Chapter 39 Alternating Current

1. What is the reactance of a capacitor connected to a constant DC source?

[Sol. $X_c = \frac{1}{\omega C}$ as $\omega = 0$ for DC, $X_c = \infty$.]

2. The voltage and current in a series AC circuit are given by $V = V_0 \cos \omega t$ & $i = i_0 \sin \omega t$. What is the power dissipated in the circuit?

[Sol. Power = $I_{rms} E_{rms} \cos \phi$.

$\phi = \frac{\pi}{2}$ so $P = 0$.]

3. Two AC's are given by $i_1 = i_0 \sin \omega t$ & $i_2 = i_0 \sin\left(\omega t + \frac{\pi}{3}\right)$. Will the rms values of the currents be equal or different?

[Sol. I_{rms} will be equal because in a complete cycle heat dissipated will be equal for both.]

4. Can the peak voltage across the inductor be greater than the peak voltage of the source in an *LCR* circuit?

[Sol. Yes, consider example below

$V_L = 9$

$V_R = 3$

$V_C = 5$]

5. In a circuit containing a capacitor and an AC source, the current is zero at the instant the source voltage is maximum. Is it consistent with Ohm's law?

[Sol. Ohm's law is valid for resistance.]

6. An AC source is connected to a capacitor. Will the rms current increase, decrease or remain constant if a dielectric slab is inserted into the capacitor?

[Sol. $X_c = \frac{1}{\omega C}$ as slab is introduced C increases and X_C decreases so current increases.]

7. When the frequency of the AC source in an *LCR* circuit equals the resonant frequency, the reactance of the circuit is zero. Does it mean that there is no current through the inductor or the capacitor?

[Sol. There is current but the potential difference across inductor and capacitor cancel each other.]

8. When an AC source is connected to a capacitor there is a steady-state current in the circuit. Does it mean that the charges jump from one plate to the other to complete the circuit?

[Sol. No.]

9. A current $i_1 = i_0 \sin \omega t$ passes through a resistor of resistance *R*. How much thermal energy is produced in one time period? A current $i_2 = -i_0 \sin \omega t$ passes through the resistor. How much thermal energy is produced in one time period? If i_1, and i_2 both pass through the resistor simultaneously, how much thermal energy is produced? Is the principle of superposition obeyed in this case?

[Sol. $I_{rms}^2 \times R \times \frac{2\pi}{\omega}$ from definition of rms current.

(b) same

(c) zero, yes]

10. Is energy produced when a transformer steps up the voltage?

[Sol. No, as voltage increases current decreases. Hence, if efficiency is 100% power will be same.]

11. A transformer is designed to convert an AC voltage of 220 V to an AC voltage of 12 V. If the input terminals are connected to a DC voltage of 220 V, the transformer usually burns. Explain.

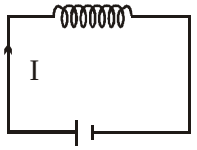
[Sol. In case of inductor

$$V - L\frac{dI}{dt} = 0$$

$$V = L\frac{dI}{dt}$$

$$\int dI = \frac{V}{L}\int dt$$

$$I = \frac{Vt}{L}$$



If direct current is connected across inductor current increases with time and transformer is also inductor. So, current can increase to large value and transfer can burn.]

12. Can you have an AC series circuit in which there is a phase difference of (a) 180° (b) 120° between the emf and the current?

[Sol. No.]

13. A resistance is connected to an AC source. If a capacitor is included in the series circuit, will the average power absorbed by the resistance increase or decrease? If an inductor of small inductance is also included in the series circuit, will the average power absorbed increase or decrease further?

[Sol. If capacitor is included

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

Hence, impedence increases so I_{rms} decreases.
Hence, I_{rms}^2 R decreases.
If the inductor of small inductance is also included then $z = \sqrt{R^2 + (X_C - X_L)^2}$.
Now, impedance gets decreased hence I_{rms} increases and I_{rms}^2 R increases.]

14. Can a hot-wire ammeter be used to measure a direct current having a constant value? Do we have to change the graduations?

[Sol. Yes, in this case I_{rms} value will be same as the DC current.]