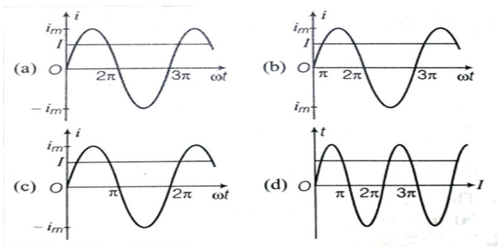
Chapter

7 ALTERNATING CURRENT

1. When an AC current passes through a resistor there is dissipation of

   (a) joule heating (b) electrical energy
   (C) power (d) Both (a) and (b)

2. Which of the following graphs , shows i/t ?



3. The electric current in a circuit is given by $i = i_0\ (t/\tau)$ for same time . The rms current for the period t = 0 to $t = \tau$ is

   (a) $\frac{i_0}{\sqrt{3}}$ (b) $\frac{i_0}{2}$ (c) $\sqrt{\frac{i_0}{2}}$ (d) $\frac{3}{4}\sqrt{i_0}$

4. What is the speed of a phasor which rotates about the origin ?

   (a) 2ω (b) $\omega/2$ (c) ω (d) $\omega/4$

5. Voltage and current in an AC circuit are given by
   V = 5 sin (100 - $\pi/6$) and I = 4 sin (100+ $\pi/6$
   (a) Voltage leads the current by 30^o
   (b) Current leads the voltage by 30^o
   (c) Current leads the voltage by 60^o
   (d) Voltage leads the current by 60^o

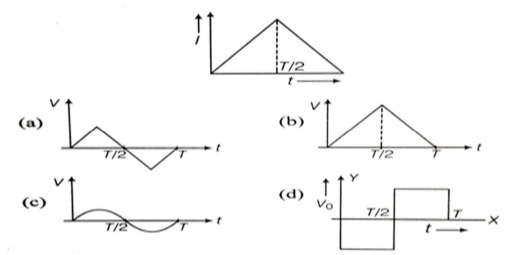
6. An alternating current is given by the equation $i = i_1$ cos $\omega t + I_2$ sin ωt . The rms current is given by

   (a) $\frac{1}{\sqrt{2}}(i_1 + i_2)$ (b) $\frac{1}{\sqrt{2}}(i_1 + i_2)^2$
   (c) $\frac{1}{\sqrt{2}}(i_1^2 + i_2^2)^{1/2}$ (d) $\frac{1}{2}(i_1^2 + i_2^2)^{1/2}$

7. If an AC main supply is given to be 220 V . What would be the average emf during a positive half - cycle?

   (a) 198 V (b) 386 V
   (c) 256 V (d) None of these

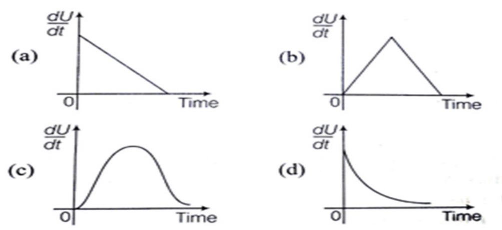
8. The current (I) in the inductance is varying with time according to the plot shown in figure. Which one of the following is correct variation of voltage with time in the coil ?



9. Two inductors L_1 (inductance 1 1mH , internal resistance 3 Ω) and L_2 (inductance 2 1mH , internal resistance 4Ω), and a resistor R (resistance 12 Ω) are all connected in parallel across a 5V battery . The circuit is switched on at time t = 0 . The ratio of the maximum to the minimum current (I_{max}/I_{min}) drawn from the battery is

   (a) 2 (b) 4 (c) 6 (d) 8

10. In an L- R circuit connected to a battery , the rate at which energy is stored in the inductor is plotted against time during the growth of current in the circuit . Which of the following figure best represents the resulting curve?

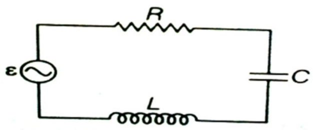


11. In capacitive AC circuit the current reaches its maximum value earlier than the voltage by
(a) Half of a period
(b) three - fourth of a period
(c) Three - two of a period
(d) One - fourth of a period

12. An alternating voltage E = $200\sqrt{2}\ sin\,(100\,t)$ is connected to a $1\mu_F$, capacitor through an AC ammeter . The reading of the ammeter shall be
(a) 10 mA (b) 20 mA (c) 40 mA (d) 80 mA

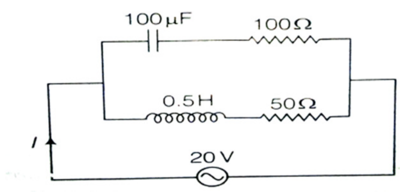
13. A resistor of 200 Ω and a capacitor of 15 μ_F are connected in series to a 220 V , 50 Hz AC source . The current in the circuit is
(a) 755 A (b) 7.55 mA
(c) 0.755 A (d) 0.755 mA

14. Consider the figure , the resistor , inductor and capacitor are in series , therefore



(a) The AC current in each element is same at any time
(b) Amplitude and phase are same in each element
(c) Both (a) and (b)
(d) Neither (a) and (b)

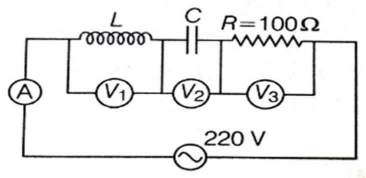
15. In the given circuit , the AC source has ω = 100rad /s. Considering the inductor and capacitor to be ideal , the correct choice (s) is (are)



(a) The current through the circuit , I is 0.3 A
(b) The current through the circuit, I is 0.3$\sqrt{2}$ A
(c) The voltage across 100Ω resistor = 10 $\sqrt{2}$ V
(d) The voltage across 50 Ω resistor = 10 V

16. In a circuit , LC and r are connected in series with an alternating voltage source of frequency f . The current leads the voltage by 45^o. The value of C is
(a) $\frac{1}{2\,\pi f\,(2\pi f\,L+R)}$ (b) $\frac{1}{\pi f\,(2\pi f\,L\,+R)}$
(c) $\frac{1}{2\,\pi f\,(2\pi f\,L-\,R)}$ (d) $\frac{1}{\pi f\,(2\pi f\,L-R)}$

17. In the given circuit , the readings of voltmeters V_1 and V_2 are 300 V each . The readings of the voltmeter V_3 and ammeter A are respectively

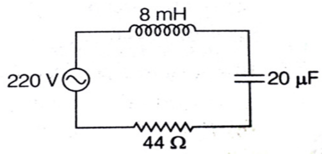


(a) 100 V , 2.0 A (b) 150 V , 2.2 A
(c) 220 V, 2.2 A (c) 220 V , 2.0 A

18. An AC source of angular frequency ω is fed across resistor R and a capacitor C in series . The current registered is I . If now the frequency of source is changed to $\omega/3$ (but maintaining the same voltage) the current in the circuit is found to be halved . Calculate the ratio of reactance to resistance at the original frequency ω

(a) $\sqrt{\frac{3}{5}}$ (b) $\sqrt{\frac{2}{5}}$ (c) $\sqrt{\frac{1}{5}}$ (d) $\sqrt{\frac{4}{5}}$

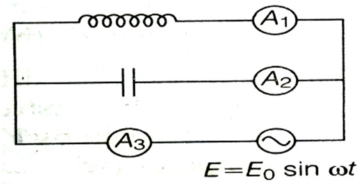
19. For the series $L-C-R$ circuit shown in the figure, what is the angular resonant frequency and amplitude of the current at the resonating frequency ?



(a) 2500 rad /s and $5\sqrt{2}\,A$
(b) 2500 rad /s and 5A
(c) 2500rad /s and $\frac{5}{\sqrt{2}}A$
(d) 25 rad /s and $5\sqrt{2}\,A$

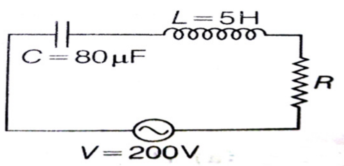
20. In non-resonant circuit , what will be the nature of circuit for frequencies higher than the resonant frequency ?
(a) Resistive (b) Capacitive
(c) Inductive (d) None of these

21. An inductor L and a capacitor C are connected in the circuit as shown in figure . The frequency of the power supply is equal to the resonant frequency of the circuit . Which ammeter will read zero ampere?



(a) A_1 (b) A_2 (c) A_3 (d) None of these

22. Figure shows a series L-C-R circuit , connected to a variable frequency 200 V source . C = 80 μF and R = 40 Ω . The source frequency which drives the circuit at resonance is



(a) 25 Hz (b) $\frac{25}{\pi}$ Hz (c) 50 Hz (d) $\frac{50}{\pi}$ Hz

23. In an AC circuit , the average power dissipated depends
(a) On the voltage
(b) current
(c) cosine of the phase angle ϕ between them
(d) All of the above

24. In AC circuit , V and I are given by
V = 100 sin (100t) V ,
i = 100sin $\left(100\, t + \frac{\pi}{3}\right) mA$. The power dissipated in circuit is

(a) $10^4 W$ (b) 10W (c) 2.5 W (d) 5W

25. A coil of self - inductance L is connected in series with a bulb B and AC source . Brightness of the bulb decreases when

(a) frequency of the AC source is decreased
(b) number of turns in the coil is reduced
(c) a capacitance of reactance X_C - X_L is included in the same circuit
(d) an iron rod is inserted in the coil

26. A lamp consumes only 50% of peak power in an AC circuit . What is the phase difference between the applied voltage and the circuit current ?

(a) $\frac{\pi}{6}$ (b) $\frac{\pi}{3}$ (c) $\frac{\pi}{4}$ (d) $\frac{\pi}{2}$

27. In an electrical $circuit$ R , L, C and an AC voltage source are all connected in series. When L is removed from the circuit, the phase difference between the voltage and the current in the circuit is $\pi/3$. If instead, C is removed from the circuit , the phase difference is again $\pi/3$. The power factor of the circuit is

(a) 1/ 2 (b) 1/ $\sqrt{2}$ (c) 1 (d) $\sqrt{3}/2$

28. An inductor 20 mH , a capacitor 50 μF and a resistor 40 Ω are connected in series across a source of emf V = 10 sin 340t . The power loss in AC circuit is

(a) 0.67 W (B) 0.76 W (c) 0.89 W (d) 0.51W

29. A charged 60 μF capacitor is connected to a 54 mH inductor . What is the angular frequency of free oscillations of the circuit?

(a) $5.5 s^{-1}$ (b) $5.5 \times 10^2 s^{-1}$
(c) $1.2 s^{-1}$ (d) $1.1 \times 10^{-3} s^{-1}$

30. A transformer having efficiency of 90% is working 200V and 3kW power supply . If the current in secondary coil is 6A , the voltage across the second coil and the current the current in the primary coil and the current in the primary coil respectively are

(a) 300V , 15 A (b) 450 V , 15 A
(c)450 V , 13.5 A (d) 600V , 15 A

31. The ratio of secondary to primary turns is 4:5 . If power input is P , then the ratio of power output to power input is

(a) 4:9 (b) 9:4 (c) 5 :4 (d) 1:1

Directions :

In the following questions* (Q .Nos. 32-33) *a statement of assertion is followed by a corresponding statements , choose the correct one .

(a) Both Assertion and reason are correct and reason is the correct explanation of Assertion .
(b) Both Assertion and Reason are correct but Reason is not the correct explanation of Assertion .
(c) Assertion is correct but Reason is incorrect.
(d) Assertion is incorrect but Reason is correct.

32. **Assertion :**

If $X_C > X_L$, $\phi$is positive and the circuit is predominatly capacitive . The current in the circuit leads the source voltage

Reason :

If If $X_C > X_L$, ϕ is negative and the circuit is predominantly inductive , the current in the circuit lags the source voltage .

33. **Assertion** :

In a series R-L-C circuit , the voltages across resistor , inductor and capacitor are 8V , i6 V and 10V , respectively . the resultant emf in the circuit is 10 V.

Reason: Resultant emf of the circuit is given by the relation

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

Directions :

(Q. Nos. 34 – 35) *In the following questions, a statement I is followed by a corresponding statement II . Of the following statements , choose the correct one.*

(a) Both statement I and statement II are correct and statement II is the correct explanation of Statemnt I .
(b) Both Statements I and statement II are correct but Statement II is not the correct explanation of Statement I .
(c) Statement I is correct but Statemnt II is incorrect .
(d) Statement I is incorrect but statement II is incorrect .

34. **Statement I** :

The opposition offered by AC circuit to the flow of AC through it is defined as impedance, It's unit is ohm .

Statement II :

The opposition offered by inductor or capacitor or both to the flow of AC through it is defined as reactance .

35. **Statement I** :

A capacitor of suitable capacitance can be used in an AC circuit in place of the choke coil .

Statement II :

A capacitor block DC and allows AC only .

36. When a voltage measuring device is connected to AC mains, the meter shows the steady input voltage of 220 V . this means

(a) input voltage cannot be AC voltage , but a DC voltage
(b) Maximum input voltage is 220V .
(c) The meter reads not v but $< v^2 >$ and is calibrated to read $\sqrt{< v^2 >}$
(d) The pointer of the meter is stuck by some mechanical defect

37. The output of step - down transformer is measured to be 24 V when connected to a 12 W light bulb . The value of the peak current is

(a) $1/\sqrt{2}\,A$ (b) $\sqrt{2}\,A$ (c) $2A$ (d) $2\sqrt{2}\,A$

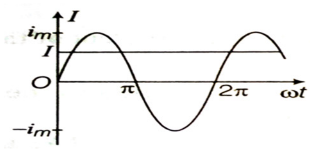
38. For a L-C-R circuit , the power transferred from the driving source to the drive oscillator is $P = I^2 Z \cos\phi$.

(a) Here , the power factor $cos\,\phi \geq 0, P \geq 0$
(b) The drive force can given no energy to the oscillator (P= 0) in some cases
(c) The driving force cannot syphon out (P<0) the energy put of oscillator
(d) The driving force can take away energy out of the oscillator

Hints and Explanations

1. (d)
Joule heating is given by i^2 R and depends on i^2 (which is always positive whether i is positive or negative) and not on i. Thus , there is joule heating and dissipation of electrical energy when an AC current passes through a resistor.

2. (c)



The rms current I is related to the peak current i_m by
$I = i_m / \sqrt{2} = 0.707\, i_m$

3. (a)
$i = i_0 \ (t/\tau)$
$i^2 = \frac{\int_0^\tau i^2 dt}{\tau} = \frac{\int_0^\tau i_0^2 \,(t/\tau)^2\, dt}{\tau}$
$= \frac{i_0^2}{\tau^3} \int_0^\tau t^2 dt = \frac{i_0^2}{\tau^3} \times \frac{\tau^3}{3} = \frac{i_0^2}{3}$
$i_{rms} = \sqrt{i^2} = \sqrt{\frac{i_0^2}{3}} = \frac{i_0}{\sqrt{3}}$

4. (c)

5. (c)
Phase difference $\Delta\phi = \phi_2 - \phi_1$
$= \pi/6 - (-\pi/6) = \pi/3$

6. (c)
$i_1 = A \sin\phi$; $i_2 = A \sin\phi$
$i = A\sin \ (\omega t + \phi)$, where A = $\sqrt{i_1^2 + i_2^2}$
$i = \sqrt{i_1^2 + i_2^2}\ sin \ (\omega t + \phi)$; $i_{rms} = \frac{i_0}{\sqrt{2}}$
$= \frac{\sqrt{i_1^2 + i_2^2}}{\sqrt{2}}$

7. (a)
$V_{av} = \frac{2}{\pi} V_0 = \frac{2}{\pi} \times \left(V_{rms} \times \sqrt{2}\right) = \frac{2\sqrt{2}}{\pi} V_{rms}$
$= \frac{2\sqrt{2}}{\pi} \times 220 = 198\, V$

8. (d)
$V = -L\ (di/dt)$, V is proportional to the slope of the i-t graph , which is constant and positive for the first half (0 to T / 2) and negative and constant for the second half ($T/2$ to T).

Note : $|V| = L\,(di/dt)$ in this case .
For first half V is − ve and for the second half it is +ve .

9. (c)
When t = 0 due to large impedance of two inductor current will flow only in 12 Ω .
∴ I_{min} = 5/12.
After sometime current become is steady then R = 12 Ω will go out of circuit only r_1 and r_2 will be effective route of current flow.
r_{eff} = 2 Ω $\Rightarrow I_{max} = \frac{5}{2} \Rightarrow \frac{I_{max}}{I_{min}} = 6$

10. (c)
Energy stored in an inductor L carrying current i is
$U = (1/2)Li^2$
Rate at which energy is stored
$= \frac{dU}{dt} = \frac{1}{2}\, L 2i \left(\frac{di}{dt}\right) = Li \left(\frac{di}{dt}\right)$
$t = 0$, i =0 $\Rightarrow dU/dt = 0$
$t = \infty$, $i = i_0$ (constant)
∴ $\frac{di}{dt} = 0 \Rightarrow \frac{dU}{dt} = 0$

11. (d)
The current reaches its maximum value earlier than the voltage by one - fourth of a period .

12. (b)
Reading of ammeter = $i_{rms} = \frac{V_{rms}}{X_C} = \frac{V_0 \omega C}{\sqrt{2}}$
$\left(\because X_C = \frac{1}{\omega C}\right)$

$= \frac{200\sqrt{2}\times 100\times(1\times 10^{-6})}{\sqrt{2}} = 2\times 10^{-2}A = 20mA$

13. (c)

Impedance of the circuit

$Z = \sqrt{R^2 + X_C^2} = \sqrt{R^2 + (2\pi v C)^{-2}}$

$= \sqrt{(200\Omega)^2 + (2\times 3.14\times 50 \times 15\times 10^{-6}F)^{-2}}$

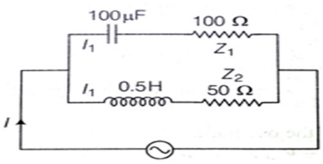
$= \sqrt{(200\Omega)^2 + (212\Omega)^2} = 291.5\ \Omega$

Therefore , the current in the circuit is

i = V/Z $= \frac{220V}{291.5\ \Omega} = 0.755A$

14. (c)

15. (a,c)



Circuit 1

$X_C = \frac{1}{\omega C} = 100\Omega \Rightarrow Z_1$

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

$\phi_1 = cos^{-1}\left(\frac{R_1}{Z_1}\right) = 45^o$

In this circuit current leads the voltage .

$i = \frac{V}{Z_1} = \frac{20}{100\sqrt{2}} = \frac{1}{5\sqrt{2}}\ A \Rightarrow V_{100\Omega}$

$= (100)i_1 = (100)\frac{1}{5\sqrt{2}}$

$V = 10\sqrt{2}$

Circuit 2

$X_L = \omega L = (100)(0.5) = 50\ \Omega$

$Z_2 = \sqrt{(50)^2 + (50)^2} = 50\sqrt{2}\ \Omega$

$\phi_2 = cos^{-1}\left(\frac{R_2}{Z_2}\right) = 45^o$

In this circuit voltage leads the current.

$i_2 = \frac{V}{Z_2} = \frac{20}{50\sqrt{2}} = \frac{\sqrt{2}}{5}A$

$V_{50\Omega} = (50)i_2 = 50\left(\frac{\sqrt{2}}{5}\right) = 10\sqrt{2}\ V$ Further ,

i_1 and i_2 have a mutual phase difference of 90^o.

$\therefore\ i = \sqrt{i_1^2 + i_2^2} = \sqrt{\frac{1}{50} + \frac{4}{50}} = \frac{1}{\sqrt{10}}A \approx 3.0\ A$

16. (a)

Tan $\phi = \frac{X_C - X_L}{R}$

$\Rightarrow\ \tan 45^o = \frac{\frac{1}{2\pi f C} - 2\pi f L}{R}$

$\Rightarrow\ C = \frac{1}{2\pi f(2\pi f L + R)}$

17. (c)

$V = \sqrt{(V_L - V_C)^2 + V_R^2}$, 220

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

Or V_R= 220 V , $i = \frac{V_R}{R} = \frac{220\ V}{100\Omega} = 2.2$ A

18. (a)

Angular frequency ω, the current in $R - C$ circuit is given by

$I_{rms} = \frac{V_{rms}}{\sqrt{R^2 + \left(\frac{1}{\omega C}\right)^2}}$

$\frac{I_{rms}}{2} = \frac{V_{rms}}{\sqrt{R^2 + \left[\frac{1}{\omega C/3}\right]^2}} = \frac{V_{rms}}{\sqrt{R^2 + \frac{1}{\omega^2 C^2}}}$

$3R^2 = \frac{5}{\omega^2 C^2} \Rightarrow \frac{\frac{1}{\omega C}}{R} = \sqrt{\frac{3}{5}} \Rightarrow \frac{X_C}{R} = \sqrt{\frac{3}{5}}$

19. (a)

Resonance frequency

$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{8\times 10^{-3}\times 20\times 10^{-6}}} = 2500 rads^{-1}$

$Resonant\ curent = V_m/R = \frac{220\sqrt{2}}{44} = 5\sqrt{2}A$

20. (c)

In non-resonant circuits,

Impedance , $Z = \sqrt{R^2 + \left(\omega L - \frac{1}{\omega C}\right)^2}$, with rise in frequency Z increases i.e., current decrease , so circuit behaves as inductive circuit .

At lower frequency $\frac{1}{\omega L} > \omega L$ the circuit becomes capacitive .

At higher frequency, the circuit is inductive.

21. (c)

This is a parallel resonant circuit n which current becomes zero at resonance.

22. (b)

Resonant frequency $v = \frac{1}{2\pi\sqrt{LC}}$

$\therefore\ v = \frac{1}{2\times 3.14\times\sqrt{5}\times 80\times 10^{-6}}$

$= \frac{1}{2\times 3.14\sqrt{(400\times 10^{-6})}}$

$= \frac{1}{2\times 3.14\times 2\times 10^{-2}}$

$= \frac{100}{3.14\times 4} = \frac{25}{3.14} = \frac{25}{\pi}\ Hz$

23. (c)

24. (c)

Power dissipated in the circuit

$P = V_{rms} \times i_{rms} \times cos\phi = \frac{200}{\sqrt{2}} \frac{1}{\sqrt{2}} \times cos\frac{\pi}{3}$

$= \frac{10^4 \times 10^{-3}}{2} \times \frac{1}{2} = \frac{10}{4} = 2.5\ W$

25. (d)

Z = $\sqrt{R^2 + X_L^2} = \sqrt{R^2 + (2\pi f v L)^2}$

$= i = \frac{V}{Z}$, $P = i^2 R$

i.e., $V \uparrow, L \uparrow \implies Z \uparrow, i \downarrow$ and $P \downarrow$

26. (b)

Power consumed by lamp

i.e., P = (1/2) $V_0 i_0\ cos\phi \implies$ P = $P_{peak}.\cos\phi$

$\implies \frac{1}{2}(P_{peak}) = P_{peak}\ 0$

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

27.(c)

Phase difference

$tan\ \phi = \frac{X_L - X_C}{R} \implies tan\frac{\pi}{3} = \frac{X_L - X_C}{R}$

When L is removed

$\sqrt{3} = X_C / R \implies X_C = \sqrt{3}\ R$

When C is removed

$tan\frac{\pi}{3} = \sqrt{3} = \frac{X_L}{R} \implies X_L = R\sqrt{3}$

Resonant circuit

$tan\ \phi = \frac{\sqrt{3}\,\mathrm{R} - \sqrt{3}\,\mathrm{R}}{R} = 0 \implies \phi = 0$

∴ Power factor $cos\ \phi = 1$

It is the condition of resonance therefore phase difference between voltage and current is zero and power factor is $cos\ \phi = 1$.

28. (d)

29. (b)

Angular frequency of free oscillations of the circuit i.e.,

$\omega = \frac{1}{\sqrt{LC}} = \frac{1}{\sqrt{(54 \times 10^{-3})(60 \times 10^{-6}) s^{-1}}}$

$= \frac{10^4}{18}\ s^{-1} = 0.55 \times 10^3 s^{-1}$

30. (b)

Initial power = 3000 W

efficiency is 90% then final power

= 3000 $\times \frac{90}{100}$ = 2700 W

$\implies V_i i_1$ = 3000 W

$V_i i_1$ = 2700 W ------ (i)

$V_2 = \frac{2700}{6} = \frac{900}{2} = 450V$ and $i_1 = \frac{3000}{2000} = 15A$

31. (d)

In an ideal transformer , there is no energy loss and flux is completely confined with the magnetic core i.e., perfectly coupled

$\frac{P_{out}}{P_{in}} = 1$

32. (b)

33. (a)

The resultant emf in the $L - C - R$ circuit is given by

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

$E = \sqrt{(8)^2 + (16 - 10)^2}$

$\implies E = \sqrt{64 + 36} \implies E$ = 10V

34. (b)

35. (b)

Capacitance or inductor can be used in AC in place chock coil as they have high reactance but uses no energy unlike high resistance .

36. (c)

The voltmeter connected to AC main read mean value $(< v^2 >)$ and is calibrated in such a way that it gives value of $< v^2 >$, which is multiplied by form factor to give rms value.

37. (a)

Secondary voltage V_S = 24 V

Power associated with secondary $P_S = 12W$

$i_S = \frac{P_S}{V_S} = \frac{12}{24} = \frac{1}{2} A = 0.5\ A$

Peak value of the current in the secondary

$i_0 = i_S\ \sqrt{2}\ (0.5)(1.414) = 0.707 = \frac{1}{\sqrt{2}} A$

38. (a,b,c)

$P = i^2 Z\ cos\ \phi$

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

R > 0 and Z > 0 $\implies cos\ \phi > 0 \implies P > 0$