CBSE Test Paper-02

Class - 12 Physics (Alternating current)

1. The main reason for preferring usage of AC voltage over DC voltage
   a. There are no DC generators
   b. DC uses alternators whereas AC uses generators
   c. AC voltages can be easily and efficiently converted from one voltage to the other by means of transformers
   d. DC Batteries are of low voltage
2. A 100 μF capacitor in series with a 40 Ω resistance is connected to a 110 V, 60 Hz supply. Maximum current in the circuit and time lag between the current maximum and the voltage maximum are
   a. 2.93 A, 1.55 ms
   b. 3.03 A, 1.50 ms
   c. 2.53 A, 1.55 ms
   d. 3.23 A, 1.55 ms
3. At resonance the current in an LCR circuit is
   a. minimum
   b. maximum
   c. zero
   d. local minimum
4. A resistor of 100 Ω and a capacitor of $10\mu F$ are connected in series to a 220 V 50 Hz ac source. Voltage across the resistor and capacitance are
   a. 66 V, 10 V
   b. 66 V, 110 V
   c. 60 V, 280 V
   d. 56 V, 210 V

5. Inductance of an inductor whose reactance is 120 Ω at 80.0 Hz is

   a. 0.239 H
   b. 0.209 H
   c. 0.199 H
   d. 0.219 H

6. What is the function of a step-up transformer?

7. Write any two factors responsible for energy losses in actual transformers.

8. Define 'quality factor' of resonance in series L-C-R circuit. What is its SI unit?

9. An electric heater is connected, turn by turn, to a dc and ac sources of equal voltages. Will the rate of heat production be same in the two cases? Explain.

10. A bulb and a capacitor are connected in series to an a.c. source of variable frequency. How will the brightness of the bulb change on increasing the frequency of the a.c. source? Give reason.

11. What happens to the power dissipation if the value of electric current passing through a conductor of constant resistance is doubled?

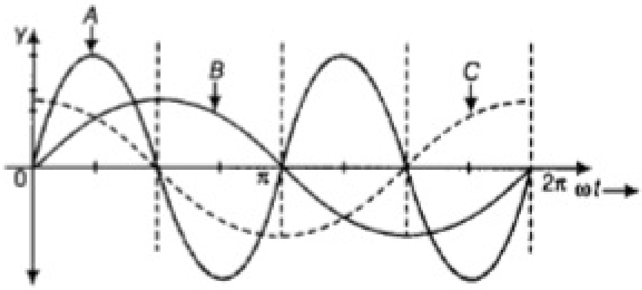
12. A series LCR circuit with $R = 20\Omega$ L = 1.5 H and $C = 35\mu F$ is connected to a variable frequency 200 V ac supply. When the frequency of the supply equals the natural frequency of the circuit, what is the average power transferred to the circuit in one complete cycle?

13. A power transmission line feeds input power at 2300 V to a step down transformer with its primary windings having 4000 turns. What should be the number of turns in the secondary in order to get output power at 230 V?

14. A current of 4 A flows in a coil when connected to a 12 V d.c. source. If the same coil is connected to a 12 V, 50 rad/s, a.c. source, a current of 2.4 A flows in the circuit. Determine the inductance of the coil. Also find the power developed in the circuit if a 2500 μF condenser is connected in series with the coil.

15. A device X is connected to an AC source, V = V_0 sin ωt. The variation of voltage,

current and power in one cycle is shown in the following graph.



i. Identify the device X
ii. Which of the curves A, B and C represent the voltage, current and the power consumed in the circuit? Justify the answer.
iii. How does its impedance vary with the frequency of the AC source? Show graphically.
iv. Obtain an expression for the current in the circuit and its phase relation with AC voltage.

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Answers

1. c. AC voltages can be easily and efficiently converted from one voltage to the other by means of transformers

   Explanation: By using the phenomenon of mutual induction, transformers allow us to easily change voltage of AC. This is necessary to cut down poer losses while supplying electricity to our homes.

2. d. 3.23 A, 1.55 ms

   Explanation: $C = 100\mu F = 100 \times 10^{-6} F$

   $R = 40\Omega$

   V = 110 volt

   f = 60Hz

   Peak voltage $V_0 = V\sqrt{2} = 110\sqrt{2}$ volt

   angular frequency $\omega = 2\pi f = 2 \times 3.14 \times 60 = 376.8 rad/$ sec

   maximum current in circuit

   $i_0 = \frac{V_0}{\sqrt{R^2 + \frac{1}{\omega^2 C^2}}} = \frac{110\sqrt{2}}{\sqrt{(40)^2 + (376.8)^2 (100 \times 10^{-6})^2}} = 3.23A$

   in CR circuit voltage lags behind the current by a phase angle of ϕ. Hence

   $\tan\phi = \frac{1/\omega C}{R} = \frac{1}{\omega CR} = \frac{1}{376.8 \times 100 \times 10^{-6} \times 40} = 0.6635$

   $\phi = \tan^{-1}(0.6635) = 33.56^\circ = \frac{33.56\pi}{180} rad$

   time lag

   $t = \frac{\phi}{\omega} = \frac{33.56\pi}{180 \times 120\pi} = 1.55 \times 10^{-3} s = 1.55 ms$

3. d. maximum

   Explanation: in LCR series circuit current

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

   at resonance

   $X_L = X_C$

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

   $Z_{\min} = R$

hence current will be maximum.

4. a. 66 V ,210 V

Explanation: $R = 100\Omega$

$C = 10\mu F$

V = 220 volt

f = 50Hz

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

$X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C} = \frac{1}{2\times 3.14\times 50\times 10\times 10^{-6}} = 318.5\Omega$

$Z = \sqrt{(100)^2 + (318.5)^2} = 333.8\Omega$

current in circuit

$i = \frac{V}{Z} = \frac{220}{333.8} = 0.66A$

voltage across the resistor $V_R = iR = 0.66 \times 100 = 66V$

voltage across the capacitor $V_C = iX_C = 0.66 \times 318.5 = 210V$

5. a. 0.239 H

Explanation: $X_L = 120\Omega$

f = 80Hz

$X_L = \omega L = 2\pi f L$

$L = \frac{X_L}{2\pi f} = \frac{120}{2\times 3.14\times 80} = 0.239H$

6. A transformer that increases voltage from primary to secondary (more secondary winding turns than primary winding turns) is called a step-up transformer.

7. Two factors for energy losses are

    1. Resistance of winding cause loss of energy.
    2. the eddy current cause heat loss.

8. **Quality factor (Q):-** The ratio of voltage drop across inductor (or capacitor) to the applied voltage,

   i.e. Le $Q = \frac{V_L}{V_R} = \frac{l_0 X_l}{I_0 R} = \frac{\omega_0 L}{R} = \frac{1}{\omega_0 CR} = \frac{1}{R}\sqrt{\frac{L}{C}}$

   Quality factor has no unit.

9. The rate of heat production in both the cases will be same. The rate of heat produced in ac and dc is resistance depended which have same behaviour for ac and dc.

10. As the frequency of the a.c. source increases, the capacitance reactance decreases $\left(X_c \propto \frac{1}{f}\right)$. More current flows through the circuit. So the bulb glows with more brightness.

11. When current is doubled, the dissipation increases four times because $P \alpha I^2$.

12. When the frequency of the a.c. supply is equal to the natural frequency, then

    $z = R$ and $\phi = 0^o$

    $\therefore z = 20\Omega$

    $I_v = \frac{E_v}{z} = \frac{200}{20}$ = 10 A

    Average power transferred

    $P = E_v I_v \cos 0^o$

    $= 200 \times 10 \times 1$ = 2000 watt.

13. V_1 = 2300 volt n_1 = 4000

    V_2 = 230 volt

    $\frac{V_2}{V_1} = \frac{n_2}{n_1}$

    or $n_2 = n_1 \frac{V_2}{V_1} = 4000 \times \frac{230}{2300} = 400\ turns$ = 400 turns

14. When the coil is connected to a d.c. source, its resistance R is given by

    $R = \frac{V}{I} = \frac{12}{4} = 3\Omega$

    When it is connected to a.c. source, the impedance Z of the coil is given by

    $Z = \frac{V_{rms}}{I_{rms}} = \frac{12}{2.4} = 5\Omega$

    For a coil $Z = \sqrt{[R^2 + (\omega L)^2]}$

    $\therefore 5 = \sqrt{[(3)^2 + (50L)^2]}$

    or 25 = $[(3)^2 + (50L)^2]$

    Solving we get L = 0.08 henry

    When the coil is connected with a condenser in series, the impedance Z' is given by

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

    $$= \left[(3)^2 + \left(50 \times 0.08 - \frac{1}{50 - 2500 \times 10^{-6}}\right)^2\right]^{1/2}$$ = 5 ohm

    Power developed

$p = V_{rms} \times I_{rms} \times cos\theta$

$cos\theta = \frac{R}{Z'} = \frac{3}{5} = 0.6$

$\therefore P = 12 \times 2.4 \times 0.6$ = 17.28 watt

15. i. Device X is a capacitor.

    As the current is leading voltage by $\pi/2$ radians. And it happens only then when an ac source is connected with a pure capacitive circuit.

    ii. Curve A represents power,

    Curve B represents voltage and

    Curve C represents current.

    As, V (t)= V_0 sinωt

    Current, I(t) = I_0 cos ωt ,with I_0 = $\frac{V_0}{X_C}$ (X_C being capacitive reactance)

    As, in the case of capacitor,

    $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$ [current is leading the voltage]

    Average power, $P = V(t)I(t) = \frac{V_0 I_0}{2} \cos\phi$

    where, ϕ = phase difference

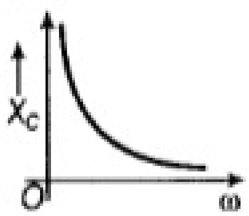
    iii. As, X_c= capacitive reactance = $\frac{1}{C\omega}$

    where, ω is angular frequency and C being capacitance of the capacitor.

    So, reactance or impedance decreases with increase in frequency.

    Graph of X_C versus ω is shown below,

    Phasor diagram

    iv. For a capacitor fed with an AC supply

    $V = \frac{q}{C}$ or $q = CV = CV_0 \sin\omega t$

    $\therefore \quad I = \frac{dq}{dt} = V_0\omega C \cos\omega t = \frac{V_0}{X_C}\sin\left(\omega t + \frac{\pi}{2}\right)$, since $\omega C = \frac{1}{X_C}$