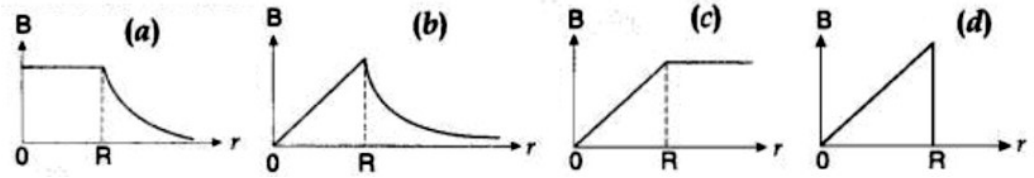
Class : XII || AHSEC || Pre Board Examination , 2024-25
Subject : Physics ||Full marks : 70||Time : 3hours|| Set - 04

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

Each of the following questions carries 1 mark each -

(a) The correct plot of the magnitude of magnetic field B vs distance r from centre of the wire is, if the radius of wire is R



Answer - (b)

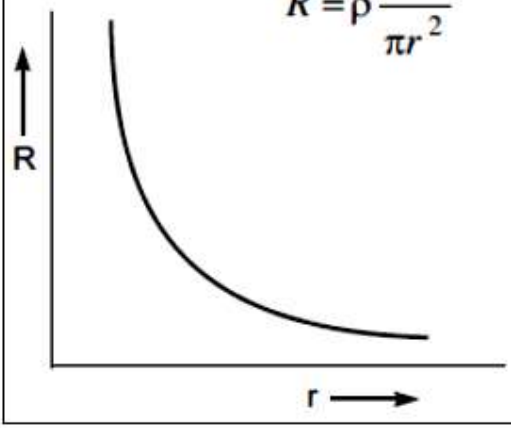
(b) Vehicles carrying inflammable materials usually have metallic ropes touching the ground during motion. Why?

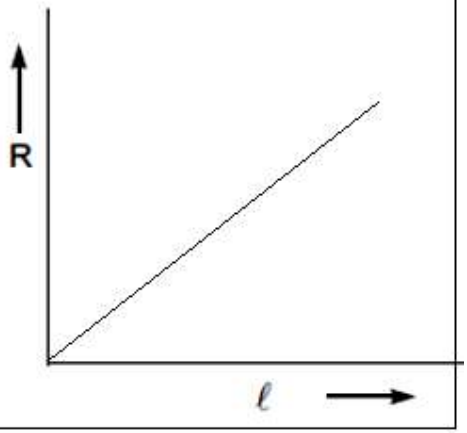
Answer- Moving vehicle gets charged due to friction. The inflammable material may catch fire due to the spark produced by charged vehicle. When metallic rope is used, the charge developed on the vehicle is transferred to the ground and so the fire is prevented

(c) Show graphically the variation of resistance of a conductor with its length and its radius .

Resistance of a conductor of length l, and radius r is given by

$$R = \rho \frac{\ell}{\pi r^2}$$





(d) Express Biot Savart's law in vector form .

According to Biot-Savart's law, the magnetic field due to a current element vector($\vec{dl}$) carrying current I at a point P with position vector $\vec{r}$ is given by

$$d\vec{B} = \frac{\mu_0}{4\pi} \frac{I\vec{dl} \times \vec{r}}{r^3} \quad .....(1)$$

in terms of unit vector $d\vec{B} = \frac{\mu_0}{4\pi} \frac{I\vec{dl} \times \hat{r}}{r^2}$ .....(2)

(e) Which of the following is diamagnetic substance

a) $\varepsilon_r = 1.5, \mu_r = 1.5$ b) $\varepsilon_r = 0, \mu_r = 1.5$ c) $\varepsilon_r = 1.5, \mu_r = 0.5$ d) $\varepsilon_r = 0.5, \mu_r = 0.5$

Answer - (c)

(f) The magnitude of the_____in a circuit is equal to the time rate of change of _____ through the circuit.(Fill up the blanks)

Answer - induced emf , magnetic flux

(g) An electron in an atom could revolve in certain _____ orbits without the _____ of radiant energy, (Fill up the blanks)

Answer- stable , emissoin

(h) The amplitude of the magnetic field part of an electromagnetic wave in vacuum is B_0 = 60 μT. What is the amplitude of the electric field part of the wave ?

$$c = \frac{E_\circ}{B_\circ}$$
$$=> E_\circ = cB_\circ = 3x10^8 x60x10^{-6} = 180x10^2 = 1.8x10^4 V/m$$

Each of the following questions carries 2 mark seach -

(a) What is quantisation of electric charge ?

A polythene piece rubbed with wool is found to have a negative charge of 3×10^{-7} C. Estimate the number of electrons transferred from which to which body?2

Amount of charge on the polythene piece, $q = -3 \times 10^{-7}$ C

Amount of charge on an electron, $e = -1.6 \times 10^{-19}$ C

Number of electrons transferred from wool to polythene = n

n can be calculated using the relation, q = ne

$$n = \frac{q}{e} = \frac{-3 \times 10^{-7}}{-1.6 \times 10^{-19}} = 1.87 \times 10^{12}$$

Therefore, the number of electrons transferred from wool to polythene is 1.87×10^{12}.

(e) What is equipotential surface ? Prove that electric field is always perpendicular to the equipotential surface . 2 Or

A slab of material of dielectric constant *K* has the same area as the plates of a parallel-plate capacitor but has a thickness (3/4)*d*, where *d* is the separation of the plates. How is the capacitance changed when the slab is inserted between the plates? 2

Solution Let $E_0 = V_0/d$ be the electric field between the plates when there is no dielectric and the potential difference is V_0. If the dielectric is now inserted, the electric field in the dielectric will be $E = E_0/K$. The potential difference will then be

$$V = E_0(\frac{1}{4}d) + \frac{E_0}{K}(\frac{3}{4}d)$$

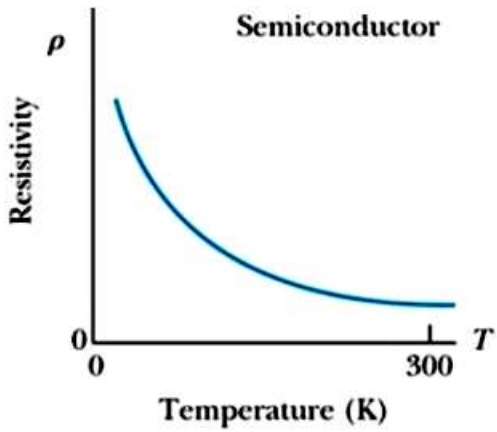
$$= E_0 d(\frac{1}{4} + \frac{3}{4K}) = V_0 \frac{K+3}{4K}$$

The potential difference decreases by the factor $(K + 3)/4K$ while the free charge Q_0 on the plates remains unchanged. The capacitance thus increases

$$C = \frac{Q_0}{V} = \frac{4K}{K+3}\frac{Q_0}{V_0} = \frac{4K}{K+3}C_0$$

(c) Draw the graph showing the variation of resistivity of semiconductor with temperature.
Why nichrome is used to make the standard resistor ? explain it graphically . 2

Temperature dependence on resistivity for semiconductors

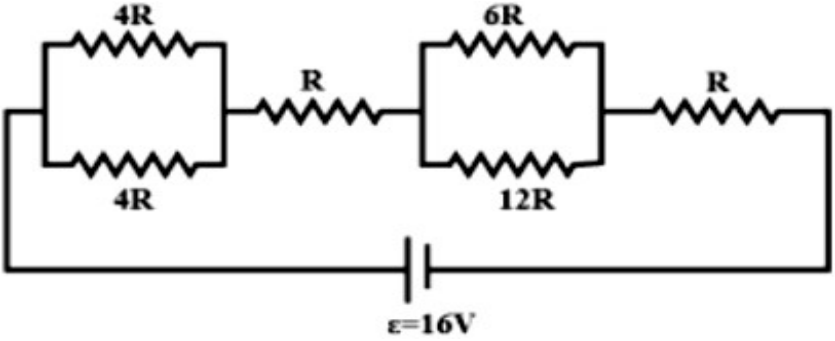


Nichrome is used to make standard resistors because it has a very low temperature coefficient of resistance, meaning its resistance changes very little with temperature fluctuations, making it ideal for maintaining a stable resistance value across a wide temperature range .

Or

The resistive network shown below is connected to a DC source of 16V. the power consumed by the

network is 4 watt. Find the value of R .



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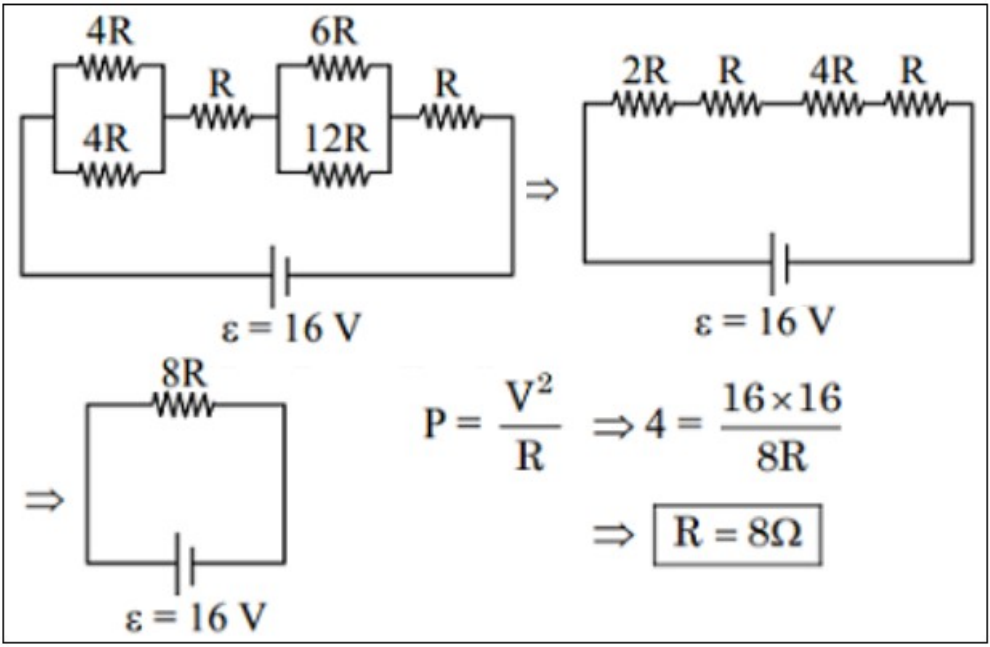


(d)" Drift velocity of the free electrons in a conductor is time independent ", explain why . 2

Or

Obtain the relation between the drift velocity and the current flowing through a conductor . 2

(e) Find the expression for force acting on a current carrying conductor placed in a uniform magnetic field . 2

(f) A short bar magnet placed with its axis at 30º with a uniform external magnetic field of 0.25 T experiences a torque of magnitude equal to 4.5×10^{-2} J. What is the magnitude of magnetic moment of the magnet? 2

Magnetic field strength, B = 0.25 T

Torque on the bar magnet, $T = 4.5 \times 10^{-2}$ J

Angle between the bar magnet and the external magnetic field, $\theta = 30°$

Torque is related to magnetic moment (M) as:

$T = MB \sin\theta$

$$\therefore M = \frac{T}{B \sin\theta} = \frac{4.5 \times 10^{-2}}{0.25 \times \sin 30°} = 0.36 \text{ J T}^{-1}$$

Hence, the magnetic moment of the magnet is 0.36 J T^{-1}.

Or

Find the expression for the force acting on a current carrying conductor placed in a uniform magnetic field . Give the direction of the force acting on the conductor . 2

(g) What is self induction ? Find the expression for the self inductance of a solenoid of cross section 'a' and length 'l' with N number of turns . ½+1½ = 2

Or

A horizontal straight wire 10 m long extending from east to west is falling with a speed of 15 m/s, at right angles to the horizontal component of the earth's magnetic field, 4×10^{-5} Wb m^{-2}.

(a) What is the instantaneous value of the emf induced in the wire?

(b) Which end of the wire is at the higher electrical potential? 2

Length of the wire, l = 10 m

Falling speed of the wire, v = 5.0 m/s

Magnetic field strength, $B = 0.3 \times 10^{-4}$ Wb m^{-2}

(a) Emf induced in the wire, e = Blv

$e = 0.3 \times 10^{-4} \times 5 \times 10 = 1.5 \times 10^{-3}$ V

(b) Using Fleming's right hand rule, the eastern end of the wire is at a higher potential.

(h) How can the fringe width increase in Young's double-slit experiment?

a. By decreasing the width of the slit

b. By reducing the separation of slits

c. By reducing the wavelength

d. By decreasing the distance between slits and the screen 2

Fringe width , $\beta = \frac{\lambda D}{d}$

a. By decreasing the width of slit , intensity of light decreases.
b. By reducung d , fringe width increases
c. By reducung wavelength , fringe width decreases .
d. By decreasing D , fringe width decreases .

(i) In Young's double slit experiment, prove that the central bright fringe is obtained at the centre of the screen . 2

(j) A junction diode has a forward resistance of 5Ω and a reverse resistance of 2500Ω . Find the current thought the diode when it is forward biased . What will be the value of current when polarities are reversed? 1+1 = 2

The junction diode is forward biased.

Therefore, the effective resistance = $25 + 10 = 35\Omega$

$\therefore$ Current in diode $I = \frac{5V}{35\Omega} = \frac{1}{7}A$

The junction diode is reversed biased.

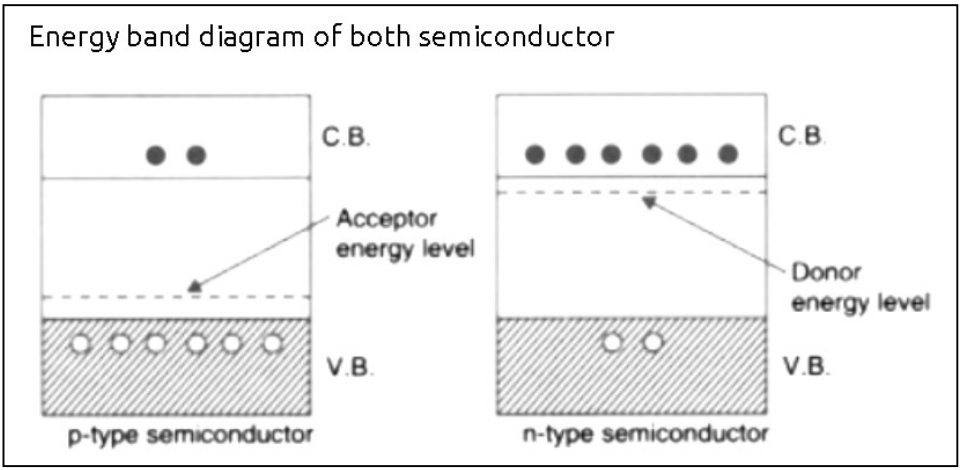
Therefore, the effective resistance = $2500 + 10 = 2510\,\Omega$

$\therefore$ Current in diode $I = \frac{5V}{2510\,\Omega} = 0.00199 = 0.002$ A

Or

Draw the n- and p-type semiconductors' energy band diagrams at a temperature T > 0 K. With their

energies, show the energy levels of the donor and acceptor. 1+1=2



Each of the following questions carries 3 marks each -

(a) Find the expression electric potential at any point due to an electric charge .

Or

Prove that the electric field at the surface of a charged conductor is σ/ε_0 , and perpendicular to the surface of the conductor in outward direction .

(b) Two cells of emf E_1 and E_2 with internal resistance r_1 and r_2 are connected in parallel with an external resistor of R . Find the expression for equivalent terminal potential difference of the combination 3

Or

Distinguish between emf E and terminal voltage V

of a cell having internal resistance ‘r’. Draw a plot showing the variation voltage V vs. the current I drawn from the cell. Using this plot, how does one determine the emf and the internal resistance of the cell? 3

(c) State Ampere’s circuital law , find an expression magnetic field due a straight conductor of infinite extent . 1+2= 3

Or .

Derive expression for magnetic field on an equatorial line of a magnetic dipole. 3

(d) The oscillating electric field of an electromagnetic wave is given by:

$E = 30 \sin [2 \times 10^{11} t + 300 \pi x]$ V/m

(i) Obtain the value of wavelength and frequency of the electromagnetic wave.

(ii) Write down the expression for oscillating magnetic field. 3

Or

Name the parts of the electromagnetic spectrum which is

(i) Suitable for RADAR systems in aircraft navigations.

(ii) Used to treat muscular strain.

(iii) Used as a diagnostic tool in medicine. Write in brief, how these waves can be produced? 3

(e) What is angle of minimum deviation ? Write down the conditions for minimum deviation . Obtain the relation between refractive index of the prism and the angle of minimum deviation . 3

Or

(i)Three lenses with magnifications 2, 3 and 10 form a combination. What is its total magnification?

The total magnification of a microscope can be find out by multiplying the power of the lenses and the eyepiece together to get the total magnification.

Given data: Lens 1 = 2

Lnes 2 = 3

Lens 3 = 10

Thus the total magnification = 2 x 3 x 10 = 60

(ii)The magnifying power of a telescope is 9. When it is adjusted for parallel rays, the distance between the objective and the eye-piece is found to be 20 cm. Find the focal lengths of the two lenses .

1+2=3

Here, $M = \frac{f_0}{f_e} = 9 \therefore f_0 = 9f_e$ .....(i)

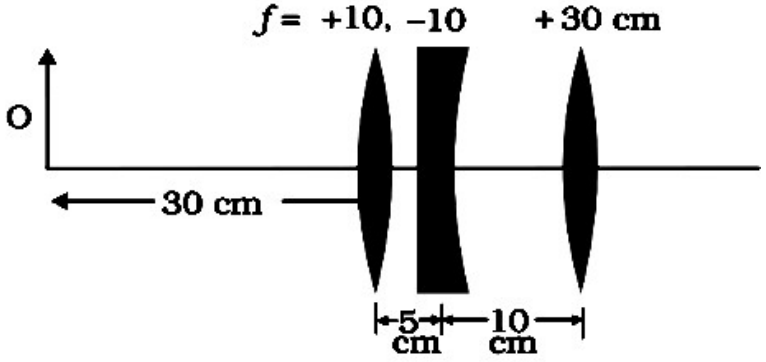
When adjusted for parallel rays, the distance between the objective anf eye piece is

$f_0 + f_e = 20cm$

Using (i), $9f_e + f_e = 20$ or $f_e = 2cm$

From (i), $f_0 = 9 \times 2cm = 18cm.$

(f) Find the position of the image formed the combination of lenses as shown below



For first lens, $u_1 = -30\text{cm}$, $f_1 = +10\text{cm}$

$\therefore$ From lens formula, $\frac{1}{f_1} = \frac{1}{v_1} - \frac{1}{u_1}$

$$\Rightarrow \frac{1}{v_1} = \frac{1}{f_1} + \frac{1}{u_1} = \frac{1}{10} - \frac{1}{30} = \frac{3-1}{30} \Rightarrow v_1 = \mathbf{15\ cm}$$

This image serves as a virtual object for second lens.

For second lens, $f_2 = -10\text{ cm}$, $u_2 = 15 - 5 = +10\text{ cm}$

$$\therefore \quad \frac{1}{v_2} = \frac{1}{f_2} + \frac{1}{u_2} = -\frac{1}{10} + \frac{1}{10} \quad \Rightarrow v_2 = \infty$$

The real image is formed by second lens at infinite distance. This acts as an object for third lens

For third lens, $f_3 = +30\text{ cm}, u_3 = \infty$

From lens formulae, $\frac{1}{v_2} = \frac{1}{f_3} + \frac{1}{u_3} = \frac{1}{30} + \frac{1}{\infty}$

$$\Rightarrow v_3 = 30\text{ cm}$$

i.e., final image is formed at a distance 30cm to the right of third lens.

Or

Find the equivalent power of the combination of the lenses as shown in the above diagram . 3

(g) (i) Write the condition of constructive interference in terms of phase difference and path difference .

(ii) If the ratio of the maximum and minimum intensity of interference is 49 : 9 , find the ratio of slit width , through which light is coming . 3

We know,

$\frac{I_{max}}{I_{min}} = \frac{(a+b)^2}{(a-b)^2} = \frac{49}{9}$ where a, b are the amplitudes

$\Rightarrow \frac{a+b}{a-b} = \frac{7}{3} \Rightarrow 3a + 3b = 7a - 7b$

or, $4a = 10b$

or, $\frac{a}{b} = \frac{10}{4} = \frac{5}{2}$

Since Intensity $\propto$ (Amplitude, A)$^2 \propto$ (slit width ,w)^2

so , $\frac{a}{b} = \frac{w_1}{w_2} = \frac{5}{2}$

Or

In a Young's double slit experiment, the slits are 2mm apart and are illuminated with a mixture of two wave lengthsλ_1= 750nm & λ_2=900nm . At what minimum distance from the common central bright fringe on a screen 2 m from the slits will a bright fringe from one interference pattern coincide with a bright fringe from the other? Calculate the fringe width for λ_I = 750nm. 3

Now from the question we can infer that

$D = 2\,m$; $d = 2\,mm = 2 \times 10^{-3} m$

Let n_1 th bright fringe of λ_1 coincide with n_2 th bright fringe of λ_2

$$\Rightarrow y_1 = y_2 \Rightarrow \frac{n_1 \lambda_1 D}{d} = \frac{n_2 \lambda_2 D}{d} \Rightarrow n_1\lambda_1 = n_2 \lambda_2$$

$$\Rightarrow \frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{900}{750} = \frac{6}{5}$$

5^{th} and 6^{th} fringes will coincide respectively.

The minimum distance is given as

$$X_{min} = \frac{n_2 \lambda_2 D}{d} = \frac{5 \times 900 \times 10^{-9} \times 2}{2 \times 10^{-3}} = 4500 \times 10^{-6} = 4.5 \times 10^{-3}\ m$$

$$X_{min} = 4.5\ mm$$

Fringe width for $\lambda_1 = \frac{\lambda_1 D}{d}$

$$= \frac{5 \times 750 \times 10^{-9} \times 2}{2 \times 10^{-3}}$$

$$= 1875 \times 10^{-6}$$

$$= 1.875 \times 10^{-3}\ m$$

(h) What are H_α , H_β and H_γ lines of Balmar series ? Explain . 3 Or

What is distance of closest approach ?

In a Geiger-Marsden experiment, what is the distance of closest approach to the nucleus of a 8 MeV α-

particle before it comes momentarily to rest and reverses its direction? (Z=79 for Gold) 1+2=3

Let r_0 be the distance of closest approach where the K.E. of α-particle is converted into its potential energy.

Given, $Z = 79$, $E_k = 8\text{MeV}$

$$K = \frac{1}{4\pi\varepsilon_0}\frac{(Ze)(2e)}{r_0}$$

$$\Rightarrow r_0 = \frac{1}{4\pi\varepsilon_0}\frac{(Ze)(2e)}{K} = \frac{2Ze^2}{4\pi\varepsilon_0 K}$$

$$\Rightarrow r_0 = \frac{9\times10^9 \times 2\times79\times(1.6\times10^{-19})^2}{8\times10^6\times(1.6\times10^{-19})}$$

$$= \frac{18\times79\times1.6\times10^{-10}}{8\times10^6}\text{m} = 2.88\times10^{-14}\text{ m}$$

(i)(a) What is thermonuclear fusion ?

(b) Explain the nuclear process by which energy is produced in Sun . 1+2=3

Or

What is radio activity ? Name the different types of radio active decays . Give example . What is half life ? 3

Section D [Each question carries 5 marks]

(a) Prove that in a purely inductive circuit , emf is

ahead of current by a phase angle of $\pi/2$.

What is mean value of AC . Prove that for full cycle It is zero .

Or

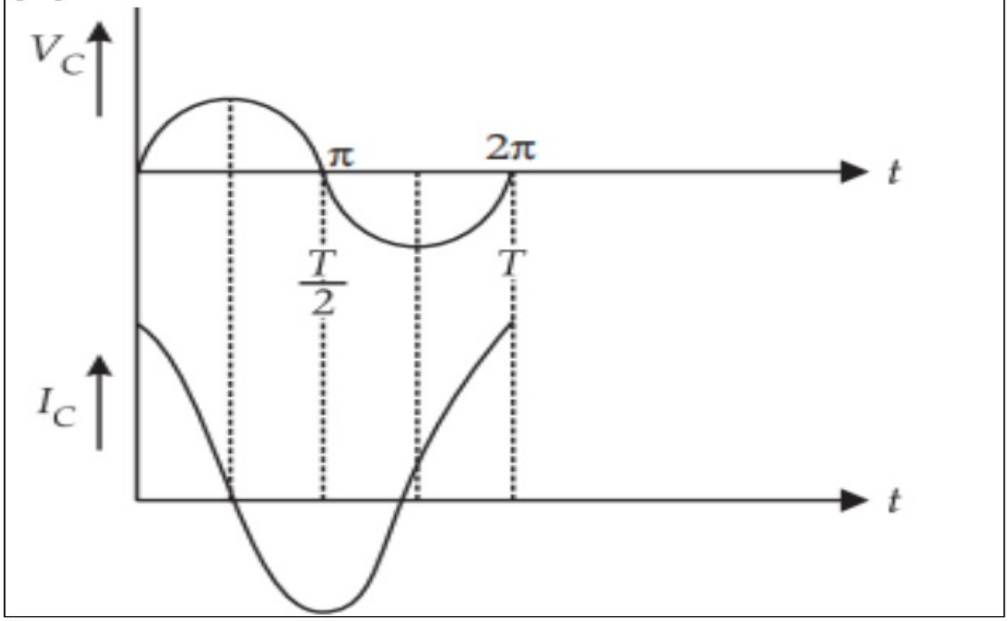
A device X is connected across as AC source of voltage $v = V_0 \sin \omega t$. The current through X is given as $i = I_0 \sin(\omega t + \pi/2)$.

(i) Identify the device X and write the expression for its reactance.

(i) The device is capacitor. The reactance of capacitor is given by $X_C = 1/\omega_C = 1/2\pi f_C$

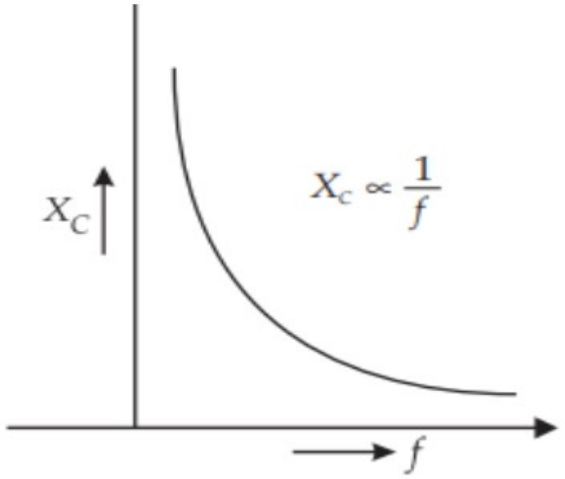
(ii) Draw graphs showing variation of voltage and current with time over one cycle of AC, for X

(ii) Graph of voltage and current w.r. to time



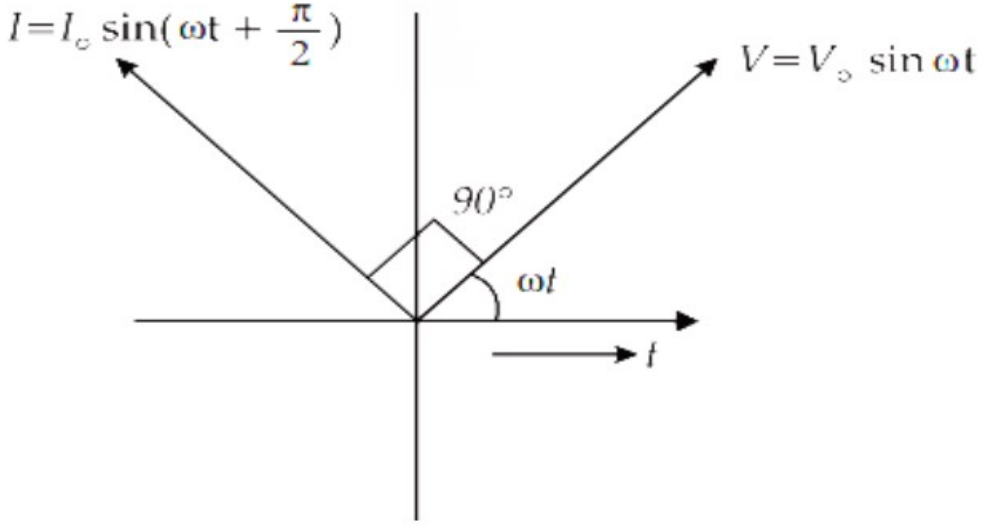
(iii) How does the reactance of the device X vary with frequency of the AC?Show this variation graphically.

(iii) Graph showing the variation of XC with frequency f



(iv) Draw the phasor diagram for the device X

(iv) Phase diagram for device X is shown in fig.



(b) (i) What are different types of emission of electrons ? name them with examples . 3

(ii) With the help of Einstein's photo electric equation find an expression for work function . 2

Or (i) Write down de broglie's hypothesis . 1

(ii)Give the photon picture of electromagnetic waves. 2

(iii) Two radiations with photon energies 0.9 eV and 3.3 eV respectively are falling on a metallic surface successively. If the work function of the metal is 0.6 eV, then find the ratio of maximum speeds of emitted electrons 2

From Einstein's photo electric equation

$$h\nu = \tfrac{1}{2}mv^2 + \phi \Rightarrow v = \sqrt{\frac{2(h\upsilon - \phi)}{m}}$$

$$v_{1_{max}} = \sqrt{\frac{2(h\upsilon - \phi)}{m}} = \sqrt{\frac{2(0.9 - 0.6)}{m}} = \sqrt{\frac{2(0.3)}{m}}$$

$$v_{2_{max}} = \sqrt{\frac{2(h\upsilon - \phi)}{m}} = \sqrt{\frac{2(3.3 - 0.6)}{m}} = \sqrt{\frac{2(2.7)}{m}}$$

$$\frac{v_{1_{max}}}{v_{2_{max}}} = \sqrt{\frac{2(0.3)}{m}} \times \sqrt{\frac{m}{2(2.7)}} = \sqrt{\frac{0.3}{2.7}} = \frac{1}{3}$$

$$(v_1 : v_2)_{max} = 1 : 3$$

(c) (i) Draw its IV characteristics of a PN junction diode .

(ii) Define Knee voltage and zener voltage .

(iii) Explain why breakdown takes place at the zener voltage?

(iv) What is dynamic resistance ? 1+2+1+1 = 5

Or

(i) What is energy required for an electron to jump to forbidden band in Silicon at room temperature?

(ii) A sample of germanium doped with pentavalent impurity is heated to 300 K. Determine the electron and hole counts if the pentavalent impurity concentration is $12 \times 10^{17}\ cm^{-3}$. Assume that the impurity atom has fully ionized. Given: $2.4 \times 10^{13}\ cm^{-3}$ is the inherent carrier concentration.

Intrinsic carrier concentration $n_i = 2.4 \times 10^{13}\ cm^{-3}$

Number of electrons $N_e = 12 \times 10^{17}\ cm^{-3}$

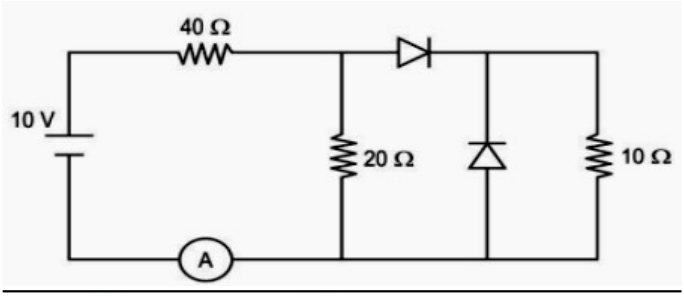
We know $n_i^2 = N_e . N_h$

Number of holes $N_h = \frac{n_i^2}{N_e} = \frac{(2.4 \times 10^{13})^2}{(12 \times 10^{17})}$

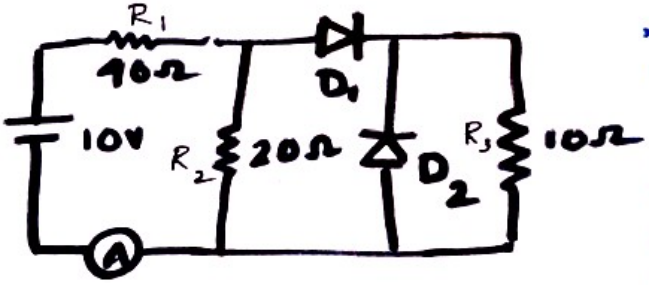
$= 0.48 \times 10^9\ cm^{-3}$

Number of holes $= 4.8 \times 10^8\ cm^{-3}$

(iii) A 10V battery is attached to 3 resistors and two ideal diodes as shown below. What will be the reading of the ammeter?



1+2+2=5



∵ D_2 is reversed biased & D_1 is forward biased so, No current will flow Through D_2.

∵ R_2 and R_3 are in parallel

$$R_{23} = \frac{R_2 R_3}{R_2 + R_3} = \frac{20 \times 10}{20+10} = \frac{200}{30} \Rightarrow R_{23} = \frac{20}{3}\ \Omega$$

∵ R_1 and R_{23} are in series

$$R_{123} = R_1 + R_{23} = 40 + \frac{20}{3} = \frac{140}{3}$$

So current in the ckt $I = \frac{V}{R_{123}} = \frac{10}{140/3} = \frac{3}{14}$ A

Reading of ammeter = $\frac{3}{14}$ A

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