



CLASS: XII
DATE: 22/09/2024

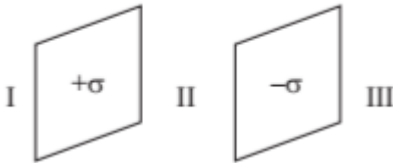
Maximum Marks: 70
Time Allowed:3 hours

General Instructions:

- There are 33 questions in all. All questions are compulsory.
- This question paper has five sections: Section A, Section B, Section C, Section D and Section E.
- All the sections are compulsory.
- 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.
- There is no overall choice. However, an internal choice has been provided in one question in Section B, one question in Section C, one question in each CBQ in Section D and all three questions in Section E. You have to attempt only one of the choices in such questions.
- Use of calculators is not allowed.
- You may use the following values of physical constants wherever 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. $\epsilon_0 = 8.854 \times 10^{-12}$ C²N⁻¹m⁻²
vii. Avogadro's number = 6.023×10^{23} per gram mole
viii. $m_p = 1.673 \times 10^{-27}$ kg ix. $m_n = 1.675 \times 10^{-27}$ kg x. $\left(\frac{1}{4\pi\epsilon_0}\right) = 9 \times 10^9$ Nm²C⁻²
xi. Boltzmann constant = 1.38×10^{-23} JK⁻¹

SECTION A

- A hemisphere is uniformly charged positively. The electric field at a point on the diameter, and away from the centre is directed. 1
(a) perpendicular to the diameter (b) parallel to the diameter
(c) at an angle tilted towards the diameter (d) at an angle tilted away from the diameter
- Electric flux emanating through a surface element $\vec{dA} = 5\hat{i}$ placed in an electric field $\vec{E} = 4\hat{i} + 4\hat{j} + 4\hat{k}$ is 1
(a) 10 units (b) 20 units (c) 4 units (d) 16 units
- Two large thin metal plates are parallel and close to each other. On their inner faces, the plates have surface charge densities of opposite signs and magnitude 27×10^{-22} Cm⁻². The electric field \vec{E} in region II in between the plates is 1

(a) 4.25×10^{-8} N C⁻¹ (b) 6.28×10^{-10} N C⁻¹
(c) 3.05×10^{-10} N C⁻¹ (d) 5.03×10^{-10} N C⁻¹
- If a charged spherical conductor of radius 10 cm has potential V at a point distance 5 cm from its centre, then the potential at a point distance 15 cm from the centre will be. 1
(a) 3 V (b) 3/2 V (c) 2/3 V (d) 1/3 V
- Four equal charges q each are placed at four corners of a square of side 'a' each. Work done in carrying a charge -q from its centre to infinity is. 1
(a) zero (b) $\frac{\sqrt{2}q^2}{\pi\epsilon_0 a}$ (c) $\frac{\sqrt{2}q}{\pi\epsilon_0 a}$ (d) $\frac{q^2}{\pi\epsilon_0 a}$

- 6 A battery is connected to the conductor of non-uniform cross-section area. The quantities or quantity which remains constant is: 1
 (a) electric field only (b) drift speed and electric field
 (c) electric field and current (d) current only
- 7 An electron is moving along positive x-axis in a magnetic field which is parallel to the positive y-axis. In which direction will the magnetic force be acting on the electron? 1
 (a) Along -x axis (b) Along -z axis (c) Along +z axis (d) Along -y axis
- 8 Two long and straight current-carrying wires, P and Q are placed parallel to each other separated by a distance of 10 cm. A wire 'R' of length 8 cm and carrying a current of 4 A is placed between the two wires P and Q as shown in fig. If the wire R, experiences a net force towards wire P, then which of the following is definitely TRUE about the current 'I' in wire Q? 1
-
- (a) Current I cannot be in the upward direction.
 (b) Current I can have any magnitude greater than 0 A in the upward direction.
 (c) Current I cannot have a magnitude of more than 15 A in the upward direction.
 (d) Current I cannot have a magnitude of more than 10 A in the upward direction.
- 9 Relative permeability of iron is 5500. Its magnetic susceptibility is 1
 (a) 5500×10^7 (b) 5499 (c) 5501 (d) 5500×10^{-7}
- 10 A 0.1 m long conductor carrying a current of 50 A is held perpendicular to a magnetic field of 1.25 mT. The mechanical power required to move the conductor with a speed of 1 m s^{-1} is 1
 (a) 62.5 mW (b) 625 mW (c) 6.25 mW (d) 12.5 mW
- 11 A solenoid with an iron core and a bulb are connected to a d.c. source. How does the brightness of the bulb change when the iron core is removed from the solenoid? 1
 (A) increases (B) decreases (C) remains same (D) first increases then decreases
- 12 The r.m.s. value of an ac of 50 Hz is 10 A. The time taken by the alternating current in reaching from zero to maximum value and the peak value of current will be 1
 (a) $2 \times 10^{-2} \text{ s}$ and 14.14 A (b) $1 \times 10^{-2} \text{ s}$ and 7.07 A
 (c) $5 \times 10^{-3} \text{ s}$ and 7.07 A (d) $5 \times 10^{-3} \text{ s}$ and 14.14 A

For Questions 13 to 16, two statements are given, one labelled **Assertion (A)** and other labelled **Reason (R)**. Select the correct answer to these questions from the options as given below.

- a) If both Assertion and Reason are true and Reason is correct explanation of Assertion.
 b) If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.
 c) If Assertion is true but Reason is false.
 d) If both Assertion and Reason are false.
- 13 **Assertion (A):** An applied electric field will polarize the polar dielectric material. 1
Reason (R): In polar dielectrics, each molecule has a permanent dipole moment, but these are randomly oriented in the absence of an externally applied electric field.
- 14 **Assertion:** It is advantageous to transmit electric power at high voltage. 1
Reason: High voltage implies high current.
- 15 **Assertion (A):** When a charged particle moves perpendicular to magnetic field then its kinetic energy and momentum gets affected. 1
Reason (R): Force changes both the magnitude and direction of velocity of charged particle.

- 16 **Assertion (A):** An electric heater is heated first by direct and then by alternating currents. For both the currents, the potential difference across the ends of the heater is the same. The rate of production of heat will be different in two cases. 1

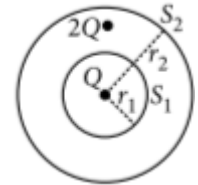
Reason (R): The resistance of a coil in alternating current will be more than the resistance of a coil in direct current, hence heat produced in case of direct current will be low.

PART B

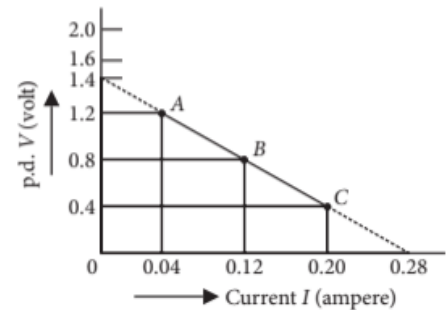
- 17 Two bodies A and B carry $-3 \mu\text{C}$ and $-0.44 \mu\text{C}$. How many electrons should be transferred from A to B so that they acquire equal charges? 2
- 18 Derive an expression for the electric field at the surface of a charged conductor and comment on the direction of the electric field. 2

OR

A sphere S_1 of radius r_1 encloses a net charge Q . If there is another concentric sphere S_2 of radius $r_2 (r_2 > r_1)$ enclosing charge $2Q$, find the ratio of the electric flux through S_1 and S_2 . How will the electric flux through sphere S_1 change if a medium of dielectric constant 5 is introduced in the space inside S_1 in place of air?



- 19 A straight-line plot showing the terminal potential difference (V) of a cell as a function of current I drawn from it is shown in the figure. Using this plot, determine (i) the emf and (ii) internal resistance of the cell. 2



- 20 Differentiate between Magnetic dipole and Electric dipole. 2

- 21 A uniform magnetic field \mathbf{B} exists in a direction perpendicular to the plane of motion of a conductor of length ' l ' translating at a velocity ' v ' as shown in the figures. 2

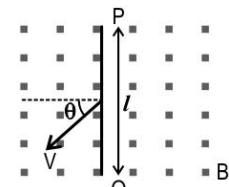
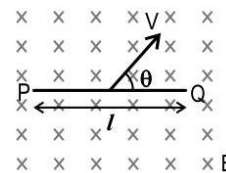


Fig a

Fig b

Write an expression for induced emf in each case. Draw a figure representing the induced emf by an equivalent battery in each case.

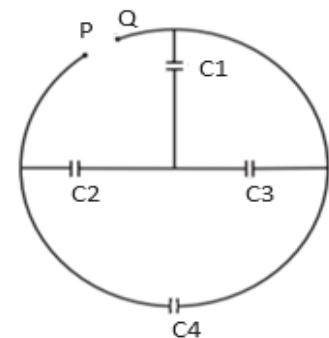
PART C

- 22 a) An electric dipole of dipole moment \vec{p} is placed in a uniform electric field \vec{E} . Obtain the expression for the torque $\vec{\tau}$ experienced by the dipole. 3

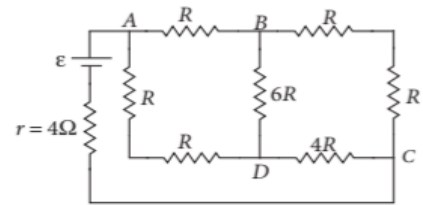
b) What happens if the field is not uniform?

- 23 a) Find the effective capacitance between points P and Q, if each capacitor has a capacitance of $6 \mu\text{F}$.

b) Find the ratio of charges on capacitors C_1 and C_4 , if the potential difference between points P and Q is 10 V. 3



- 24 A battery of internal resistance $r = 4 \Omega$ is connected to the network of resistances, as shown in figure. Find the power delivered to the network?

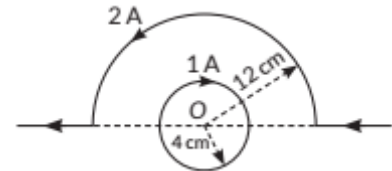


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- 25 (a) Briefly describe how the current sensitivity of a moving coil galvanometer can be increased.
 (b) A galvanometer shows full scale deflection for current I_g . A resistance R_1 is required to convert it into a voltmeter of range $(0 - 1 \text{ V})$ and a resistance R_2 is required to convert it into a voltmeter of range $(0 - 2 \text{ V})$. Find the resistance of the galvanometer.

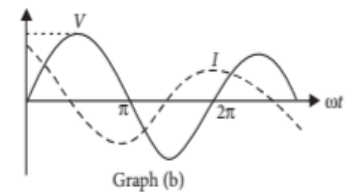
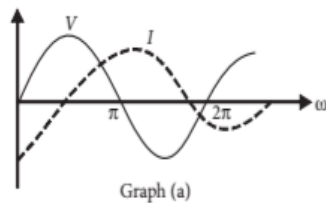
OR

A current carrying circular loop and a straight wire bent partly in the form of a semicircle are placed as shown in the figure. Find the magnitude and direction of net magnetic field at point O.



3

- 26 What are ferromagnetic materials? Explain ferromagnetism with the help of suitable diagrams, using the concept of magnetic domain.
- 27 (a) Obtain the expression for the magnetic energy stored in a solenoid in terms of magnetic field B , area A and length l of the solenoid.
 (b) How does this magnetic energy compare with the electrostatic energy stored in a capacitor?
- 28 For a series LCR circuit, connected to a sinusoidal AC voltage source, identify the graph that corresponds to $\omega > 1/\sqrt{LC}$. Give reason.



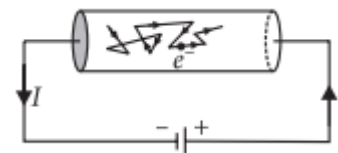
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PART D

- 29 **Mechanism of Current Flow in a Conductor:** Metals have a large number of free electrons nearly 10^{28} per cubic metre. In the absence of electric field, average terminal speed of the electrons in random motion at room temperature is of the order of 10^5 m s^{-1} . When a



a potential difference V is applied across the two ends of a given conductor, the free electron in the conductor experiences a force and are accelerated towards the positive end of the conductor. On their way, they suffer frequent collisions with the ions/atoms of the conductor and lose their gained kinetic energy. After each collision, the free electrons are again accelerated due to electric field, towards the positive end of the conductor and lose their gained kinetic energy in the next collision with the ions/atoms of the conductor. The average speed of the free electrons with which they drift towards the positive end of the conductor under the effect of applied electric field is called drift speed of the electrons.

4

(i) Magnitude of drift velocity per unit electric field is

- (a) current density (b) current (c) resistivity (d) mobility

(ii) The drift speed of the electrons depends on

- (a) dimensions of the conductor
 (b) number density of free electrons in the conductor
 (c) both (a) and (b)

(d) neither (a) nor (b)

(iii) We are able to obtain fairly large currents in a conductor because

(a) the electron drift speed is usually very large

(b) the number density of free electrons is very high, and this can compensate for the low values of the electron drift speed and the very small magnitude of the electron charge

(c) the number density of free electrons as well as the electron drift speeds are very large, and these compensate for the very small magnitude of the electron charge

(d) the very small magnitude of the electron charge has to be divided by the still smaller product of the number density and drift speed to get the electric current.

OR

(iii) Drift speed of electrons in a conductor is very small i.e., $v = 10^{-4} \text{ m s}^{-1}$. The Electric bulb glows immediately when the switch is closed because.

(a) drift velocity of electron increases when switch is closed

(b) electrons are accelerated towards the negative end of the conductor

(c) the drifting of electrons takes place at the entire length of the conductor

(d) the electrons of conductor move towards the positive end and protons of conductor move towards negative end of the conductor.

(iv) The number density of free electrons in a copper conductor is $8.5 \times 10^{28} \text{ m}^{-3}$. How long does an electron take to drift from one end of a wire 3 m long to its other end? The area of cross-section of the wire is $2.0 \times 10^{-6} \text{ m}^2$ and it is carrying a current of 3A.

(a) $8.1 \times 10^4 \text{ s}$

(b) $2.7 \times 10^4 \text{ s}$

(c) $9 \times 10^3 \text{ s}$

(d) $3 \times 10^3 \text{ s}$

30 **Radiations by Electromagnetic Waves**

Electrons oscillating in a circuit give rise to radio waves. A transmitting antenna radiates most effectively the radio waves of wavelength equal to the size of the antenna. The infrared waves incident on a substance set into oscillation all its electrons, atoms and molecules. This increases the internal energy and hence the temperature of the substance.

(i) If v_g , v_x and v_m are the speeds of gamma rays, X-rays and microwaves respectively in vacuum, then

(a) $v_g > v_x > v_m$

(b) $v_g < v_x < v_m$

(c) $v_g < v_x > v_m$

(d) $v_g = v_x = v_m$

(ii) Which of the following will deflect in electric field?

(a) X-rays

(b) gamma-rays

(c) cathode rays

(d) ultraviolet rays

(iii) gamma-rays are detected by

(a) point contact diodes

(b) thermopiles

(c) ionization chamber

(d) photocells

4

OR

(iii) The frequency of electromagnetic wave, which best suited to observe a particle of radius $3 \times 10^{-4} \text{ cm}$ is the order of

(a) 10^{15} Hz

(b) 10^{14} Hz

(c) 10^{13} Hz

(d) 10^{12} Hz

(iv) We consider the radiation emitted by the human body. Which one of the following statements is true?

(a) The radiation emitted is in the infrared region.

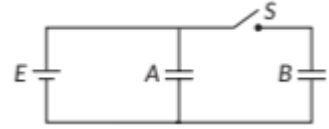
(b) The radiation is emitted only during the day.

(c) The radiation is emitted during the summers and absorbed during the winters.

(d) The radiation emitted lies in the ultraviolet region and hence it is not visible.

PART E

- 31 Two identical parallel plate capacitors A and B are connected to a battery of V volt with the switch S closed. The switch is now opened and the free space between the plates of the capacitors is filled with a dielectric of dielectric constant K . Find the ratio of the total electrostatic energy stored in both capacitors before and after the introduction of the dielectric.

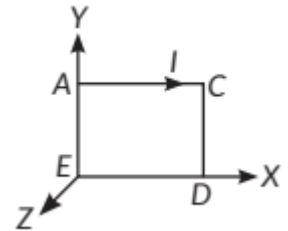


OR

- (a) Use Gauss's law to derive the expression for the electric field \vec{E} due to a straight uniformly charged infinite line of charge density $\lambda \text{ Cm}^{-1}$.
 (b) Draw a graph to show the variation of E with perpendicular distance r from the line of charge.
 (c) Two long straight parallel wires carry charges λ_1 and λ_2 per unit length. The separation between their axes is d . Find the magnitude of the force exerted on unit length of one due to the charge on the other.

5

- 32 (i) An α -particle, a deuteron and a proton enter a uniform magnetic field normally with the same kinetic energy and describe circular paths. Find the ratio of radii of their paths.
 (ii) Give the direction of magnetic field acting on the current carrying coil ACDE shown in the figure so that the coil is in unstable equilibrium.



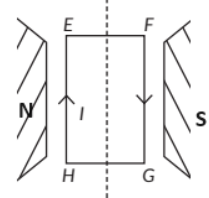
- (iii) Why do we use a low resistance ammeter in a circuit to measure current?

OR

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- (a) Two straight long parallel conductors carry currents I_1 and I_2 in the same direction. Deduce the expression for the force per unit length between them. Depict the pattern of magnetic field lines around them.

- (b) A rectangular current carrying loop EFGH is kept in a uniform magnetic field as shown in the figure.



- (i) What is the direction of the magnetic moment of the current loop?
 (ii) When is the torque acting on the loop: (A) maximum, (B) zero?

- 33 (a) In a series LCR circuit connected across an AC source of variable frequency, obtain the expression for its impedance, and draw a plot showing its variation with frequency of the AC source.

- (b) What is the phase difference between the voltages across inductor and the capacitor at resonance in the LCR circuit?

- (c) When an inductor is connected to a 200 V dc voltage, a current of 1 A flows through it. When the same inductor is connected to a 200 V, 50 Hz ac source, only 0.5 A current flows. Explain, why? Also, calculate the self-inductance of the inductor.

5

OR

- (a) A lamp is connected in series with a capacitor. Predict your observations for d.c. and a.c. connections. What happens in each case if the capacitance of the capacitor is reduced?

- (b) A coil of 0.01 henry inductance and 1 ohm resistance is connected to 200-volt, 50 Hz ac supply. Find the impedance of the circuit and time lag between maximum alternating voltage and current.

[$\tan^{-1}(3.14) = 72^\circ$]