 = \frac{3\times 10^8}{3}\times 0.0073 = 7.3\times 10^5 \ m/s$$

b. Orbital period, $T = \frac{2\pi r}{v}$

As $r_1 = 0.53\times 10^{-10} \ m$

$$T_1 = \frac{2\pi\times 0.53\times 10^{-10}}{2.19\times 10^6} = 1.52\times 10^{-16} s$$

As $r_2 = 4r_1$ and $v_2 = \frac{1}{2}v_1$

$$T_2 = 8T_1 = 8\times 1.52\times 10^{-16} s = 1.216\times 10^{-15} s$$

As $r_3 = 9r_1$ and $v_3 = \frac{1}{3}v_1$

$$\therefore T_3 = 27T_1 = 27\times 1.52\times 10^{-16} s = 4.1\times 10^{-15} s$$

27. Angular spread due to diffraction $= \frac{\lambda}{a}$

$\therefore$ Linear spread on the screen of camera = $\frac{L\lambda}{a}$

Thus, the size of the spot of light becomes large when a is small.

As the incident beam is parallel, the geometrical linear spread will be a.

$\therefore$ Size of the spot $= a + \frac{L\lambda}{a}$

$$= (\sqrt{a})^2 + \left(\sqrt{\frac{L\lambda}{a}}\right)^2 - 2\sqrt{L\lambda} + 2\sqrt{L\lambda} \ = \left(\sqrt{a} - \sqrt{\frac{L\lambda}{a}}\right)^2 + \sqrt{4L\lambda}$$

Hence, the size of the spot will be minimum when

$$\sqrt{a} - \sqrt{\frac{L\lambda}{a}} = 0 \ \text{ or } a = \frac{L\lambda}{a}$$

i.e., when geometric and diffraction broadenings are equal. Minimum size of the spot = $\sqrt{4L\lambda}$

28. **(a)** We know $e = L\dfrac{dI}{dt}$

Thus, $\dfrac{e_1}{e_2} = \dfrac{L_1}{L_2} = \dfrac{8}{2} = 4$

(b) We know, $P = e\,I$

$P_1 = P_2$

$e_1 I_1 = e_2 I_2$

$\therefore\ \dfrac{I_1}{I_2} = \dfrac{e_2}{e_1} = \dfrac{1}{4}$

(c) We know,

$U = \dfrac{1}{2}LI^2$

and $\dfrac{I_1}{I_2} = \dfrac{e_2}{e_1}$

$$\therefore \frac{U_1}{U_2} = \frac{\frac{1}{2}L_1}{\frac{1}{2}L_2}\left(\frac{I_1}{I_2}\right)^2 = \frac{8}{2}\left(\frac{1}{4}\right)^2 = \frac{1}{4}$$

OR

i. Let RS moves with speed v rightward and also *RS* is at distances x_1 and x_2 from *PQ* at instants t_1 and t_2, respectively.

Change in flux, $d\phi = \phi_2 - \phi_1 = Bl\left(x_2 - x_1\right)$ $\left[\because \text{ magnetic flux, } \phi = \vec{B}, \vec{A} = BAcos0^0 = Blx\right]$

$\Rightarrow d\phi = Bldx \Rightarrow \dfrac{d\phi}{dt} = Bl\dfrac{dx}{dt} = Blv\left[\because v = \dfrac{dx}{dt}\right]$

If resistance of loop is *R*, then $I = \dfrac{vBl}{R}$

ii. Magnetic force $= BIl\sin 90^\circ$

$= \left(\dfrac{vBl}{R}\right)Bl = \dfrac{vB^2l^2}{R}$

Now, External force must be equal to magnetic force

$\therefore$ External force $= \dfrac{vB^2l^2}{R}$

iii. As, $P = I^2R = \left(\dfrac{vBl}{R}\right)^2 \times R = \dfrac{v^2B^2l^2}{R^2} \times R$

$\therefore P = \dfrac{v^2B^2l^2}{R}$

(SECTION – D)

29. **Read the text carefully and answer the questions:**

All the known radiations from a big family of electromagnetic waves which stretch over a large range of wavelengths. Electromagnetic wave include radio waves, microwaves, visible light waves, infrared rays, UV rays, X-rays and gamma rays. The orderly distribution of the electromagnetic waves in accordance with their wavelength or frequency into distinct groups having widely differing properties is electromagnetic spectrum.

(i) **(D)** infrared waves

Explanation:

Infrared rays can be converted into electric energy as in solar cell.

(ii) **(C)** radiowaves

Explanation:

Radiowaves have longest wavelength.

(iii) **(D)** cathode rays

Explanation:

Cathode rays are invisible fast moving streams of electrons emitted by the cathode of a discharge tube which is maintained at a pressure of about 0.01 mm of mercury.

OR

(D) λ-rays

Explanation:

λ-rays have minimum wavelength.

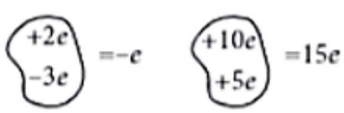
(iv) **(C)** microwave, infrared, ultraviolet, gamma rays

Explanation:

$\lambda_{\text{micro}} > \lambda_{\text{infra}} > \lambda_{\text{ultra}} > \lambda_{\text{gamma}}$

30. **Read the text carefully and answer the questions:**

The smallest charge that can exist in nature is the charge of an electron. During friction, it is only the transfer of electrons that makes the body charged. Hence net charge on anybody is an integral multiple of the charge of an electron $[1.6\times10^{-19} C]$ i.e.



where n = 1, 2, 3, 4, ... Hence nobody can have a charge represented as 1.1e, 2.7e, $\frac{3}{5}e$, *etc.*

Recently, it has been discovered that elementary particles such as protons or neutrons are composed of more elemental units called quarks.

(i) **(D)** Circular line of force

Explanation:

Circular line of force

(ii) **(D)** $3.2\times10^{-18} C$

Explanation:

From, q = ne, $n = \frac{q}{e} = \frac{3.2\times10^{-18}}{1.6\times10^{-19}} = 20$

As n is an integer, hence this value of charge is possible.

(iii) **(A)** 6.25×10^9

Explanation:

Charge on the body is $q = ne$

$\therefore$ No. of electrons present on the body is

$$\frac{q}{\varepsilon} = \frac{1\times10^{-9}C}{1.6\times10^{-9}C} = 6.25\times10^9 \; n = f$$

(iv) **(D)** 198.19 years

Explanation:

Here, $n = 10^9$ electrons per second

Charge given per second, $q = ne = 10^9 \times 1.6\times10^{-19}C$

Total charge, $Q = 1(given)$

$\therefore$ Time required = $\frac{Q}{q} = \frac{1}{1.6\times10^{-10}}s$

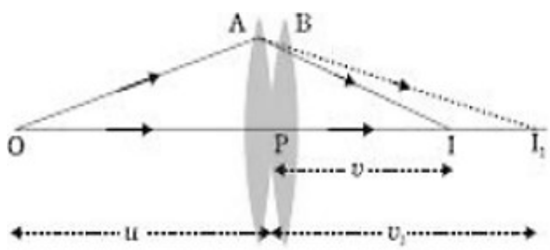
$$= 6.25\times10^9 s$$

$$\therefore \frac{6.25\times10^9}{3600\times24\times365}\text{year}$$

$= 198.19$ years

(SECTION – E)

31. **(a)**



For less A

$$\frac{1}{f_1} = \frac{1}{v_1} = \frac{1}{u}eg \qquad ...(i)$$

For less B

$$\frac{1}{f_2} = \frac{1}{v} = \frac{1}{v_1}eg \qquad ...(ii)$$

Adding equation (i) and (ii)

$$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{v_1} - \frac{1}{u} + \frac{1}{v} - \frac{1}{v_1}$$

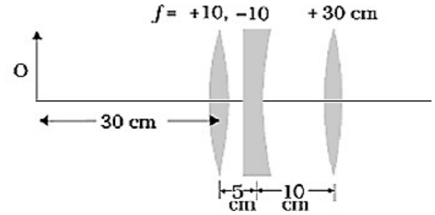
$$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{v} - \frac{1}{u}$$

$$\frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{F}$$

$\therefore$ Equivalent power

$$P = P_2 + P_2$$

(b) Image formed by lens of $f = +10\,cm$



$$\frac{1}{v_1} - \frac{1}{u_1} = \frac{1}{f_1}$$

$$\frac{1}{v_1} - \frac{1}{30} = \frac{1}{10}$$

$\therefore \quad v_1 = 15cm$

This image formed by lens act as object from concave lens

$\therefore \quad u_2 = 15 - 5 = 10\,cm$

$$\frac{1}{f_2} + \frac{1}{v_2} = \frac{1}{u_2}$$

$$\frac{1}{v_3} = \frac{1}{\infty} = \frac{1}{30}$$

$\therefore \quad v = \infty$

Therefore, virtual image forms at right of concave lens at $v = \infty$ and act as conves lens. $(f = +30\,cm)$ = 15 – 5 =10 *cm*

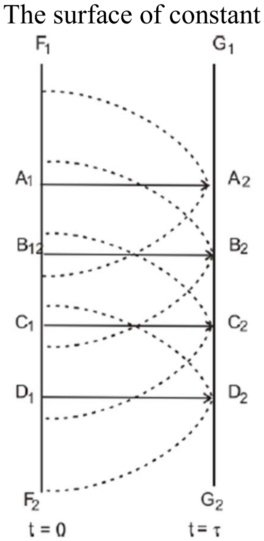
$$\frac{1}{v^3} = \frac{1}{4} - \frac{1}{f_s}$$

$$\frac{1}{v^3} = \frac{1}{\infty} = \frac{1}{30}$$

$v_3 = 30\,cm$

OR

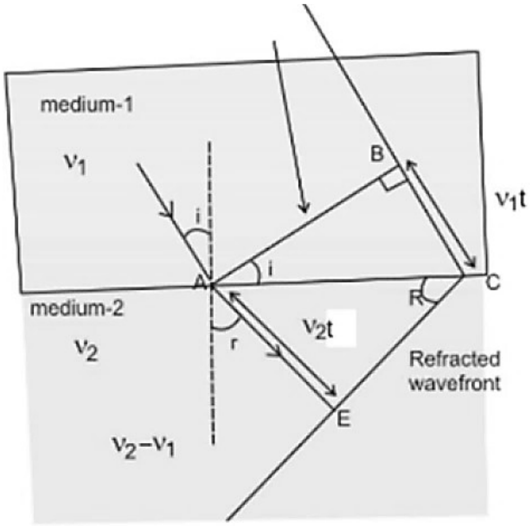
a. The surface of constant phase is known as a wavefront.



The geometrical construction of wavefront:

To determine the wavefront at *t* = *r* draw spheres of radius *vr* from each point on F_1F_2 and draw a common tangent spheres to obtain the new position of the wavefront.

b.



The ratio of the speed of light in vaccum to the speed of light in the medium is termed as refractive index of medium. Let us consider the medium I, which is optically denser than medium 2.

Let the speed of light be v_1 in medium I and v_2 in medium II.

Always, note that $v_2 > v_1$

A plane wave *AB* propagates and hits the interface at an angle *i*. and can be the time taken be the wavefront to travel the distance *BC*. Now, we want to draw the refracted wavefront. We can draw a sphere of radius v_2 with A as centre. Let the surface tangent to the sphere passing through point *C*, as there fracted wavefront. Now, Let the surface be tangent to the sphere at *E*.

In ΔABC

$\sin i = \frac{v_1 t}{AC}$ and,

In ΔAEC

$\sin r = \frac{v_2 t}{AC}$

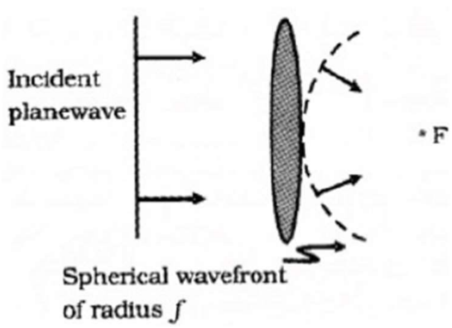
On dividing both the equations, we finally have,

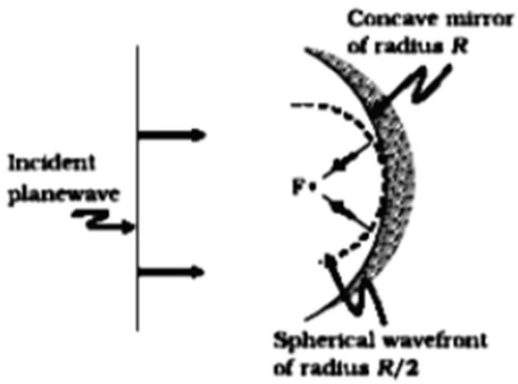
$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = \frac{\frac{c}{v_2}}{\frac{c}{v_1}}$$

Hence, $\frac{\sin i}{\sin r} = \frac{n_2}{n_1}$

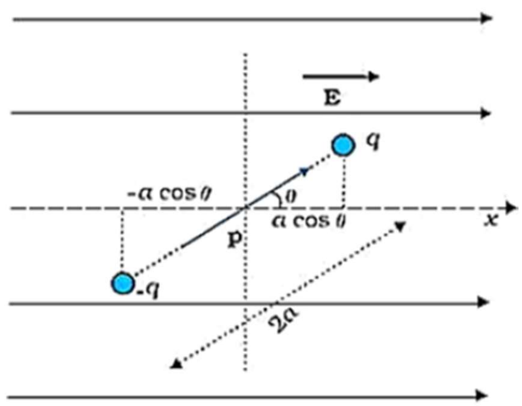
This is the verified Snell's law.

c.





32. **(i)**



The amount of work done in rotating the dipole from $\theta = \theta_0$ to $\theta = \theta_1$ by the external torque

$$W = \int_{e_0}^{\theta_1} \tau_{ext} d\theta = \int_{\theta_0}^{a} pE \sin\theta d\theta$$

For $\theta_0 = \frac{\pi}{2}$ and $\theta_1 = \theta = pE\left(\cos\frac{\pi}{2} - \cos\theta\right)$

$U(\theta) = -pE\cos\theta = -\vec{p}.\vec{E}$

1. Potential energy is maximum when:
   $\vec{p}$ is antiparallel to $\vec{E}$
2. Potential energy is minimum when:
   $\vec{p}$ is along to $\vec{E}$

(ii) Dipole Moment Calculation:

The charge $q = 1.0 \times 10^{-12} C.$

Separation vector $\vec{d} = (3mm, 4mm) = (3\times10^{-3} m, 4\times10^{-3} m)$

Dipole moment $\vec{p} = q\vec{d} = (1.0\times10^{-12}\times3\times10^{-3}, 1.0\times10^{-12}\times4\times10^{-3})$

= $(3.0\times10^{-15}, 4.0\times10^{-15}) C.m.$

Torque Calculation:

Electric field $\vec{E} = 1000i\, V/m$

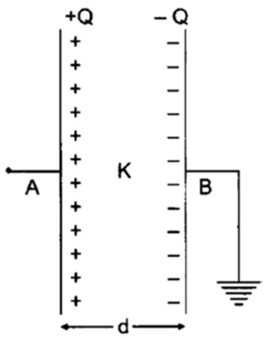
Torque $\vec{r} = \vec{p} - \vec{E}$

$\vec{r} = (3.0\times10^{-15}\hat{i} + 4.0\times10^{-15}\hat{j})\times1000\hat{i} = (4.0\times10^{-15}\times1000)\hat{k}$

$\vec{r} = 4.0\times10^{-12} N\cdot m\hat{k}$

OR

Principle of a Capacitor: A capacitor works on the principle that the capacitance of a conductor increases appreciably when an earthed conductor is brought near it. **Parallel Plate Capacitor:** Consider a parallel plate capacitor having two plane metallic plates A and B, placed parallel to each other (see fig.). The plates carry equal and opposite charges +Q and -Q respectively.



In general, the electric field between the plates due to charges +Q and -Q remains uniform, but at the edges, the electric field lines deviate outward. If the separation between the plates is much smaller than the size of plates, the electric field strength between the plates may be assumed uniform. Let A be the area of each plate, 'd' the separation between the plates, K the dielectric constant of medium between the plates. If σ is the magnitude of charge density of plates, then

$$\sigma = \frac{Q}{A}$$

The electric field strength between the plantes

$E = \dfrac{\sigma}{K\varepsilon_0}$ where ε_0 = permittivity of free space. …(i)

The potential difference between the plates, $V_{AB} = Ed = \dfrac{\sigma d}{K\varepsilon_0}$ ..(ii)

Putting the value of σ, we get

$$V_{AB} = \frac{\left(\frac{Q}{A}\right)d}{K\varepsilon_0} = \frac{\sigma d}{K\varepsilon_0 A} \text{ or } C = \frac{K\varepsilon_0 A}{d} \qquad \ldots\text{(iii)}$$

This is a general expression for capacitance of parallel plate capacitor. Obviously, the capacitance is directly proportional to the dielectric constant of medium between the plates.

For air capacitor ($K = 1$); capacitance $C = \dfrac{\varepsilon_0 A}{d}$. This is expression for the capacitance of a parallel plate air capacitor. It can be seen that the capacitance of parallel plate (air) capacitor is:

a. directly proportional to the area of each plate.

b. inversely proportional to the distance between the plates.

c. independent of the material of the plates.

33. **(a)** Total initial energy,

$$E = \frac{Q_0^2}{2C} = \frac{10^{-2} \times 10^{-2}}{2 \times 50 \times 10^{-6}} = 1J$$

This energy shall remain conserved in the absence of resistance.

(b) Angular frequency, $\omega = \dfrac{1}{\sqrt{LC}} = \dfrac{1}{(20\times10^{-3}\times50\times10^{-6})^{1/2}} = 10^3\, rad\, s^{-1}$

Thus, $f = \dfrac{10^3}{2\pi} = 159 Hz$

(c) $Q = Q_0 \cos \omega t$

Or $Q = Q_0 \cos \frac{2\pi}{T} t$, where $T = \frac{1}{f} = \frac{1}{159} s = 6.3\, ms$

Energy stored is completely electrical at $t = 0, T/2, 3T/2 \ldots$

Electrical energy is zero i.e., energy stored is completely magnetic at

$t = \frac{T}{4}, \frac{3T}{4}, \frac{5T}{4}$

(d) At $t = \frac{T}{4}, \frac{3T}{4}, \frac{5T}{4}, \ldots$, the total energy is shared equally between the inductor and the capacitor. As,

$\because \quad Q = Q_0 \cos \frac{\omega / T}{8} = Q_0 \cos \frac{\pi}{4} = \frac{Q_0}{\sqrt{2}}$

$\therefore \quad$ Electrical energy $= \frac{Q^2}{2C} = \frac{1}{2} \frac{Q_0^2}{2C}$, which is half of the total energy.

(e) R damps out the LC oscillations eventually. The whole of the initial energy 1.0 J is eventually dissipated as heat.

OR

(i) The figure shows the variation of resistance and reactance versus angular frequency, thus the Curve *B* corresponds to inductive reactance and curve *C* corresponds to resistance.

At resonance,

$X_L = X_C$

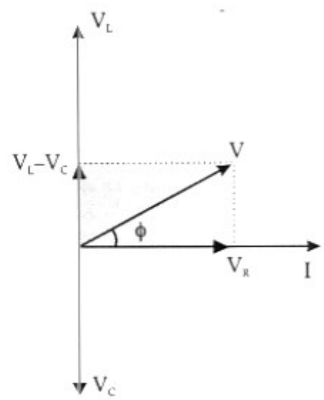
Therefore, impedance is given as:

$Z = \sqrt{R^2 + (X_L + X_C)^2}$

$Z = R$

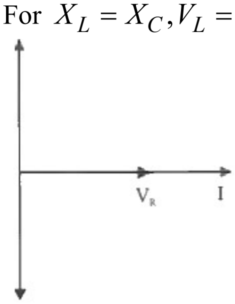
Thus, a series LCR circuit at resonance behaves as a purely resistive circuit.

For $X_L > X_C, V_L > V_C$. Therefore a phasor diagram is:



Here, ϕ is phase difference.

For $X_L = X_C, V_L = V_C$. Therefore, phasor diagram is:



ii. A Series resonance LCR circuit is called an acceptor circuit.

They are widely used in the tuning mechanism of a radio or a TV.