Class : XII || *AHSEC* || Pre Board Examination , 2024-25

Subject : Physics ||Full marks : 70||Time : 3hours|| Set - 02

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

Each of the following questions carries 1 mark each -

1. According to Coulomb's law, which is the correct relation for the following figure? 1

(i) $q_1 q_2 > 0$ (ii) $q_1 q_2 = 0$ (c) $q_1 q_2 < 0$ (b) $q_1 q_2 = 1$

Ans- Since force is attractive in nature , which negative in nature , so (c)$q_1 q_2 < 0$

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2. Inside a conductor , electric field is ______ (zero / constant) , where as electric potential is _________ (zero / constant). [Fill up both the blank positions]

Ans - zero , constant

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3. The resistivity of alloy manganin

(i)Increases rapidly with increases of temperature

(ii)Decreases linearly with increases in temperature

(iii)Increases rapidly with decreases in temperature

(iv) Is nearly independent of temperature

Ans - (iv)

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4. If two identical currents , flowing through straight conductors of infinite extent , seperated by 1 m in vacuum , made to attract each other by a force of 2×10^{-7} N /m , then magnitude of the current is _____________________ . (Fill up the blank)

Ans - 1 ampere

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5. From Gauss's law of magnetism , it is known that , magnet never exit as a ______ (Fill up the blank)

Ans - mono pole

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6. Define 1 henry .

7. The looping current induced in the surface of a conductor, when placed in a varying magnetic field is known as ___________ . (Fill up the blank)

Ans - eddy current

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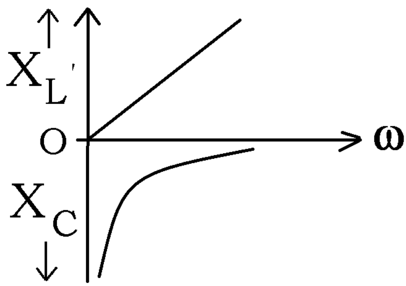
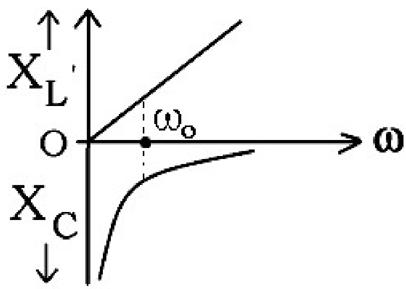
8. Locate the resonant angular frequency ω_o in the following graph between X_L and X_C with ω .



Ans - Since at resonance , $\omega = \omega_o$, $X_L = X_C$, so we plot it in graph as shown below



Each of the following questions carries 2 mark seach -

9. Match the following ----------------

(A) Electric potential ----------(a) [$M^{1} L^{0} T^{-2} A^{-1}$]

(B)Electric permitivity ---------- (b) [$M^{-1} L^{-2} T^{4} A^{2}$]

(C) Capacitance -------------- (c) [$M^{-1} L^{-3} T^{4} A^{2}$]

(D) Magnetic field -------------- (d) [$M^{1} L^{2} T^{-3} A^{-1}$]

Ans- (A)---(d)

(B)---(c)

(C)--(b)

(D)---(a)

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9. A parallel plate capacitor with air between the plates has a capacitance of 12 pF (1pF=10^{-12} F). What will be the capacitance if the distance between the plates is reduced by half , and the space between them is filled with a substance of dielectric constant 5 ?

Ans-

$$C = \frac{\epsilon_0 A}{d} \quad \text{(the medium is air)}$$

$$C = 12\,pF = 12 \times 10^{-12} F \Rightarrow \frac{\epsilon_0 A}{d} = 12 \times 10^{-12}$$

Let the new capacitance be C'

$$C' = \frac{\epsilon_0 KA}{d'} \qquad \text{now, } K = 5,\ d' = d/2$$

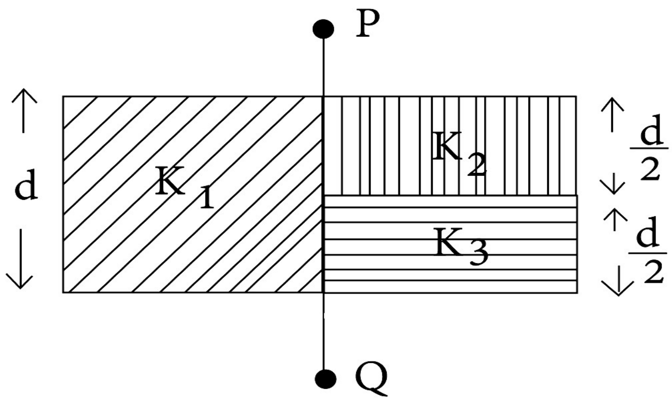
$$= \frac{\epsilon_0 \times 5 \times A}{d/2} = 10 \times \frac{\epsilon_0 A}{d} = 10 \times 12 \times 10^{-12}$$

$$= 12 \times 10^{-12}\,F$$

$$= 120\,pF.$$

Or

Find equivalent capacitance between P and Q



(ii) In figure, a series combination of two capacitors C_2 and C_3, of plate areas A/2 and plate separations d/2, is in parallel with a capacitor C_1 of plate area A/2 and plate separation d.

$$\therefore C_1 = \frac{k_1\varepsilon_0(A/2)}{d} = \frac{\varepsilon_0 A}{2d}k_1$$

$$C_2 = \frac{k_2\varepsilon_0(A/2)}{d/2} = \frac{\varepsilon_0 A}{d}k_2,$$

$$C_3 = \frac{k_3\varepsilon_0(A/2)}{d/2} = \frac{\varepsilon_0 A}{d}k_3$$

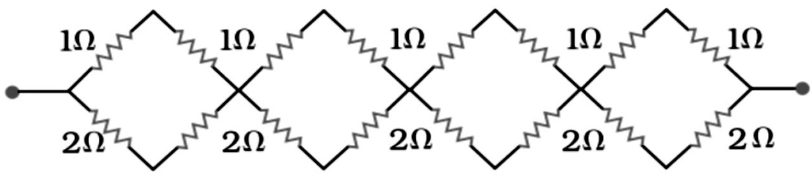
$\therefore$ For the series combination of C_2 and C_3,

$$\frac{1}{C_4} = \frac{1}{C_2} + \frac{1}{C_3} \quad \therefore C_4 = \frac{C_2C_3}{C_2+C_3} = \frac{\varepsilon_0 A}{d}\left(\frac{k_2k_3}{k_2+k_3}\right)$$

$\therefore$ Finally, for the parallel combination of C_1 and C_4,

$$C'' = C_1 + C_4 = \frac{\varepsilon_0 A}{2d}k_1 + \frac{\varepsilon_0 A}{d}\left(\frac{k_2k_3}{k_2+k_3}\right) = \frac{\varepsilon_0 A}{d}\left(k_1 + \frac{k_2k_3}{k_2+k_3}\right)$$

11. Determine the equivalent resistance of networks shown below

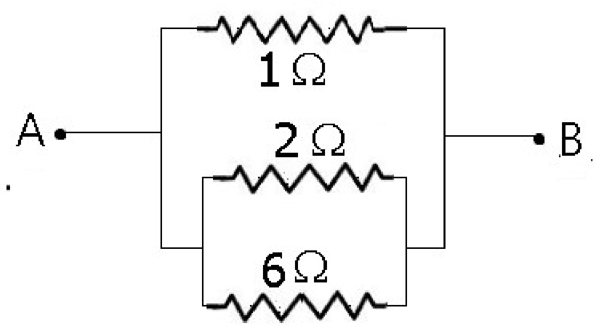


$$R = \frac{(1+1)\times(2+2)}{(1+1)+(2+2)} \times 4 = \frac{1\times 4}{2+4}\times 4 = \frac{4}{6}\times 4 = \frac{8}{3}$$

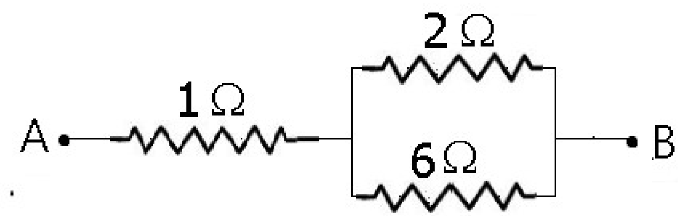
12. How would you connect resistances 1 Ω , 3 Ω & 6 Ω so as to get equivalent resistances of 0.67 Ω and 3 Ω. Draw the required circuit diagram .

Ans -

To have a resistance of 0.67 Ω ,



To have a resistance of 3.0 Ω ,



13. A proton , a deuterium and an α-particle, with same kinetic energy , enter perpendicularly into a region of uniform magnetic field . Compare the radii of circular paths followed by them.

Ans-

$$K = \frac{1}{2} m v^2 \Rightarrow 2mK = m^2 v^2$$

$$\Rightarrow \sqrt{2mK} = mv$$

Radius of the circular path entering the magnetic field perpendicularly

$$r = \frac{mv}{Bq} = \frac{\sqrt{2mE}}{Bq}, \quad \therefore r \propto \frac{\sqrt{m}}{q}$$

$$\text{Hence, } r_p : r_d : r_\alpha = \frac{\sqrt{m_p}}{q_p} : \frac{\sqrt{m_d}}{q_d} : \frac{\sqrt{m_\alpha}}{q_\alpha}$$

$$= \frac{\sqrt{m}}{e} : \frac{\sqrt{2m}}{e} : \frac{\sqrt{4m}}{2e}$$

$$= 1 : \sqrt{2} : 1$$

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14. Explain how Lenz's law establishes the law of conservation of energy.

Or

Show that total energy required to build up a current I in an inductor of coefficient of induction ‘L’ Is ½ LI^2.

15. Find the expression for the emf induced in a rod rotating perpendicularly in a uniform magnetic field acting perpendicularly inward to the plane of paper .

Or

A long solenoid with 15 turns per cm has a small loop of area 2.0 cm^2 placed inside the solenoid normal to its axis. If the current carried by the solenoid changes steadily from 2.0 A to 4.0 A in 0.1 s, what is the induced emf in the loop while the current is changing?

Ans-

Number of turns on the solenoid = 15 turns/cm = 1500 turns/m

Number of turns per unit length, n = 1500 turns

The solenoid has a small loop of area, A = 2.0 cm^2 = 2×10^{-4} m^2

Current carried by the solenoid changes from 2 A to 4 A.

Change in current in the solenoid, di = 4 − 2 = 2 A

Change in time, dt = 0.1 s

Induced emf in the solenoid is given by Faraday's law as:

$$e = \frac{d\phi}{dt} \quad ...(i)$$

Where, ϕ = Induced flux through the small loop = BA ... (ii)

B = Magnetic field $= \mu_0 ni \quad ...(iii)$

μ_0 = Permeability of free space = $4\pi \times 10^{-7}$ H/m

Hence, equation (i) reduces to:

$$e = \frac{d}{dt}(BA) = e = \frac{d}{dt}(BA) = A\mu_0 n \times \left(\frac{di}{dt}\right)$$

$$= 2 \times 10^{-4} \times 4\pi \times 10^{-7} \times 1500 \times \frac{2}{0.1}$$

$$= 7.54 \times 10^{-6} \text{ V}$$

Hence, the induced voltage in the loop is 7.54×10^{-6} V.

16. Draw the wavefront due to

(i) a source at infinity

(ii) the dispersion light through a prism .

17. The intensity of two superposing waves are $4I_0$ and I_0 . The intensity of the bright fringe is $7I_0$. Find out the phase difference between the two superposing waves.

Ans-

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

$$\Rightarrow 7I_o = I_o + 4I_o + 2\sqrt{I_o \times 4I_o}\cos\phi$$

$$\Rightarrow 7I_o = 5I_o + 2 \times 2I_o\cos\phi$$

$$\Rightarrow 2I_o = 4I_o\cos\phi$$

$$\Rightarrow \frac{1}{2} = \cos\phi \quad \Rightarrow \phi = \frac{\pi}{3}$$

18.Draw the energy bands diagram of N-type semiconductor and P-type semiconductor at T > 0K.

Or

Draw the energy bands diagram of an intrinsic semiconductor at T = 0 K behaves like insulator and at T > 0 K behaving like a conductor .

Each of the following questions carries 3 marks each -

19. State Gauss's law.

Find an expression for electric field due to a straight conductor of infinite extent having λ as linear charge density .

Or

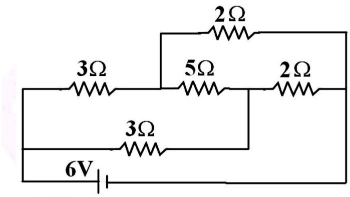
What is electric dipole moment ? Give its SI unit .

Two point charges +q and -q are placed at (- a , 0) and (+ a , 0) on the X-axis . Calculate electric field due to this arrangement of charges at (0 , + a) on the Y axis .

1+2 =3

20. State Kirchhoff's loop law and name the laws on which they are based on.

Calculate the current drawn from the battery in the given network shown here.



1+2 =3

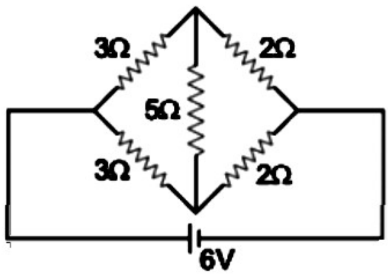
[∴ Bridge is in balanced condition, no current flows through 5Ω resistance]

$\frac{1}{R} = \frac{1}{5} + \frac{1}{5} = \frac{2}{5}$

$\Rightarrow R = 2.5\,\Omega$

Current in the circuit $= \frac{6}{2.5} A$

$= 2.4A$



Or

Find the expression for resistivity of the material of a conductor. 3

21. Using Biot Savart's law , find an expression magnetic field due a current loop at a point on its axis. 3

Or

Using Ampere's circuital law , find the magnetic field due a solenoid . 3

22. Establish Ampere's Maxwell equation . 3

Or

Give two important properties of γ rays , X rays and Ultra violet rays . 2 x ½ x 3 =3

23. Draw the ray diagram showing the formation of image of a tiny object by a compound telescope .

A small telescope has an objective lens of focal length 120cm and an eyepiece of focal length 4cm . What is the magnifying power of the telescope? What is the separation between the objective and the eyepiece? 1½+1+½=3

Ans-

$$M = \frac{|f_o|}{|f_e|} = \frac{120}{4} = 30$$

$$\text{Seperation} = |f_o| + |f_e| = 120 + 4 = 124$$

Or

Write down the formula for magnifying power of a compound microscope . If f_o = l cm , f_e = 5 cm and L = 30 cm respectively, calculate the total magnification of the microscope. 1+2=3

Ans-

$$M = \frac{L\,D}{f_e\,f_o} = \frac{30 \times 25}{1 \times 5} = 150$$

24. Establish the Lens Maker's formula . 3

Or

Define power of a lens . What is its SI unit ?

Which two of the following lenses L_1, L_2 and L_3 will you select as objective and eyepiece for constructing the best possible (i) telescope (ii) microscope? Give reason to support your answer. iii)the aperture of the objective of ……….. is preferred to be large?

Lenses	Power (P)	Aperture(A)
L_1	3 D	8cm
L_2	6 D	1 cm
L_3	10 D	1 cm

1+1+1=3

(i) Telescope

L_2 : objective L_3 : eyepiece

Reason : Light gathering Power and magnifying power will be larger.

(ii) Microscope

L_3 : objective L_1 : eyepiece

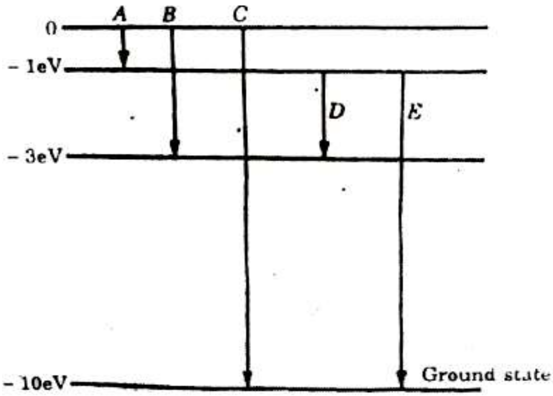
Reason : Angular magnification is more for short focal length of objective and eyepiece.

25. When monochromatic light of wavelength λ is incident on a single slit of width a, show how the diffraction pattern is formed at screen by the interference of the wavelets from the slit. Show that,besides the central maxima at $\theta = 0$, secondary maxima are observed at $\theta = (n + ½)\lambda/a$. 3

Or

When monochromatic source of light of wavelength λ is incident on a single slit of width a, show how the diffraction pattern is formed at screen by the interference of the wavelets from the slit. Show that,besides the central maxima at $\theta = 0$, secondary minima at $= n\lambda/a$. 3

26. The energy levels of an atom of element X are shown in the diagram. Which one of the level transitions will result in the emission of photons of wavelength 620nm? support your answer with mathematical calculations.



Name the hydrogen spectral series that can be observed in the visible region. 3

$$E = \frac{hc}{\lambda} = \frac{6.6. \times 10^{-34} \times 3 \times 10^{8}}{620 \times 10^{-9}}$$

$$= 3.2 \times 10^{-19}\ J$$

$$= \frac{3.2 \times 10^{-19}}{1.6 \times 10^{-19}} = 2\ eV$$

This corresponds to the transition "D"

Or

Show that the radius of the orbit in hydrogen atom varies as $\mathbf{n^2}$, where n is the principal quantum number of atom . 3

27.(a) Give one example of nuclear fission and nuclear fusion.

(b) Deuterium undergoes fusion as per the reaction:

$$\mathbf{{}_1H^2 + {}_1H^2 \rightarrow {}_2He^3 + {}_0n^1 + 3.27\ MeV}$$

Find the duration for which an electric bulb of 500 W can be kept glowing by the fusion of 100 g of deuterium.

Or

Number of deuterium atoms is 2 kg $= \frac{6.023 \times 10^{23}}{2} \times 2000 = 6.023 \times 10^{26}$

Energy released when 6.023×10^{23} nuclei of deuterium fuse together

$= \frac{3.2}{2} \times 6.023 \times 10^{26} MeV = \frac{3.2 \times 6.023 \times 10^{26}}{2} \times 1.6 \times 10^{-13} J$

$= 15.42 \times 10^{13}\ J = 15.42\ Ws$

Power of lamp = 100 W

If the lamp glows for time t, then electric energy consumed = 100 t

$\therefore 100\ t = 15.42 \times 10^{33}$

$\therefore t = 0.1542 \times 10^{13}\ s = \frac{0.1542 \times 10^{13}}{365 \times 86400} y = 4.0 \times 10^{4}\ y$

Calculate the energy released in the following reaction

$$^{238}_{92}U \longrightarrow \,^{234}_{90}Th + \,^{4}_{2}He + Q$$

[Mass of $^{238}_{92}U$ = 238.05079 u,

Mass of $^{234}_{90}Th$ = 234.043630 u,

Mass of $^{4}_{2}He$ = 4.002600 u, 1u = 931.5 MeV/c²]

Ans-

The process is $^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He + Q$

The energy released $(\alpha - particle)$

$$Q = (M_U - M_{TH} - M_{He}) \times 931\ MeV$$

$$= (238.05079 - 234.04363 - 4.00260) \times 931\ MeV$$

$$= (0.00456\, u) \times 931\ MeV$$

$$= 4.25\, MeV$$

Section E [Each question carries 5 marks]

28. Define mutual inductance between a pair of coils.

Derive an expression for the mutual inductance of two long coaxial solenoids of the same length wound one over the other.

Two coils are placed close to each other. A current change of 4 A/s in the first coil induces an EMF of

0.8 V in the second coil. Calculate the mutual inductance between the two coils. 5

Ans -

We know that emf is related to the mutual inductance by

$$e = M\frac{\Delta i}{\Delta t}$$

Substituting the given values,

$$0.8\ \text{V} = M \times 4\ \text{A/s}$$

$$\Rightarrow M = \frac{0.8\ \text{V}}{4\ \text{A/s}} = 0.2\ \text{H}$$

Or

State the laws of photo electric effect .

Photoelectrons are emitted from a metal surface when illuminated with UV light of wavelength 330 nm. The minimum amount of energy required to emit the electrons from the surface is 3.5×10^{-19} J. Calculate :

(a) the energy of the incident radiation

(b) the kinetic energy of the photoelectron. 5

Ans -

Here, $\lambda = 300nm = 300 \times 10^{-9}m = 3 \times 10^{-7}m$

$V_0 = 0.54V$

(i) Energy of the incident photon.

$$E = \frac{hc}{\lambda} = \frac{(6.63 \times 10^{-34}) \times (3 \times 10^8)}{3 \times 10^{-7}}$$

$$= 6.63 \times 10^{-19}J = \frac{6.63 \times 10^{-19}}{1.6 \times 10^{-19}}eV = 4.14eV$$

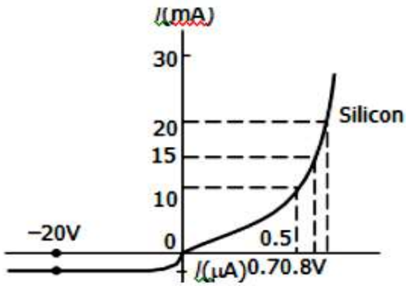
(ii) Max. K.E. of emitted photoelectron is

$K_{\max} = eV_0 = e \times 54V = 0.54eV$

(iii) As, $K_{\max} = \frac{hc}{\lambda} - \phi_0 = \frac{hc}{\lambda} - K_{\max}$

$$= 4.14eV - 0.54eV = 3.6eV$$

29.Draw the I-V characteristics of PN junction diode . Define knee voltage and zener voltage . The V-I characteristic of a silicon diode is as shown in the figure. Calculate the resistance of the diode at (i) I = 5 mA and (ii) V = –20V



1 +2+2=5

Ans-

(a) From the curve , at I = 20 mA, V = 0.8 V,
I = 10 mA, V = 0.7V

$$R_{fb} = \frac{\Delta V}{\Delta I} = \frac{0.1V - 0}{10\ mA - 0} = 10\Omega$$

(b) From the curve at V = -10 V, I = -1 μA,

Therefore, $R_{rb} = \frac{\Delta V}{\Delta I} = \frac{-10\ V - 0}{-1\ \mu A - 0} = 1.0 \times 10^7 \Omega$

Or

What is extrinsic semiconductor ?

With proper diagram , give the differences between P type and N type extrinsic semiconductor .

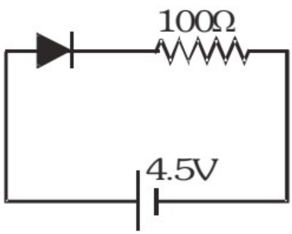


Figure shows a diode connected to an external resistance of 1000 Ω and an e.m.f. of 4.5 V . Assuming that the barrier potential developed in diode is 0.5 V . Obtain the value of current in the circuit in milliampere.

1 + 2 +2 = 5

Ans-

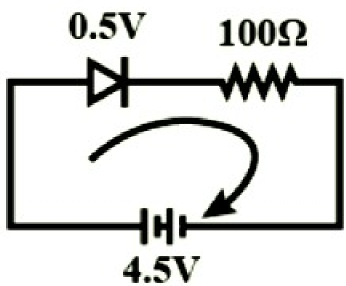
Apply Kirchhoff's voltage law in the circuit,

$\Rightarrow 4.5 = 0.5 + 100I$

$\Rightarrow 100I = 4$

$\Rightarrow I = \frac{4}{100}$

$= 0.4mA$



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30. (i) Prove that an ideal capacitor in an ac circuit does not dissipate power.

(ii) An inductor of 200 mH, a capacitor of 400 μF and a resistor of 10 Ω are in series to ac source of 50 V of variable frequency. Calculate the angular frequency at which maximum power dissipation occurs in the circuit and the corresponding value of the effective current and the value of Q-factor in the circuit.

Ans -

Here, $L = 200mH = \frac{2}{10}H \qquad R = 10ohm, E_v = 50V$

$C = 400\nu F = 400 \times 10^{-6}F = 4 \times 10^{-4}F$

(i) Maximum power dissipation occurs in the circuit at resonance, i.e., when

$\omega L = \frac{1}{\omega C}$

or $\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{\frac{2}{10} \times 4 \times 10^{-4}}} = \frac{1}{\sqrt{80 \times 10^{-6}}} = \frac{10^3}{8.944}$

$= 111.8 rad/s$

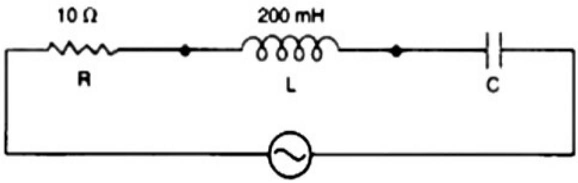
$I_v = \frac{E_v}{Z} = \frac{E_v}{R} = \frac{50}{10} = 5A$

(ii) $Q = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{1}{10}\sqrt{\frac{2/10}{4 \times 10^{-4}}} = \frac{1}{10} \times \frac{100}{1.47} = 2.237$

Or

In the following circuit, calculate the of the capacitor,if the power factor of the circuit is unity Calculate the Q factor of this circuit . What is the significance of the Q-factor in ac circuit? Given the angular frequency of the ac source to be 1 rad/s. Calculate the average power dissipated in the circuit.

Ans-



(i) power factor, $\cos\phi$ = R/z = 1 or z = R

$$\therefore \quad X_C = X_L \quad \text{or} \quad \frac{1}{2\pi f C} = 2\pi f L$$

$$\text{or } C = \frac{1}{4\pi^2 f^2 L} = \frac{1}{4 \times 9.87 \times (50)^2 \times 200 \times 10^{-3}} = 5 \times 10^{-5}\text{F} = \mathbf{50\ \mu F}$$

$$(ii)\ \text{Q-Factor} = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{1}{10}\sqrt{\frac{200 \times 10^{-3}}{5 \times 10^{-5}}} = \mathbf{6.32}$$

Average power dissipation

$$P_{av} = \frac{V_{rms}^2}{R} = \frac{(50)^2}{10} = 250W$$

<u>For angular frequency of the ac source ω = 1 rad/s</u>

Here, R $= 10\ \Omega, L = 200mH = 0.2H, V_{rms} = 50V,$

power factor $\cos\phi = 1$ and $\omega = 1 s^{-1}$

(a) For power factor to be one, $X_L = X_C \Rightarrow L\omega = \frac{1}{C\omega}$

⇒ Capacitance

$$C = \frac{1}{L\omega^2} = \frac{1}{0.2 \times (1)^2} = 5\ F$$

(b) The Q-factor $= \frac{X_L}{R} = \frac{L\omega}{R} = \frac{0.2 \times 1}{10} = 0.02$

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