CBSE Test Paper-05

Class - 12 Physics (Alternating Current)

1. A coil has a resistance of 48.0 Ω. At a frequency of 80.0 Hz the voltage across the coil leads the current in it by 53°. Inductance of the coil is
   a. 0.114 H
   b. 0.84 H
   c. 0.94 H
   d. 0.124 H
2. The voltage across the terminals of an ac power supply varies with time according to $\mathrm{V}\cos\omega\mathrm{t}$. The voltage amplitude is V = 45.0 V. Average potential difference between the two terminals of the power supply is
   a. 35.8 V
   b. 33.8 V
   c. 37.8 V
   d. zero V
3. For a series LCR circuit the input impedance at resonance
   a. equals the resistance $\omega\mathrm{L}$
   b. equals the resistance R
   c. equals the resistance $1/\omega\mathrm{C}$
   d. equals the resistance $\mathrm{R}+\mathrm{j}\omega\mathrm{L}$
4. The correct equation for a series LCR circuit excited by AC is
   a. $L\frac{d^2q}{dt^2}+R\frac{dq}{dt}+\frac{q}{C}=v_m sin\omega t$
   b. $L\frac{d^2q}{dt^2}+R\frac{dq}{dt}+2\frac{q}{C}=v_m sin\omega t$
   c. $L\frac{d^2q}{dt^2}+2R\frac{dq}{dt}+\frac{q}{C}=0$
   d. $L\frac{d^2q}{dt^2}+R\frac{dq}{dt}+\frac{q}{C}=0$
5. A light bulb and an open coil inductor are connected to an ac source . If an iron rod is inserted into the interior of the inductor then
   a. The bulb glows brighter
   b. The bulb glows dimmer
   c. The bulb glows on and off

d. The bulb glow is unaffected

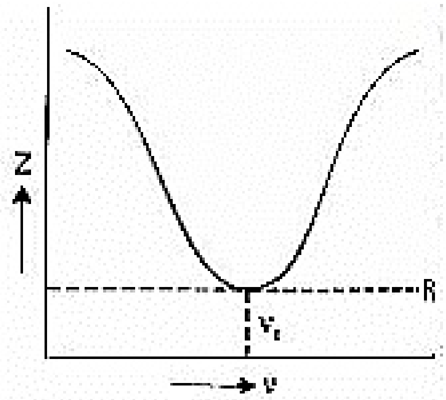
6. When an AC source is connected across an inductor, show on a graph the nature of variation of the voltage and the current over one complete cycle.

7. Obtain the resonant frequency ω_r of a series LCR circuit with L = 2.0 H, C = $32\mu F$ and $R = 10\Omega$ What is the Q-value of this circuit?

8. The peak value of emf in AC is $E_{0.}$ Write its (i) rms (ii) average value over a complete cycle.

9. A lamp is connected in series with a capacitor. Predict your observation when this combination is connected in turn across
   i. AC source and
   ii. a DC battery. What change would your notice in each case if the capacitance of the capacitor is increased?

10. Sketch a graph showing the variation of impedance of LCR circuit with the frequency of applied voltage.



11. A light bulb is rated 150 W for 220 V AC supply of 60 Hz. Calculate
    i. the resistance of the bulb
    ii. the rms current through the bulb.
12. An a.c. voltage V = Vm sin $\omega t$is applied across a
    i. series RC circuit in which the capacitance impedance is 'a' times the resistance in the circuit.
    ii. series RL circuit in which the inductive impedance is 'b' times the resistance in the circuit.

Calculate the value of the power factor of the circuit in each case.

13. An a.c. source of angular frequency ω is fed across a resistor R and a capacitor C in series. The current registered is i. If now the frequency of the source is charged to $\frac{\omega}{3}$ (but maintaining the same voltage), the current in the circuit is found to be halved. Calculate the ratio of reactance of resistance at the original frequency.

14. If the circuit is connected to 110 V, 12 kHz supply. Hence explain the statement that a capacitor is a conductor at very high frequencies. Compare this behaviour with that of a capacitor in d.c. circuit after the steady state?

15. An AC voltage V = V_0 sin ωt is applied across a pure inductor L. Obtain an expression for the current I in the circuit and hence obtain the
    i. inductive reactance of the circuit and
    ii. the phase of the current flowing with respect to the applied voltage.

CBSE Test Paper-05

Class - 12 Physics (Alternating Current)

Answers

1. d. 0.124 H

   Explanation: $R = 48\Omega$

   f = 80Hz

   $\phi = 53^{\circ}$

   $\omega = 2\pi f = 2 \times 3.14 \times 80$

   in series LR circuit

   $\tan\phi = \frac{\omega L}{R}$

   $\tan 53^{\circ} = \frac{2\times3.14\times80\times L}{48}$

   $\frac{4}{3} = \frac{2\times3.14\times80\times L}{48}$

   L = 0.124H

2. d. zero V

   Explanation: average value of AC voltage for a half cycle is positive and similarly, the mean value of AC voltage for other half cycle is negative.

   Average potential difference between the two terminals for complete full cycle

   $V_{av} = (0.637V_0) + (-0.637V_0) = 0$

3. b. equals the resistance R

   Explanation: Impedance in series LCR circuit

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

   at resonance

   $X_L = X_C$

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

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

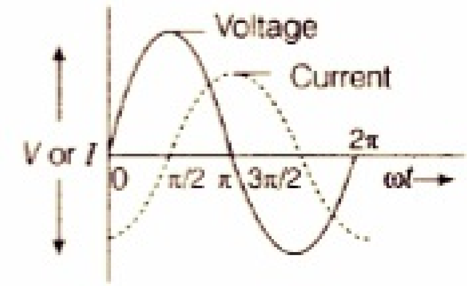
4. a. $L\frac{d^2q}{dt^2} + R\frac{dq}{dt} + \frac{q}{C} = v_m sin\omega t$

   Explanation: The LHS of equation contains expression for current through inductor, resistor and capacitor respectively. Each expression on LHS is a result of basic mathematical derivation. On the rhs we have the overall current in the circuit

5. b. The bulb glows dimmer

Explanation: As the iron rod is inserted, the magnetic field inside the coil magnetizes the iron increasing the magnetic field inside it. Hence, the inductance of the coil increases. Consequently, the inductive reactance of the coil increases. As a result, a larger fraction of the applied ac voltage appears across the inductor, leaving less voltage across the bulb. Therefore, the glow of the light bulb decreases.

6. For an AC circuit having inductor, the current and voltage equation are shown below. Here the current lags the voltage in phase by an angle of $\frac{\pi}{2}$.
$V = V_0 \sin \omega t$
$I = I_0 \sin(\omega t - \pi/2)$
The graphical variation of voltage and current are given below.



7. Here, L = 2.0 H, $C = 32\mu F = 32 \times 10^{-6} F$
R = 10 Ohm
$\omega_r = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{2.0 \times 32 \times 10^{-6}}} = \frac{10^3}{8}$ = 125 rad/s
$Q = \frac{1}{R}\sqrt{\frac{L}{C}} = \frac{1}{10}\sqrt{\frac{2}{32 \times 10^{-6}}}$
$Q = \frac{1000}{40}$ = 25

8. E_0 = peak value of emf
   i. $[E_{rms}] = E_0/\sqrt{2}$
   ii. $[E_{av}]$ =zero

9. i. On increasing capacitance, current will increase. It also increases the brightness of bulb. As capacitance increases, capacitive reactance $(X_c = 1/\omega C)$ decreases, impedance Z decreases, hence current increases.
   ii. A capacitor does not allow DC current pass through it, as the capacitive reactance

becomes infinite due to zero frequency of DC voltage or current. Hence, there will be no flow of current through the circuit and hence the bulb will not glow.

10. The impedance of LCR circuit is

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

$$= \sqrt{R^2 + \left(2\pi vL - \frac{1}{2\pi vC}\right)^2}$$

The variation of Z with v is as shown in figure at

v = vr; $X_L = X_c$

Z = R = minimum

11. i. Given P = 150W, V = 220V

electric power is $P=V^2/R$

Resistance of the bulb, $R = \frac{V^2}{P}$

$R = \frac{220\times220}{150} = 322.7\Omega$

ii. As, $I_{rms} = \frac{V_{rms}}{R} = \frac{220}{322.7}\ (V_{rms} = V = 220\text{V})$

$\Rightarrow I_{\text{rms}} = 0.68\text{A}$

12. i. Power factor in RC circuit is

$\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2+X_C^2}}$

Here X_C = aR

$\therefore \cos\phi = \frac{R}{\sqrt{R^2+a^2R^2}} = \frac{1}{\sqrt{1+a^2}}$

ii. Power factor in RL circuit is

$\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{R^2+X_L^R}}$

Here X_L = bR

$\therefore \cos\phi = \frac{R}{\sqrt{R^2+b^2R^2}} = \frac{1}{\sqrt{1+b^2}}$

13. At angular frequency ω , the current in R-C circuit is given by

$i_{rms} = \frac{E_{rms}}{\sqrt{\left[R^2+\left(\frac{1}{\omega^2C^2}\right)\right]}}$ ....(i)

When frequency is changed to $\frac{\omega}{3}$, the current is halved. Thus

$$\frac{i_{rms}}{2}=\frac{E_{rms}}{\sqrt{\left[R^2+\frac{1}{\left(\frac{\omega}{3}\right)^2C^2}\right]}}=\frac{E_{rms}}{\sqrt{\left[R^2+\left(\frac{9}{\omega^2C^2}\right)\right]}}\text{....(ii)}$$

From equations (i) and (ii), we have

$$\frac{1}{\sqrt{\left[R^2+\left(\frac{1}{\omega^2C^2}\right)\right]}}=\frac{2}{\sqrt{\left[R^2+\left(\frac{9}{\omega^2C^2}\right)\right]}}$$

Solving this equation, we get

$$3R^2=\frac{5}{\omega^2C^2}$$

Hence, the ratio of reactance to resistance is $\frac{\left(\frac{1}{\omega C}\right)}{R}=\sqrt{\left(\frac{3}{5}\right)}$

14. a. For the high frequency,

$$\omega=2\pi f=2\pi\times 12\times 10^3\ rad\ s^{-1}$$

$$\therefore I_0=\frac{E_0}{\sqrt{R^2+\frac{1}{\omega^2C^2}}}=\frac{2E_v}{\sqrt{R^2+\frac{1}{\omega^2C^2}}}$$

$$\text{or } I_0=\frac{\sqrt{2}\times 100}{\sqrt{1600+\frac{1}{4\pi^2\times 144\times 10^6\times 10^{-8}}}}A$$

$$=\frac{1.414\times 110}{\sqrt{1600+0.0176}}A=\frac{1.414}{40}A$$

= 3.9 A

[It may be noted that the C term is negligible at higher frequencies]

b. $\tan\phi=\frac{1}{2\pi\times 12\times 10^3\times 10^{-4}\times 40}=\frac{1}{96\pi}$

ϕ is nearly zero at high frequency.

It is clear from here that at high frequency, C acts as a conductor. For a D.C. circuit, after steady state has been reached, $\omega=0$ and C amount to an open circuit.

15. Due to change in flux, the emf is induced in the coil. The rate of change of flux will give the value of emf.

i. Let an alternating voltage, V = V_0 sin ωt(V_0 being peak value of the AC voltage) is applied across pure inductor of inductance L. The magnitude of induced emf is given by

$e=LdI/dt$, L and dI/dt are the inductance of the inductor and time rate of change of the current respectively.

For the circuit,

Magnitude of induced emf= Applied voltage

i.e. $L\frac{dI}{dt} = V_0 \sin \omega t$ or $dI = \frac{V_0}{L} \sin \omega t dt$

On integrating both sides, we get

$I = \frac{V_0}{L} \int \sin \omega t dt$

$= \frac{V_0}{L}\left(\frac{-\cos \omega t}{\omega}\right)$

or $I = -\frac{V_0}{\omega L} \cos \omega t$

$= -\frac{V_0}{\omega L} \sin\left(\frac{\pi}{2} - \omega t\right)$

$\therefore \quad I = \frac{V_0}{X_L} \sin\left(\omega t - \frac{\pi}{2}\right)$ ....(a)

where, $X_L = \omega L$ = inducting reactance of the given circuit.

where, I_0 = peak value of current of AC

But, $V = V_0 \sin \omega t$....(b)

ii. From Eqs. (a) and (b) it is clear that AC lags behind the voltage by phase $\pi/2$