Chapter

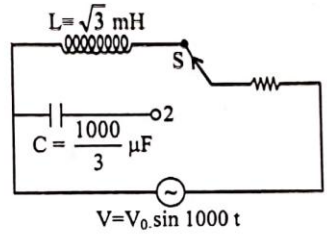
24 Alternating Current

Single Correct Option Type Questions

Q.1 An inductance L, a capacitance C and a resistance R may be connected to an AC source of angular frequency ω, in three different combinations of RC, RL and LC in series. Assume that $\omega L = \frac{1}{\omega C}$. The power drawn by the three combinations are P_1, P_2, P_3 respectively, then,

(A) $P_1 > P_2 > P_3$ (B) $P_1 = P_2 < P_3$ (C) $P_1 = P_2 > P_3$ (D) $P_1 = P_2 = P_3$

Q.2 In the given AC circuit, when switch S is at position 1, the source emf leads current by $\pi/6$ Now, if the switch is at position 2, then



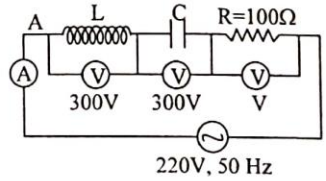
(A) current leads source emf by $\frac{\pi}{4}$ (B) current leads source emf by $\frac{\pi}{3}$

(C) source emf leads current by $\frac{\pi}{4}$ (D) source emf leads current by $\frac{\pi}{3}$.

Q.3 A coil of inductance 0.12 H and resistance 5Ω is connected to an AC–source of 13 V, $\frac{50}{\pi}$ Hz. The power factor of this circuit is

(A) $\frac{12}{5}$ (B) $\frac{12}{13}$ (C) 5 (D) $\frac{5}{13}$.

Q.4 In the circuit shown below, what will be the reading of the voltmeter and ammeter?

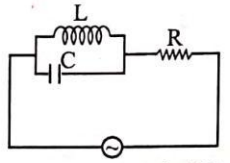


(A) 800 V, 2A (B) 300 V, 2A (C) 220 V, 2.2A (D) 100 V, 2A

Q.5 An electric lamp designed for operation on 110V AC is connected to a 220 V AC supply, through a choke coil of inductance 2H, for proper operation. The angular frequency of the AC is $100\sqrt{10}$ rad/s. If a capacitor is to be used in place of the choke coil, its capacitance must be

(A) 1 μF (B) 2 μF (C) 5 μF (D) 10 μF

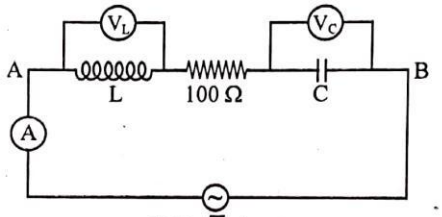
Q.6 In the given circuit inductance $L = \frac{50}{\pi^2} \times 10^{-2}$ Henry, capacitance C = 200 μF and R = 100 Ω are attached as shown. An alternating voltage V = 5 sin 100 πt is applied across the circuit. Find current in the resistance R and voltage across inductor as a function of time t.



V=5 sin 100πt

(A) 0 A, V = 5 sin 100πt
(B) I = 0.05 sin 100πt, V = 5 sin 100πt
(C) I = 0.05 sin 100πt, V = 0 volt
(D) None of these

Q.7 In the circuit shown, the reading of ammeter is 10 A and that of V_C = 200 V. The reading of V_L is



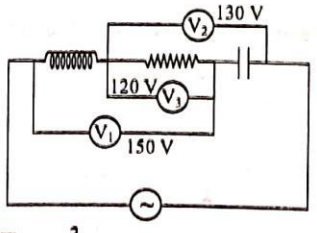
$1000\sqrt{2}\sin\omega t$

(A) 200 V
(B) $200\sqrt{2}$ V
(C) $(-1200 + 1000\sqrt{2})$ V
(D) Zero

Q.8 An AC source of frequency f is fed across a resistor R and a capacitor C in series. The current flowing in the circuit is I. If now the frequency of source is changed to $\frac{f}{3}$, without any change in magnitude of voltage, the current in the circuit in the circuit is found to halved. The ratio of reactance to resistance at the original frequency f will be

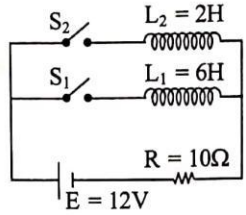
(A) $\frac{3}{\sqrt{5}}$
(B) $\frac{\sqrt{3}}{5}$
(C) $\sqrt{\frac{5}{3}}$
(D) $\sqrt{\frac{3}{5}}$

Q.9 In the circuit reading of voltmeters (rms value) V_1, V_2, V_3 are 150 V, 130 V and 120V respectively. Find the applied ac rms voltage and power factor of the circuit.



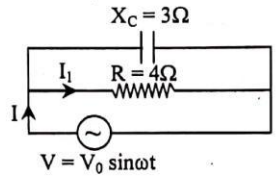
(A) $40\sqrt{10}$ V, $\frac{3}{\sqrt{10}}$
(B) $30\sqrt{7}$ V, $\frac{3}{\sqrt{8}}$
(C) $50\sqrt{10}$ V, $\frac{7}{\sqrt{10}}$
(D) $30\sqrt{10}$ V, $\frac{3}{\sqrt{7}}$

Q.10 In the circuit arrangement shown in figure, initially both the switches S_1 and S_2 are open. At t = 0. the switch S_1 is closed and at $t = t_0$, the switch S_2 is also closed when the current in L_1 has become $i_1 = 0.756A$. At $t = t_0$, the magnitude of current i_2 and rate of change of current $\frac{di_2}{dt}$ are given by ; (i_2 is the current in L_2)



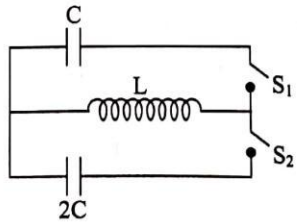
(A) zero, $3As^{-1}$ (B) 0.567A, 2.22 As^{-1} (C) 0.567 A, 3 As^{-1} (D) zero, 2.22 As^{-1}

Q.11 A capacitor and resistor are connected with an A.C. source as shown in figure. Reactance of capacitor is $X_c = 3\Omega$ and resistance of resistor is 4Ω. Phase difference between current I and I_1 is $\left[\tan^{-1}\left(\frac{3}{4}\right) = 37°\right]$



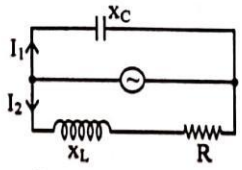
(A) 90° (B) zero (C) 53° (D) 37°

Q.12 A capacitor of capacitance C is charged to potential V_0 and is connected in circuit as shown in the figure. Switch S_1 is closed at t = 0. After time $t = \frac{\pi\sqrt{LC}}{6}$, switch S_1 is opened while switch S_2 is closed. If initially both the switches were open and capacitor of capacitance 2C was uncharged, the maximum charge stored on 2C would be



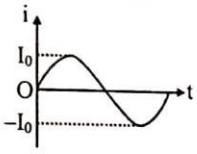
(A) $\frac{CV_0}{\sqrt{2}}$ (B) $\frac{CV_0}{2}$ (C) $\frac{CV_0}{4}$ (D) None of the above

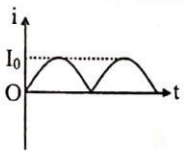
Q.13 In the shown AC circuit phase difference between currents I_1 and I_2 is

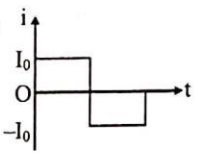


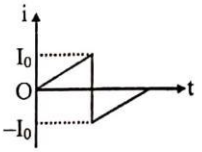
(A) $\frac{\pi}{2} - \tan^{-1}\frac{X_L}{R}$ (B) $\tan^{-1}\frac{X_L - X_C}{R}$ (C) $\frac{\pi}{2} + \tan^{-1}\frac{X_L}{R}$ (D) $\tan^{-1}\frac{X_L - X_C}{R} + \frac{\pi}{2}$

Q.14 If I_1, I_2, I_3 and I_4 are the respective r.m.s. values of the time varying currents as shown in the four cases I, II, III and IV. Then identify the correct relations.









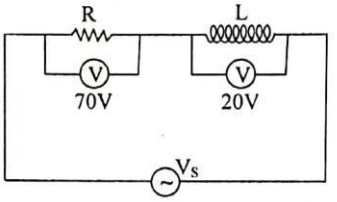
(A) $I_1 = I_2 = I_3 = I_4$ (B) $I_3 > I_1 = I_2 > I_4$ (C) $I_3 > I_4 > I_2 = I_1$ (D) $I_3 > I_2 > I_1 > I_4$

Statement Based Questions

Q.15 In the given figure.

Statement-1 : The source voltage is 72.8 V.

Statement-2 : $V_S^2 = V_R^2 + V_L^2$



(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(B) Statement-1 is true, statement-2 true and statement-2 is NOT is correct explanation for statement.
(C) Statement-1 is true, statement-2 is false.
(D) Statement-1 is false, statement-2 is true.

Q.16 **Statement-1 :** Average power output in AC circuit may be zero.

Statement-2 : $P_{av} = V_m I_m \cos\phi$. If $\cos\phi = 0$, $P_{av} = 0$.

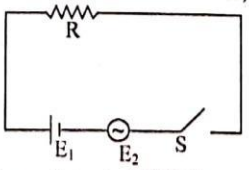
(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(B) Statement-1 is true, statement-2 true and statement-2 is NOT is correct explanation for statement.
(C) Statement-1 is true, statement-2 is false.
(D) Statement-1 is false, statement-2 is true.

Multiple Correct Option Type Questions

Q.17 A current of 4A flows in a coil when connected to 12V dc source. If the same coil is connected to a 12V, 50 rad/s source, a current of 2.4 A flows in the circuit. Then

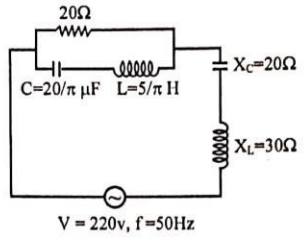
(A) $R = 4\Omega$ (B) $R = 3\Omega$ (C) $L = 4H$ (D) $L = 0.08$ H.

Q.18 In the circuit shown in the figure $R = 50\Omega$, $E_1 = 25\sqrt{3}$ volt and $E_2 = 25\sqrt{6}\sin(\omega t)$ volt where $\omega = 100\ \pi s^{-1}$. The switch is closed at $t = 0$ and remains closed for 14 minutes, then it is opened



(A) The amount of heat produced in the resistor is 63000 J.
(B) The amount of heat produced in the resistor is 7000 J.
(C) If total amount of heat produced is used to heat 3 kg of water at 20°C, the final temperature will be 25°C.
(D) The value of direct current that will produce same amount of heat in same time through same resistor will be $\sqrt{1.5}$ A.

Q.19 The circuit shown below is :



(A) purely resistive (B) purely inductive (C) purely capacitive (D) zero power factor

Q.20 A series RLC circuit is driven by a generator at frequency 1000 Hz. The inductance is 90.0 mH. Capacitance is 0.500 μF; and the phase constant has a magnitude of 60.0° (Take $\pi^2 = 10$)

(A) Here current leads the voltage in phase

(B) Here voltage leads the current in phase

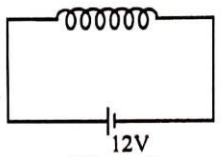
(C) Resistance of circuit is $\frac{80\pi}{\sqrt{3}}\Omega$

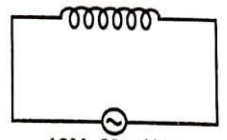
(D) At resonance $\omega = \frac{\sqrt{2}}{3} \times 10^4$ rad/sec.

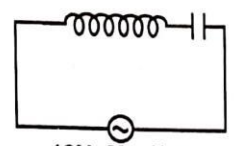
Passage Based Questions

Passage # 1 (Q.21 to 23)

A steady current 4A flows in an inductor coil when connected to a 12V dc source as shown in figure 1. If the same coil is connected to an AC source of 12 V, 50 rad/s, a current of 2.4 A flows in the circuit as shown in figure 2. Now after these observations, a capacitor of capacitance $\frac{1}{50}$ F is connected in series with the coil and with the same AC source as shown in figure 3.


12V
(Figure 1)


12V, 50rad/sec.
(Figure 2)


12V, 50rad/sec.
(Figure 3)

Q.21 The inductance of the coil is nearly equal to

(A) 0.01 H (B) 0.02 H (C) 0.04 H (D) 0.08 H

Q.22 The resistance of the coil is :

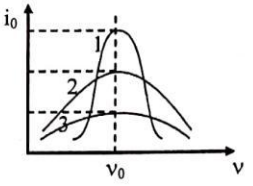
(A) 1 Ω (B) 2 Ω (C) 3 Ω (D) 4 Ω

Q.23 The average power supplied to the circuit after connecting capacitance in series is approximately equal to :

(A) 24 W (B) 72 W (C) 144 W (D) None of these

Passage # 2 (Q.24 to 26)

The figure represents variation of peak current i_0 with applied frequency ν of the AC source of three different LCR circuits having different resistances. The value of inductance L and capacitance C are same for all the three circuits.



Q.24 If R_1, R_2 and R_3 be the resistance of circuit 1, 2 and 3 respectively, then

(A) $R_1 > R_2 > R_3$ (B) $R_1 < R_2 < R_3$ (C) $R_1 > R_2 = R_3$ (D) $R_1 = R_2 = R_3$

Q.25 If $R_1 = 1\ \Omega$, $R_2 = 5\ \Omega$, $R_3 = 10\ \Omega$ and $L = \frac{900}{\pi}$ mH, $C = \frac{40}{\pi}\ \mu$F, then the value of ν_0 is

(A) 250 Hz (B) 125 Hz (C) $\frac{250}{6}$ Hz (D) $\frac{250}{3}$ Hz

Q.26 In the previous question, the frequency with which energy oscillates between Electric Field Energy and Magnetic Field Energy, is

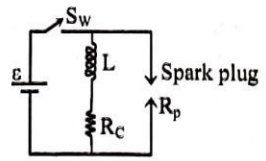
(A) $\frac{1}{4\pi\sqrt{LC}}$ (B) $\frac{1}{\pi\sqrt{LC}}$

(C) $\frac{1}{2\pi\sqrt{LC}}$ (D) the energy in the electric field does not oscillate

Passage # 3 (Q.27 & 28)

The spark plug in an automobile engine is an R-L circuit as shown in figure. The circuit that provides the spark uses an inductor as the energy source. Initially switch is closed and allows current to build through the inductor. When the switch is open the current decreases rapidly through inductor and a large emf is induced by inductor.

Given $\varepsilon = 12$ V, $L = 10$ mH, $R_c = 10\ \Omega$, $R_p = 7k\Omega$



Q.27 If switch must be closed for up to three time constants. Find this time

(A) 3 ms (B) 1.5 ms (C) 6 ms (D) 1/3 ms

Q.28 The spark occurs in the spark plug because

(A) Spark plug short circuits the inductor

(B) Spark plug short circuits the battery

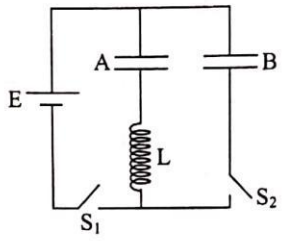
(C) Due to large induced emf generated by inductor air in the gap in spark plug gets ionized

(D) Spark produced is due to conversion of magnetic field energy of inductor to visible electromagnetic radiations.

Passage # 4 (Q.29 & 30)

Two uncharged identical capacitors A and B, each of capacitance C, and an inductor of inductance L are arranged as shown in the adjacent figure.

At t = 0, the switch S_1 is closed while switch S_2 remains open. At time $t = t_0 = \sqrt{LC}\frac{\pi}{2}$, switch S_2 is closed while switch S_1 is opened.



Q.29 The current flowing through the inductor at $t = t_0$ is

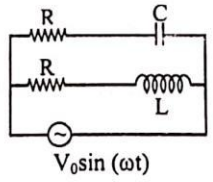
(A) $2CE\frac{1}{\sqrt{LC}}$ (B) 0 (C) $\frac{CE}{2}\times\frac{1}{\sqrt{LC}}$ (D) $CE\times\frac{1}{\sqrt{LC}}$

Q.30 After switch S_2 is closed and S_1 is opened, the maximum value of current through the inductor is

(A) $\left(\sqrt{\frac{C}{L}}\right)E$ (B) $\left(\sqrt{\frac{C}{2L}}\right)E$ (C) $\left(\sqrt{\frac{3}{2}\frac{C}{L}}\right)E$ (D) $\left(\sqrt{\frac{5}{4}\frac{C}{L}}\right)E$

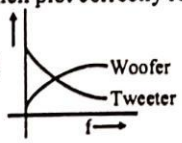
Passage # 5 (Q.31 to 33)

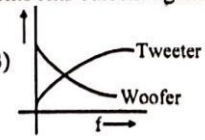
A loudspeaker system uses alternating current to amplify sound of certain frequencies consists of 2 speakers.

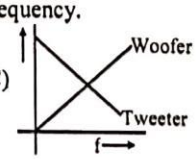


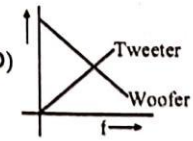
Tweeter-which has smaller diameter produces high frequency sounds. Woofer-which has larger diameter produces low frequency sound. For purpose of circuit analysis, we can take both speakers to be of equal resistance R. The equivalent circuit is shown in the figure. The 2 speakers are connected to the amplifier via capacitance and inductance respectively. The capacitor in tweeter branch blocks the low frequency sound but passes the high frequency. The inductor in woofer branch does the opposite.

Q.31 Which plot correctly represents rms current against frequency.

(A) 

(B) 

(C) 

(D) 

Q.32 What is the frequency which is sounded equally loudly by both speakers

(A) $\frac{1}{2\pi}\sqrt{\frac{R^2}{L^2}-\frac{1}{LC}}$ (B) $\frac{1}{2\pi}\sqrt{\frac{4R^2}{L^2}-\frac{1}{LC}}$ (C) $\frac{1}{2\pi}\sqrt{\frac{1}{LC}-\frac{R^2}{4L^2}}$ (D) $\frac{1}{2\pi\sqrt{LC}}$

Q.33 For a combination of L, R & C the current in woofer & tweeter are always found to have a phase difference of πl 2. What is the relation between L, R & C.

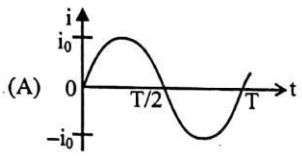
(A) $L = 2R^2C$ (B) $L = \sqrt{2}R^2C$ (C) $L = R^2C$ (D) $L = \frac{R^2C}{\sqrt{2}}$

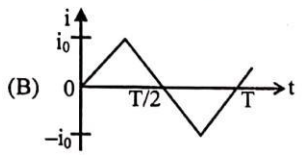
Column Matching Type Questions

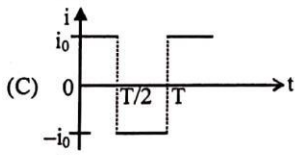
Q.34 Match the column :

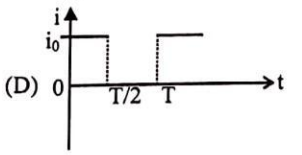
In column I, variation of current I with t is given in figures. In column II root mean square current i_{rms}, and average current. Match the column I with corresponding quantities given in Column II

Column -I

(A) 

(B) 

(C) 

(D) 

Column-II

(P) $i_{rms} = \frac{i_0}{\sqrt{3}}$

(Q) Average current for positive half cycle is i_0

(R) Average current for position half cycle is $\frac{i_0}{2}$

(S) Full cycle average current is zero

(T) Frequency of current is 1/T

Q.35 Match the Following :

Column-I	Column-II
(A) LCR circuits	(P) Resonant curve will be flattened
(B) Inductor	(Q) Sharpness indicates sensitivity
(C) More of friction or dampness	(R) Have resonant frequency $\omega = \frac{1}{\sqrt{LC}}$ with $A \to A_{max}$
(D) Radio Tuner's characteristic curve	(S) Mass

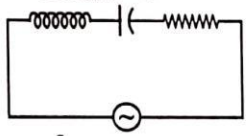
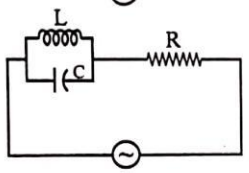
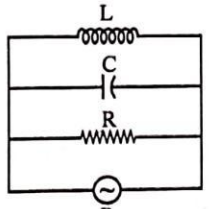
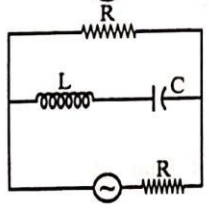
Q.36 Match the Following :

Column-I	Column-II
(A) For square wave having peak value v_0	(P) $v_0 > v_{rms} > v_{av}$
(B) For sinusoidal wave having peak value v_0	(Q) In a pure inductance.
(C) Current leads the voltage by $\pi/2$	(R) $v_{av} = v_{rms} = v_0$
(D) Wattless current	(S) In a pure capacitance

Q.37 Match the following :

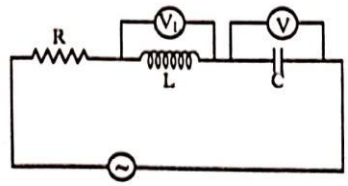
Column-I	Column-II
(A) In L–R series circuit if switch is closed at t = 0 (u sin of DC source)	(P) Current at t = 0 is non–zero
(B) In L–C series combination switch is closed at t = 0 (if initially the capacitor is fully charged)	(Q) Nothing can be said about the current
(C) If voltage $V=V_0$ sin ωt is applied to pure inductor at t = 0	(R) Current in the circuit is zero at t = 0
(D) If voltage $V = V_0$ sin ωt is applied at t = 0 to L–C–R series circuit	(S) Magnetic field energy in inductor is zero at t = 0

Q.38 Let X_L, X_C be the inductive reactance and capacitive reactance and R be the resistance in each of the circuits given in Column-I. Let V_L, V_C and V_R be the r.m.s. voltage drop in each case and i be the r.m.s. current from mains. The supply voltage is 10 V. $X_L = 10\ \Omega$ and $R = 10\ \Omega$.

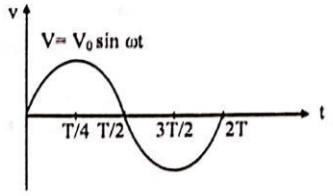
Column – I		Column – II	
(A)		(P)	i = 1 A
(B)		(Q)	i = 0
(C)		(R)	$V_L = 10$ V
(D)		(S)	$V_C = 10$ V

Numeric Response Type Questions

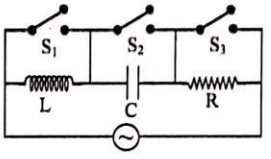
Q.39 In the circuit shown, Resistance R = 100 Ω, inductance $L = \frac{2}{\pi}$ H and capacitance $C = \frac{8}{\pi}$ μF are connected in series with an AC source of 200V and unknown frequency if the reading of each hot wire voltmeters are $\frac{2}{n} \times 10^3$ Volt then find value of n.



Q.40 In an L-R series circuit, a sinusoidal voltage $V = V_0 \sin \omega t$ is applied. It is given that $L = 35$ mH, $R = 11\Omega$, $V_{rms} = 220$ V, $\omega/2\pi = 50$ Hz and $\pi = 22/7$. The amplitude of current in the steady state is 5n A. Find n.

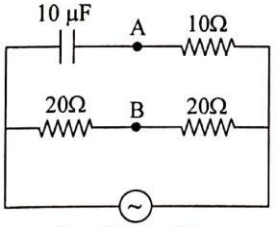


Q.41 Consider the circuit shown in figure. With switch S_1 closed and the other two switches open, the circuit has time constant 0.05 sec. With the switch S_2 closed and the other two switches open, the circuit has time constant 2 sec. With switch S_3 closed and the other two switches open, the circuit oscillates with a period T. Find T (in sec). (Take $\pi^2 = 10$)



Q.42 In a series LCR circuit with a source $E_0 = 50$ V, $R = 300\ \Omega$, frequency $\nu = \frac{50}{\pi}$ Hz. The average electric field energy stored in the capacitor and average magnetic field energy stored in the coil are 25 mJ and 5 mJ respectively. RMS current in the circuit is 0.10 A. If the sum of rms potential differences across the three elements in volts is $(10 \times n)$. Then find value of n .

Q.43 In the given circuit the maximum potential difference between the points A and B is V_1 volt. If the $10\ \Omega$ resistance is replaced by $40\ \Omega$ resistance, the maximum potential difference between points A and B is V_2 volt. Find V_2/V_1.



ANSWER KEY

Single Correct Option type Questions

1. (C)	**2.** (C)	**3.** (D)	**4.** (C)	**5.** (C)	**6.** (A)	**7.** (C)
8. (D)	**9.** (A)	**10.** (D)	**11.** (C)	**12.** (A)	**13.** (C)	**14.** (B)

Statement Based Questions

15. (C) **16.** (A)

Multiple Correct Option type Questions

17. (B,D) **18.** (A,C,D) **19.** (B,D) **20.** (B,C,D)

Passage Based Questions

21. (D)	**22.** (C)	**23.** (A)	**24.** (B)	**25.** (D)	**26.** (B)	**27.** (A)
28. (C)	**29.** (D)	**30.** (C)	**31.** (B)	**32.** (D)	**33.** (C)	

Column Matching Type Questions

34. A → S,T ; B → P,R,S,T ; C → Q,S,T ; D → Q,T

35. A → Q,R ; B → S ; C → P ; (D) → Q

36. A → R ; B → P ; C → S ; D → Q,S

37. A → R ; B → P ; C → S ; D → Q

38. A → P,R,S ; B → Q,R,S ; C → P,R,S ; D → P,R,S

Numeric Response Type Questions

39. 2 **40.** 4 **41.** 2 **42.** 9 **43.** 1