SECTION – [A]

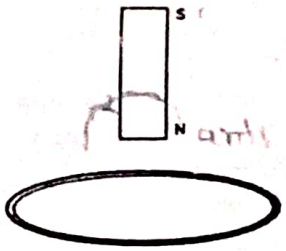
1. A particle of mass 1.96×10^{-15} kg remains suspended between two horizontal metallic plates, kept one above the other 2 cm apart, when the potential difference between them is 800 V. The charge on the particle is:
(1) 2e (2) 3e (3) 4e (4) 5e

2. A metallic hemisphere of radius r is placed in a region having a uniform electric field E perpendicular to its cross-section. The electric flux ϕ passing through the hemisphere is:
(1) $\frac{2}{3}\pi r^3 E$ (2) $\pi r^2 E$ (3) $2\pi r E$ (4) $2\pi r^2 E$

3. W units of work are required to turn a magnetic needle lying parallel to a magnetic field by 60° angle. Find the torque required to maintain the same position of the needle.
(1) W (2) 2W (3) $\sqrt{3}$ W (4) $\sqrt{\frac{3}{2}}$ W

4. The susceptibility of a magnetic material is 0.9853. Identify the type of the magnetic material.
(1) Diamagnetic (2) Paramagnetic
(3) Ferromagnetic (4) Data insufficient.

5. A bar magnet is falling down with its N-Pole downwards towards a closed metallic ring as shown below. Find the direction of induced current flowing through the ring, when viewed from top.
(1) Clockwise (2) Anticlockwise
(3) First clockwise and then anticlockwise
(4) First anticlockwise and then clockwise



6. The peak value of an alternating current is 14.14 A. If the frequency of the current is 50 Hz, find the time the current takes in reaching its maximum value from zero.
(1) $\frac{1}{50}$ sec (2) $\frac{1}{100}$ sec (3) $\frac{1}{150}$ sec (4) $\frac{1}{200}$ sec

7. The current lags behind the voltage by $\frac{\pi}{2}$ radian in a.c. circuit having
(1) L only (2) R only (3) C only (4) L, R circuit

8. At an axial point, distance r away from the centre of an electric dipole, the electric potential is proportional to
(1) r^{-1} (2) r (3) r^{-3} (4) r^{-2}

9. In an ammeter, 5% of the main current is passing through the galvanometer. If the resistance of the galvanometer is G, then find the shunt resistance.
(1) 19 G (2) 20 G (3) G/19 (4) G/20

10. A charged particle after being accelerated through a potential difference 'V' enters in a uniform magnetic field and moves in a circle of radius r. If V is doubled, the radius of the circle will become

(1) 2r (2) $\sqrt{2}r$ (3) 4r (4) $\frac{r}{\sqrt{2}}$

11. In electromagnetic induction, the induced emf in a coil is independent of
(1) change of flux. (2) time
(3) resistance of the coil (4) number of turns in the coil

12. The electromagnetic waves used to purify water are
(1) Infrared rays (2) Ultraviolet rays (3) X-rays (4) Gamma rays

Directions: For Question- 13 to 16
(1) If both Assertion and Reason are true and Reason is the correct explanation of Assertion.
(2) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
(3) If Assertion is true but Reason is false
(4) If both Assertion and Reason are false.

13. **Assertion (A):** The force with which two charges attract or repel each other are not affected by the presence of a third charge.
Reason (R): Force on any charge due to a number of other charges is the vector sum of all the forces on that charge due to other charges, taken one at a time.

14. **Assertion (A):** Ohm's law is not valid, if current depends on voltage non-linearly.
Reason (R): Ohm's law is a fundamental law of nature.

15. **Assertion (A):** On increasing the current sensitivity of a galvanometer by increasing the number of turns may not necessarily increase its voltage sensitivity.
Reason (R): The resistance of the coil of galvanometer increases on increasing the number of turns.

16. **Assertion (A):** When a bar of copper is placed in an external magnetic field, the field lines get concentrated inside the bar.
Reason (R): Copper is a paramagnetic substance.

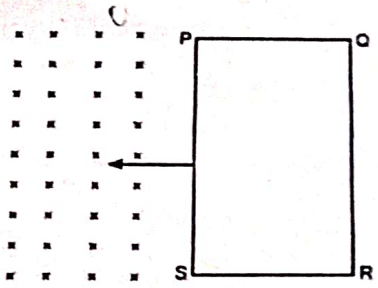
SECTION – [B]

17. Three point charges, 1 pC each are kept at the vertices of an equilateral triangle of side 10 cm. Find the net electric field at the centroid of triangle.

18. Three charges –q, Q and –q are placed at equal distances on a straight line. If the potential energy of the system of these charges is zero, then what is the ratio Q : q?

19. Two long and parallel straight wires A and B carrying currents of 8.0 A and 5.0 A in the same direction are separated by a distance of 4.0 cm. Estimate the force on a 10 cm section of wire A.

20. The closed loop PQRS is moving into a uniform magnetic field acting at right angle to the plane of the paper as shown in figure. State the direction in which the induced current flows in the loop.



OR

Two identical loops, one of copper and the other of aluminium are rotated with the same speed, in a uniform magnetic field acting normal to the plane of the loops. State with reason, for which of the coils; (i) induced emf and (ii) induced current, will be more.

21. Which constituent radiations of electromagnetic spectrum is used
(i) in RADAR
(ii) in photographs of internal parts of human body/as a diagnostic tool in medicine.
(iii) for taking photographs of sky, during night and fog conditions.
(iv) has the largest penetrating power

SECTION – [C]

22. Find the expression for the capacitance of a parallel plate capacitor of plate area A and plate separation d when (i) a dielectric slab of thickness t and (ii) a metallic slab of thickness t, where (t < d) are introduced one by one between the plates of the capacitor. In which case would the capacitance be more and why?

OR

(a) Define the term 'electric flux' and write its dimensions.

(b) A plane surface, in shape of a square of side 1 cm is placed in an electric field $\vec{E} = \left(100\frac{N}{C}\right)\hat{i}$ such that the unit vector normal to the surface is given by $\hat{n} = 0.8\hat{i} + 0.6\hat{k}$. Find the electric flux through the surface.

23. (i) State and explain Ampere's circuital law.
(ii) Two long straight parallel wires separated by 20 cm, carry 5 A and 10 A current respectively in the same direction. Find the magnitude and direction of the net magnetic field at a point midway between them.

24. (a) State the principle of working of a transformer.
(b) Define the efficiency of a transformer
(c) Calculate the current drawn by the primary of a 90% efficient transformer which steps down 220 V to 22 V if the output resistance is 440 Ω

25. Two identical circular coil A and B, each of radius R are lying in perpendicular planes such that they have a common centre. Calculate the magnitude and direction of the magnetic field at the common centre of the coils if the currents carried by them are I and $\sqrt{3}$ I respectively.

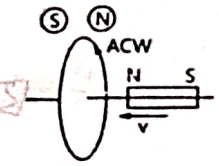
26. How are electromagnetic waves produced? What is the source of energy of these waves? Write mathematical expression for electric and magnetic field of an electromagnetic wave propagating along the z-axis. Write any two important properties of electromagnetic waves.

27. A small compass needle of magnetic moment M is free to turn about an axis perpendicular to the direction of uniform magnetic field B. The moment of inertia of the needle about the axis is I. The needle is slightly disturbed from its stable position and then released. Prove that it executes simple harmonic motion. Hence deduce the expression for its time period.

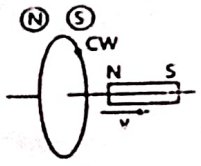
28. Define relaxation time of the free electrons drifting in a conductor. How is it related to the drift velocity of free electrons? Use this relation to deduce the expression for the electrical resistivity of the material.

SECTION – [D]

29. Lenz's law states that the direction of induced current in a circuit is such that it opposes the change which produces it. Thus, if the magnetic flux linked with a closed circuit increases, the induced current flows in such a direction that a magnetic flux is created in the opposite direction of the original magnetic flux. If the magnetic flux linked with the closed circuit decreases, the induced current flows in such a direction so as to create a magnetic flux in the direction of the original flux



(Rest)
(Coil face behaves as North pole to oppose the motion of magnet)



(Rest)
(Coil face behaves as South pole to oppose the motion of magnet)

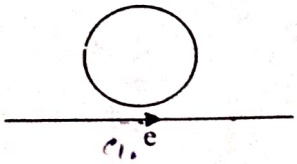
Read the given passage carefully and give the answer of the following questions:

(i) Which of the following statement is correct?
A. The induced emf is not in the direction opposing the change in magnetic flux so as to oppose the cause which produces it.
B. The relative motion between the coil and magnet produces change in magnetic flux.
C. emf is induced only if the magnet is moved towards coil.
D. emf is induced only if the coil is moved towards magnet.

(ii) The polarity of induced emf is given by:
A. Ampere's circuital law
B. Biot-Savart law
C. Lenz's law
D. Fleming's right hand rule

(iii) Lenzs law is a consequence of the law of conservation of:
A. charge
B. mass
C. momentum
D. energy

(iv) Near a circular loop of conducting wire as shown in the figure, an electron moves along a straight line. The direction of the induced current if any in the loop is:
A. variable
B. clockwise
C. anti-clockwise
D. zero



OR

Two identical circular coils A and B are kept in a horizontal tube side by side without touching each other. If the current in the coil A increases with time, in response, the coil B:
A. is attracted by A
B. remains stationary
C. is repelled
D. rotates

30. According to Ohm's law, the current flowing through a conductor is directly proportional to the potential difference across the ends of the conductor i.e., $I \propto V \Rightarrow \frac{V}{I} = R$, where R resistance of the conductor.

Electrical resistance of a conductor is the obstruction possessed by the conductor to the flow of electric current through it. It depends upon length, area of cross-section, nature of material and temperature of the conductor. We can write, $R \propto \frac{l}{A}$ or $R = \rho\frac{l}{A}$ where ρ is electrical resistivity of the material of the conductor.

Read the given passage carefully and give the answer of the following questions:

(i) Dimensions of electric resistance is:
A. $[ML^2T^{-2}A^{-2}]$ B. $[ML^2T^{-3}A^{-2}]$ C. $[M^{-1}L^{-2}T^{-1}A]$ D. $[M^{-1}L^2T^{-2}A^{-2}]$

(ii) If 1μA current flows through a conductor when potential difference of 2V is applied across its ends, then the resistance of the conductor is:
A. $2\times10^6\Omega$ B. $3\times10^6\Omega$ C. $1.5\times10^5\Omega$ D. $5\times10^7\Omega$

(iii) Specific resistance of a wire depends upon:
A. length B. cross-sectional area C. mass D. None of these

(iv) The graph between potential difference and current through a conductor is:
A. a straight line B. curve
C. first curve then straight line D. first straight line then curve

OR

(v) The resistivity of the material of a wire 1.0 m long, 0.4 mm in diameter and having a resistance of 2.0 Ω is:
A. $1.57\times10^{-6}\ \Omega m$ B. $5.25\times10^{-7}\ \Omega m$ C. $7.12\times10^{-5}\ \Omega m$ D. $2.55\times10^{-7}\ \Omega m$

SECTION – [E]

31. (a) A galvanometer of resistance G is converted into a voltmeter to measure up to V volts by connecting a resistance R_1 in series with the coil. If a resistance R_2 is connected in series with it, then it can measure up to V/2 volts. Find the resistance R in terms of R_1 and R_2 required to be connected to convert it into a voltmeter that can read up to 2 V. Also, find the resistance G of the galvanometer in terms of R_1 and R_2.

(b) Use Biot-Savart's law to obtain an expression for the magnetic field at the centre of a circular loop of radius 'a' and carrying a current 'I'. Draw the magnetic field lines for a current loop indicating the direction of magnetic field.

OR

(a) An electron is moving with a velocity $\vec{v}=(3\times10^6\,m/s)\hat{i}$. It enters a region of magnetic field $\vec{B}=(91\,mT)\hat{k}$

(i) Calculate the magnetic force $\vec{F}_B$ acting on electron and the radius of its path.

(ii) Trace the path described by it.

(b) What is current sensitivity of a galvanometer? Show how the current sensitivity of a galvanometer may be increased. "Increasing the current sensitivity of a galvanometer may not necessarily increase its voltage sensitivity." Explain

32. (i) Describe the construction and working of a transformer and hence obtain the relation for $\left(\frac{V_s}{V_p}\right)$ in terms of number of turns of primary and secondary. Discuss four main causes of energy loss in a real transformer.

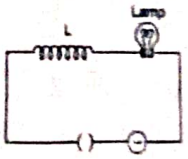
(ii) A small town with a demand of 1200 kW of electric power at 220 V is situated 20 km away from an electric plant generating power at 440 V. The resistance of the two wires line carrying power is 0.5Ω per km. The town gets the power from the line through a 4000-220 V step-down transformer at a sub-station in the town. Estimate the line power loss in the form of heat.

OR

(a) (i) An Ac voltage $V = V_m \sin\omega t$ (V_m = 310 V and f = 50 Hz) is connected to a pure capacitor of capacitance 15 μF. Calculate: (a) the reactance of the capacitor and (b) the amplitude of the current.

(ii) Write the expression of current through the capacitor as a function of time.

(b) A lamp is connected in series with an inductor and an AC source. What happens to the brightness of the lamp when the key is plugged in and an iron rod is inserted inside the inductor? Explain.



33. (i) Using Gauss's law, derive an expression for the electric field intensity due to an infinitely long, straight wire of linear charge density λC/m.

(ii) Four point charges of 1μC, −2μC, 1μC and −2μC are placed at the corners A, B, C and D respectively of a square of side 30 cm. Find the net force acting on a charge of 4μC placed at the centre of the square.

OR

(i) An electric dipole when held at 30° with respect to a uniform electric field of 10^4 N/C experienced a torque of 9×10^{-25} Nm. Calculate dipole moment of the dipole.

(ii) Two dielectric slabs of dielectric constants K_1 and K_2 are filled in between the two plates, each of area A, of the parallel plate capacitor as shown. Find net capacitance of the capacitor.