BUDHA DAL PUBLIC SCHOOL, PATIALA
First Term Examination (1 September 2025)

Class XII (Science)

Subject - Physics - 042 (Set - A)

Time: 3hrs **M.M. 70**

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

Section - A

Q1. A charge q is placed at the centre of the line joining two equal positive charges Q. The system of the three charges will be in equilibrium, if q is equal to

a) $-\frac{Q}{2}$ b) $-\frac{Q}{4}$ c) $+\frac{Q}{4}$ d) $+\frac{Q}{2}$

Q2. The maximum power drawn out of the cell from a source is given by

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

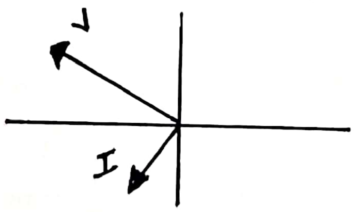
Q3. In a circular coil of radius r, the magnetic field at the centre is proportional to

a) r^2 b) r c) $1/r$ d) $1/r^2$

Q4. A coil contains N turns of insulted copper wire of diameter d and resistivity p wound on a cylinder of diameter D. What is the total resistance between the two ends of the coil of copper wire? (given: D>>d)

a) $\frac{4pND}{d^2}$ b) $\frac{8pND}{d^2}$ c) $\frac{2pND}{d^2}$ d) $\frac{12pND}{d^2}$

Q5. If the phasor diagram for a device connected to AC supply is as shown in the figure, then which of the following statements is true?



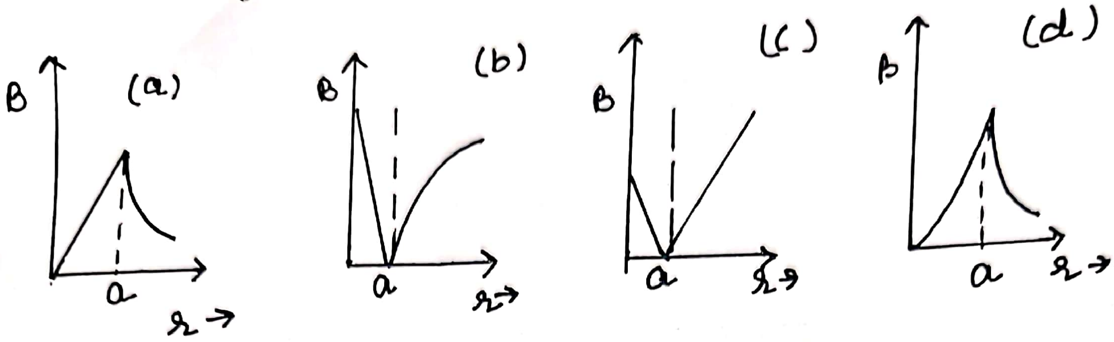
a) When the frequency of the AC source is increased than the impedance of the device decreases.
b) This device behaves as conducting wire when connected across DC source.
c) When the frequency of the AC source is decreased than the impedance of the device decreases.
d) This device stores energy in the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

Q6. A spherical metal shell A of radius R_A and a solid metal sphere B of radius 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) $E_A^{inside} = 0$ b) $Q_A < Q_B$ c) $\frac{\sigma_A}{\sigma_B} \neq \frac{R_B}{R_A}$ d) $E_A^{on\ surface} > E_B^{on\ surface}$

A - 1

Q7. 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?



Q8. 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 $t = 2\ s$ is

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

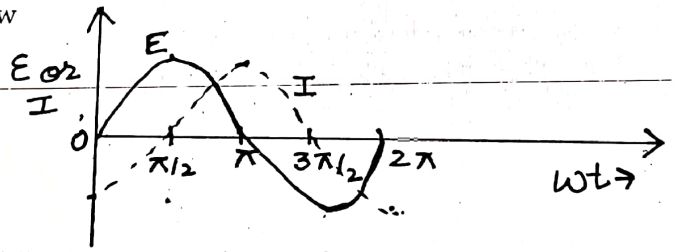
Q9. Four charges equal to $-Q$ are placed at the four corners of a square and a charge q is at its centre. If the system is in equilibrium, the value of q is

a) $-\frac{Q}{4}(1+2\sqrt{2})$ b) $\frac{Q}{4}(1+2\sqrt{2})$ c) $-\frac{Q}{2}(1+2\sqrt{2})$ d) $\frac{Q}{2}(1+2\sqrt{2})$

Q10. 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) 0.0064^0C^{-1} b) 0.0034^0C^{-1} c) 0.0025^0C^{-1} d) 0.0012^0C^{-1}

Q11. The variation of instantaneous current I (t) and instantaneous emf $\xi(t)$ versus ωt for a circuit is shown below

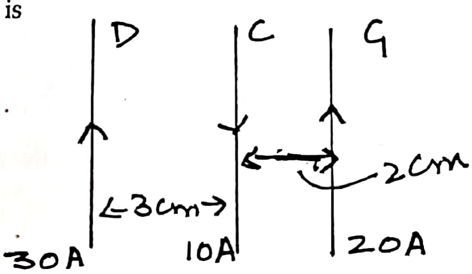


Which of the following statement is correct?

a) The voltage lags behind the current by $\pi/2$
b) The voltage leads the current by $\pi/2$
c) The voltage and the current are in phase
d) The voltage leads the current by π

Q12. Three long, straight parallel wires, carrying current, are arranged as shown in the figure. The force experienced by a 25 cm length of wire C is

a) 10^{-3} N
b) 2.5×10^{-3} N
c) Zero
d) 1.5×10^{3} N



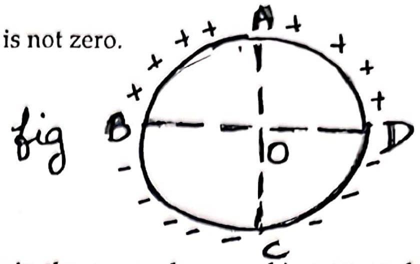
In the following questions, a statement of Assertion (A) is followed by a statement of Reason (R). Mark the correct choice as:

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

A-2

Assertion (A) : Equal amount of positive and negative charges are distributed uniformly on two halves of a thin circular ring as shown in figure. The resultant electric field at the centre O of the ring is along OC.

Reason (R) : It is so because the net potential at O is not zero.



Q14. Assertion (A) : A charged particle with velocity v in the $x-y$ plane, making an angle $\theta\left(0<0<\frac{\pi}{2}\right)$ 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.

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.

Q16. 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.

Section - B

Q17. Draw 3 equipotential surfaces corresponding to a field that uniformly increases in magnitude but remains constant along Z-direction. How are these surfaces different from that of a constant electric field along Z-direction?

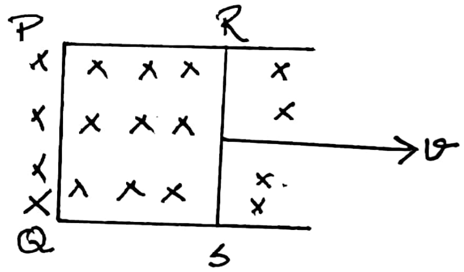
Q18. Using the concept of drift velocity of charge carries in a conductor, deduce the relationship between current density and resistivity of the conductor.

Q19. A proton and an alpha particle of the same velocity enter in turn a region of uniform magnetic field, acting perpendicular to their direction of motion. Deduce the ratio of the radii of the circular paths of the same radius. Is this statement true or false?

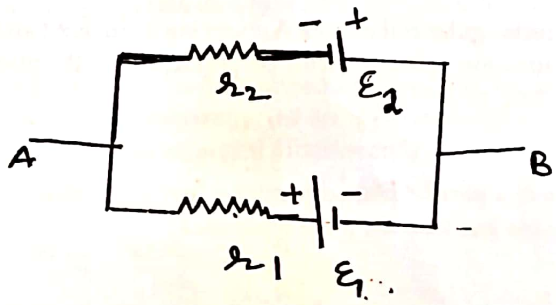
Q20. Figure shows a rectangular conducting loop PQSR in which arm RS of length 'l' is moveable. The loop is kept in a uniform magnetic field 'B' directed downward perpendicular to the plane of the loop. The arm RS is moved with a uniform speed 'v'.

Deduce the expression for:

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



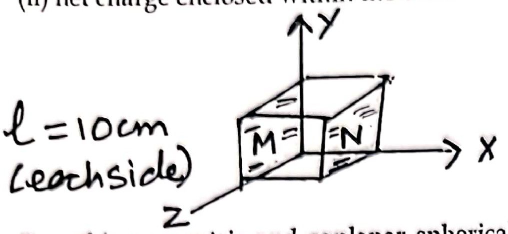
Q21. Find the emf (ϵ_0) and internal resistance (r_0) of a battery which is equivalent to a parallel combination of two batteries of emfs ϵ_1 *and* ϵ_2 and internal resistances r_1 *and* r_2 respectively, with polarities as shown in figure.



Section - C

Q22. 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 n 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

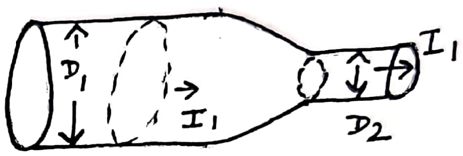
Two thin concentric and coplanar spherical shells, or radii a and b (b > a) carry charges, q and Q, respectively. Find the magnitude of the electric field, at a point distant x, from their common centre for

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

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

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?



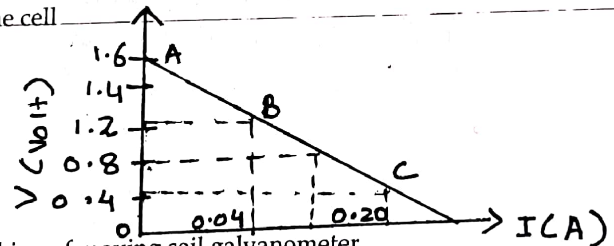
OR

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.

a) emf of the cell

b) maximum current obtained from the cell

c) internal resistance of the cell



Q24. a) Explain the principle and working of moving coil galvanometer

b) How the galvanometer can be converted into voltmeter

Q25. Using phasor diagram, derive an expression for the impedance of a series LCR - circuit. Find the frequency of the circuit at resonance.

Q26. 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 180^0.

b) In which case is the potential energy of the magnet minimum?

Q27. Derive an expression for the torque on a rectangular coil of area A, carrying a current I and placed in a magnetic field B. The angle between the direction of B and vector perpendicular to the plane of the coil is θ. Indicate the direction of the torque acting on the loop.

Q28. Deduce the expression for the capacitance of a parallel plate capacitor when a dielectric slab is inserted between its plates. Assume the slab thickness less than the plate separation.

Case Based Questions:

. 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).

1) 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:

   a) $\frac{1}{2}$ b) $\frac{1}{4}$ c) 2 d) 1

2) A wire of length 0.5m and cross-sectional area 1.0×10^{-7} 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 $\Omega^{-1} m^{-1}$) is:

   a) 2.5×10^4 b) 3.0×10^3 c) 3.75×10^4 d) 5.0×10^7

3) The temperature coefficient of resistance of nichrome is 1.70×10^{-4} $^0C^{-1}$. In order to increase resistance of a nichrome wire by 8.5%, the temperature of the wire should be increased by:

   a) 250⁰C b) 500⁰C c) 850⁰C d) 1000⁰C

4) A) Consider the contribution of the following factors I and II in resistivity of a metal:
   I) Relaxation time of electrons
   II) Number of electrons per unit volume

   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

0. **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.

1) Which of the following is a polar molecule?

   a) O_2 b) H_2 c) N_2 d) HCl

2) Which of the following statements about dielectric is correct?

a) A polar dielectric has a net dipole moment in absence of an external electric field which gets modified due to the induced dipoles.

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

c) Dielectrics contain fee 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

a) Increases and the electric field inside it also increases

b) Decreases and the electric field also decreases

c) Decreases and the electric field increases

d) 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

a) $\left[\frac{4K}{5K+1}\right]C_0$ b) $\left[\frac{K+5}{4}\right]C_0$ c) $\left[\frac{5K}{4K+1}\right]C_0$ d) $\left[\frac{K+4}{5K}\right]C_0$

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) $\frac{3}{16}$

Section – E

Q31. 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 $x \gg a$,

$$\vec{E} = 2\vec{p}/(4\pi\varepsilon_0 x^3)$$

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

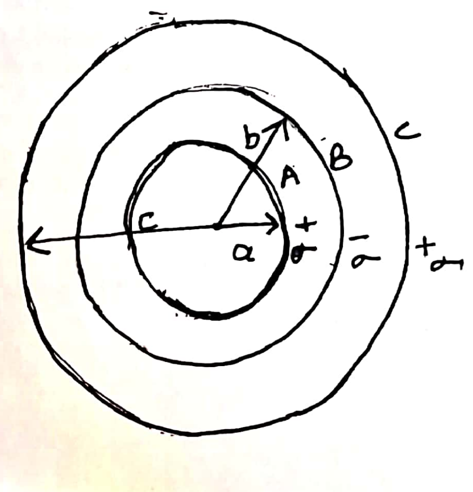
c) If this dipole were kept in a uniform external electric field E_v, diagrammatically represent the position of the dipole in stable and unstable equilibrium and write the expressions for the torque acting on the dipole in both the cases.

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.

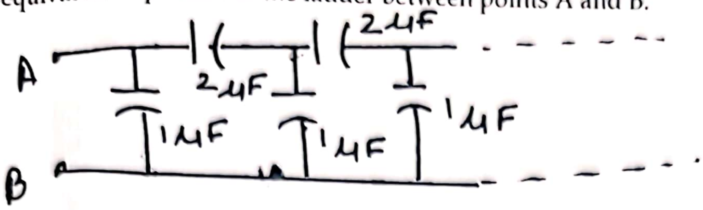
i) Find potential of three shells A, B, C

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



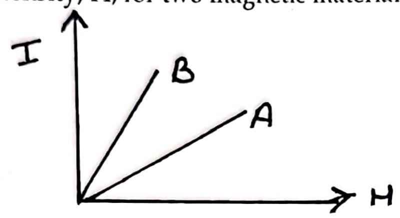
32. a) Two long straight parallel conductors carry steady currents I_1 and I_2 separated by a distance d. If the currents are flowing in the same direction, show how the magnetic field set-up in one produces an attractive force on the other. Obtain the expression for this force. Hence define one ampere.

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.

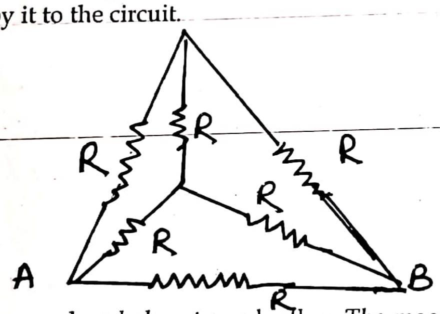


i) Identify the materials A and B

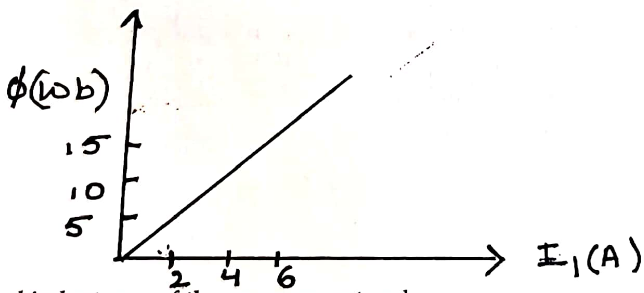
ii) For the material A, plot the variation of intensity of magnetisation versus temperature.

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.

Q33. a) The ends of six wires, each of resistance R (= 10Ω) 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 I1 flowing in coil C_1 as shown in the figure. Find



i) the mutual inductance of the arrangement and

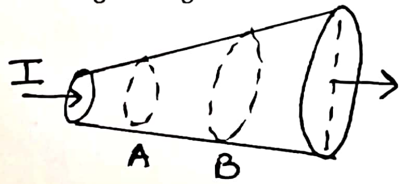
ii) the rate of change of current $\left(\frac{dI_1}{dt}\right)$ that will induce an emf of 100 V and coil C_2.

OR

Current I (= 1 A) is passing through a copper rod (n = 8.5×10^{28} m^{-3}) of varying cross-sections as shown in the figure. The areas of cross-section at points A and B along its length are 1.0 × 10-7 m2 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.



A-7