Explanations

1. (a) The value of AC current is

$$I = I_0 \sin\omega t = I_0 \sin 2\pi f t$$

$$\Rightarrow I = (I_{rms} \times \sqrt{2}) \sin\left(2\pi \times 50 \times \frac{1}{600}\right)$$

$$= 15 \times \sqrt{2} \times \sin\frac{\pi}{6} = 15 \times \sqrt{2} \times \frac{1}{2} = \frac{15}{\sqrt{2}} \text{A}$$

2. (c) We know that phase difference between AC and source voltage is $\frac{\pi}{2}$ only in either purely inductive (L) circuit or purely capacitive circuit or series combination of L-C circuit but not in L-R circuit.

3. (d) The impedance of a series L-C-R circuit is given by

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

4. (d) Given, voltage, $E = E_0 \sin\omega t$

Current, $I = I_0 \sin\left(\omega t + \frac{\pi}{2}\right)$

The phase difference between current and voltage is $\phi = \frac{\pi}{2}$.

$\therefore$ Average power dissipated, $P = VI\cos\phi$

$$= V_0 I_0 \cos\frac{\pi}{2} = 0$$

5. (c) Given, $V_R = 20\text{ V}$, $V_L = 15\text{ V}$, $V_C = 30\text{ V}$

Here, $V_C > V_L$

$\therefore$ Resultant voltage in the circuit,

$$V = \sqrt{V_R^2 + (V_C - V_L)^2}$$

$$V = \sqrt{(20)^2 + (30-15)^2} = \sqrt{625} = 25\text{ V}$$

6. (a) The impedance of a L-C-R circuit is

$$Z = \sqrt{R^2 + (X_L - X_C)^2} = \sqrt{R^2 + \left(2\pi fL - \frac{1}{2\pi fC}\right)^2}$$

As, f increases, Z decreases and hence, current in the circuit increases upto resonant frequency and after that if f increases further, then Z starts increasing and hence, current decreases.

7. (b) Given, $R = 15\,\Omega$, $L = 80\text{ mH} = 80\times10^{-3}\text{ H}$

and $f = 50\text{ Hz}$

Since, voltage and current are in phase, so the circuit is in resonance.

$\therefore$ Resonant frequency, $f = \frac{1}{2\pi\sqrt{LC}}$

$$\Rightarrow \quad C = \frac{1}{f^2 4\pi^2 L}$$

$$= \frac{1}{(50)^2\times4\times\pi^2\times80\times10^{-3}} = 127\,\mu\text{F}$$

8. (b) Given, $R = 300\,\Omega$, $C = \frac{25}{\pi}\mu\text{F} = \frac{25}{\pi}\times10^{-6}\text{ F}$,

$V = 200\text{ V}$, $f = 50\text{ Hz}$

The capacitive reactance, $X_C = \frac{1}{2\pi fC}$

$$= \frac{1}{2\pi\times50\times\frac{25}{\pi}\times10^{-6}} = 400\,\Omega$$

So, impedance of circuit, $Z = \sqrt{R^2 + X_C^2}$

$$= \sqrt{(300)^2 + (400)^2}$$

$$= 500\,\Omega$$

Current in circuit, $I = \frac{V}{Z} = \frac{200}{500} = 0.4\text{ A}$

9. (a) Power factor of a series L-C-R circuit is given as

$$\cos\phi = \frac{R(\text{Resistance})}{Z(\text{Impedance})}$$

As, at resonance, $Z = R \Rightarrow \cos\phi = 1$

10. (c) A series L-C-R AC circuit is more selective if its resonance is sharp. In this case maximum current will be more. This implies that the circuit will have higher value of Q-factor.

As, $\quad Q\text{-factor} = \frac{\omega_0 L}{R}$

So, for increasing it, L should be large and R should be small.

11. (d) The core of a transformer is laminated to reduce the effect of eddy currents. These are the current produced in metal parts due to changing magnetic field.

12. (a) When power is drawn from the secondary coil of the transformer, its dynamic resistance increases.

13. (b) Transformer is a device based on the principle of mutual induction which is used for converting large AC at low voltage into small current at high voltage and *vice-versa*.

14. (c) If I_s and I_p be the currents in the primary and secondary coils at any instant and the energy losses be zero, then

Power in secondary coil = Power in primary coil

$$V_s \times I_s = V_p \times I_p$$

$$\Rightarrow \quad \frac{I_p}{I_s} = \frac{V_s}{V_p} = \frac{N_s}{N_p} = \text{Transformer ratio}$$

Given, $\quad \frac{N_p}{N_s} = \frac{2}{3}$, $I_p = 3\text{ A}$

$$\Rightarrow \quad I_s = \frac{N_p}{N_s} I_p = \frac{2}{3}\times3 = 2\text{ A}$$

15. (d) A transformer works in both direction. So, a step-up transformer can be used as a step-down transformer by connecting input to secondary windings and taking output from primary windings.

16. (c) The supply has voltage of $V = V_m \sin\omega t$ and the current through an inductor is

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

Thus, current lags behind the voltage or emf by $\pi/2$, when AC flows through an inductor.

The inductive reactance is directly proportional to the inductance and the frequency of the current as $X_L = \omega L = 2\pi\nu L$. So, it increases as the frequency of AC source increases.

17. (a) When the capacitor is connected to an AC source, it limits or regulates the current, but does not completely prevent the flow of charge.

It is because, the capacitor is alternately charged and discharged as the current reverses each half cycle.

18. (a) Capacitive reactance is inversely proportional to frequency as $X_C = \frac{1}{\omega C} = \frac{1}{2\pi f C}$

As, DC does not have any frequency, i.e. $f = 0$, hence $X_C = \infty$.

So, no DC current flows through capacitor.

But AC varies like a sine function with some frequency, so it passes easily through capacitor.

Hence, capacitor serves as a barrier for DC and offers an easy path to AC.

19. (a) At resonance, $X_C = X_L$ and $Z = R$.

$\therefore$ Power factor, $\cos\phi = \frac{R}{Z} = 1$

20. (b) When frequency is doubled,

$$X_L = 2R \qquad (\text{as, } X_L \propto \omega)$$

and $$X_C = \frac{R}{2} \qquad \left(\text{as, } X_C \propto \frac{1}{\omega}\right)$$

$$\therefore \quad Z = \sqrt{R^2 + \left(2R - \frac{R}{2}\right)^2} = \frac{\sqrt{13}}{2} R$$

At resonance, $X_C = X_L$

21. (d) A choke coil is an electrical device which is used for controlling AC only without wasting electrical energy.

Choke coil works on the principle of self induction.

22. (i) (b) Since, resonant frequency, $f_r = \frac{1}{2\pi\sqrt{LC}}$

When $L' = 2L$ and $C' = 2C$

$$\therefore \quad f_r' = \frac{1}{2\pi\sqrt{L'C'}} = \frac{1}{2\pi\sqrt{2L \cdot 2C}} = \frac{1}{2} \cdot \frac{1}{2\pi\sqrt{LC}} = \frac{f_r}{2}$$

(ii) (a) At resonance frequency, $X_L = X_C$.

(iii) (d) At resonance, impedance (Z) is given as

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

$$= \sqrt{R^2 + 0^2} \qquad (\because X_L = X_C)$$

$$Z = R$$

$\therefore$ Power factor, $\cos\phi = \frac{R}{Z} = \frac{R}{R} = 1$

(iv) (c) At resonance condition of series L-C-R circuit, voltages developed across capacitor and inductor are in same magnitude but opposite in phase ϕ, i.e. $\phi = 180^\circ$

(v) (d) At resonance, $X_L = X_C$

$$\therefore \quad Z = R$$

$\therefore$ Power factor, $\cos\phi = \frac{R}{Z} \Rightarrow \cos\phi = \frac{R}{R}$

$$\Rightarrow \quad \cos\phi = 1$$

$$\Rightarrow \quad \cos\phi = \cos 0^\circ$$

$$\phi = 0^\circ$$

Resonance occurs at all values of R.

The series resonant circuit is also called an acceptor circuit because when number of frequencies are fed to it, it accepts one frequency f_r and rejects all other frequencies.