Sample Paper 6

ANSWER KEYS																			
1	(b)	**7**	(c)	**13**	(b)	**19**	(b)	**25**	(a)	**31**	(b)	**37**	(b)	**43**	(b)	**49**	(c)	**55**	(a)
2	(d)	**8**	(d)	**14**	(a)	**20**	(c)	**26**	(b)	**32**	(d)	**38**	(b)	**44**	(a)	**50**	(c)		
3	(b)	**9**	(c)	**15**	(a)	**21**	(a)	**27**	(d)	**33**	(c)	**39**	(d)	**45**	(a)	**51**	(a)		
4	(b)	**10**	(a)	**16**	(d)	**22**	(a)	**28**	(a)	**34**	(d)	**40**	(b)	**46**	(c)	**52**	(b)		
5	(a)	**11**	(d)	**17**	(b)	**23**	(a)	**29**	(c)	**35**	(d)	**41**	(c)	**47**	(a)	**53**	(c)		
6	(c)	**12**	(c)	**18**	(c)	**24**	(c)	**30**	(c)	**36**	(a)	**42**	(a)	**48**	(d)	**54**	(c)		

SOLUTIONS

1. (d) Capacity of parallel plate capacitor

$$C = \frac{\varepsilon_r \varepsilon_0 A}{d} \qquad (\text{For air } \varepsilon_r = i)$$

So, $\frac{\varepsilon_0 A}{d} = 8 \times 10^{-12}$

If $d \to \frac{d}{2}$ and $\varepsilon_r \to 6$ then new capacitance

$$C' = 6 \times \frac{\varepsilon_0 A}{d/2} = 12 \frac{\varepsilon_0 A}{d} = 12 \times 8 \text{ pF} = 96 \text{ pF}$$

2. (d) 3. (d)

4. (b) $C_1 < C_2$

$$\therefore \frac{C_1}{C_1 + C_2} < \frac{1}{2} \text{ and } \frac{C_2}{C_1 + C_2} > \frac{1}{2}$$

$$C = \frac{C_1 C_2}{C_1 + C_2} = C_1 \cdot \frac{C_2}{C_1 + C_2} > \frac{C_1}{2}$$

Similarly, $C < \frac{C_2}{2}$

5. (c) In vacuum, $F = \frac{1}{4\pi\varepsilon_0} \frac{q^2}{r^2}$ …(i)

Suppose, force between the chrages is same when charges are r' distance apart in dielectric.

$$\therefore \quad F' = \frac{1}{4\pi\varepsilon_0} \frac{q^2}{kr'^2} \qquad \text{…(ii)}$$

From (i) and (ii), $kr'^2 = r^2$ or, $r = \sqrt{k}r'$

In the given situation, force between the charges would be

$$F' = \frac{1}{4\pi\varepsilon_0} \frac{q^2}{\left(\frac{r}{2} + \sqrt{4}\frac{r}{2}\right)^2} = \frac{4}{9} \frac{q^2}{4\pi\varepsilon_0 r^2} = \frac{4F}{9}$$

6. (b)

7. (c) The potential energy is negative whenever there is attraction. Since a positive and negative charge attract each other therefore their energy is negative. When both the charges are separated by infinite distance, they do not attract each other and their energy is zero.

8. (a) The conduction electrons collides with each other more. the specific resistance of a conductor increases with temperature according to the reaction $\rho_T = \rho_0^{eEg/kgT}$ where ρ_0 is the specific resistance at 0° C, E_g = energy of the gap between the valence and the conduction band, k_B is the Boltzmann constant and T, the temperature of the resistor.

9. (b) When the temperature increases, resistance increases. As the e.m.f. applied is the same, the current density decreases the drift velocity decreases. But the rms velocity of the electron due to thermal motion is proportional to $\sqrt{T}$. Therefore, the Thermal velocity increases.

10. (c) $I = \frac{dQ}{dt} = 10t + 3$

At t = 5s, I = 10 × 5 + 3 = 53 A

11. (b) Resistance of a wire is given by $R = \rho \frac{l}{a}$

If the length is increased by 10% then new

length $l' = l + \frac{1}{10} = \frac{11}{10} l$

In that case, area of cross-section of wire would decrease by 10%

$\therefore$ New area of cross-section

$$A' = A - \frac{A}{10} = \frac{9}{10}A$$

$$\therefore\ R' = \rho\frac{\ell'}{A'} = \rho\frac{\frac{1}{10}l}{\frac{9}{10}A}$$

$$R' = \frac{11}{9}\rho\frac{l}{R} \quad R' = 1.21R$$

Thus the new resistance increases by 1.21 times. The specific resistance (resistivity) remains unchanged as it depends on the nature of the material of the wire.

12. **(d)** Kirchhoff's first law is based on conservation of charge and Kirchhoff's second law is based on conservation of energy.

13. **(b)** The charged particle will move along the lines of electric field (and magnetic field). Magnetic field will exert no force. The force by electric field will be along the lines of uniform electric field. Hence the particle will move in a straight line.

14. **(b)** The magnetic field from the centre of wire of radius R is given by

$$B = \left(\frac{\mu_0 I}{2R^2}\right)r \quad (r < R) \Rightarrow B \propto r$$

and $B = \dfrac{\mu_0 I}{2\pi r}$ $(r > R) \Rightarrow B \propto \dfrac{1}{r}$

From the above descriptions, we can say that the graph (b) is a correct representation.

15. **(b)** $\theta = \dfrac{NiAB}{C} \Rightarrow \theta \propto N$ [Number of turns]

16. **(d)** $\dfrac{P}{Q} = \dfrac{l}{(100-l)}$ or $P = \dfrac{l}{100-l} \times Q = \dfrac{20}{80} \times 1 = 0.25\Omega.$

17. **(d)**

18. **(a)**

19. **(c)** $B = \dfrac{H}{\cos\theta} = \dfrac{0.50}{\cos 30^\circ} = \dfrac{0.50 \times 2}{\sqrt{3}} = 1/\sqrt{3}$

20. **(c)**

21. **(b)**

22. **(b)** Self inductance $= \mu_0 n^2 AL = \mu_0 n^2 (\ell \times b) \times L$

So, when all linear dimensions are increased by a factor of 2. The new self inductance becomes $L' = 8L$.

23. **(b)** $\dfrac{I_0}{\sqrt{2}}$ = RMS current

24. **(c)** When resistance is connected to A.C source, then current & voltage are in same phase.

25. **(a)**

26. **(d)** Torque, $\vec{\tau} = \vec{p} \times \vec{E} = pE\sin\theta$

$4 = p \times 2 \times 10^5 \times \sin 30^\circ$

or, $p = \dfrac{4}{2 \times 10^5 \times \sin 30^\circ} = 4 \times 10^{-5}$ Cm

Dipole moment, $p = q \times l$

$$q = \frac{p}{l} = \frac{4 \times 10^{-5}}{0.02} = 2 \times 10^{-3}\,C = 2mC$$

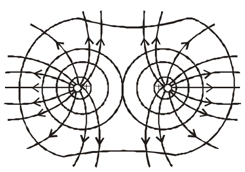
27. **(c)** Charges (q) = 2×10^{-6} C, Distance (d) = 3 cm $= 3 \times 10^{-2}$ m and electric field (E) = 2×10^5 N/C. Torque (τ) = q.d.

$E = (2 \times 10^{-6}) \times (3 \times 10^{-2}) \times (2 \times 10^5) = 12 \times 10^{-3}$ N–m.

28. **(c)** By Gauss's theorem, $\phi = \dfrac{Q_{in}}{\epsilon_0}$

Thus, the net flux depends only on the charge enclosed by the surface. Hence, there will be no effect on the net flux if the radius of the surface is doubled.

29. **(c)** Equipotential surfaces are normal to the electric field lines.



The following figure shows the equipotential surfaces along with electric field lines for a system of two positive charges.

30. **(c)** ABCDE is an equipotential surface, on equipotential surface no work is done in shifting a charge from one place to another.

31. **(d)** For resonant frequency to remain same

$\sqrt{LC}$ = constant

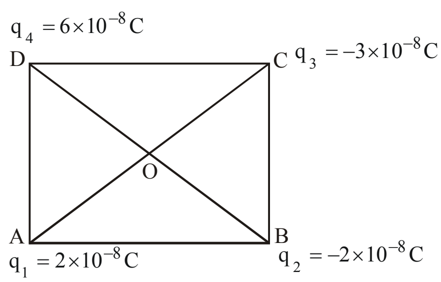
LC = constant

As, $C \rightarrow 4C$

$\therefore\ L \rightarrow \dfrac{L}{4}$

32. **(a)**

33. **(a)** $AC = BD = \sqrt{(\sqrt{2})^2 + (\sqrt{2})^2} = 2$ m



$$\therefore DO = OB = AO = OC = \frac{2}{2} = 1m$$

$\therefore$ Potential at the centre O, $V = k\frac{q}{r}$

$$V = k\left[\frac{2\times10^{-8}}{1} + \frac{-2\times10^{-8}}{1} + \frac{-3\times10^{-8}}{1} + \frac{6\times10^{-8}}{1}\right]$$

$$V = k\times3\times10^{-8} = 9\times10^{9}\times3\times10^{-8} \text{ volt}$$

$$= 27\times10 = 270 \text{ V}$$

34. **(d)** Since due to wrong connection of each cell the total emf reduced to 2ε then for wrong connection of three cells the total emf will reduced to $(n\varepsilon - 6\varepsilon)$ whereas the total or equivalent resistance of cell combination will be *nr*.

35. **(b)** If we apply Kirchhoff's loop rule to the loop BCDEB in clockwise direction the changes in potential across R_3 and R_4 are negative. Therefore $i_3 R_3$ and $i_3 R_4$ should have negative sign. But for this clockwise direction we are moving in a direction opposite to i_2 across R_2. Current flows from higher potential to lower potential but we are moving from lower potential to higher potential *i.e.*, potential is increasing. So the change in potential is positive. Therefore $i_2 R_2$ has positive sign.

36. **(d)**

37. **(a)** As voltage of appliance remains constant, the amount of heat produced is given by,

$$H = \frac{V^2}{R}t \qquad \dots(i)$$

when resistance is reduced by 20%, new resistance is R′ = R – 0.2 R = 0.8 R

$$H' = \frac{V^2}{0.8R}t' \qquad \dots(ii)$$

Equating Eqs. (i) and (ii), we get

$$\frac{V^2}{R}t = \frac{V^2}{0.8R}t'$$

$$\Rightarrow \quad t' = 0.8t = 0.8\times12 = 9.6 \text{ min}$$

38. **(b)** $I_g = 0.1I,\ I_s = 0.9I;\ S = I_g\ R_g / I_s$

$$= 0.1\times900/0.9 = 100\,\Omega.$$

39. **(c)** Magnetic dipole moment

$$m = iA = \frac{e}{T}\times\pi r^2 = \frac{e}{(2\pi r/v)}\times\pi r^2 = \frac{erv}{2}.$$

$$= \frac{1.6\times10^{-19}\times50\times10^{-12}\times2.2\times10^{6}}{2}$$

$$= 8.8\times10^{-25}\ \text{Am}^2.$$

40. **(a)**

41. **(a)** $E = \frac{d}{dt}(NMI) \Rightarrow E = NM\frac{dI}{dt} \Rightarrow E = \frac{NMI}{t}$

emf induced per unit turn $= \frac{E}{N} = \frac{MI}{t}$

42. **(d)** In LCR series circuit, resonance frequency f_0 is given by

$$L\omega = \frac{1}{C\omega} \Rightarrow \omega^2 = \frac{1}{LC} \qquad \therefore\ \omega = \sqrt{\frac{1}{LC}} = 2\pi f_0$$

$$\therefore\ f_0 = \frac{1}{2\pi\sqrt{LC}} \qquad \text{or} \qquad f_0 \alpha \frac{1}{\sqrt{C}}$$

When the capacitance of the circuit is made 4 times, its resonant frequency become f_0'

$$\therefore\ \frac{f_0'}{f_0} = \frac{\sqrt{C}}{\sqrt{4C}} \qquad \text{or} \qquad f_0' = \frac{f_0}{2}$$

43. **(b)** Given $\frac{\ell_1}{\ell_2} = \frac{1}{2}$ and $\frac{N_1}{N_2} = \frac{1}{2}$ From

$$L = \frac{\mu_0 N^2 A}{\ell} \alpha \frac{N^2}{\ell}$$

we get, $\frac{L_1}{L_2} = \left(\frac{N_1}{N_2}\right)^2 \Big/ \left(\frac{\ell_1}{\ell_2}\right) = \frac{(1/2)^2}{1/2} = \frac{1}{2}$

44. **(a)**

45. **(d)** The magnetic field at any point on the closed loop is due to all the three currents, but line integral of i_3 over the closed loop will be zero.

46. **(d)** Two equipotential surfaces are not necessarily parallel to each other.

47. **(a)** Because of high permeability of the iron, the entire magnetic field will pass through iron, and so rest space becomes free from magnetic field.

48. **(a)** Reversing the direction of the current reverses the direction of the magnetic field. However, it has no effect on the magnetic-field energy density, which is proportional to the square of the magnitude of the magnetic field.

49. **(a)** The magnetic field of two equal halfs of the loop is equal and opposite and so $\vec{B} = 0$.

50. **(c)** Flux going in pyramid $= \frac{Q}{2\varepsilon_0}$.

which is divided equally among all 4 faces.

$\therefore$ Flux through one face $= \frac{Q}{8\varepsilon_0}$

51. **(b)** In a uniform electric field $\vec{E}$, dipole experiences a torque $\vec{\tau}$ given by $\vec{\tau} = \vec{p} \times \vec{E}$ but experiences no force. The potential energy of the dipole in a uniform electric field $\vec{E}$ is $U = -\vec{p}.\vec{E}$

52. **(a)** Step up transformer

$$\frac{N_s}{N_p} = \frac{V_s}{V_p} \Rightarrow \frac{10}{1} = \frac{V_s}{4000}$$

$\therefore$ $V_s = 40{,}000$ V

Step down transformer

$$\frac{N_p}{N_s} = \frac{V_p}{V_s} = \frac{40{,}000}{200} = \frac{200}{1}$$

53. **(b)** Power P = V × I

$$\Rightarrow \quad I = \frac{P}{V} = \frac{600 \times 1000}{4000} = 150 \text{ A}$$

Total resistance = 0.4 × 20 = 8 Ω

$\therefore$ Power dissipated as heat = $I^2R = (150)^2 \times 8$

$= 180{,}000\text{W} = 180 \text{ kW}$

$$\therefore \quad \% \text{ loss} = \frac{180}{600} \times 100 = 30\%$$

54. **(b)** Transformers are used in AC circuits only.

55. **(c)** A transformer is employed to obtain a suitable AC voltage.