

BUDHA DAL PUBLIC SCHOOL, PATIALA
First Term Examination (1 September 2025)
Class XII (Science)
Subject - Physics (Set - B)

M.M. 70

Time: 3hrs

General Instructions:

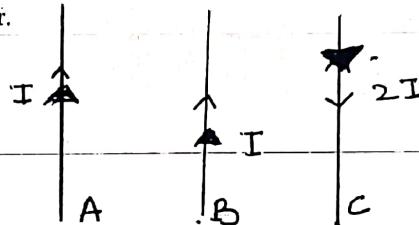
- (1) There are 33 questions in all. All questions are compulsory.
- (2) This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
- (3) All the sections are compulsory.
- (4) Section A contains sixteen questions, twelve MCQ and four Assertion Reasoning based of 1 mark each, Section B contains five questions of two marks each, Section C contains seven questions of three marks each, Section D contains two case study based questions of four marks each and Section E contains three long answer questions of five marks each.
- (5) Use of calculators is not allowed.
- (6) You may use the following values of physical constants where ever necessary

- i) $c = 3 \times 10^8 \text{ m/s}$
- ii) $m_e = 9.1 \times 10^{-31} \text{ kg}$
- iii) $e = 1.6 \times 10^{-19} \text{ C}$
- iv) $\mu_0 = 4\pi \times 10^{-7} \text{ TmA}^{-1}$
- v) $h = 6.63 \times 10^{-34} \text{ Js}$
- vi) $\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{ N}^{-1} \text{ m}^{-2}$
- Vii) Avogadro's number = 6.023×10^{23} per gram mole

Section - A

Q1. A, B and C are parallel conductors of equal lengths carrying currents I, I and $2I$ respectively. Distance between A and B is x . Distance between B and C is also x . F_1 is the force exerted by B on A. F_2 is the force exerted by C on A. Choose the correct answer.

- a) $F_1 = 2 F_2$
- b) $F_2 = 2 F_1$
- c) $F_1 = F_2$
- d) $F_1 = -F_2$



Q2. A wire has a resistance of 3.1Ω at 300°C and a resistance 4.5Ω at 100°C . The temperature coefficient of resistance of the wire is

- a) $0.0064^\circ\text{C}^{-1}$
- b) $0.0034^\circ\text{C}^{-1}$
- c) $0.0025^\circ\text{C}^{-1}$
- d) $0.0012^\circ\text{C}^{-1}$

Q3. The magnetic flux linked with a coil at any instant t is given by $\phi = 5t^3 - 100t + 300$, the emf induced in the coil at $t = 2 \text{ s}$ is

- a) -40 V
- b) 40 V
- c) 140 V
- d) 300 V

Q4. In a purely resistive a.c. circuit, the current

- a) is in phase with the emf
- b) leads the emf in phase by $\pi \text{ rad}$
- c) leads the emf in phase by $\frac{\pi}{2} \text{ rad}$
- d) lags behind the emf in phase by $\frac{\pi}{4} \text{ rad}$

Q5. A charge Q is placed at each of the opposite corners of a square. A charge, q is placed at each of the other two corners. If the net electrical force on Q is zero, then Q/q equals

- a) $-2\sqrt{2}$
- b) -1
- c) 1
- d) $-\frac{1}{\sqrt{2}}$

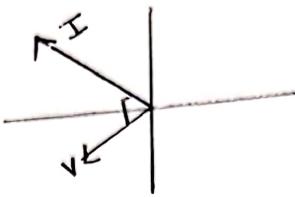
Q6. Consider the charge configuration and a spherical Gaussian surface as shown in the figure while calculating the flux of the electric field over the spherical surface, the electric field will be due to

- a) q_2
- b) only the positive charges
- c) all the charges
- d) $+q_1$ and $-q_1$

B-1

Q7.

If the phasor diagram for a device connected to AC supply is as shown in the figure, the which of the following statements is true?



Assertion (A) : A uniform field is along x-axis. If a helical path with a

Reason (R) : The

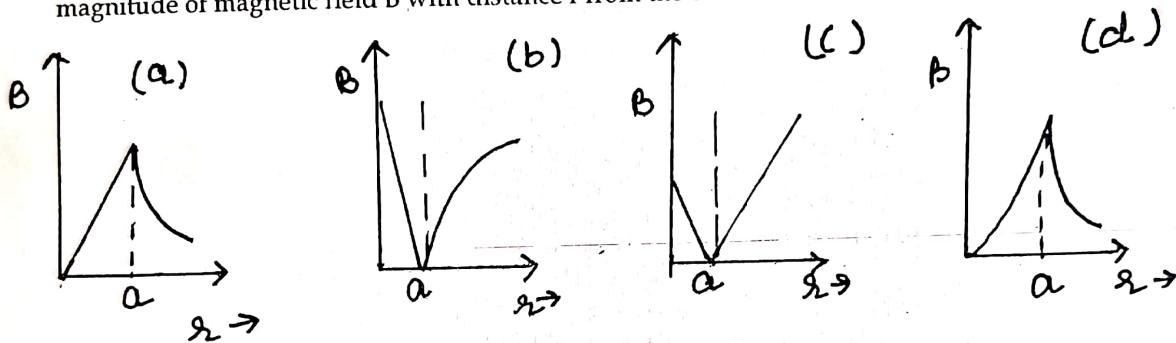
- a) When the frequency of the AC source is increased than the impedance of the device decreases.
- b) This device behaves as conducting wire when connected across DC source.
- c) When the frequency of the AC source is decreased than the impedance of the device decreases.
- d) This device stores energy in the form of magnetic potential energy.

Q8. In a circular coil of radius r , the magnetic field at the centre is proportional to r^2 b) r c) $1/r$ d) $1/r^2$

Q9. The maximum power drawn out of the cell from a source is given by

$$\frac{\epsilon^2}{2r} \quad b) \frac{\epsilon^2}{4r} \quad c) \frac{\epsilon^2}{r} \quad d) \frac{\epsilon^2}{3r}$$

Q10. A long straight wire of circular cross-section (radius a) carries a steady current I and the current I is uniformly distributed across this cross-section. Which of the following plots represents the variation of magnitude of magnetic field B with distance r from the centre of the wire?



Q11. A coil contains N turns of insulated copper wire of diameter d and resistivity ρ wound on a cylinder of diameter D . What is the total resistance between the two ends of the coil of copper wire? (given: $D \gg d$)

$$a) \frac{4\rho ND}{d^2} \quad b) \frac{8\rho ND}{d^2} \quad c) \frac{2\rho ND}{d^2} \quad d) \frac{12\rho ND}{d^2}$$

Q12. A spherical metal shell A of radius R_A and a solid metal sphere B of radius R_B ($R_B < R_A$) are kept far apart and each is given charge $+Q$. Now they are connected by a thin metal wire. Then

$$a) E_A^{inside} = 0 \quad b) Q_A < Q_B \quad c) \frac{\sigma_A}{\sigma_B} \neq \frac{R_B}{R_A} \quad d) E_A^{on\ surface} > E_B^{on\ surface}$$

In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Mark the correct choice as:

- a) Both A and R correct and R is the correct explanation of A.
- b) Both A and R correct and R is not the correct explanation of A.
- c) A is not correct but R is correct.
- d) A is correct but R is not correct.

Q13. Assertion (A) : The induced emf in a loop is zero if the magnetic flux through the loop remains constant.

Reason (R) : Faraday's law states that the induced emf is directly proportional to the rate of change of magnetic flux through the loop.

Q14. Assertion (A) : Total energy of an electron in hydrogen atom is negative.

Reason (R) : The centripetal force is provided by electrostatic force.

Q15. Assertion (A) : The charge induced in a closed circuit increases if the rate of change of flux associated with the circuit increases rapidly.

Reason (R) : The emf induced in a closed circuit is directly proportional to the rate of change of flux associated with the coil.

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Assertion (A) : A charged particle with velocity v in the $x - y$ plane, making an angle θ ($0 < \theta < \frac{\pi}{2}$) with x -axis. If a uniform magnetic field \vec{B} is applied in the region, along y -axis, the particle will move in a helical path with its axis parallel to x -axis.

Reason (R) : The direction of the magnetic force acting on a charged particle moving in a magnetic field is along the velocity of the particle.

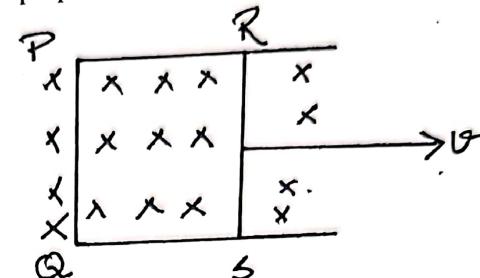
Section - B

Q17.

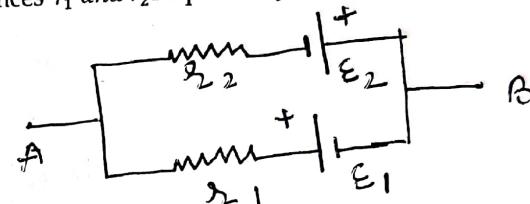
Figure shows a rectangular conducting loop PQSR in which arm RS of length 'l' is moveable. The loop is kept in a uniform magnetic field 'B' directed downward perpendicular to the plane of the loop. The arm RS is moved with a uniform speed 'v'.

Deduce the expression for:

1. The emf induced across the arm 'RS'
2. The external force required to move the arm



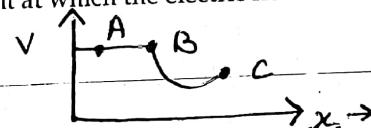
Q18. Find the emf (ϵ_0) and internal resistance (r_0) of a battery which is equivalent to a parallel combination of two batteries of emfs ϵ_1 and ϵ_2 and internal resistances r_1 and r_2 respectively, with polarities as shown in figure.



Q19. The variation of electrostatic potential V with distance 'x' for a given charge distribution. From the points marked A, B and C, identify the point at which the electric field is:

a) zero b) maximum

Explain your answer in each case.



Q20. Using the concept of drift velocity of charge carriers in a conductor, deduce the relationship between current density and resistivity of the conductor.

Q21. A proton and an alpha particle of the same velocity enter at the right angles into a uniform magnetic field of intensity B . Calculate the ratio of the radii of their paths, when they enter the field with the same momentum.

Section - C

Q22. The magnetic moment $5J/T$ of a bar magnet points along a uniform magnetic field $0.4 T$.

- a) Calculate (i) the potential energy of the bar magnet, and (ii) the work done in turning the magnet by 180° .
- b) In which case is the potential energy of the magnet minimum?

Q23. Current flows through a constricted conductor, as shown in figure. The diameter $D_1 = 2.0 \text{ mm}$ and the current density to the left of the constriction is $j = 1.27 \times 10^6 \text{ Am}^{-2}$.

- i) What current flows into the constriction?
- ii) If the current density is doubled as it emerges from the right side of the constriction, what is diameter D_2 ?

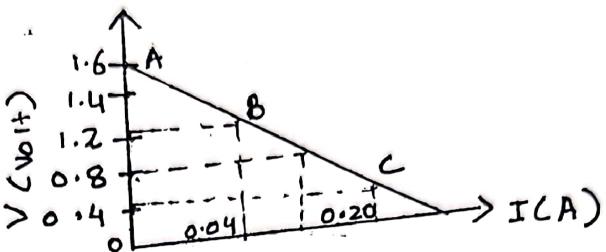


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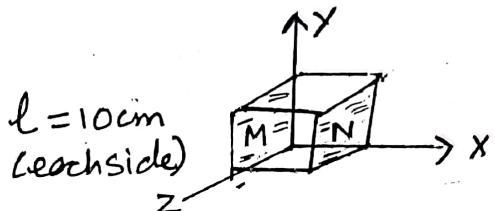
OR

Potential differences across terminals of a cell were measured (in volt) against different currents (in ampere) flowing through the cell. A graph was drawn which was a straight line ABC, as shown in figure. Determine from the graph.

- emf of the cell
- maximum current obtained from the cell
- internal resistance of the cell



Q24. Electric field in figure is directed along $+X$ direction and given by $E_x = 5 Ax + 2 B$, where E is in NC^{-1} and x is metre, A and B are constants with dimensions. Taking $A = 10 NC^{-1} m^{-1}$ and $B = 5 NC^{-1}$, calculate : (i) the electric flux through the cube (ii) net charge enclosed within the cube



OR

Two thin concentric and coplanar spherical shells, of radii a and b ($b > a$) carry charges q and Q respectively. Find the magnitude of the electric field, at a point distant x , from their common centre for

- $0 < x < a$
- $a \leq x < b$

Q25. a) Explain the principle and working of moving coil galvanometer
b) How the galvanometer can be converted into voltmeter

Q26. Define power for an a.c. circuit. Derive an expression for the average power of a series LCR circuit connected to an a.c. source. Discuss the various special cases.

Q27. A long solenoid with closely wound turns has n turns, per unit of its length. A steady current I flows through this solenoid. Use Ampere's circuital law to obtain an expression, for the magnetic field, at a point on its axis and close to its mid point. Draw its field lines.

Q28. A parallel-plate capacitor is charged by a battery which is then disconnected. A dielectric slab is then inserted to fill the space between the plates. Explain the changes, if any, that occur in the values of (i) charge on the plates, (ii) electric field between the plates, (iii) p.d. between the plates.

Section - D

Case Based Questions:

Q29. Read the following passage and answer the following:

Dielectrics play an important role in design of capacitors. The molecules of a dielectric may be polar or non-polar. When a dielectric slab is placed in an external electric field, opposite charges appear on the two surfaces of the slab perpendicular to electric field. Due to this an electric field is established inside the dielectric.

The capacitance of a capacitor is determined by the dielectric constant of the material that fills the space between the plates. Consequently, the energy storage capacity of a capacitor is also affected. Like resistors, capacitors can also be arranged in series and/or parallel.

- Which of the following is a polar molecule?
 - O_2
 - H_2
 - N_2
 - HCl
- Which of the following statements about dielectric is correct?
 - A polar dielectric has a net dipole moment in absence of an external electric field which gets modified due to the induced dipoles.

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b) The net dipole moments of induced dipoles is along the direction of the applied electric field.

c) Dielectrics contain free charges.

d) The electric field produced due to induced surface charges inside a dielectric is along the external electric field.

3) When a dielectric slab is inserted between the plates of an isolated charged capacitor, the energy stored in it

- Increases and the electric field inside it also increases
- Decreases and the electric field also decreases
- Decreases and the electric field increases
- Increase and the electric field decreases

4) A) An air-filled capacitor with plate area A and plate separation d has capacitance C_0 . A slab of dielectric constant K, area A and thickness $\left[\frac{d}{5}\right]$ is inserted between the plates. The capacitance of the capacitor will become

- $\left[\frac{4K}{5K+1}\right]C_0$
- $\left[\frac{K+5}{4}\right]C_0$
- $\left[\frac{5K}{4K+1}\right]C_0$
- $\left[\frac{K+4}{5K}\right]C_0$

OR

B) Two capacitors of capacitances $2C_0$ and $7C_0$ are first connected in series and then in parallel across the same battery. The ratio of energies stored in series combination to that in parallel is

a) $\frac{1}{4}$ b) $\frac{1}{6}$ c) $\frac{2}{15}$ d) $\frac{3}{16}$

Q30. Read the following passage and answer the following:

In a metallic conductor, an electron, moving due to thermal motion, suffers collisions with the heavy fixed ions but after collision, it will emerge out with the same speed but in random directions. If we consider all the electrons, their average velocity will be zero. When an electric field is applied, electrons move with an average velocity, known as drift velocity (v). The average time between successive collisions is known as relaxation time (τ). The magnitude of drift velocity per unit electric field is called mobility (μ). An expression for current through the conductor can be obtained in terms of drift velocity, number of electrons per unit volume (n), electronic charge ($-e$) and the cross-sectional area (A) of the conductor. This expression leads to an expression between current density (j) and the electric field (\vec{E}). Hence, an expression for resistivity (ρ) of a metal is obtained. This expression helps us to understand increase in resistivity of a metal with increase in its temperature, in terms of change in relaxation time (τ) and change in the number density of electrons (n).

- Consider two cylindrical conductors A and B, made of the same metal connected in series to a battery. The length and the radius of B are twice that of A. If μ_A and μ_B are the mobility of electrons in A and B respectively, then $\frac{\mu_A}{\mu_B}$ is:
 - $\frac{1}{2}$
 - $\frac{1}{4}$
 - 2
 - 1
- A wire of length 0.5m and cross-sectional area $1.0 \times 10^{-7} \text{ m}^2$ is connected to a battery of 2 V that maintain a current of 1.5 A in the conductivity of the material of the wire (in $\Omega^{-1} \text{ m}^{-1}$) is:
 - 2.5×10^4
 - 3.0×10^3
 - 3.75×10^4
 - 5.0×10^7
- The temperature coefficient of resistance of nichrome is $1.70 \times 10^{-4} \text{ }^{\circ}\text{C}^{-1}$. In order to increase resistance of a nichrome wire by 8.5%, the temperature of the wire should be increased by:
 - 250°C
 - 500°C
 - 850°C
 - 1000°C
- A) Consider the contribution of the following factors I and II in resistivity of a metal:
 - Relaxation time of electrons
 - Number of electrons per unit volume

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The resistivity of a metal increases in its temperature because:

- a) I decreases and II increases
- b) I increases and II is almost constant
- c) Both I and II increase
- d) I decreases and II is almost constant

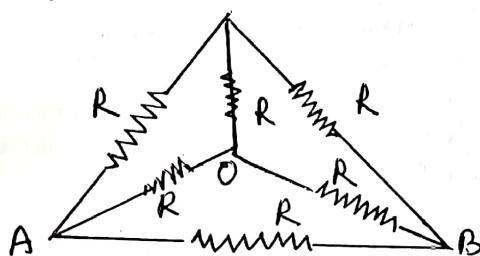
OR

B) A steady current flows in a copper wire of non-uniform cross-section, section the following three physical quantities.

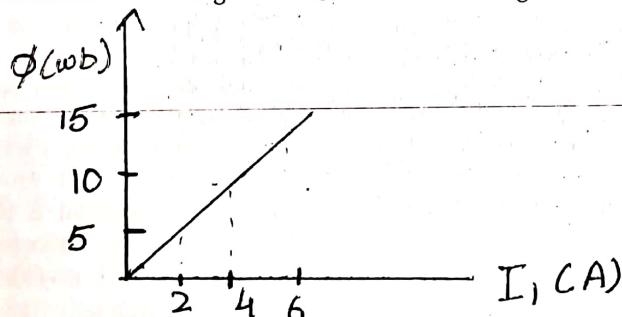
- I) Electric field II) Current density III) Drift speed
- a) II and III change, but I is constant
- b) I and III change, but III is constant
- c) I and III change, but II is constant
- d) All I, II and III change

Section - E

Q31. a) The ends of six wires, each of resistance R ($= 10\Omega$) are joined as shown in the figure. The points A and B of the arrangement are connected in a circuit. Find the value of the effective resistance offered by it to the circuit.



b) Two coils C_1 and C_2 are placed close to each other. The magnetic flux ϕ_2 linked with the coil C_2 varies with the current I_1 flowing in coil C_1 as shown in the figure. Find

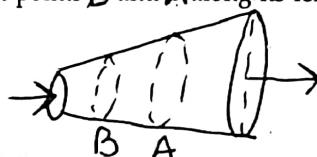


- i) the mutual inductance of the arrangement and
- ii) the rate of change of current ($\frac{dI_1}{dt}$) that will induce an emf of 100 V and coil C_2 .

OR

Current I ($= 1$ A) is passing through a copper rod ($n = 8.5 \times 10^{28} \text{ m}^{-3}$) of varying cross-sections as shown in the figure. The areas of cross-section at points B and A along its length are $1.0 \times 10^{-7} \text{ m}^2$ and 2.0×10^{-7} respectively.

Calculate :



- I) the ratio of electric fields at points A and B.
- II) the drift velocity of free electrons at point B.

Q32. a) An electric dipole of dipole moment \vec{p} consists of point charges $+q$ and $-q$ separated by a distance $2a$ apart. Deduce the expression for the electric field \vec{E} due to the dipole at a distance x from the centre of the dipole on its axial line in terms of the dipole moment \vec{p} . Hence show that in the limit $x \gg a$,

$$\vec{E} = 2\vec{p}/(4\pi\epsilon_0 x^3)$$

b) Draw a graph of E versus r for $r \gg a$

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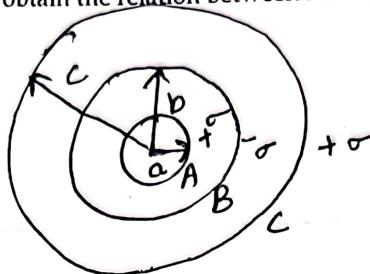
c) If this dipole were kept in a uniform external electric field E_p , diagrammatically represent the position of the dipole in stable and unstable equilibrium and write the expressions for the torque acting on the dipole in both the cases.

OR

Three concentric metallic shells A, B and C of radii, a, b and c ($a < b < c$) have surface charge densities $+\sigma$, $-\sigma$ and $+\sigma$ respectively, as shown in figure.

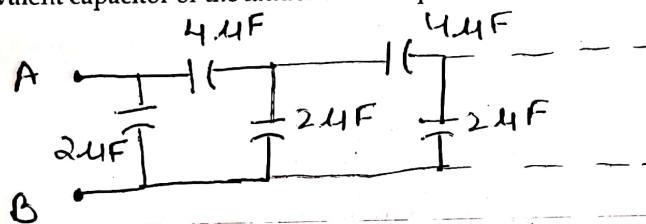
i) Find potential of three shells A, B, C

ii) If shells A and C are at the same potential, obtain the relation between radii a, b, c



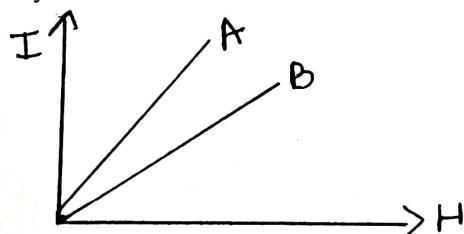
Q33. a) Two long straight parallel conductors carry steady currents I_1 and I_2 separated by a distance d. If the currents are flowing in the same direction, show how the magnetic field set-up in one produces an attractive force on the other. Obtain the expression for this force. Hence define one ampere.

b) Find the equivalent capacitor of the ladder between points A and B.



OR

a) The following figure shows the variation of intensity of magnetization versus the applied magnetic field intensity, H, for two magnetic materials A and B.



i) Identify the materials A and B
 ii) For the material A, plot the variation of intensity of magnetisation versus temperature.
 b) Derive the expression of magnetic field at any point on the axis of circular coil carrying current and find the magnetic dipole moment of coil.

B-7