CBSE
Class XII Physics
Board Paper – (Term 1 – 2021)

Time: 90 minutes **Maximum Marks: 35**

General Instructions:

(i) *This questions paper contains **55** questions out of which **45** questions are to be attempted. All questions carry equal marks.*
(ii) *The Question Paper consists of **three** sections, Section A, Section B and Section C.*
(iii) *Section A consists of **25** questions. Attempt any **20** questions from questions No. **1** to **25**.*
(iv) *Section B contains **24** questions. Attempt any **20** questions from questions No. **26** to **49**.*
(v) *Section C consists of **6** questions. Attempt any **5** questions from questions No. **50** to **55**.*
(vi) *The first **20** question attempted in section A and Section B and first 5 questions attempted in Section C by a candidate will be evaluated.*
(vii) *There is only **one** correct option for every multiple choice question (MCQ). Marks will not be awarded for answering more than one option.*
(viii) *There is **no** negative marking*

SECTION – A

This section consists of 25 multiple choice questions with over tilt choice to attempt any 20 questions. In case more than desirable number of questions are attempted, only first 20 questions will be considered for evaluation.

Q 1. An electric dipole placed in a non-uniform electric field will experience:
(A) Only a force
(B) Only a torque
(C) both force and torque
(D) Neither force nor torque

Q 2. Let NI be the number of electric field lines going out of an imaginary cube of side that encloses an isolated point charge 2q and N_2 be the corresponding number for an imaginary sphere of radius that encloses an isolated point charge 3q. Then (N_1/N_2) is:

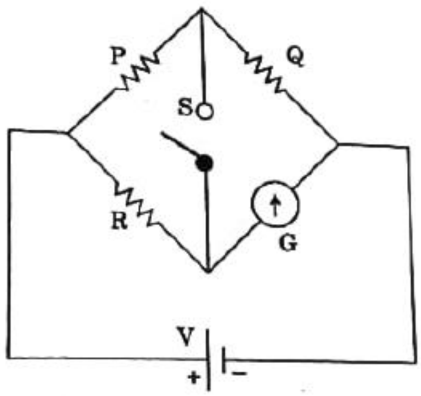
(A) $\frac{1}{x}$

(B) $\frac{2}{3}$

(C) $\frac{9}{4}$

(D) π

Q 3. In the circuit given below P ≠ R and the reading of the galvanometer is same with Switch S open or closed. Then:



(A) $I_Q = I_R$
(B) $I_R = I_G$
(C) $I_P = I_G$
(D) $I_Q = I_G$

Q 4. Two wires A and B, of the same material having length in the ratio 1: 2 and diameter in the ratio 2: 3 are connected in series with a battery. The ratio of the potential differences (V_A/ V_B) across the two wires respectively is:

(A) $\frac{1}{3}$

(B) $\frac{3}{4}$

(C) $\frac{4}{5}$

(D) $\frac{9}{8}$

Q 5. Two moving coil galvanometers G_1 and G_2 have the following particulars respectively:

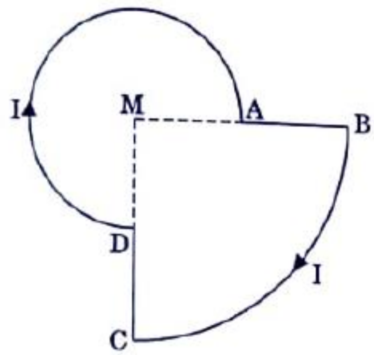
$N_1=30$, $A_1 = 3.6 \times 10^{-3}$ m^2, $B_1= 0.25$ T

$N_2= 42$, $A_2 = 1.8 \times 10^{-3}$, m^2, $B_2 = 0.50$ T

The spring constant is same for both the galvanometers. The ratio of current sensitivities of G_1 and G_2 is

(A) 5 : 7
(B) 7 : 5
(C) 1:4
(D) 1 : 1

Q 6. A current I is flowing through the loop as shown in the figure (MA = R, MB = 2R). The magnetic field at the centre of the loop is $\frac{\mu_o I}{R}$ times:



(A) $\frac{5}{16}$, into the plane of the paper

(B) $\frac{5}{16}$, out of the plane of the paper

(C) $\frac{7}{16}$, out of the plane of the paper

(D) $\frac{7}{16}$, into the plane of the paper

Q 7. A capacitor and an inductor are connected in two different ac circuits with a glowing in each circuit. The bulb glows more brightly when:
(A) the number of turns in the inductor is increased
(B) the separation between the plates of the capacitor is increased
(C) an iron rod is introduced into the inductor
(D) a dielectric is introduced into the gap between the plates of the capacitor

Q 8. A pure inductor of 318 mH and a pure resistor of 75 Ω are connected in series to an ac source Of 50 Hz. The voltage across 75 Ω resistor is found to be 150 V. The source voltage is:
(A) 150 V
(B) 175 V
(C) 220 V
(D) 250 V

Q 9. The electric potential at a point on the axis of a short electric dipole, at a distance x from the mid -point of dipole is proportional to:

(A) $\frac{1}{x^4}$

(B) $\frac{1}{x^{3/2}}$

(C) $\frac{1}{\ }$

(D) $\frac{1}{x^2}$

Q 10. Let F_1 be the magnitude of the force between two small spheres, charged to a constant potential in free space and F_2 be the magnitude of the force between them in a medium of dielectric constant k. Then (F_1 / F_2) is:

(A) $\frac{1}{k}$
(B) k
(C) k^2
(D) $\frac{1}{k^2}$

Q 11. infinity resistance in a resistance box has:

(A) a resistance of 10^5 Ω
(B) a resistance of 10^7 Ω
(C) a resistance of ∞ resistance
(D) a gap only

Q 12. A battery of 15 V and negligible internal resistance is connected across a 50 Ω resistor. The amount of energy dissipated as heat in the resistor in one minute is:

(A) 122 J
(B) 270 J
(C) 420 J
(D) 720 J

Q 13. Lenz's law is the consequence of the law of conservation of:

(A) energy
(B) charge
(C) mass
(D) momentum

Q 14. The vertical component of earth's magnetic field at a place is $\left(\frac{1}{\sqrt{3}}\right)$, times the horizontal J3 component. The angle of dip at that place is:

(A) 0°
(B) 30°
(C) 45°
(D) 60°

Q 15. A long straight wire in the horizontal plane carries a current of 15 A in north to south direction. The magnitude and direction of magnetic field at a point 2.5 m east of the wire respectively are:

(B) 1.2 μT, vertically downward
(C) 0.6 μT, vertically upward
(D) 0.6 μT, vertically downward

Q 16. The emf induced in a 10 H inductor in which current changes from 11 A to 2 A in 9×10^{-1} s is:
(A) 10^4 V
(B) 10^3 V
(C) 10^2 v
(D) 10 v

Q 17. A charge Q is placed at the centre of the line joining two charges q and q. The system of the three charges will be in equilibrium if Q is:
(A) $+\frac{q}{3}$
(B) $-\frac{q}{3}$
(C) $+\frac{q}{4}$
(D) $-\frac{q}{4}$

Q 18. Electric flux of an electric field $\vec{E}$ g through an area d $\vec{A}$ is given by:
(A) $\vec{E} \times d\vec{A}$
(B) $\frac{\vec{E} \times d\vec{A}}{\varepsilon_0}$
(C) $\vec{E} \, . \, d\vec{A}$
(D) $\frac{\vec{E} \, . \, d\vec{A}}{\varepsilon_0}$

Q 19. In a potentiometer experiment, the balancing length with a cell is 120 cm. When the cell is shunted by a 1 Ω resistance, the balancing length becomes 40 cm. The internal resistance of the cell is:
(A) 10 Ω
(B) 7 Ω
(C) 3 Ω
(D) 2 Ω

Q 20. An electron is projected with velocity $\vec{v}$ along the axis of a current carrying long solenoid. Which one of the following statements is true?
(A) The path of the electron will be circular about the axis.
(B) The electron will be accelerated along the axis.
(C) The path of the electron will be helical.

(D) The electron will continue to move with the same velocity $\vec{v}$ along the axis of the solenoid.

Q 21. If the speed v of a charged particle moving in a magnetic field $\vec{B}$ ($\vec{v}$ is perpendicular to $\vec{B}$) is halved, then the radius of its path will:
(A) not change
(B) become two times
(C) become one- fourth
(D) become half

Q 22. A metal plate is getting heated. Which one of following statements is **incorrect**?
(A) It is placed in a space varying magnetic field that does not vary with time.
(B) A direct current is passing through the plate.
(C) An alternating current is passing through the plate.
(D) It is placed in a time varying magnetic field.

Q 23. In an ac circuit the applied voltage and resultant current are $E = E_0 \sin \omega t$ and $I = I_0 \sin (\omega t + \frac{\pi}{2})$ respectively. The average power consumed in the circuit is:
(A) $E_0 I_0$
(B) $\frac{E_0 I_0}{2}$
(C) $\frac{E_0 I_0}{\sqrt{2}}$
(D) Zero

Q 24. The speed acquired by a free electron when accelerated from rest through a potential difference of 100 V is :
(A) 6×10^6 ms^{-1}
(B) 3×10^6 ms^{-1}
(C) 4×10^5 ms^{-1}
(D) 2×10^3 ms^{-1}

Q 25. Which one of the following is **not** affected by the presence of a magnetic field?
(A) A current carrying conductor
(B) A moving charge
(C) A stationary charge
(D) A rectangular current loop with its parallel to the felid

SECTION B

This section consists of **24** multiple choice questions with over all choice to attempt any **20** questions. In case more than desirable number of questions are attempted, only first **20** questions will be considered for evaluation.

Q 26. Two point charges + 16q and – 4q are located at x = 0 and x = L. The location of the point on x-axis at which the resultant electric field due to these charges is zero, is:

(A) 8 L
(B) 6 L
(C) 4 L
(D) 2 L

Q 27. An electric dipole of dipole moment 4×10^{-5} C-m, kept in a uniform electric field of 10^{-3} NC^{-1}, experience a torque of 2×10^{-8} Nm. The angle which the dipole makes with the electric field is :

(A) 30°
(B) 45°
(C) 60°
(D) 90°

Q 28. Three identical charges are placed on x-axis from left to right with adjacent charges separated by a distance d. The magnitude of the force on a charge from its nearest neighbour charge is F. Le $\hat{1}$ be the unit vector along + x axis, then the net force on each charge from left to right is :

(A) $(2\,E\hat{1}, -2\,F\hat{1}, 2\,F\hat{1})$

(B) $(F\hat{1}, 0, F\hat{1})$

(C) $(-\frac{5}{4}F\hat{1}, 0, +\frac{5}{4}F\hat{1})$

(D) $(2\,F\hat{1}, 0, 2\,F\hat{1})$

Q 29. Two students A and B calculate the charge flowing through a circuit. A concludes that 300 C of charges flows in 1 minute. B concludes that 3.125×10^{19} electrons flow in 1 second. IF the current measured in the circuit is 5A, then the correct calculation is done by :

(A) A
(B) B
(C) both A and B
(D) neither A nor B

Q 30. The resistance of two wires having same length and same area of cross-section are 2Ω and 8Ω respectively. If the resistivity of 2Ω wire is 2.65×10^{-8} Ω–m then the resistivity of 8Ω wire is :

(A) 10.60×10^{-8} Ω-m

(B) 8.32×10^{-8} Ω-m

(C) 7.61×10^{-8} Ωm

(D) 5.45×10^{-8}Ωm

Q 31. In a certain region field $\vec{E}$ and magnetic field $\vec{B}$ are perpendicular to each other. An electron enters the region perpendicular to the direction of both $\vec{E}$ and $\vec{B}$ moves undeflected. The speed of the electron is :

(A) $\vec{E}.\vec{B}$

(B) $|\vec{E} \times \vec{B}|$

(C) $\frac{|\vec{E}|}{|\vec{B}|}$

(D) $\frac{|\vec{B}|}{|\vec{E}|}$

Q 32. A test charge of 1.6×10^{-19} C is moving with a velocity $\hat{v} = (4\hat{i} + 3\hat{k}\text{ N})\text{ m s}^{-1}$ in a magnetic field $\hat{B} = (3\hat{k} + 4\hat{i})$ T. The force on this test charge is :

(A) $24\hat{j}$ N

(B) $-24\hat{i}$ N

(C) $24\hat{k}$ N

(D) 0

Q 33. In a series LCR circuit, at resonance the current is equal to :

(A) $\frac{V}{R}$

(B) $\frac{V}{X_c}$

(C) $\frac{V}{X_L - X_C}$

(D) $\frac{V}{\sqrt{R^2 + (X_L - X_C)^2}}$

Q 34. The frequency of an ac source for which a 10 μF capacitor has a reactance of 1000Ω is :

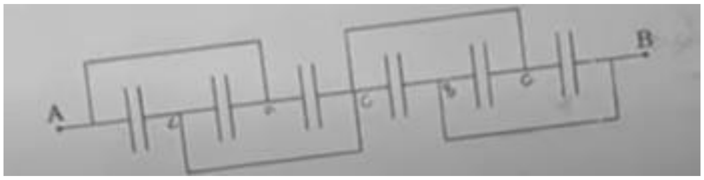
(A) $\frac{1000}{\pi}$ Hz

(B) 50 Hz

(C) $\frac{50}{\pi}$ Hz

(D) $\frac{100}{\pi}$ Hz

Q 35. In the given network all capacitors used are identical and each one is of capacitance C. Which of the following is the equivalent capacitance between the points A and B?



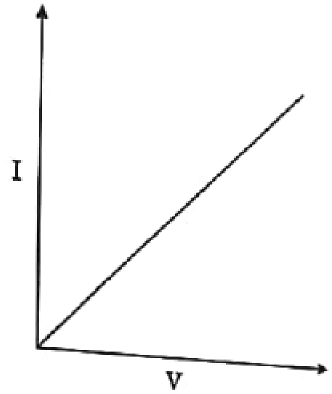
(A) 6C

(B) $\frac{5}{2}$C

(C) $\frac{3}{2}$C

(D) $\frac{5}{6}$C

Q 36. The given figure shows I – V graph of a copper wire whose length and area of cross-section are L and A respectively. The slope of this curve becomes :



(A) less if the length of the wire is increased
(B) more if the length of the wire is increased
(C) more if a wire of steel of same dimension is used
(D) more if the temperature of wire is increased

Q 37. When a potential difference V is applied across a conductor at temperature T, the drift velocity of the electrons is proportional to :

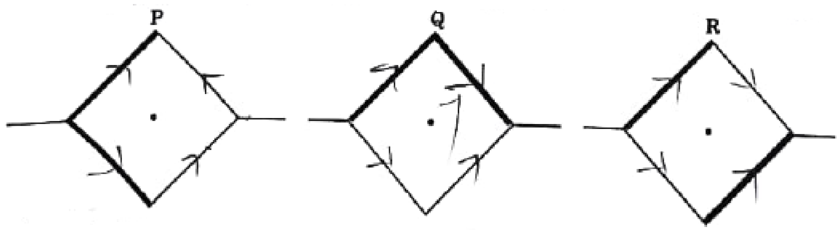
(A) T

(B) $\sqrt{T}$

(C) V

(D) $\sqrt{V}$

Q 38. Two identical thick wires and two identical thin wires, all of the same material and the same length form a square in three different ways P, Q and R as shown. Due to the current in these loops the magnetic field at the centre of the loop will be zero in case of :



(A) P and R only

(B) Q and R only

(C) P and Q only

(D) P, Q and R

Q 39. A circular current carrying coil produces a magnetic field B_0 at its centre. The coil is rewound so as to have three turns and the same current is passed through it. The new magnetic field at the centre is:

(A) $3\ B_0$

(B) $\frac{B_0}{3}$

(C) $\frac{B_0}{9}$

(D) $9\ B_0$

Q 40. Which one of the following statements is true?

(A) An inductor has infinite resistance in a dc circuit.

(B) A inductor and a capacitor both cannot conduct in a dc circuit.

(C) A capacitor can conduct in a dc circuit but not an inductor.

(D) An inductor can conduct in a dc circuit but not a capacitor.

Q 41. The magnetic flux linked with a coil is given by $\phi = 5t^2 + 3t + 16$, where is ϕ in webers and t in seconds. The induced emf in the coil at t = 5 s will be:

(A) 53 V

(B) 43 V

(C) 10V

(D) 6V

Q 42. If a charge is moved against a coulomb force of an electric field, then the:
(A) intensity of the electric field increases
(B) intensity of the electric field decreases
(C) work is done by the electric field
(D) work is done by the external source

Q 43. A charge Q is located at the centre of a circle of radius r. The work done in moving a test charge q_0 from point A to point B (at opposite ends of diameter AB) so as to complete a semicircle is $\left[k = \frac{1}{4\pi\varepsilon_0}\right]$:
(A) $k\frac{q_0 Q}{r}$
(B) $k\frac{Q q_0}{r^2}$
(C) $k q_0 Q r$
(D) Zero

Q 44. A long solenoid carrying current produces a magnetic field B along its axis. If the number of turns in the solenoid is halved and current in it is doubled, the new magnetic field will be:
(A) $\frac{B}{2}$
(B) B
(C) 2B
(D) 4B

Question Nos. ***45*** *to* ***49*** *are Assertion (A) and statements Reason (R) type questions. Given below are two statements labelled as Assertion (A) and Reason (R). Select the most appropriate answer from the options given below.*
(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).
(C) Assertion (A) is true, but Reason (R) is false.
(D) Assertion (A) is false, but Reason (R) is true.

Q 45. **Assertion (A):** A bar magnet experiences a torque when placed in a magnetic field.
Reason (R): A bar magnet exerts a torque on itself due to its own magnetic field.

Q 46. **Assertion (A):** In a series LCR circuit connected to an ac source, resonance can take place.
Reason (R): At resonance $X_L = X_C$

Q 47. Assertion (A): When a charged particle moves with velocity $\vec{v}$ in a magnetic field $\vec{B}$ $(\vec{v} \perp \vec{B})$, the force on the particle does no work.

Reason (R): The magnetic force is perpendicular to the velocity of the particle.

Q 48. Assertion (A): Induced emf in two coils made of wire of the same length and the same thickness, one of copper and another of aluminium is same. The current in copper coil is more than the aluminium coil.
Reason (R): Resistance of aluminium coil is more than that of copper coil.

Q 49. Assertion (A): A transformer is used to increase or decrease ac voltage only.
Reason (R): A transformer works on the basis of mutual induction.

SECTION C

*This section consists of **6** multiple choice questions with an overall choice to attempt any **5** questions. In case more than the desirable number of questions are attempted, only the first **5** questions will be considered for evaluation.*

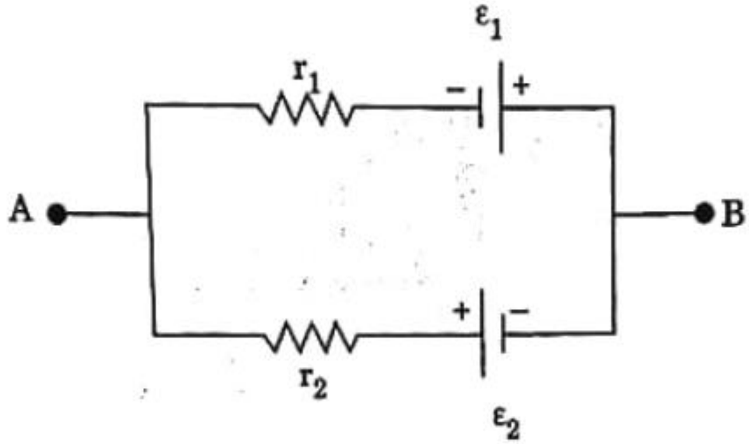
Q 50. Two charged spheres A and B having their radii in the ratio 1: 2 are connected together with a conducting wire. The ratio of their surface charge densities $\left(\frac{\sigma_A}{\sigma_B}\right)$ will be.

(A) $\frac{1}{2}$
(B) 2
(C) $\frac{1}{4}$
(D) 4

Q 51. A current carrying square loop is suspended in a uniform magnetic field acting in the plane of the loop. If the force on one arm of the loop is $\vec{F}$, the net force on the remaining three arms of the loop will be.
(A) $3\vec{F}$
(B) $-3\vec{F}$
(C) $\vec{F}$
(D) $-\vec{F}$

Case – Study

A battery is a combination of two or more cells. In the following figure, a single batter is represented in which two cells of emf ε_1 and ε_2, and internal resistance r_1 and r_2 respectively are connected.



Answer the following questions:

Q 52. The equivalent emf of this combination is :

(A) $\frac{\varepsilon_1 r_1 + \varepsilon_2 r_2}{r_1 + r_2}$

(B) $\frac{\varepsilon_1 r_1 - \varepsilon_2 r_2}{r_1 + r_2}$

(C) $\frac{\varepsilon_1 r_2 - \varepsilon_2 r_1}{r_1 + r_2}$

(D) $\varepsilon_1 - \varepsilon_2$

Q 53. For terminal B to be negative :

(A) $\varepsilon_1 r_2 > \varepsilon_2 r_1$

(B) $\varepsilon_1 r_2 < \varepsilon_2 r_1$

(C) $\varepsilon_1 r_1 > \varepsilon_2 r_2$

(D) $\varepsilon_2 r_2 = \varepsilon_1 r_1$

Q 54. The current in the internal circuit is:

(A) $\frac{\varepsilon_1 + \varepsilon_2}{r_1 + r_2}$

(B) $\frac{\varepsilon_2 - \varepsilon_1}{r_1 + r_2}$

(C) $\frac{\varepsilon_1}{r_1} - \frac{\varepsilon_2}{r_2}$

(D) $\frac{\varepsilon_1}{r_2} - \frac{\varepsilon_2}{r_1}$

Q 55. The equivalent internal resistance of the combination is:

(A) $\frac{r_1 + r_2}{r_1 r_2}$

(B) $r_1 + r_2$

(C) $\frac{r_1 r_2}{r_1 + r_2}$

(D) $r_1 - r_2$

Solution

Section A

1. Correct option – c: Both force and torque
   An electric dipole placed in a non-uniform electric field will experience both force and torque.

2. Correct option – b: 2/3
   $\Phi = q/\varepsilon$
   $= (2q/\varepsilon_0)/(3q/\varepsilon_0)$
   Thus, $N_1/N_2 = 2/3$

3. Correct option – b: $I_R = I_G$
   From given diagram, we can observe that when switch is closed or open the reading on galvanometer is same and resistance P and R are not same.
   Using the balanced condition, we can say that
   Current in resistance R and G will be same.
   Thus, $I_R = I_G$

4. Correct option – d:
   Given that,
   Length of wire 1, $L_1 = L$
   Diameter of 1st wire, $D_1 = 2D$
   Area of cross-section, $A_1 = \pi\left(\frac{2D}{2}\right)^2 = \pi D^2$
   $\therefore$ Resistance of wire 1, $R_1 = \frac{\rho L}{A} = \frac{\rho L}{\pi D^2}$
   Similarly,
   Length of wire 2, $L_2 = 2L$
   Diameter of 2nd wire, $D_2 = 3D$
   Area of cross-section, $A_2 = \pi\left(\frac{3D}{2}\right)^2 = \frac{9}{4} \times \pi D^2 = \frac{9}{4}A$
   $\therefore\ R_2 = \frac{\rho(2L)}{\frac{9}{4}A} = \frac{8}{9}R$
   Hence, the ratio of the potential difference of two wires are
   $\frac{V_1}{V_2} = \frac{IR}{\frac{8}{9}IR} = \frac{9}{8}$

5. Correct option – a: $\frac{5}{7}$
   Given that,
   $N_1 = 30$
   $A_1 = 3.6 \times 10^{-3}\ m^2$
   $B_1 = 0.25\ T$
   $N_2 = 42$

B_2 =0.5 T

Now,

$$\frac{I_2}{I_1} = \frac{N_2B_2A_2}{N_1B_1A_1} = \frac{42 \times 0.5 \times 1.8 \times 10^{-3}}{30 \times 0.25 \times 3.6 \times 10^{-3}} = \frac{7}{5}$$

$$\therefore \frac{I_1}{I_2} = \frac{5}{7}$$

6. Correct option – d: $\frac{7}{16}$, into the plane of the paper.

Now for the given figure, the magnetic field at centre M due to current flowing through DA will be

$$B_{DA} = \frac{\mu_0 I}{4\pi R} \times \left(\frac{3\pi}{2}\right) = \frac{3\mu_0 I}{8R}$$

Similarly, the magnetic field due to the current flowing through BC is

$$B_{BC} = \frac{\mu_0 I}{4\pi(2R)} \times \left(\frac{\pi}{2}\right) = \frac{\mu_0 I}{16R}$$

Whereas, magnetic field due to AB and CD will be zero since point M lies on the straight line.

Hence net magnetic field for the given case will be

$B = B_{DA} + B_{BC} + B_{AB} + B_{CD} = \left(\frac{3\mu_0 I}{8R} + \frac{\mu_0 I}{16R} + 0 + 0\right) = \frac{7\mu_0 I}{16R}$ And by using the right-hand thumb rule we can conclude that direction of the magnetic field will be in the plane of the paper.

7. Correct option – d:

a dielectric is introduced into the gap between the plates of the capacitor.

From the given condition, the effective resistance for two circuits is

$$R_1 = \sqrt{r^2 + \left(\frac{1}{\omega C}\right)^2} \ \& \ R_2 = \sqrt{r^2 + (\omega L)^2}$$

Based on the preceding equations, we may conclude that increasing the gap between the plates of the capacitor reduces capacitance, which causes R1 to increase, resulting in a decrease in current.

As a result, the brightness of the bulb will diminish because its brightness is directly proportional to the current running through it.

Hence, the bulb will glow brighter when a dielectric is introduced into the gap between the plates of the capacitor.

8. Correct option – d: 250 V

Given that,

f = 50 Hz

L = 318 mH = 0.318

R = 75 Ω

V_R = 150 V

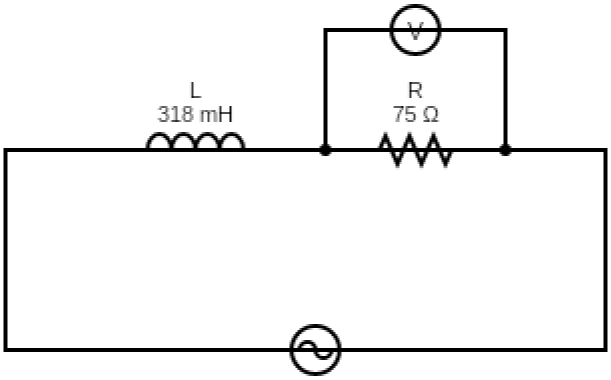
Current through R, $I = \frac{V}{R} = \frac{150}{75} = 2$ A

Now,

$X_L = 2\pi f L = 2\pi \times 50 \times 0.318 \approx 100\ \Omega$

$V_L = IX_L = 2 \times 100 = 200$ V

Hence the total voltage, $V_{total} = (V_R^2 + V_L^2)^{\frac{1}{2}} = \sqrt{150^2 + 200^2} = 250$ V



9. Correct option – d: $\frac{1}{r^2}$

Now,

Electric potential for a dipole is given as

$V = \frac{1}{4\pi\epsilon_0}\frac{p\cos\theta}{r^2} \Rightarrow V \propto \frac{1}{r^2}$

10. Correct option – b: k

The force between two small spheres is given as

$F_1 = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}$ Whereas the force between them in the dielectric medium is

$F_2 = \frac{q_1 q_2}{4\pi k\epsilon_0 r^2} \ldots (\because \epsilon = k\epsilon_0)$

$\therefore \frac{F_1}{F_2} = \frac{1}{1/k} = k$

11. Correct option – d: a gap only

Taking out the infinity plug introduces the air gap in the circuit. Since air is a bad conductor of electricity, no current flows, implying that the infinity resistance in the circuit is introduced.

12. Correct option – b: 270 J

Given that,

Voltage, V = 15 V

Time, t =60 s

Internal resistance, r = 50 Ω

Now,

Heat energy dissipated in time t is given gas

E =VIt

$\text{i.e.}, E = \frac{V^2}{r}t \ldots (\because V = Ir)$

$E = \frac{15^2}{50} \times 60 = 270\ \text{J}$

13. Correct option – a: Energy

Lenz's law is based on the principle of conservation of energy.

14. Correct option – b: 30°

Given that,

$B_v = \frac{1}{\sqrt{3}} B_H$

Also, $\tan\theta = \frac{B_V}{B_H} = \frac{\frac{B_H}{\sqrt{3}}}{B_H} = \frac{1}{\sqrt{3}}$

$\theta = \tan^{-1}\left(\frac{1}{\sqrt{3}}\right) = 30°$

15. Correct option – a: 1.2 μT, Vertically upward

Given that,

Current, I = 15 A

Distance, d = 2.5 m

Now,

The magnitude of the magnetic field, $B = \frac{\mu_0 I}{2\pi r} = \frac{4\pi\times10^{-7}\times15}{2\pi\times2.5}$

$\therefore B = 1.2\ \mu T$

And according to the right-hand thumb rule, the direction magnetic field will be upward.

16. Correct option – c: 10^2 V

Given that,

Inductance, L = 10 H

ΔI = 11 – 2 = 9 A

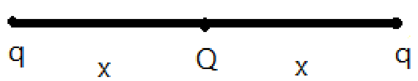
Time, t = 0.9 sec

Now,

$\epsilon = -L\frac{dI}{dt} = -\frac{10\times9}{0.9} = -100\ V$

17. Correct option – d: $-\frac{q}{4}$

A charge Q is placed at the centre of the line joining two charges q and q as shown below.



Now, for the system to be in equilibrium force between charges must be zero (ie., F =0).

$\therefore \frac{kq^2}{4x^2} + \frac{kqQ}{x^2} = 0 \Rightarrow Q = -\frac{q}{4}$

18. Correct option – c: $\vec{E}.d\vec{A}$

For the given case we know that electric flux is the dot product of the electric field and area of the cross section.

i.e., $\vec{\phi} = \vec{E}.d\vec{A}$

19. Correct option – d: 2 Ω

Given that,

Balancing length, l_1 = 120 cm

Shunted resistance, R = 1 Ω

New balancing length after shunting, l_2= 40 cm

Internal resistance, $r = R\left(\frac{120-40}{40}\right) = 2\ \Omega$

20. Correct option – d:

The electron will continue to move with the same velocity v along the axis of the solenoid.

As we know when an electron is projected with velocity v along the axis of a current-carrying long solenoid, it will continue to move with the same velocity v along the axis of the solenoid.

21. Correct option – d: Become half

Now,

$r = \frac{mv}{qB} \Rightarrow v \propto r$

22. Correct option –a:

It is placed in a space varying magnetic field that does not vary with time.

A metal plate can be heated by any of the flowing methods.

- Passing DC or AC through plates
- Keeping it time-varying magnetic field which produces induced current.

23. Correct option – d: Zero

Now,

Power = VI or EI

$\therefore P = E_0 I_0 \sin\omega t \times \sin\left(\omega t + \frac{\pi}{2}\right) = \text{zero}$

24. Correct option – a: $6 \times 10^6 m/s$

Given that,

Potential difference, V =100 V

Charge of electron, e = 1.6×10^{-19} C

Now,

$eV = \frac{1}{2} m_e v^2 \Rightarrow v = \sqrt{\frac{2eV}{m_e}} = 6 \times 10^6 m/s$

25. Correct option – c: A stationary charge

As we know charges at rest or rest remain unaffected by magnetic fields since force depends on velocity, and velocity is zero in the case of stationary charges.

Section B

26. Correct option – d: 2L

Given that,

Two-point charge +16q and -4q and located at x =0 and x = L

Now, we know that

$E = \frac{Q}{4\pi\epsilon_0 r^2} \Rightarrow \frac{16}{(L+x)^2} = \frac{-4}{x^2}$

$\therefore x = 2L$

27. Correct option – a:

Given that,

Dipole moment, $p = 4\times 10^{-5}$ C-m.

Electric field, $E = 10^{-3}$ N/C

Torque, $\tau = 2\times 10^{-8}$ Nm

Now,

The torque due to dipole is given as

$\tau = pE\sin\theta \Rightarrow \theta = \sin^{-1}\left(\frac{\tau}{pE}\right)$

$\therefore \theta = \sin^{-1}\left(\frac{2\times10^{-8}}{4\times10^{-5}\times10^{-3}}\right) = 30°$

28. Correct option – c: $(-\frac{5F}{4}\hat{\imath}, 0\,\hat{\imath}, +\frac{5F}{4}\hat{\imath})$

Charge, $q = q_1 = q_2 = q_3$

Distance between two charges = d

Now,

Force on the first charge due to charge q_3 will be

$$F_{12} = \frac{kq^2}{d^2}$$

Force on the first charge due to charge q_3 will be

$F_{13} = k\frac{q^2}{4d^2}$

Thus net force acting on charge q_1 is

$F_{net} = F_{12} + F_{13} = F + \frac{F}{4}$

$\therefore F_{net} = -\frac{5F}{4}\hat{\imath}$

Here, the negative sign shows that force will be along the negative x-axis.

From this, we can conclude that force acting on three charges are $(-\frac{5F}{4}\hat{\imath}, 0\,\hat{\imath}, +\frac{5F}{4}\hat{\imath})$

29. Correct option – c: Both A and B

Given that,

According to the conclusion of A:

Charge flowing in 1 min, Q = 300 C

Time, t = 1 min = 60 sec

According to the conclusion of B:

Number of electron flows in 1 sec, $n = 3.125\times 10^{19}$ electron

Now,

Total current trough circuit according to A, $I_A = \frac{Q}{t} = 5$ A

Similarly

The total current through circuit according to B, $I_B = \frac{ne}{t} = \frac{3.125\times1.6\times10^{19}\times10^{-19}}{1} = 5$ A

30. Correct option – a: $10.6 \times 10^{-8}\Omega - m$

Given that,

$R_1 = 2\ \Omega$

$R_2 = 8\ \Omega$

$L_1 = L_2 = L$

$A_1 = A_2 = A$

Now,

$R = \frac{\rho L}{A} \Rightarrow \frac{R_1}{R_2} = \frac{\rho_1}{\rho_2}$

$\therefore \rho_2 = 2.65 \times 10^{-8} \times \frac{8}{2} = 10.6 \times 10^{-8} \Omega - m$

31. Correct option – c: $\frac{|\vec{E}|}{|\vec{B}|}$

According to the equation of Lorentz force, the net force acting on electrons due to the electric and magnetic field is given as

$\vec{F} = \vec{E} + (\vec{v} \times \vec{B})$

$\therefore |\vec{E}| + (|\vec{v}| \times |\vec{B}|) = 0$ ... ($\because$ Electron moves undeflected)

$\overrightarrow{|v|} = \frac{|\vec{E}|}{|\vec{B}|}$

32. Correct option – d: 0

Given that,

Charge, q = 1.6× 10^{-19} C

Velocity, $\vec{v} = 4\hat{i} + 3\hat{k}$

Magnetic field, $\vec{B} = 3\hat{k} + 4\hat{i}$

Now the force acting on test charge is

$F_B = q(v \times B) = 0$ N

33. Correct option – a: $\frac{V}{R}$

At resonance, the value of current can be expressed as

$I = \frac{V}{R}$ ... ($\because X_c = X_L$)

34. Correct option – c: $\frac{50}{\pi}$ Hz

Now,

As we know reactance of capacitor can be expressed as

$X_c = \frac{1}{\omega C} = \frac{1}{2\pi f C} \Rightarrow f = \frac{1}{2\pi X_c C}$

$f = \frac{1}{2\pi \times 1000 \times 10 \times 10^{-6}} = \frac{50}{\pi}$ Hz

The frequency of an ac source for which a 10μF capacitor have a reactance of 1000 Ω is $\frac{50}{\pi}$ Hz

35. Correct option – c:

36. Correct option – a: will be less if the length of wire is increased.

From Ohm's law, we know that,

$\frac{1}{R} = \frac{I}{V} = \text{slope}$

Hence for the given case, we can modify the above equation as

$\text{slope} = \frac{1}{R} = \frac{A}{\rho L}$

Now from this, we can conclude that the slope will be less if the length of the wire is increased.

37. Correct option – c: V

When a potential difference V is applied across a conductor at temperature T, the drift velocity of the electrons is proportional to V as we can see below.

$v_d = \frac{eV}{mI}\tau \ldots \left(\because E = \frac{V}{I}\right)$

$\therefore v_d \propto V$

38. Correct option – a: P and R only

From the given figure we can see that the net magnetic field at the centre of loop P and R will be zero since the current is flowing in a closed loop.

39. Correct option – d: $9B_0$

Now,

For the given case $2\pi r = 3\times 2\pi r' \Rightarrow r' = r/3$

Initial magnetic field

$\therefore B_0 = \frac{H_0 I}{2r} \Rightarrow B = \frac{9H_0 I}{2r} = 9B_0$

40. Correct option – d: An inductor can conduct in a dc circuit but not a capacitor.

As we know capacitors can be used for AC but not for DC, similarly, the inductor can conduct DC by obstructing AC.

41. Correct option – a: 53 V

The magnetic flux linked with a coil is given by ϕ

As we know according to Faraday's law of electromagnetic induction, the emf induced by the current-carrying coil is given as

$\epsilon = \frac{d\phi}{dt} = \frac{d(5t^2+3t+16)}{dt} = 10t + 3$

$\epsilon = 10(5) + 3 = 53\text{ V}$

42. Correct option – d: Work is done by the external source

As we know the work is said to be done by an external source when a charge is moving against a coulomb's force of an electric field.

43. Correct option – d: Zero

A charge Q is at the centre of a circle with radius r. the work done in moving a test charge q_0 from point A to point B.

i.e., $W = Fs\cos\theta = 0$

44. Correct option – b: B

The magnetic field produced by a solenoid of N turns will be given as

$B = \mu_0 NI$

And for our case, if the number of turns is reduced to half and the current flowing through it doubled its initial value then the magnetic field produced by them will be

$B' = \mu_0\left(\frac{N}{2}\right)(2I) = B$

45. Correct option – c: Assertion (A) is true, but Reason (R) is false.

For the given case, we know that a bar magnet experiences torque when it placed in a magnetic field

Also, we must note that the bar magnet doesn't exert a net torque on itself due to its own magnetic field although some of its components do.

46. Correct option – b: Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of Assertion (A).
For an LCR circuit that is connected to an AC power source the resonating frequency is given as
$\omega = \frac{1}{\sqrt{LC}} \ldots (X_c = X_L)$
Here, X_c and X_L are Capacitive reactance & Inductive reactance respectively.
Hence we can conclude that both Assertion and Reason are correct but Reason is not the correct explanation for assertion.

47. Correct option – a: Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
According to the equation of Lorentz force, the direction of the magnetic field is always perpendicular to the velocity of the particle and the force acting on it is expressed as.
$F_B = q(\vec{v} \times \vec{B})$ And from the above equation, we can see that force is also perpendicular to velocity or displacement.
Hence the force on the particle does not work because force is perpendicular to the displacement.
i.e., $W = F.dr = Fdr\cos\theta = 0$

48. Correct option – a: Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
For the given case, we know that resistance of the material is directly proportional to resistivity which is the intrinsic property of material, as a result of this resistance offered to the current flowing through the aluminium coil will be greater than the copper coil.
Hence we can conclude that the current in the copper coil is more than the aluminium coil although the induced emf is the same for both.

49. Correct option – a: Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of Assertion (A).
As we know, a transformer works on the principle of mutual inductance and it is used to increase or decrease AC voltage only.

Section C

50. Correct option – b: 2
For a uniform charged distribution the surface charged density for the sphere can be expressed as
$\sigma = \frac{q}{4\pi r^2} \Rightarrow \left(\frac{\sigma_A}{\sigma_B}\right) = \frac{q_A r_B^2}{q_B r_A^2}$
Now since both the spheres are connected, the electric potential across both surfaces will be
$V_A = V_B \Rightarrow \frac{q_A}{q_B} = \frac{r_A}{r_B}$

$\therefore \left(\frac{\sigma_A}{\sigma_B}\right) = \frac{r_B}{r_A} = 2:1$

51. Correct option – d: -F

As we know force on two parallel arms of the current-carrying square loop will be zero, since $\vec{dl} \times \vec{B} = 0$.

Thus the force on the arm opposite to the one on which force acting is F will be –F.

Hence option d is correct among all.

Case – study

52. Correct option – c: $\frac{r_2\epsilon_1+r_1\epsilon_2}{r_2+r_1}$

The equivalent emf of the given combination is given as shown below.

$$\epsilon_{eq} = \frac{\frac{\epsilon_1}{r_1}+\frac{\epsilon_2}{r_2}}{\frac{1}{r_1}+\frac{1}{r_2}} = \frac{r_2\epsilon_1+r_1\epsilon_2}{r_2+r_1}$$

53. Correct option – b: $r_2\epsilon_1 + r_1\epsilon_2$

As we know for the given combination the equivalent emf is given as shown below.

$$\epsilon_{eq} = \frac{r_2\epsilon_1+r_1\epsilon_2}{r_2+r_1}$$

Hence from this, we can conclude that for the given combination of cells, the thermal B can be negative only if $r_2\epsilon_1 < r_1\epsilon_2$.

54. Correct option – a: $\frac{\epsilon_1+\epsilon_2}{r_1+r_2}$

According to Ohm's law, we know that electric current in a circuit is directly proportional to potential difference or emf across any given circuit.

i.e., $I = \frac{\epsilon_1+\epsilon_2}{r_1+r_2}$

55. Correct option – c: $\frac{r_1r_2}{r_1+r_2}$

In the given combination the cells are connected in parallel hence the equivalent internal resistance for the given circuit will be

$$\frac{1}{r_{eq}} = \frac{1}{r_1} + \frac{1}{r_2} \Rightarrow r_{eq} = \frac{r_1r_2}{r_1+r_2}$$