Solution | CBSE-XII |Test No-07 |Vidyarthi & Shiksha

Pre-Board Examination : 2025-26

Sub : Physics

(The figures in the margin indicate full marks for the questions)

Time – 3 hours **Full marks-70**

SECTION-A

1. **(D)**

Explanation: ^6C: $1s^2\ 2s^2\ 2p^2$

^{14}Si: $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^2$

The energy required to take out an electron from the 3rd orbit of Si is much smaller than to take out an electron from the 2nd orbit of C. So, Si has a significant number of free electrons while C has a negligibly small number of free electrons.

2. **(A)** ionic crystal

Explanation: In an ionic crystal, cations and anions are arranged in alternate form.

3. **(A)** $\frac{1}{x^2}$

The electric potential of dipole is given by

$V = \frac{1}{x^2}$

Electric potential at a point wl' eh lies at a distance x from the mid-point of the dipole will be proportional to $\frac{1}{x^2}$

4. **(B)** Insulators

Explanation: Insulators

5. **(A)** three or less than three

Explanation: The electron theory states that all matter is composed of atoms and the atoms are composed of smaller particles called protons, electrons, and neutrons. The electrons orbit the nucleus which contains the protons and neutrons. It is the valence electrons that we are most concerned with in electricity. These are the electrons which are easiest to break loose from their parent atom. Normally, conductors have three or less valence electrons; insulators have five or more valence electrons; and semiconductors usually have four valence electrons.

6. **(B)** 1

For a point inside the solid cylinder,

$$B_i = \frac{\mu_0 Ir}{2\pi a^2}$$

At $r = \frac{a}{2}$

$$B_i = \frac{\mu_0 I}{4\pi a}$$

For a point outside the solid cylinder,

$$B_0 = \frac{\mu_0 I}{2\pi r}$$

At $r = 2a$

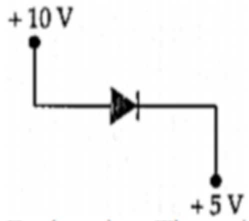
$$B_0 = \frac{\mu_0 I}{4\pi a}$$

Thus, $\frac{B_1}{B_2} = 1$

7. **(C)** Frequency

[1]

8. (C)



Explanation: The p-side is at higher potential (+10V) and n-side is at lower potential (+5V).

9. (C) 460 nm

Given, $\lambda_m = 230$ nm

$\lambda_a = ?$

$$n = \frac{c}{v} = \frac{3\times10^8}{1.5\times10^8} = 2$$

$$2 = \frac{\lambda_a}{\lambda_m}$$

$\lambda_a = 2 \times \lambda_m = 2 \times 230 = 460$ nm

10. (B) $[ML^2T^{-3}A^{-2}]$

Explanation: Power = i^2R

$$\Rightarrow \frac{\text{Work done}}{\text{Time}} - \frac{\text{Force} \times \text{Distance}}{\text{Time}}$$

$$\Rightarrow [R] = \left[\frac{MLT^{-2}L}{T}\right]\left[\left(\frac{1}{A^2}\right)\right]$$

$\Rightarrow [R] = ML^2T^{-3}A^{-2}$

11. (C) For a uniform electric field, they are concentric spheres.

12. (C) $q = \frac{\tau}{[(2a)E\sin\theta]} = \frac{4}{2\times10^{-2}\times2\times10^5\sin30^\circ}$

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

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

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

Both proton and electron are moving with same velocity. So, $\lambda \propto \frac{1}{m}$. So, the reason is true.

Mass of proton > mass of electron.

So, wavelength of electron > wavelength of proton. So, the assertion is true and reason is the proper explanation of the assertion.

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

Explanation: Electrons being emitted as photoelectrons have different velocities. Actually, all the electrons do not occupy the same level of energy but they occupy continuous band and levels. So, electrons being knocked off from different levels come out with different energies. The work function is the energy required to pull the electron out of the metal surface. Naturally, electrons on the surface will require less energy to be pulled out hence will have lesser work function as compared with those deep inside the metal.

So, Both Assertion and Reason are true and Reason is the correct explanation of Assertion.

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

Diamagnetic substances exhibit magnetism due to absence unpaired electrons, diamagnetic materials do not have permanent magnetic dipole moment, thus both Assertion and Reason are true and Reason is the correct explanation of Assertion

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

As electrostatic force is conservative force, so reason is true. Also, conservative force means work done doesn't depend on path followed and work done in moving a charge around a closed path in an electric field is always zero for conservative force. Therefore, both Assertion and Reason are true and Reason is the correct explanation of Assertion.

SECTION-B

17. $B = \dfrac{E}{c}$

$= \dfrac{6.3 V/m}{3\times10^{8} m/s} = 2.1 \times 10^{-8}$ T

To find the direction, we note that E is along y-direction and the wave propagates along x-axis. Therefore, B should be in a direction perpendicular to both x- and y-axes. Using vector algebra, c = E × B should be along the x-direction.

Since, $(+\hat{j})\times(+k) = i$, B is along the z-direction. E is along y direction and c is along x direction

Thus, $B = 2.1 \times 10^{-8}$ kT.

18. For plano-convex lens,

$$\frac{1}{f} = (\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{f} = (1.5-1)\left(\frac{1}{15}-\frac{1}{\infty}\right)$$

$$= (0.5)\left(\frac{1}{15}-0\right) = \frac{5}{10}\times\frac{1}{15} = \frac{1}{30}$$

Plano-concave lens,

$$\frac{1}{f} = (\mu-1)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

$$\frac{1}{f} = (1.5-1)\left(\frac{1}{\infty}-\frac{1}{15}\right)$$

$$= (0.5)\left(0-\frac{1}{15}\right) = -\frac{1}{30}$$

$\therefore$ u = + 20 cm

$$\therefore\ v = \frac{uf}{u+f} = \frac{20\times(-30)}{20-30} = \frac{-600}{-10}$$

v = +60 cm

19. (i) The minimum energy required to free the electron from the ground state of H-atom is called ionisation energy.

The ionisation energy for H-atom,

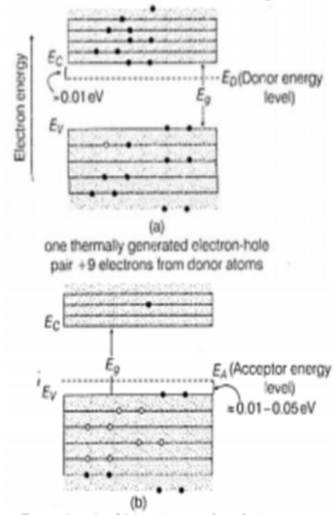
$E = E_{\infty} - E_1$

$E = 0 - (-13.6)$

E = 13.6 eV

20. Energy Band in Extrinsic Semiconductors: In extrinsic semiconductors, additional energy states due to donor impurities (E_D) and acceptor impurities (EA) also exist. In the energy band diagram of n-type semiconductor, the donor energy level ED is slightly below the bottom Ec of conduction band and the electrons from this level move into conduction band with very small supply of energy.

In p-type semiconductors, the acceptor energy level EA is slightly above the top energy level Ev of the valence band. With very small supply of energy an electron from the valence band can jump to the level EA and ionise the acceptor negatively.



Energy bands of (a) n- type semiconductor at T > 0 K (b) p-type semiconductor at T > 0 K

21. (i) Impedance of the circuit Z

$$Z = \sqrt{R^2 + (X_C)^2} = \sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}$$

$$Z = \sqrt{(200)^2 + \left(\frac{1}{(100\pi)^2 \times \left(\frac{50}{\pi}\right)^2 \times 10^{-6}}\right)}$$

$$Z = \sqrt{(200)^2 + \left(\frac{1}{(100)^2 \times 2500 \times 10^{-6}}\right)}$$

Z = 200 Ω

(ii) Phase angle ϕ and

$$\tan\phi = \frac{Z}{R} = \frac{200}{200} = 1$$

$\phi = \tan^{-1}(1)$

$\phi = 45°$

[3]

SECTION-C

22. As EMFs ε_1 and ε_2 are opposing each other and $\varepsilon_2 > \varepsilon_1$, so

Net emf = $\varepsilon_2 - \varepsilon_1 = 4 - 2 = 2$ V

This emf sends circuit I in the anticlockwise direction.

Total resistance = $R + r_1 + r_2 = 5 + 1 + 2 = 8\Omega$

Current in the circuit

$$= \frac{\text{Net emf}}{\text{Total resistance}} = \frac{2}{8} = 0.25 \text{ A}$$

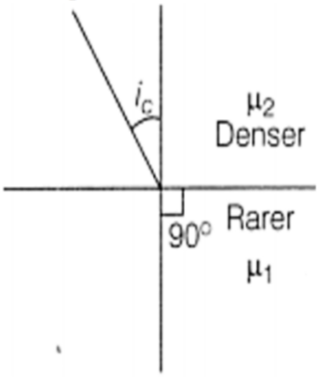
(i) Current inside the cell ε_2 flows from –ve to +ve terminal, so the terminal p.d. of this cell is

$V_a - V_b = \varepsilon_2 - Ir_2 = 4.0 - 0.25 \times 2.0 = 3.5$ V

(ii) Current inside the cell ε_1 flows from +ve to –ve terminal. Hence the terminal p.d. of this cell is

$V_a - V_b = \varepsilon_1 + Ir_1 = 2.0 + 0.25 \times 1.0 = 2.25$ V

23. Critical angle for a pair of given media in contact can be defined as, "the angle of incidence in denser medium for which angle of refraction in rarer is 90°. If the angle of incidence of light, when travelling from a denser medium to a rarer medium, is greater than the critical angle, then total internal reflection takes place.



From Snell's law, $\mu_2 \times \sin i_c = \mu_1 \times \sin 90°$

$$\therefore \frac{\mu_1}{\mu_2} = \frac{\sin i_c}{\sin 90°} \Rightarrow \frac{\mu_1}{\mu_2} = \sin i_c \qquad [\because \sin 90° = 1]$$

$$\text{or } \frac{\mu_2}{\mu_1} = \frac{1}{\sin i_c} \Rightarrow {}^1\mu_2 = \frac{1}{\sin i_c}$$

24. As $\frac{40\Omega}{10\Omega} = \frac{60\Omega}{15\Omega}$

The bridge is balanced.

P.D. across AB = P.D. across AD

or $40 I_1 = 60 I_2$

or $\frac{I_1}{I_2} = \frac{60}{40} = 1.5$

or $I_1 = 1.5 I_2$

Heats produced in time t in different arms of Wheatstone bridge are

$H_{Ab} = I_1^2 RT = (1.5I_2)^2 \times 40 \times t = 90 I_2^2 t$

$HBC = I_1^2 \times 10 \times t = (1.5I_2)^2 \times 10 \times t = 22.5_2^2 t$

$H_{Ad} = I_2^2 \times 60 \times t = 60\, I_2^2 t$

$H_{DC} = I_2^2 \times 15 \times t = 15\, I_2^2 t$

Hence the ratio of the heats produced in the four arms is

$H_{AB} : H_{BC} : H_{AD} : H_{DC}$

$= 90\, I_2^2\, t : 22.5\, I_2^2\, t : 60\, I_2^2\, t : 15\, I_2^2\, t$

$= 90 : 22.5 : 60 : 15 = 6 : 1.5 : 4 : 1$

25. Density of nuclear matter is the ratio of mass of nucleus to its volume.

If m is the average mass of a nucleon and A is the mass number of element, then the mass of nucleus = mA. If R is the nuclear radius, then volume of nucleus = $= \frac{4}{3}\pi R^3$

$$= \frac{4}{3}\pi \left(R_0 A^{1/3}\right)^3$$

As, density of nuclear matter

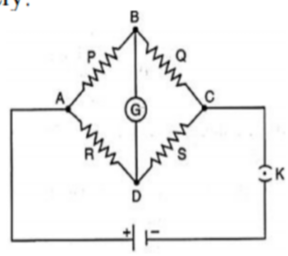
$$= \frac{\text{mass of nucleus}}{\text{volume of nucleus}}$$

$$\rho = \frac{mA}{\frac{4}{3}\pi R_0^3 A}$$

$$\rho = \frac{3m}{4\pi R_0^3}$$

Thus, the density of nucleus is a constant, independent of A, for all nuclei.

26. The Wheatstone bridge is an arrangement of four resistances. In this bridge, four resistances are connected on four arms of a quadrilateral. Across one diagonal, a battery and key are connected. Across the second diagonal, a galvanometer is connected as shown in the figure. Consider P, Q, R, and S are four resistances connected on the sides AB, BC, AD, and DC of the quadrilateral respectively.



Galvanometer G is connected between points B and D and battery B is connected between A and C' Now in the balance condition, when the deflection in the galvanometer is zero in the closed mesh ABDA, then by applying Kirchhoff's law,

$I_1P - I_2P = 0$ or $I_1P = I_2R$ ..... (i)

In closed mesh CBDC,

$I_1Q = I_2S$ ..... (ii)

Dividing (i) by (ii), $\frac{P}{Q} = \frac{R}{S}$

This is the balanced condition for the Wheatstone bridge.

27. The significance of a negative value of electrostatic potential energy indicates that the system of charges is in a stable configuration. When the potential energy is negative, it means that work has been done to bring the charges closer together and they are bound in a more stable arrangement.

Given, $q_1 = 4uC = 4 \times 10^{-6}$ C.

$q_2 = 4uC = -4 \times 10^{-6}$ C.

and $q_3 = 2uC = 2 \times 10^{-6}$ C.

$d = 2$ cm $= 2 \times 10^{-2}$ m

Using $U = \frac{1}{4\pi\varepsilon_0}\left[\frac{q_1q_2}{r} + \frac{q_2q_3}{r} + \frac{q_3q_1}{r}\right]$

Putting the values,

$= \frac{9\times10^9}{2\times10^{-2}}$ $[4 \times 10^{-6} \times (-4 \times 10^{-6}) + (-4 \times 10^{-6})$

$\times (2 \times 10^{-6}) + (4 \times 10^{-6}) \times 2 \times 10^{-6}]$

$= \frac{9\times10^9\times10^{-12}}{2\times10^{-2}}[-16-8+8]$

$= -7.2$ mJ

28. maximum emf produced in the coil,

$e_0 = NBA\omega$

$= 100 \times 0.8 \times 0.5 \times 60$

$= 2400$ V ....(i)

$\therefore I_0 = \frac{e_0}{R} = \frac{2400}{100} = 24^a$

$\therefore$ Power dissipated, $P = e_0 \times I_0$

$= 2400 \times 24 = 57600$

$= 576 \times 10^2$ W

SECTION-D

29. Maxwell showed that the speed of an electromagnetic wave depends on the permeability and permittivity of the medium through which it travels. The speed of an electromagnetic wave in free space is given by $c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$. The fact led Maxwell to predict that light is an electromagnetic wave. The emergence of the speed of light from purely electromagnetic considerations is the crowning achievement of Maxwell's electromagnetic theory. The speed of an electromagnetic wave in any medium of permeability μ and permittivity ε will be $\frac{c}{\sqrt{K\mu_r}}$

where K is the dielectric constant of the medium and μ_r is the relative permeability.

(i) **(B)** $ML^{-1}T^{-2}$

Explanation: $\frac{1}{2}\varepsilon_0E^2$ = energy density

$= \frac{\text{Energy}}{\text{Volume}}$

$\therefore \left[\frac{1}{2}\varepsilon_0E^2\right] = \frac{ML^2T^{-2}}{L^3} = \left[ML^{-1}T^{-2}\right]$

(ii) **(C)** $[\varepsilon_0] = M^{-1}L^{-3}T^4A^2$

Explanation: As $\varepsilon_0 = \frac{q_1q_2}{4\pi FR^2}$ (from Coulomb's law)

$\varepsilon_0 = \frac{C^2}{Nm^2}\frac{[AT]^2}{MLT^{-2}L^2} = M^{-1}L^{-3}T^4A^2$

(iii) (A) wavelength is halved and the frequency remains unchanged.

Explanation: The frequency of the electromagnetic wave remains same when it passes from one medium to another.

Refractive index of the medium,

$$n = \sqrt{\frac{\varepsilon}{\varepsilon_0}} = \sqrt{\frac{4}{1}} = 2$$

Wavelength of the electromagnetic wave in the medium,

$$\lambda_{med} = \frac{\lambda}{n} = \frac{\lambda}{2}$$

OR

(C) the speed of light $c = 3 \times 10^8$ m s^{-1} in free space

Explanation: The velocity of electromagnetic waves in free space (vacuum) is equal to velocity of light in vacuum (i.e., 3×10^8 ms^{-1}).

(iv) (A) β-rays

Explanation: β-rays consists of electrons which are not electromagnetic in nature.

30. (i) (A) inertia in mechanics

(ii) (B) 12.5 Wb

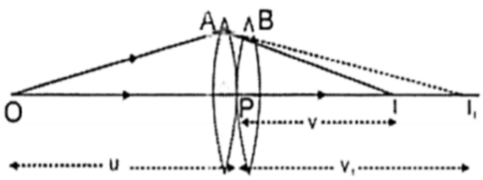
(iii) (C) $L \propto R_2$

(iv) (C) Farad

SECTION-E

31.

(i)



Two thin lenses, of focal length f_1 and f_2 are kept in contact. Let O be the position of the object and let u be the object distance. The distance of the image (which is at I_1), for the first lens is v_1.

This image serves as object for the second lens. Let the final image be at I. We then have

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

$$\frac{1}{f_2} = \frac{1}{v} - \frac{1}{v_1}$$

Adding, we get

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

$$\therefore \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$\therefore P = P_1 + P_2$

(ii) A ray of light passing from the air through an equilateral glass prism undergoes minimum deviation. Thus, At a minimum deviation

$$r = \frac{A}{2} = 30°$$

We are given that, $i = \frac{3}{4}A = 45°$

$$\therefore \mu = \frac{\sin 45°}{\sin 30°} = \sqrt{2}$$

$\therefore$ Speed of light in the prism $v = \frac{c}{\mu} = \frac{c}{\sqrt{2}}$

$= (2.1 \times 10^8 \, ms^{-1})$

OR

The light on passing through the narrow slit undergoes diffraction. A diffraction pattern consisting of alternate bright and dark bands is obtained on the screen.

(i) Angular width of principal maximum,

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

It is not affected when screen is moved away (D increases) from the slit plane.

(ii) Now linear width x of the central maximum is given by

$$x = \frac{2\lambda D}{a}$$

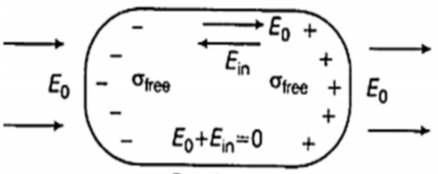
Thus if the screen is moved away the linear width of the central maximum will increase too.

Difference between interference and diffraction

(i) In interference all the fringes will be of equal intensity but in diffraction the central maximum will have high intensity and in the rest of the fringes intensity falls rapidly.

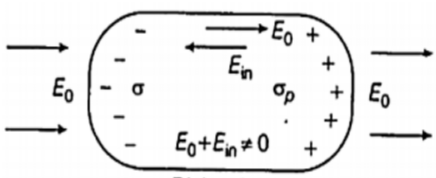
(ii) In interference all the fringes will be of equal width but in diffraction the central maximum will have the highest width and for the other fringes width will diminish fast.

32. (i) (a) When a capacitor is placed in an external electric field, the free charges present inside the conductor redistribute themselves in such a manner that the electric field due to induced charges opposes the external field within the conductor. This happens until a static situation is achieved, i.e, when the two fields cancel each other and the net electrostatic field in the conductor becomes zero.



Conductor

(b) In contrast to conductors, dielectrics are non-conducting substances, i.e. they have no charge carriers. Thus, in a dielectric, free movement of charges in not possible. It turns out that the external field induces dipole moment by stretching molecules of the dielectric. The collective effect of all the molecular dipole moments is the net charge on the surface of the dielectric which. produces a field that opposes the externa field. However, the opposing field is so induced, that does not exactly cancel the external field. It only reduces it. The extent of the effect depends on the nature of dielectric.



Dielectric

Both polar and non-polar dielectrics develop net dipole moment in the presence of an external field. The dipole moment per unit volume is called polarisation and is denoted by P for linear isotropic dielectrics.

$P = \chi E$

where, X is constant of proportionality and is called electric susceptibility of the electric slab.

(ii) (a) At point C, inside the shell, electric field inside a spherical shell is zero. Thus , the force experienced by charge at centre C will also be zero.

$\because F_C = qE$ (E_{inside} the shell = 0)

$\therefore F_C = 0$

At point A $|F_A| = 2Q\left[\frac{1}{4\pi\varepsilon_0}\cdot\frac{3Q/2}{x^2}\right]$

$F = \frac{3Q^2}{4\pi\varepsilon_0 x^2}$, away from shell.

(b) Electric flux through the shell,

$\phi = \frac{1}{\varepsilon_0}\times$ magnitude of charge enclosed by shell $= \frac{1}{\varepsilon_0}\times\frac{Q}{2} = \frac{Q}{2\varepsilon_0}$

OR

Radius of sphere A = R

Surface charge density on sphere A = σ

Radius of sphere B = 2R

Surface charge density on sphere B = σ

Before contact, the charge on sphere A,

Q_1 = Surface charge density × Surface area

$\Rightarrow Q_1 = \sigma \cdot 4\pi R^2$ ...(i)

Before contact, the charge on sphere B is

Q_2 = Surface charge density × Surface area

$Q_2 = \sigma \cdot 4\pi(2R)^2 = \sigma \cdot 16\pi R^2$ ....(ii)

Let after the contact, the charge on A be Q_1 and the charge on B be Q_2. According to the conservation of charge, the charge before contact is equal to charge after contact.

$Q'_1 + Q'_2 = Q_1 + Q_2$

Now, from Eqs. (i) and (ii), we get =

$= 20\pi R^2\sigma$ .....(iii)

As they are in contact. So, they have same potential.

Potential on sphere A is $V_A = \frac{1}{4\pi\varepsilon_0}\cdot\frac{Q'_1}{R}$

Potential on sphere B is $V_B = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q'_2}{2R}$

So, $V_A = V_B$

$\Rightarrow \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q'_1}{R} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{Q'_2}{2R}$

$\Rightarrow \frac{Q'_1}{R} = \frac{Q'_2}{2R}$

$\Rightarrow 2Q'_1 = Q'_2$ ...(iv)

Putting the value of Q'_2 in Eq. (iii), we get

$Q'_1 + Q'_2 = 20\,\pi R^2\sigma$

$\Rightarrow 3Q'_1 = 20\,\pi R^2\sigma$

$\Rightarrow Q'_1 = \frac{20}{3}\pi R^2\sigma$

and $Q'_2 = \frac{40}{3}\pi R^2\sigma$ [from Eq. (iv)]

Let the new charge densities be σ_1 and σ_2.

$\sigma_1 = \frac{Q'_1}{4\pi R^2} = \frac{20\pi R^2\sigma}{3\times 4\pi R^2} = \frac{5}{3}\sigma$

$\sigma_2 = \frac{Q'_2}{4\pi(2R)^2} = \frac{40\pi R^2\sigma}{3\times 4\pi\times 4R^2} = \frac{40\sigma}{16\times 3}$

$\Rightarrow \sigma_2 = \frac{10\sigma}{4\times 3} = \frac{5}{6}\sigma$

Thus, the surface charge densities on sphere after contact are $\frac{5}{3}\sigma$ and $\frac{5}{6}\sigma$.

33. (i) (a) Alternating emf, $E = E_0 \sin \omega t$

Current in the circuit, labelled l

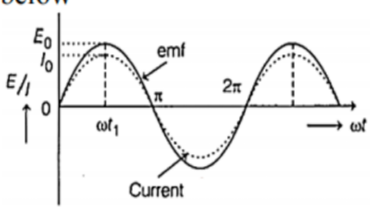
$= \frac{E}{R} = \frac{E_0}{R} \sin \omega t$

or $l = l_0 \sin \omega t$

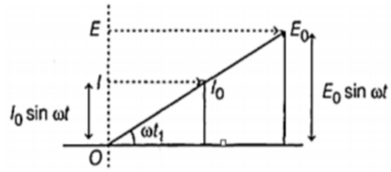
where, $l_0 = \frac{E_0}{R}$ is the peak value of current. R

(b) Phase difference between the emf and the current is zero.

(c) Graphical representation of the emf and the current is as shown in figure below



(d) Phasor diagram is as shown in figure below



(ii) Given, resistance, $R = 10\ \Omega$

rms value of voltage, $E_{rms} = 110$ V

$\therefore$ rms current, $I_{rms} = \frac{E_{rms}}{R} = \frac{110}{10} = 11A$

OR

(i) (a) Here, P $\rightarrow$ Armature coil

Brushes B_1 or B_2 $\rightarrow$ Brushes

(b) Principle: An AC generator works on the principle of electromagnetic induction. According to this, whenever there is change in the magnetic flux linked with a coil, an emf is induced across the ends of the coil.

Working: The coil is rotated with a uniform angular speed co in the magnetic field 6 of the permanent/electromagnet such that the axis of coil is perpendicular to magnetic field. As the coil rotates, magnetic flux through it changes due to which an emf is induced across the ends of the coil.

(ii) Expression for alternating emf

Let θ be the angle between the direction and magnetic field B and area vector A. As, co is the angular speed, then at any time t, $\theta = \omega t$

Flux through the coil at any time,

$\phi_B = BA \cos\theta = BA \cos \omega t$

From Faraday's law, the emf induced in rotating a coil of N turns is

$E = \frac{1}{2} = -NBA\frac{d}{dt}(\cos\omega t)$

Thus, instantaneous emf, $E = NBA\omega \sin \omega t$

This emf will be maximum for $\sin \omega t = \pm 1$

or at = 90°, 270° and $E_{max} = E_0 = NBA\omega$

$E = E_0 \sin \omega t$

This gives the expression for emf induced. As emf £ is a sine function, it varies periodically as the coil rbtates.
