CBSE Sample Paper 11

Class XII Exam 2022-23

Physics

Time: 3 Hours **Max. Marks: 70**

General Instructions:

1. There are 35 questions in all. All questions are compulsory.
2. This question paper has five sections: Section A, Section B, Section C, Section D and Section E. All the sections are compulsory.
3. Section A contains eighteen MCQ of 1 mark each, Section B contains seven questions of two marks each, Section C contains five questions of three marks each, section D contains three long questions of five marks each and Section E contains two case study based questions of 4 marks each.
4. There is no overall choice. However, an internal choice has been provided in section B, C, D and E. You have to attempt only one of the choices in such questions.
5. Use of calculators is not allowed.

SECTION - A

18 Marks

1. F is the force of attraction between two point electric charges separated by d in a medium. How far apart should these be kept in the same medium such that the force between them is $\frac{F}{3}$?

(a) $\sqrt{3}d$ (b) d

(c) $3d$ (d) d^2 1

2. Which of the following part of electromagnetic spectrum to which a wavelength of 21 cm (emitted by hydrogen in interstellar space) belongs?

(a) Micro waves (b) Infrared waves

(c) X-rays (d) Radio Waves 1

3. An electron with charge, -e and mass m travels at a speed v in a plane perpendicular to a magnetic field of magnitude B. The electron follows a circular path of radius R. In a time t, the electron travels halfway around the circle. The amount of work done by the magnetic field is:

(a) 0 (b) 1

(c) ∞ (d) – 1 1

4. An alternating current from a source is given by $i = 10 \sin 314t$. The effective value of current is:

(a) 7.50 A (b) 7.07 A

(c) 7.77 A (d) 0.07 A 1

5. What is the value of angular momentum of electron in the second orbit of Bohr's model of hydrogen atom?

(a) $\frac{h}{2\pi}$ (b) $\frac{2h}{\pi}$

(c) $\frac{h}{4\pi}$ (d) $\frac{h}{\pi}$ 1

6. The sections of cross section of two wires A and B of the same metal and length have a ratio of 2:1. The ratio of current flowing in A and B if the same potential difference is applied across each wire in turn is:

(a) 1 : 2 (b) 2 : 1

(c) 4 : 1 (d) 1 : 4 1

7. In the following nuclear reaction, Identify unknown labelled X.

$$^{22}_{11}Na + X \longrightarrow ^{22}_{10}Ne + \nu_e$$

(a) electron (b) proton

(c) neutron (d) antineutrino 1

8. How does the width of a depletion region of a pn junction vary if doping concentration is increased?

(a) increases (b) decreases

(c) remain same (d) constant 1

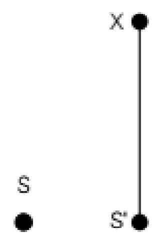
9. When a voltage drop across a pn junction diode is increased from 0.70 V to 0.71 V, the change in the diode current is 10 mA. What is the dynamic resistance of diode?

(a) 0.5 Ω (b) 2 Ω
(c) 1 Ω (d) 0.7 Ω 1

10. Which specially fabricated pn-junction diode is used for detecting light intensity?

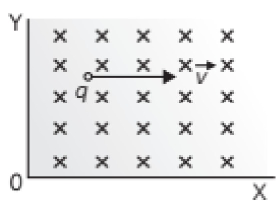
(a) p-type (b) n-type
(c) photodiode (d) None of these 1

11. Two waves from two coherent sources S and S' superimpose at X as shown in the figure. If X is a point on the second minima and SX – S'X is 4.5 cm. Calculate the wavelength of the waves.



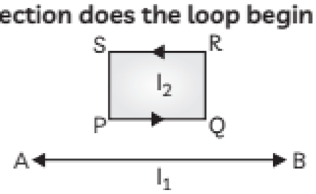
(a) 3 cm (b) 0 cm
(c) 6 cm (d) 9 cm 1

12. A point charge +q is moving with speed v perpendicular to the magnetic field B as shown in the given figure. What should be the magnitude of the applied electric field so that the net force acting on the charge is zero?



(a) $E = v^2B$ (b) $E = vB^2$
(c) $E = v^2B^2$ (d) $E = vB$ 1

13. In the figure, straight wire AB is fixed; white the loop is free to move under the influence of the electric currents flowing in them. In which direction does the loop begin to move?



(a) towards the wire
(b) away from wire
(c) No movement shown
(d) None of these 1

14. Which of the following is not working due to total internal reflection?

(a) Working of optical Fibre.
(b) Difference between apparent and realdepth of a pond.
(c) Mirage on hot summer day.
(d) Brilliance of diamond. 1

15. A red light beam is used to create a diffraction pattern. What if the red light is replaced with blue light?

(a) Bands disappear.
(b) Bands become broader and farther apart.
(c) No change will take place.
(d) Diffraction bands become narrow and crowded together. 1

Two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below:

(a) Both A and R are true and R is the correct explanation of A.
(b) Both A and R are true and R is NOT the correct explanation of A.
(c) A is true but R is false.
(d) A is false and R is also false.

16. Assertion (A): In a non uniform electric field, a dipole will have translatory as well as rotatory motion.
Reason (R): In a non uniform electric field, a dipole experiences a force as well as torque. 1

17. Assertion (A): Electric field is always normal to equipotential surfaces and along the direction of decreasing order of potential.
Reason (R): Negative gradient of electric potential is electric field. 1

18. Assertion (A): A convex lens of focal length 30 cm can't be used as a simple microscope in normal setting.
Reason (R): For normal setting, the angular magnification of simple microscope is M = D/f. 1

SECTION - B

14 Marks

19. Two straight infinitely long wires are fixed in space so that the current in the left wire is 2 A and directed out of the plane of the page and the current in the right wire is 3 A and directed into the plane of the page. In which region(s) is/are there a point on the x-axis, at which the magnetic field is equal to zero due to these currents carrying wires? Justify your answer.

2

20. Draw the graph showing intensity distribution of fringes with phase angle due to diffraction through single slit.

OR

What should be the width of each slit to obtain n maxima of double slit pattern within the central maxima of single slit pattern? 2

21. Deduce an expression for the potential energy of a system of two point charges q_1 and q_2 located at positions r_1 and r_2 respectively in an external field $(\vec{E})$.

OR

Establish the relation between electric field and electric potential at a point.

Draw the equipotential surface for an electric field pointing in (+Z) direction with its magnitude increasing at constant rate along (–Z) direction. 2

22. Explain with help of circuit diagram, the action of a forward biased p-n junction diode which emits spontaneous radiation. State the least band gap energy of this diode to have emission in visible region. 2

23. An electric dipole, when held at 30° with respect to a uniform electric field of 10^4 N/C, experienced a torque of 9×10^{-26} Nm. Calculate dipole moment of the dipole. 2

24. Draw the energy band diagram when intrinsic semiconductor (Ge) is doped with impurity atoms of Antimony (Sb). Name the extrinsic semiconductor so obtained and majority charge carriers in it. 2

25. Write two characteristics of image formed when an object is placed between the optical centre and focus of a thin convex lens. Draw the graph showing variation of image distance v with object distance u in this case. 2

SECTION - C

15 Marks

26. What is drift velocity? Derive expression for drift velocity of electrons in a good conductor in terms of relaxation time of electrons? 3

27. A variable resistor R is connected across a cell of emf E and internal resistance r.

(A) Draw the circuit diagram.

(B) Plot the graph showing variation of potential drop across R as function of R.

(C) At what value of R current in circuit will be maximum?

OR

A storage battery is of emf 8 V and internal resistance 0.5 ohm is being charged by d.c supply of 120 V using a resistor of 15.5 ohm.

(A) Draw the circuit diagram.

(B) Calculate the potential difference across the battery.

(C) What is the purpose of having series resistance in this circuit? 3

28. (A) Explain de-Broglie argument to propose his hypothesis. Show that de-Broglie wavelength of photon equals electromagnetic radiation.

(B) If, deuterons and alpha particle are accelerated through same potential, find the ratio of the associated de-Broglie wavelengths of two.

OR

State the main implications of observations obtained from various photoelectric experiments. Can these implications be explained by wave nature of light? Justify your answer. 3

29. Derive an expression for the frequency of radiation emitted when a hydrogen atom de-excites from level n to level (n – 1). Also show that for large values of n, this frequency equals to classical frequency of revolution of an electron. 3

30. (A) Give the difference and between nuclear fission and nuclear fusion.

(B) Suppose we consider fission of a $^{56}Fe_{26}$ into two equal fragments of $^{28}Al_{13}$ nucleus. Is the fission energetically possible? Justify your answer by working out Q value of the process.

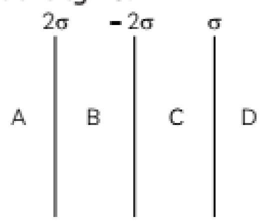
Given $(m)^{56}Fe_{26}$ = 55.93494u and $(m)^{28}Al_{13}$ = 27.98191u. 3

SECTION - D

15 Marks

31. (A) State Gauss's law in electrostatics. Show that with help of suitable figure that outward flux due to a point charge Q, in vacuum within gaussian surface, is independent of its size and shape.

(B) In the figure there are three infinite long thin sheets having surface charge density $+2\sigma$, -2σ and $+\sigma$ respectively. Give the magnitude and direction of electric field at a point to the left of sheet of charge density $+2\sigma$ and to the right of sheet of charge density $+\sigma$.



OR

(A) Define an ideal electric dipole. Give an example.

(B) Derive an expression for the torque experienced by an electric dipole in a uniform electric field. What is net force acting on this dipole.

(C) An electric dipole of length 2cm is placed with its axis making an angle of 60° with respect to uniform electric field of 10^5N/C. If it experiences a torque of $8\sqrt{3}$ Nm, calculate the magnitude of charge on the dipole, and its potential energy. 5

32. (A) Derive the expression for the current flowing in an ideal capacitor and its reactance when connected to an ac source of voltage, $V = V_0 \sin\omega t$.

(B) Draw its phasor diagram.

(C) If resistance is added in series to capacitor what changes will occur in the current flowing in the circuit and phase angle between voltage and current?

OR

(A) State the principle of ac generator.

(B) Explain with the help of a well labelled diagram, its working and obtain the expression for the emf generated in the coil.

(C) Is it possible to generate emf without rotating the coil? Explain. 5

33. (A) Define a wave-front.

(B) Draw the diagram to show the shape of plane wave front as they pass through (i) a thin prism and (ii) a thin convex lens. State the nature of refracted wave front.

(C) Verify Snell's law of refraction using Huygens's principle.

OR

(A) State main considerations taken into account while choosing the objective of astronomical telescope.

(B) Draw a ray diagram of reflecting type telescope. State its magnifying power.

(C) State the advantages of reflecting type telescope over the refracting type? 5

SECTION - E

8 Marks

34. *Faraday Cage: A Faraday cage or Faraday shield is an enclosure made of a conducting material. The fields within a conductor cancel out with any external fields, so the electric field within the enclosure is zero. These Faraday cages act as big hollow conductors you can put things in to shield them from electrical fields. Any electrical shocks the cage receives, pass harmlessly around the outside of the cage.*

(A) Which material can be used to make a Faraday cage? 1

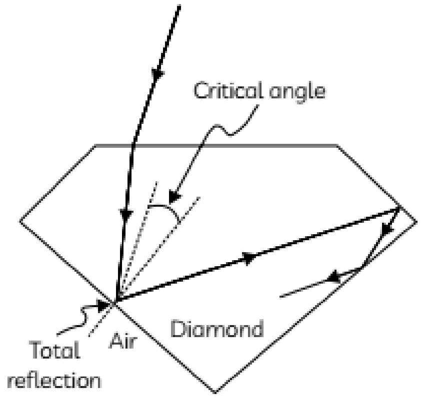
(B) What is the electrical force inside a Faraday cage when it is struck by lightning? 1

(C) An isolated point charge +q is placed inside the Faraday cage. Calculate the charge on surface:

OR

A point charge of 2C is placed at centre of Faraday cage in the shape of cube with surface of 9 cm edge. Find the number of electric field lines passing through the cube normally. 2

35. Sparking Brilliance of Diamond:



The total internal reflection of the light is used in polishing diamonds to create a sparking brilliance. By polishing the diamond with specific cuts, it is adjusted the most of the light rays approaching the surface are incident with an angle of incidence more than critical angle. Hence, they suffer multiple reflections and ultimately come out of diamond from the top. This gives the diamond a sparking brilliance.

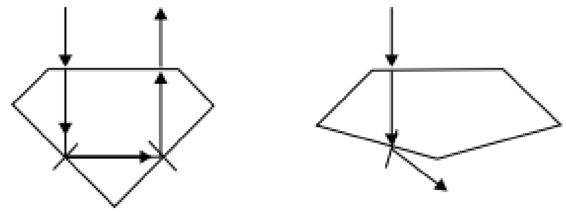
(A) The critical angle for a diamond is 24.4°. Then find its refractive index. 1

(B) A diamond is immersed in a liquid with a refractive index greater than water. Then find the change in the critical angle for total internal reflection. 1

(C) Light cannot easily escape a diamond without multiple internal reflections. Identify the reason.

OR

The following diagram shows same diamond cut in two different shapes.



What is the brilliance of diamond in the second diamond? 2

SOLUTION

SECTION - A

1. *(a)* $\sqrt{3d}$

Explanation: If two point charges q_1 and q_2 are separated by distance *d*.

$$F = \frac{Kq_1q_2}{d^2}$$

Suppose if force becomes, $\frac{F}{3}$.

Let the distance be *x*.

$$\frac{F}{3} = \frac{Kq_1q_2}{x^2}$$

$$\Rightarrow \quad \frac{Kq_1q_2}{3d^2} = \frac{Kq_1q_2}{x^2}$$

$$x^2 = 3d^2$$

$$x = \sqrt{3}d$$

2. *(d) Radio waves*

Explanation: Radio waves have wavelengths of 1 mm to 100 km. Hence, 21 cm lies at short wavelength end of radio waves.

Uses : In T.V. and radio communication systems.

3. *(a) 0*

Explanation: When a charged particle having mass m carrying charge q enters in the magnetic field of magnitude B such that it acquires circular path, then definitely force acting on the particle will be perpendicular to applied magnetic field, i.e. particle moves under a force whose magnitude remains constant but direction changes continuously and is always perpendicular to the velocity. As a result particle always follow circular path with constant speed *v*, the force acting on particle as the centripetal

force, $F = \frac{mv^2}{r} = qVB$

Now workdone in moving the particle,

$$W = \vec{F}.\vec{S} = FS\cos 90°$$

$$= 0 \text{ Joule.}$$

4. *(b) 7.07A*

Explanation: For given alternating current source,

$$i = 10 \sin 314t$$

As we know,

$$i = i_0 \sin\omega t$$

Hence, $i_0 = 10$

$$i_{rms} = \frac{i_0}{\sqrt{2}}$$
$$= \frac{10}{\sqrt{2}}$$
$$= 5\sqrt{2}$$
$$= 5 \times 1.414$$
$$= 7.07 \text{ A}$$

Related Theory

➥ *For one complete cycle the mean value of alternating current is zero. The mean value of A.C. for a half-cycle is 0.637 times or 63.7% of the peak value.*

5. *(d)* $\frac{h}{\pi}$

Explanation: For an electron having mass m revolving around the nucleus with velocity v in a orbit of radius r, angular momentum is given by *mvr*. According to Bohr's postulate electrons can revolve only in those orbits in which their angular momentum is an integral multiple of $\frac{nh}{2\pi}$, where *h* is planck's universal constant.

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

For second orbit $n = 2$

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

6. *(b) 2:1*

Explanation: We know that,

$$R = \rho\frac{l}{A}$$

Hence, $R \propto \frac{l}{A}$

If the area are in the ratio 2:1, the resistance will be in the ratio of 1:2.

And $I = \frac{V}{R}$

$$I \propto \frac{1}{R}$$

Hence, the current will be in the ratio of 2:1.

7. *(a) electron*

Explanation:

$$_{11}Na^{22} + X \rightarrow {}_{10}Ne^{22} + \nu_e$$

$$_{11}Na^{22} + {}_{-1}\beta^0 \rightarrow {}_{10}Ne^{22} + \nu_e$$

electron

In the given above equation atomic number is decreased by 1 and there is no change in atomic mass of the decaying nucleus, which is possible with the emission of β - particle only.

Related Theory

➥ *When an α-particle is emitted from the nucleus of a radioactive atom, the atomic number decreases by 2 and the mass number decreases by 4.*

8. *(b) decreases*

Explanation: The process of adding impurity to an intrinsic semiconductor in a controlled manner is called doping. It increases significantly the electrical conductivity of the semiconductor. With the increase in the rate of doping the thickness of the depletion layer generated at the junction decreases. Even if one part of a p–n junction is heavily doped, the thickness of depletion layer on that side (p-side) becomes less than that of other side.

9. *(c) 1Ω*

Explanation: Dynamic resistance =

$$\frac{\text{Change in voltage}}{\text{Change in current}} = 1 \text{ ohm}$$

Change in voltage drop across a pn-junction diode = 0.71 – 0.70

$$\Delta V = 0.01 \text{ V}$$

Change in diode current, $\Delta i = 10 \text{ mA} = 10 \times 10^{-3}$A

Dynamic resistance, $R_d = \frac{\Delta v}{\Delta i}$

$$= \frac{0.01}{10 \times 10^{-3}} = \frac{0.01}{0.01}$$

$$= 1\ \Omega$$

Related Theory

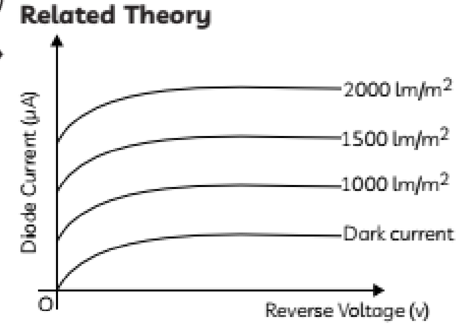
➥ *In the forward characteristic of p–n junction diode. However, beyond the turning point, the current varries almost linearly with voltage. In this region, R_d is almost independent of V and ohm's law is obeyed.*

10. *(c) photodiode*

Explanation: Photodiode is a reverse-biased p–n junction made from a photosensitive semiconductor. Its upper surface is open to light while the remaining sides of the plastic are painted black.

Related Theory

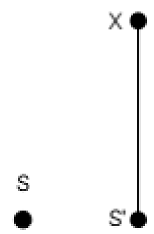
➥



The voltage-ampere characteristic curve for three different values of Ge photodiode. Only dark current passes through origin. Current increases with increase in illumination for a given reverse voltage.

11. *(a) 3 cm*

Explanation:



For two given waves travelling from two coherent sources S and S', X is a point of on the second minima.

$SX - S'X = 4.5$ cm

Wavelength of the waves λ = ?

When two waves travelling from two coherent sources superimpose to each other, interference pattern is obtained.

For the minimum intensity,

$$\text{path difference, } x = (2n-1)\frac{\lambda}{2}$$

For second minima, $n = 2$

$$x = \frac{3\lambda}{2}$$

$$4.5 = \frac{3\lambda}{2}$$

$\Rightarrow$ $\lambda = 3$ cm.

Related Theory

- *The ratio of intensities of light at maxima and minima is the ratio of intensities of bright and dark fringes.*

$$\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 \sim a_2)^2}$$

Where, a_1 and a_2 are amplitudes of two light waves.

12. *(d) E = vB*

Explanation: Force on the charge due to the magnetic field = qVB sin

Since, B is $\perp$ to the plane of paper and in words,

$$F = qVB \sin 90°$$

$$F = qVB \text{ (along OY)}$$

Force on the charge due to electric field

$$F = qE$$

Net force on the charge is zero, if,

$$qE = qVB$$

$$E = VB \text{ (along YO)}$$

13. *(a) towards the wire*

Explanation: Since, current in AB and arm PQ are in the same direction. Therefore, wire will attract the arm PQ with a force (say F_1).

But repels the arm RS with a force (say F_2)

Since, arm PQ is closer to the wire AB.

So, $F_1 > F_2$

i.e. the loop will move towards the wire.

14. *(b) Difference between apparent and realdepth of a pond.*

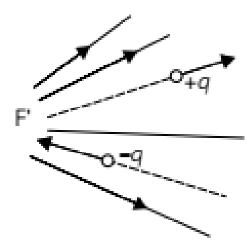
Explanation: Difference between Apparentand real death of a pond is due to there fraction of light and other three phenomenainvolved with total internal reflection.

15. *(d) Diffraction bands become narrow andcrowded together.*

Explanation: The width of the fringe in diffraction pattern is given as $\frac{D\lambda}{d}$ As a result, when red light is replaced with blue light, the wavelength reduces, causing the fringe width to decrease and the pattern to become shorter and more congested together.

16. *(a) Both A and R are true and R is the correct explanation of A.*

Explanation : When an electric dipole is kept in a non-uniform electric field f_{net} (not equal to symbol) 0, T_{net} = (not equal to symbol) 0.



In this case motion of the dipole is combination of translatory and rotatory motion.

Related Theory

- *When a dipole is kept in uniform electric field, the net translatory force on the dipole is zero, therefore there will be translatory motion of the dipole in a uniform electric field.*

17. *(b) Both A and R are true and R is NOT the correct explanation of A.*

Explanation: For a uniform electric field, equipotential surfaces are a family of planes perpendicular to the lines of force.

The electric field intensity at a point in an electric field in a given direction is equal to the negative potential gradient in that direction.

$$E = -\frac{dV}{dx}$$

Related Theory

- *In a family of equipotential surfaces, the surfaces are closer together where the electric field is stronger and further apart where the field is weaker.*

18. *(b) Both A and R are true and R is NOT the correct explanation of A.*

Explanation: In the simple microscope or magnifying glass is just a thin, short-focus convex lens carrying a handle. The object to be seen is placed between the lens and its focus and the eye is placed just behind the lens. The position of object between the lens and its focus is so adjusted that the image is formed at the least distance of distinct vision (D) from the eye.

Magnification power, $M = 1+\frac{D}{f}$

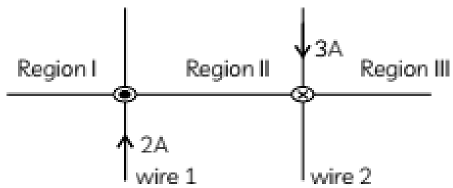
It is clear that shorter the focal length of the lens, larger is the magnifying power.

For relaxed eyes, image is formed at infinity. In this case object will be at focus of the lens.

Magnification power, $m = \frac{D}{f}$.

SECTION - B

19.



The direction of magnetic field intensity $\vec{B}$ at any point on the x-axis can be calculated by right hand palm rule no. 1 (or Maxwell's right hand screw rule), $\vec{B}$ is perpendicular to the plane of page.

Due to wire (1) magnetic field intensity to the left of it will be perpendicular to the plane of page outward and due to wire (2) will be downward. So region I direction of magnetic field intensity will be opposite. So resultant intensity can be zero.

$$\vec{B} = \vec{B}_1 + \vec{B}_2$$

$$B = B_1 - B_2 = \frac{\mu_0}{2\pi}\left[\frac{i_1}{R_1} - \frac{i_2}{R_2}\right]$$

In region II magnetic field intensity due to both wires will be perpendicular to the plane of paper downward, so it cannot be zero.

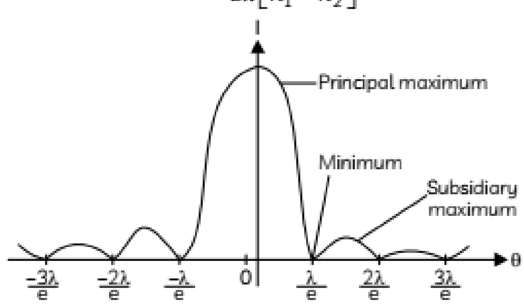
$$B = B_1 + B_2.$$

In region III magnetic field intensity due to wire (1) will perpendicular to plane of paper downward and due to wire (2) it will be perpendicular to the plane of paper outward. So resultant magnetic field intensity.

$$B = B_1 - B_2$$

$$= \frac{\mu_0}{2\pi}\left[\frac{i_1}{R_1} - \frac{i_2}{R_2}\right]$$

20.



In diffraction pattern a central bright band having on both sides narrower alternately dark and bright bands of decreasing intensity will obtain. If the intensity of the central maxima is I_0 then the intensity of the first and second secondary maxima are found to be $\frac{I_0}{22}$ and $\frac{I_0}{61}$. Thus diffraction fringes are of unequal width and unequal intensities.

OR

As we know

$$\frac{n\lambda}{d} = \frac{2\lambda}{a}$$

$n = \frac{2d}{a}$ where, d is separation between slit and a width of slit.

Let width of single slit = a

Distance between slits = d

In Young's double slit experiment,

Separation between n maxima is given by,

$$Y_n = \frac{n\lambda D}{d}$$

Angular separation between n maxima is given by,

$$\theta_n = \frac{n\lambda}{d}$$

Path difference = a sinθ = aθ = λ

$$\theta = \frac{\lambda}{a}$$

The angular width of the central maximum in the diffraction pattern due to single slit of width a is given by,

$$2\theta = 2\frac{\lambda}{a}$$

According to question to obtain n maxima of double slit pattern within the central maxima of single slit pattern,

$$\frac{n\lambda}{d} = \frac{2\lambda}{a}$$

$$n = \frac{2d}{a}$$

$$a = \frac{2d}{n}$$

21. Expression for the potential energy of a system of two point charges in an external electric field $\vec{E}$:

Let two point charges q_1 and q_2 are located at r_1 and r_2 respectively, in an external electric field.

Workdone to bring a charge q_1 in the electric field at distance $\vec{r}_1 = q_1 V(\vec{r}_1)$

Workdone to bring a charge q_2 in the electric field at distance $\vec{r}_2 = q_2 V(\vec{r}_2)$

Workdone on charge q_2 against the field due to q_1 = $\frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{\vec{r}_{12}}$, where $\vec{r}_{12}$ is the distance between charge q_1 and q_2.

By the principle of superposition for fields, work done on q_2 against two fields will add with workdone in bringing q_2 to r_2, which is given as

$$w_2 + w_{12} = q_2 V(\vec{r}_2) + \frac{q_1 q_2}{4\pi\varepsilon_0 \vec{r}_{12}}$$

So potential energy of the system

= total workdone in assembling the configuration

$$U = W_1 + W_2 + W_{12}$$

$$U = q_1 V(\vec{r}_1) + q_2 V(\vec{r}_2) + \frac{q_1 q_2}{4\pi\varepsilon_0 r_{12}}$$

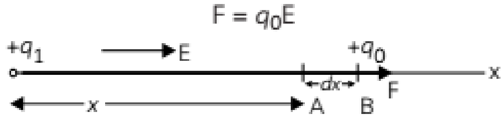
OR

Relationship between electric field and electric potential at a point :

Let a small positive test charge q_0 is moved in the electric field from point B to A. Potential at point A is V and at point B is (V – dV).

Force acting on q_0 in the direction of electric field

$$F = q_0 E$$



So to move the charge from B to A, an external agent will have to work against the force F.

$$dW = F(-dx)$$

Where, $(-dx)$ is the magnitude of the displacement from B to A.

$$dW = -q_0 E dx$$

$$\frac{dW}{q_0} = -E dx \quad ...(i)$$

By the definition of potential difference

$$\frac{dW}{q_0} = V - (V - dV) = dV \quad ...(ii)$$

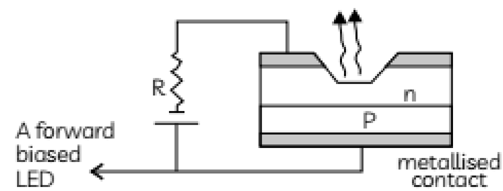
From eqns (i) and (ii)

$$-E dx = dV$$

$$E = -\frac{dV}{dx}$$

22. LED is forward biased p–n junction which emits light spontaneously converts the biasing electrical energy into optical energy, like infrared and visible light.

When the p–n junction is forward biased, electrons are sent from n region to p–region (where they are minority carriers) and holes are sent from p region to n region (where they are minority carriers). Near the junction, the concentration of minority carriers increases as compared to equilibrium concentration. On either side near junction, the excess minority carriers combine with the majority carriers. On recombination, the energy is released in the form of photons. Photons with energy equal to or slightly less than the band gap are emitted. When the forward bias of the diode is small, the intensity of emitted light is small. As the forward current increases, intensity of light increases and reaches a maximum. Further, increase in forward current decreases the light intensity.



For emission in visible range least band energy required is 1.8 eV.

23. Given,

$$\theta = 30°$$
$$\tau = 9 \times 10^{-26} \text{ Nm}$$
$$E = 10^4 \text{ N/C}$$
$$p = ?$$

As we know that,

$$\tau = pE \sin\theta$$

$$p = \frac{\tau}{E\sin\theta}$$

$$p = \frac{9\times10^{-26}}{10^4 \times \sin 30°}$$

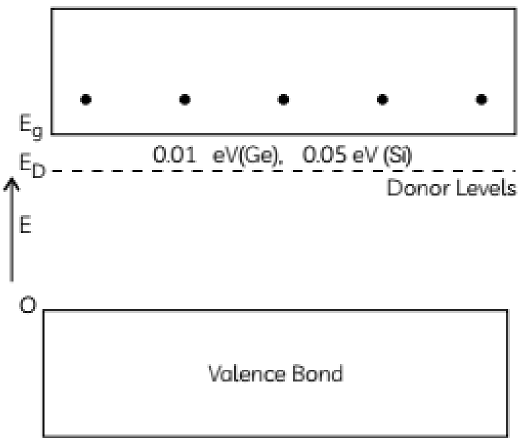
$$p = \frac{9\times10^{-26}\times10^{-4}}{1/2}$$

$$p = 18 \times 10^{-30} \text{ Cm.}$$

24. Energy band diagram when intrinsic semiconductor (Ge) is doped with impurity atoms of Antimony (Sb):

When a pentavalent impurity atom like antimony, phosphorous or arsenic is added to Ge or (Si) crystal, it replaces a Ge (or Si) atom in the crystal lattice. Four electrons of impurity atom form covalent bonds with four electrons of Ge and fifth electron becomes free to move and acts as a charge carrier.

The fifth valence electrons of the impurity atoms occupy some discrete energy levels just below the conduction band. At room temperature these the fifth electrons of almost all the donor atoms are thermally excited from the donor levels into the conduction band. At room temperature the thermal excitation from the valence band is small, there are very few holes in this band.



n–type extrinsic semiconductor is obtained by doping of impurity atoms of Antimony (Sb) in intrinsic semiconductor (Ge).

In *n*–type semiconductors majority charge carriers are electrons.

25. Characteristics of image formed when an object is placed between the optical centre and focus of a thin convex lens :

(i) Virtual and erect image is formed on the same side of the lens as the object.

(ii) Image size is larger than object.

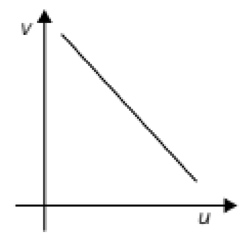
By using the lens maker's formula

$$\frac{1}{f}=\frac{1}{v}-\frac{1}{u}$$

□ $$\frac{1}{v}=\frac{1}{u}+\frac{1}{f},$$

In the given case both *u* and *v* are negative,

So, $\frac{1}{v}=\frac{1}{u}-\frac{1}{f}$, which depicts a straight line represented by, $y = mx + c$.



SECTION - C

26. It is defined as the average velocity with which free electrons gets drifted in a direction opposite to that of electric field.

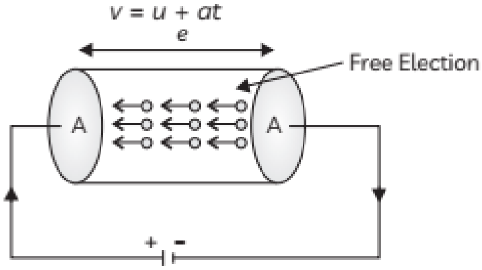
If *m* is the mass of the electron and e be the charge of electron, then on application of the electric field E, acceleration acquired by the electron is:

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

As we know,

First equation of motion,

$$v = u + at$$



Since, the average velocity,

$$u = 0, v = v_d, t = \tau$$

(relaxation time)

Then,

$$v_d = a\tau$$

$$v_d = \frac{eE\tau}{m}$$

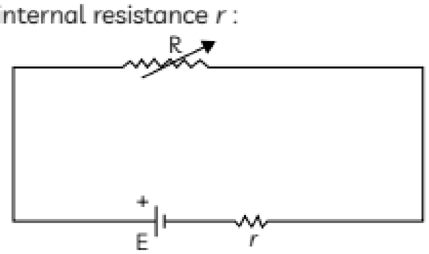
Where, e is the change on electron

E is the electric field intensity

τ is the relaxation time.

And m is the mass of electron.

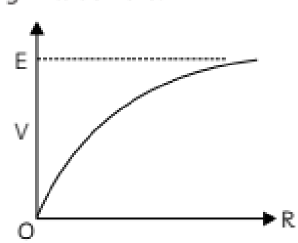
27. (A) Circuit diagram for a variable resistors R connected across a cell of emf E and internal resistance *r* :



Variable resistor R will be in series combination with internal resistance *r*.

Net resistance, $R_{eq} = (R + r)$

(B) Potential drop across the resistor R will be maximum, when internal resistance of the battery will be zero.



$V = E - ir$

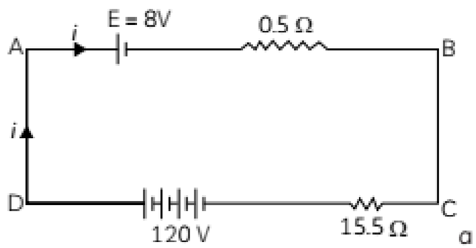
(C) Current flowing in the circuit,

$$i = \frac{E}{R+r}$$

For the current to be maximum, value of (R+r) should be minimum. Since practically r can not be zero because of material of electrolyte used, so to draw maximum current R will be zero.

OR

(A)



When a battery is charged by using an external D.C. supply current will flow from positive terminal of battery to the negative (i.e. in the reverse direction).

(B) By using KVL,

$$8 + 0.5 \times i + 15.5 \times i - 120 = 0$$

$$\Rightarrow \quad 16\,i - 112 = 0$$

$$\Rightarrow \quad i = 7\text{ A}$$

When battery is charged, potential difference across the battery

$$V = E + ir$$

$$= 8 + 7 \times 0.5 = 8 + 3.5$$

$$= 11.5 \text{ Volt}$$

(C) Series resistor of resistance 15.5 Ω is used in the given circuit to limit the current drawn from the source.

28. (A) de–Broglie reasoned out that matter possesses momentum ($p = mv$) and kinetic energy ($K = \frac{1}{2}mv^2$). So matter is supposed to have a particle nature. In 1924, de–Broglie introduced a bold hypothesis that, like radiation, matter should, have dual nature. He reached on this conclusion on the basis of that the entire universe is composed of matter and electromagnetic radiation and that nature loves symmetry. So according to de–Broglie, all material particles in motion have wave nature also. According to quantum theory of radiation, energy of photon, $E = h\nu$

By Einstein's mass-energy relation $E = mc^2$

$$\Rightarrow \quad m = \frac{E}{c^2} = \frac{h\nu}{c^2}$$

Momentum of photon $p = m \times c = \frac{h\nu}{c^2} \times c$

$$p = \frac{h\nu}{c} = \frac{hc}{c\lambda} \quad \left[\because \nu = \frac{c}{\lambda}\right]$$

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

(B) The de–Broglie wavelength of V-volt electrons is given by

$$\lambda = \frac{h}{\sqrt{2mk}} = \frac{h}{\sqrt{2mqV}}$$

$$\frac{\lambda_\alpha}{\lambda_d} = \frac{\sqrt{m_d q_d}}{\sqrt{m_\lambda q_\lambda}} = \sqrt{\frac{2 \times 1e}{4 \times 2e}} = \frac{1}{2}$$

Since both deuterons and alpha particles are accelerated through same potential,

$$\frac{\lambda_d}{\lambda_\alpha} = \frac{\sqrt{m_d q_d}}{\sqrt{m_\alpha q_\alpha}} = \sqrt{\frac{2 \times 1e}{4 \times 2e}} = \frac{1}{2}$$

Hence, the wavelength of deuteron is more than the wavelength of the alpha particle.

Mass of deuteron is equal to double of H atom and charge is same as that of H atom.

Mass of α-particle is equal to 4 times of H atom and charge on it is double that of it.

So alpha particle will have shortest de–Broglie wavelengths composed to deuterons.

OR

Implications of observations obtained from various Photoelectric experiments:

Lenard and Millikan gave the following laws on the basis of experiments on photoelectric effect :

(1) The rate of emission of photoelectrons from the surface of a metal varies directly as the intensity of the incident light falling on the surface.

(2) The maximum kinetic energy of the emitted photoelectrons is independent of the intensity of the incident light.

(3) The maximum kinetic energy of the photoelectrons increases linearly with increase in the frequency of the incident light.

(4) If the frequency of the incident light is below a certain lowest value, then no phtoelectron is emitted from the metal. This lowest frequency (threshold frequency) is different for different metals.

(5) As soon as the light is incident on the surface of the metal, the photoelectrons are emitted instantly, that is, there is no time-lag between incidence of light and emission of electrons.

Failure of Wave Theory: These characteristics of the photoelectric effect cannot be explained on the basis of the wave theory of light. It is due to three main reasons:

(1) According to the wave theory, the energy carried by a light beam is distributed uniformly over a wavefront and is measured by the intensity of the beam. Thus, when light falls on a metal surface, the energy of the wave should be transferred uniformly to the electrons in the surface before they are emitted out. Obviously, the energy taken up by the electrons must increase as the intensity of light is increased. This is against the experimental observation that the maximum energy of the emitted electrons is independent of the light intensity.

(2) According to the wave theory the light of any frequency, however low it is, should be capable of ejecting electrons from a surface, provided only that the light is intense enough. Experiment, however, shows that light of frequency lower than a certain threshold value cannot eject photoelectrons, no matter how intense it is.

(3) If the incident light is very feeble, the electron should take appreciable time before it acquires sufficient energy to come out from the surface. But there is no time-lag between incidence of the light on the surface and the emission of the photoelectrons.

Thus, wave theory fails in explaining the experimental observations regarding the photoelectric effect.

29. The frequency ν of emitted radiation when a hydrogen atom de-excites from level n to level (n–1) can be calculated as,

$$e = h\nu = E_2 - E_1$$

$$\nu = \frac{E_2 - E_1}{h}$$

$$= \frac{mz^2e^4}{8\varepsilon_0^2h^3}\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

In the given case $n_1 = (n-1)$ and $n_2 = n$

$$\nu = \frac{mz^2e^4}{8\varepsilon_0^2h^3}\left[\frac{1}{(n-1)^2} - \frac{1}{n^2}\right]$$

$$= \frac{mz^2e^4}{8\varepsilon_0^2h^3}\left[\frac{n^2-(n-1)^2}{n^2(n-1)^2}\right]$$

$$= \frac{mz^2e^4}{8\varepsilon_0^2h^3}\frac{(2n-1)}{n^2(n-1)^2}$$

For Large n, (2n – 1) 2n and (n – 1)n

$$\nu = \frac{mz^2e^4 \times 2n}{8\varepsilon_0^2h^3 n^2 \times n^2} = \frac{mz^2e^4}{4\varepsilon_0^2h^3n^3}$$

For hydrogen atom z = 1

$$\nu = \frac{me^4}{4\varepsilon_0^2h^3n^3} \quad ...(i)$$

In Bohr's atomic model,

velocity of electron in n^{th} orbit is $v = \frac{nh}{2\pi mr}$

radius of orbital path $r = \frac{n^2h^2\varepsilon_0}{\pi mze^2}$

frequency of revolution $\nu = \frac{v}{2\pi r} = \frac{nh}{2\pi mr(2\pi r)}$

$$= \frac{nh}{4\pi^2mr^2} = \frac{me^4}{4\varepsilon_0^2h^3n^3} \quad ...(ii)$$

From eqns (i) and (ii) we can say that for large values of n, frequency of radiation emitted when a hydrogen atom de-excites from level n to level (n–1) is same as that of classical frequency of revolution of an electron.

30. (A) Difference between Nuclear fission and nuclear fusion:

(1) In fission when neutrons are bombarded on a heavy nucleus, it splits in two nearly equal weight framents while in fusion, at a very high temperature and high pressure two light nuclei combine to form a heavy nucleus.

(2) For the same mass, the energy released in fusion process is much more than that in the fission process.

(3) Fission process can be controlled. Nuclear reactor is based on the controlled fission reaction. Fusion reaction can not be controlled. This is why fusion reactor could not be constructed so far.

(B) In the process of fission of ${}_{26}fe^{56}$, let energy Q be released.

$${}_{26}fe^{56} = 2\,{}_{13}Al^{28} + Q$$

Given (m) ${}_{26}fe^{56}$ = 55.93494 U

(m) ${}_{13}Al^{28}$ = 27.98191 U

Mass difference, Δm = 2× mass of Al atom – mass of fe atom

= 2×27.98191 – 55.93494

= 0.02888

According to mass energy relation, the energy released $\Delta E = \Delta mc^2$

$= 0.02888 \times (3\times10^8)^2$

$= 0.25992 \times 10^{16}$J

= 0.02888 × 931.5 MeV

[∵ $1u\times c^2$ = 931.5 MeV]

= 26.90172 MeV

SECTION - D

31. (A) **Gauss' Law:** The electric flux ϕE through any closed surface is equal to $\frac{1}{\varepsilon_0}$ times the net charge q enclosed by the surface.

$\phi_E = \oint \vec{E}.d\vec{A} = \frac{q}{\varepsilon_0}$, where ε_0 is permittivity of free space.

The Gauss theorem in electrostatics gives a relation between the electric flux through any closed hypothetical surface and the charge enclosed by the surface.

Proof: Let a point charge +q is placed at O inside a closed surface. Let dA be the small area element surrounding a point P on the surface. Let op = r.

The area element may be represented by a vector $d\vec{A}$ drawn outward along the normal to the elements.

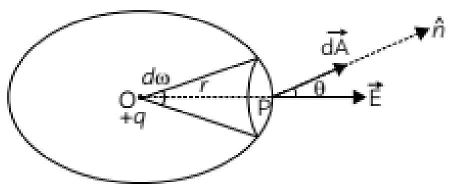
Let electric field intensity at point P be $\vec{E}$ due to charge +q.

The electric flux through the area element dA is,

$$d\phi_E = \vec{E}.d\vec{A} = EdA\cos\theta$$

where, θ is the angle between the vectors $\vec{E}$ and $d\vec{A}$.

$$d\phi_E = \frac{q}{4\pi\varepsilon_0}\frac{dA}{r^2}\cos\theta$$



Since, $\frac{dA\cos\theta}{r^2}$ is the solid angle $d\omega$ subtended by the area dA at the point O.

$$\because \quad d\phi_E = \frac{q}{4\pi\varepsilon_0}d\omega$$

$\therefore$ Total flux through the entire surface,

$$\phi_E = \frac{q}{4\pi\varepsilon_0}\oint d\omega$$

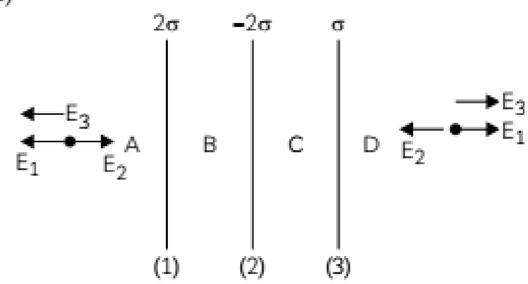
$$= \frac{q}{4\pi\varepsilon_0}\times 4\pi$$

[$\because \oint d\omega = 4\pi$, the solid angle subtended by the entire closed surface at the point O.]

$$\therefore \phi_E = \frac{q}{\varepsilon_0}$$

which is clearly independent of the size and shape of Gaussian surface.

(B)



Given, thin long sheets have surface charge density $+2\sigma$, -2σ and $+\sigma$ respectively. We need to calculate electric field intensity at point A and point D.

At point A,

Let electric field intensities due to plates (1), (2) and (3) be $\vec{E}_1$, $\vec{E}_2$ and $\vec{E}_3$.

$E_1 = \frac{2\sigma}{2\varepsilon_0}$ (away from sheet 1)

$E_2 = \frac{2\sigma}{2\varepsilon_0}$ (towards sheet 1)

$E_3 = \frac{\sigma}{2\varepsilon_0}$ (away from sheet 1)

Resultant intensity, $E_A = E_1 - E_2 + E_3$

$$= \frac{2\sigma}{2\varepsilon_0} - \frac{2\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0}$$

$= \frac{\sigma}{2\varepsilon_0}$ (away from sheet 1 or towards left)

At point D

$E_1 = \frac{2\sigma}{2\varepsilon_0}$ (away from sheet 1)

$E_2 = \frac{2\sigma}{2\varepsilon_0}$ (towards sheet 2)

$E_3 = \frac{\sigma}{2\varepsilon_0}$ (away from sheet 3)

Resultant Intensity, $E_D = E_1 - E_2 + E_3$

$$= \frac{2\sigma}{2\varepsilon_0} - \frac{2\sigma}{2\varepsilon_0} + \frac{\sigma}{2\varepsilon_0}$$

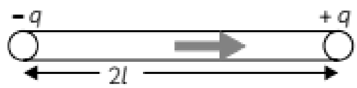
$$= \frac{\sigma}{2\varepsilon_0}$$

(away from sheet 3 or towards right)

OR

(A) **Electric dipole :** A pair of equal and opposite point charges placed at a short distance apart is called an electric dipole. The product of one charge and the distance between the charges is called the magnitude of the electric dipole moment p.

Let two charges $-q$ and $+q$ be placed at small distance Say 2l.



The magnitude of electric dipole moment

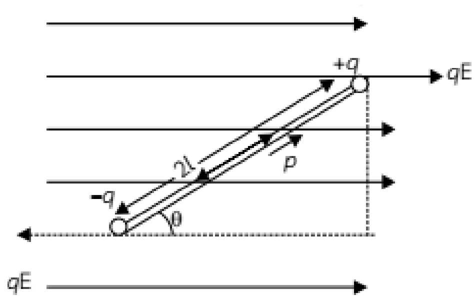
$$P = q \times 2l$$

$$P = 2ql$$

It is a vector quantity whose direction is along the line joining the two charges, pointing from the negative charge to positive charge.

Examples: Molecules like HCl, H_2O etc are electric dipoles. In some molecules one end of the molecule is positively charged and the other end is equally negatively charged. Such molecules are electric dipoles.

(B) Derivation for the calculation of torque on an electric dipole in a uniform electric field:



When an electric dipole is kept in an external uniform electric field, a couple acts on it, which tries to align the dipole in the direction of the field. This is called the restoring couple.

The dipole moment vector $\vec{P}$ making an angle θ with the field $\vec{E}$. Let $-q$ and $+q$ be the charges forming the dipole and 2l is the distance between them. Due to electric field $\vec{E}$, the charge $+q$ experiences a force $q\vec{E}$ (in the direction of the field) and the charge $-q$ experiences an equal and opposite force $q\vec{E}$ (opposite to the field). Since these two forces are equal and opposite, the net transplatory force on the dipole will become zero, so there will be no translatory motion of the dipole in a uniform electric field. But since forces $q\vec{E}$ and $-q\vec{E}$ are acting at different points so these will form a couple, and try to rotate the dipole along the direction of uniform electric field.

The moment of this restoring couple is known as torque.

$\tau = qE\,(2l\sin\theta)$

$= 2ql\,E\sin\theta$

$\tau = pE\sin\theta$ N–m

In vector form,

$\Rightarrow \vec{\tau} = \vec{p} \times \vec{E}$

(C) Given, $2l = 2$ cm $\quad \theta = 60^o$

$E = 10^5$ N/C $\quad \tau = 8\sqrt{3}$ Nm

$q = ?\quad U = ?$

$\tau = pE\sin\theta$

$8\sqrt{3} = 2ql\,E\,\text{Sin}\theta$

$= q \times (2 \times 10^{-2}) \times 10^5\,\text{Sin}60^o$

$8\sqrt{3} = 2 \times 10^3 q\,\dfrac{\sqrt{3}}{2}$

$\Rightarrow q = 8 \times 10^{-3}$ C

Potential energy, $PE = -PE\cos\theta$

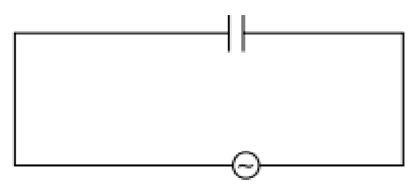
$= -q \times 2l\,E\cos\theta$

$= -8 \times 10^{-3} \times 2 \times 10^{-3} \times 10^5 \cos 60^o$

$= -16 \times \dfrac{1}{2}$

$= -8$ J

32. (A)



Let an alternating emf given by $V = V_0 \sin\omega t$ be applied across the plates of capacitor having capacitance C. As the emf is alternating, the charge on the capacitor plates varies continuously and correspondingly current flows in the connecting leads. If q be charge on the capacitor plates and i is current at any instant, instantaneous potential difference across the plates of capacitor must be equal to the applied emf.

$\dfrac{q}{C} = E_0 \sin\omega t$

$\therefore$ Instantaneous current $i = \dfrac{dq}{dt} = \dfrac{d}{dt}(E_0 C\sin\omega t)$

$= CE_0\omega\cos\omega t$

$i = \dfrac{E_0}{1/\omega C}\sin(\omega t + \pi/2)$

Since maximum value of $\sin(\omega t + \pi/2)$ is 1,

So, $i_{max} = \dfrac{E_0}{1/\omega C}$ ...(i)

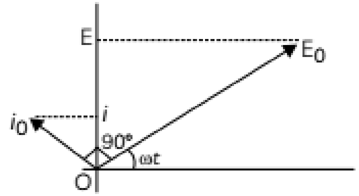
$\therefore i = i_0 \sin\left(\omega t + \dfrac{\pi}{2}\right)$ ...(ii)

Where, $i_0C = \frac{E_0}{1/\omega C}$ is the peak value of current.

On compairing equation (2) with

$E = E_0 \sin\omega t$

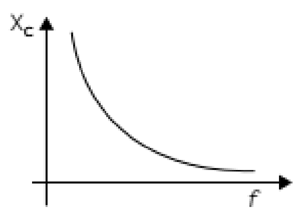
it is clear that the current leads the emf by a phase angle $\frac{\pi}{2}$



From eq (1) peak value of current $i_0 = \frac{E_0}{1/E\omega C}$

Applying Ohm's law we find that $\frac{1}{\omega c}$ is equivalent to net resistance of the circuit. It represents the effective opposition of the capacitor to the flow of ac. It is known as the reactance of the capacitor or capacitive reactance (x_c).

$$X_c = \frac{1}{\omega C} = \frac{1}{2\pi f C}$$

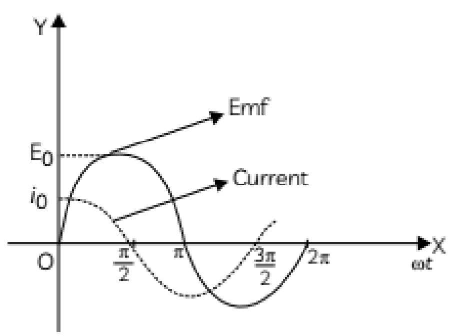


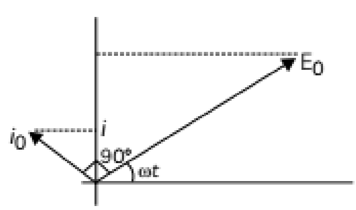
The capacitive reactance decreases with increasing frequency of current as $x_c \propto \frac{1}{f}$. So graph between x_c and f represents a rectangular hyperbola.

(B) **Phasor Diagram:**

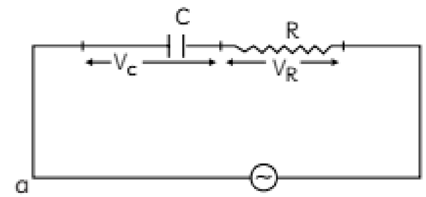
The emf lags behind the current by a phase angle of $\frac{\pi}{2}$ or 90° i.e. When the emf is zero.

The current is maximum or vice-versa.





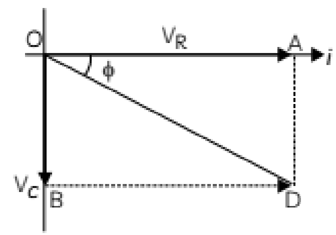
(C)



When a resistance R is added in series with capacitor of capacitance C, the instantaneous potential difference across the capacitor and resistor are given by

$V_c = ix_c$ and $V_R = ix_R$

Now V_R will be in same phase as that of current i while V_c lags behind by 90°.



So resultant applied emf can be calculated as

$$E^2 = V_R^2 + V_C^2$$

$$= i^2 (R^2 + x_c^2)$$

$$i = \frac{E}{\sqrt{R^2 + x_c^2}}$$

Here $\sqrt{R^2 + x_c^2}$ represents the effective resistance of the circuit and is called the impedance Z of the circuit.

From phasor diagram,

phase angle, $\phi = \frac{V_C}{V_R} = \frac{x_c}{R} = \frac{1/\omega C}{R}$

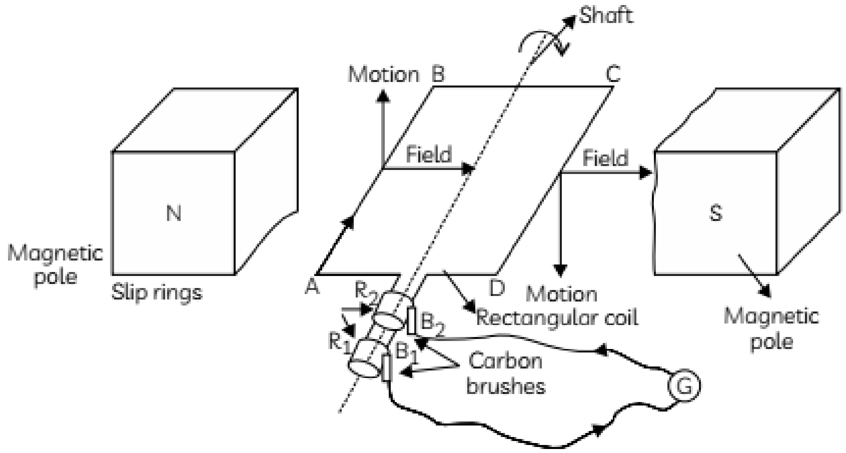
OR

(A) **Principle of ac generator:**

The principle of ac generator is based on electromagnetic induction. When a closed coil is rotated rapidly in a strong magnetic field, the number of magnetic flux-lines (magnetic flux) passing through coil changes continously. Thus an emf is induced in the coil and a current flows in it in a direction given by fleming's right hand rule. In ac generator mechanical energy expanded in rotating the coil appears as electrical energy in the coil.

(B) **Working:**

The schematic diagram for the AC generator is as follows:



In the figure, coil ABCD is placed in the magnetic field. The coil ABCD is horizontal initially. It is made to rotate in the clockwise sense and the arm AB moves up while CD moves down. According to Fleming's right hand rule, the direction of the induced current will be along ABCD. When the coil completes half rotation, the arm CD moves up and AB moves down. Now the direction of the induced current is opposite along DCBA.

The brush B_2 is now positive relative to B, and remains so as long the coil reaches the vertical position again. After this, B_1 is again positive relative to B_2. As a result, an alternating potential difference is developed between B_1 and B_2, generating an alternating current in the circuit.

The magnetic flux linked with a coil is written as:

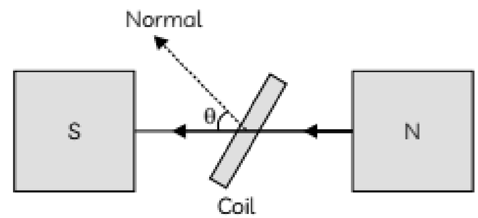
$$\phi = BA \cos \theta$$

Where θ is the angle between the magnetic field and the area vector of the coil.

$$e = -\frac{d\phi}{dt}$$

$$= BA \sin\theta \ \theta \frac{d\theta}{dt}$$

When a coil is rotated inside the magnetic field, the angle between the area vector and magnetic field changes with time due to which emf is induced. Let A be the area of one true of the coil, N be the number of turns in the coil, $\vec{B}$ be the strength of the magnetic field. Let at some instance the angle between the area vector (direction normal to the coil) of the coil and the magnetic field be θ:



∴ The magnetic flux associated with the given coil in this position is as follows:

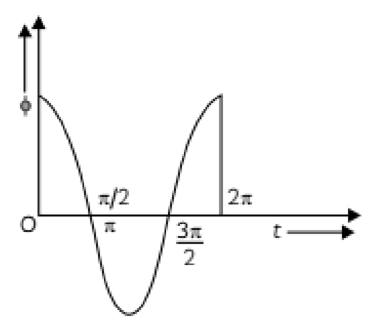
$$\phi = N(\vec{B}.\vec{A})$$

$$= NBA \cos \theta$$

$$= NBA \cos \omega t \quad \text{...(i)}$$

In the above formula, 'ω' is angular velocity of the coil.

The magnetic flux varies with time according to the following figure:



The induced emf is given by,

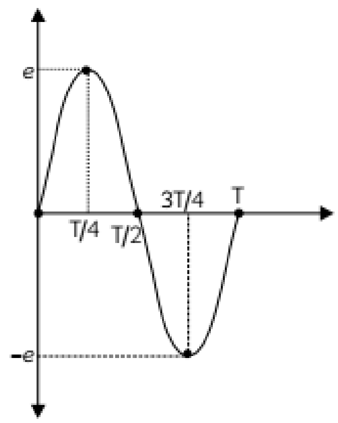
$$e = -\frac{d\phi}{dt} = -\frac{d}{dt}(NAB \cos\omega t)$$

$$= -NAB \frac{d}{dt}(\cos \omega t)$$

$$= -NAB(-\sin \omega t)\omega$$

$$\therefore \quad e = NAB\, \omega \sin \omega t$$

The alternating emf varies with the time as follows,



Where T is time period of AC.

(C) The magnitude of induced emf in a coil rotating in a magnetic field changes continuously with time and is given by,

$$e = NBA\omega \sin\omega t$$

When there is no rotation in the coil, $\omega = 0$

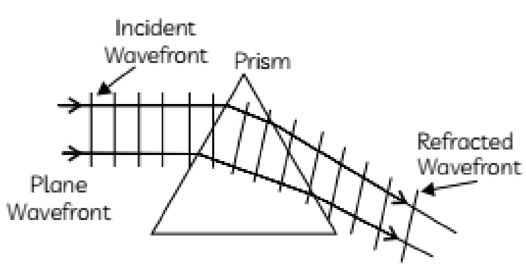
i.e. $e = 0$

It is not possible to generate emf without having rotation in the coil.

33. (A) Wave front: If a surface is drawn in a medium such that all the medium particles lying in the surface are in the same phase of oscillation then the surface is called a wavefront.

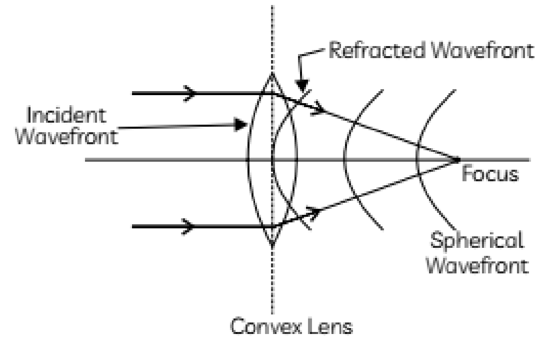
(B) (1) When a plane wavefront hits a thin prism, lower half of the wave meets the glass first and so, this part of the wave is slowed down. This means that the upper part is moving fast and thus the wavefront bends as it enters the prism and so, we get a plane wavefront which is slanted.

Hence, the emerging wavefront is plane wavefront.

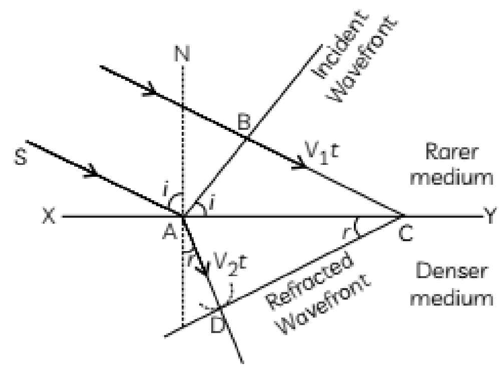


(2) When a plane wavefront hits the lens, it is the centre of the wave that meets the glass first and so this part of the wave is slowed down first (light waves move slower in glass than they do in air). This means that the outer portions of the wave converges. As the wave lean the lens the outer portions move into the air first and so speed up first. This means that the outer portions move off more rapidly first and so the curvature of the wave is further increased so converging the light more strongly.

Hence, the emerging wavefront is spherical wavefront.



(C) **Verification of Snell's Law of refraction using Huygen's formula:**



Let a wavefront AB incident on a plane surface XY, separating two media 1 and 2. Let V_1 and V_2 be the velocities of light in two media such that $v_1 > v_2$.

The wavefront first strikes at point A and then at the successive points towards C. According to Huygen's principle, from each point on AC, the secondary wavelets start growing in the second medium with speed v_2. Let the disturbance takes time t to travel from B to C, then $BC = v_1t$. During the time the disturbance from B reaches the point C, the secondary wavelets from point A must have spread over a hemisphere of radius $AD = v_2t$ in the second medium. The tangent plane CD drawn from point C over this hemisphere of radius v_2t will be the new refracted wavefront.

Let the angels of incidence and refraction be i and r respectively.

From ΔABC, $\sin\Delta BAC = \sin i = \frac{BC}{AC}$

From ΔADC, Sin□DCA = Sin$r$ = $\frac{AD}{AC}$

$$\Rightarrow \frac{Sin i}{Sin r} = \frac{BC}{AD} = \frac{v_1 t}{v_2 t}$$

$$\Rightarrow \frac{Sin i}{Sin r} = \frac{v_1}{v_2} = {}^1\mu_2 \text{ (constant)}$$

This proves Snell's Law of refraction. The constant $^1\mu_2$ is called the refractive index of the second medium with respect to first medium.

OR

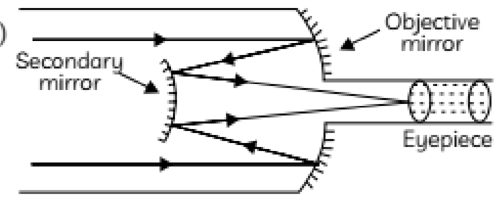
(A) The main considerations with an astronomical telescope are:

(i) Its light gathering power. The light gathering power and hence the brightness of the image is directly proportional to the area of the objective lens.

(ii) The resolving power is the ability to observe two close distant objects distinctly, which also depends on the diameter of the objective lens.

(iii) High magnifying power A telescope having high magnifying power produces apparently a magnified image which enables to see the finer details of the distinct object.

(B)



Magnifying Power:

$$m = \frac{f_0}{f_e}$$

(C) Advantages of reflecting telescope over a refracting telescope are:

(1) Reflecting telescope is free from chromatic and spherical aberrations unlike refracting telescope.

Thus image formed is sharp and bright.

(2) It has a larger light gathering power so that a bright image of even far off object is obtained.

(3) Resolving power of reflecting telescope is large.

SECTION - E

34. (A) A foraday cage is a container made of conductiong material, such as wire mesh or metal plates which is used to block electromagnetic fields. A Foraday cage operates because an external electric field causes the electric charges within the cage's conducting material to be distributed so that they cancel the field's effect in the cage's interior.

(B) The protective metal compartment of a car acts as a faraday cage to protect its passengers from external electric charges such as lightning.

It works because an outside electric field causes a redistribution of the electric charges within the enclosure's conducting material, which in turn cancel's the field's effect in the cage's interior.

(C) Since E = 0 inside the faraday cage, so flux through this, surface = 0.

According to Gauss's law total charge enclosed by the faraday cage = 0.

So all charge goes on outer surface.

OR

Given $q = 2\ \mu C = 2\times10^{-6}$ C

Since cube has 6 symmetrical faces in which charge is placed at the centre of the cube. If flux through any one surface be ϕ_ε then total flux through the cube will be $6\phi_\varepsilon$

By Gauss's theorem,

$$\phi_\varepsilon = \frac{q}{\varepsilon_0} = \frac{2\times10^{-6}}{8.85\times10^{-12}}$$
$$= 0.22598\times10^{6}$$
$$= 2.26\times10^{5}\ Nm^2/C$$

35. (A) The critical angle for a diamond 24.4°

For total internal reflection,

refractive index, $n = \frac{1}{\sin C} = \frac{1}{\sin 24.4°} = 2.42$

Related Theory

➥ *Since refractive index depends upon the wavelength of light, the critical angle for a given pair of media is different for different wavelengths (colours) of light.*

(B) When diamond is immersed in a liquid with a refractive index greater than water, then its resultant refractive index will decrease. As a result critical angle will increase since

$$n = \frac{1}{\sin C}$$

(C) The brilliancy of a diamond is due to small critical angle with respect to air. The light which enters the diamond is totally reflected repeatedly at the various faces of the diamond and emerges only when the angle of incidence at some faces is less than the critical angle. As a result all the light entering the diamond emerges in a few directions only and the diamond sparkles brilliantly when seen along these directions.

OR

More the total internal reflection of light ray at the various faces of the diamond, it will cause more the brilliance of diamond.

In second diamond total internal reflection is occuring only at one face while in first diamond total internal reflection is occuring at two surfaces. So brilliance of diamond in the second diamond will be less than the first.