COMPETENCY-FOCUSED PRACTICE QUESTIONS

ISC-CLASS XII

PHYSICS

PREFACE

With a growing emphasis on competency-based education globally, the educational landscape in India has also steered towards high-quality learning experiences that allow learners to incorporate critical thinking and problem-solving approaches. This approach goes beyond rote memorisation and focuses on developing the skills and knowledge that students need to apply in their real-world scenarios.

The Council for the Indian School Certificate Examinations (CISCE), as a national-level progressive examination board, has taken several steps to infuse competency-based education in CISCE schools through teacher capacity-building on item development for competency-based assessments and the incorporation of competency-focused questions at the ICSE and ISC levels from the examination year 2024.

To further facilitate the adoption of competency-based assessment practices in schools and to support teachers and students towards the preparation for attempting higher-order thinking questions in future board examinations, Item Banks of **Competency-Focused Practice Questions** for selected subjects at the ICSE and ISC levels have been developed. This Item Bank consists of a rich variety of questions, both objective and subjective in categories, aimed at enhancing the subject-specific critical and analytical thinking skills of the students.

In this Item Bank, each question is accompanied by the topic and cognitive learning domain/s that it intends to capture. The cognitive domains reflected in these questions include understanding, analysis, application, evaluation and creativity, along with some questions of the higher-order recall domain. The Answer Key at the end presents the possible answers to a given question, but it is neither limiting nor exhaustive.

These practice questions are also meant to serve as teacher resources for classroom assignments and as samplers to develop their own repository of competency-focused questions. Apart from offering a good practice of higher-order thinking skills, engaging with these questions would allow students to gauge their own subject competencies and use these *assessments for learning* to develop individual learning pathways.

During the development of this Item Bank, a large pool of questions was prepared by a team of experienced CISCE teachers. The questions that were finalised by the internal and external reviewers as being higher-order competency-focused questions have been collated in this item bank.

I acknowledge and appreciate all the ICSE and the ISC subject matter experts who have contributed to the development and review of these high-quality competency-focused questions for CISCE students.

We are hopeful that teachers and students will utilise these questions to support their teaching-learning processes.

August 2024

Dr. Joseph Emmanuel
Chief Executive & Secretary
CISCE

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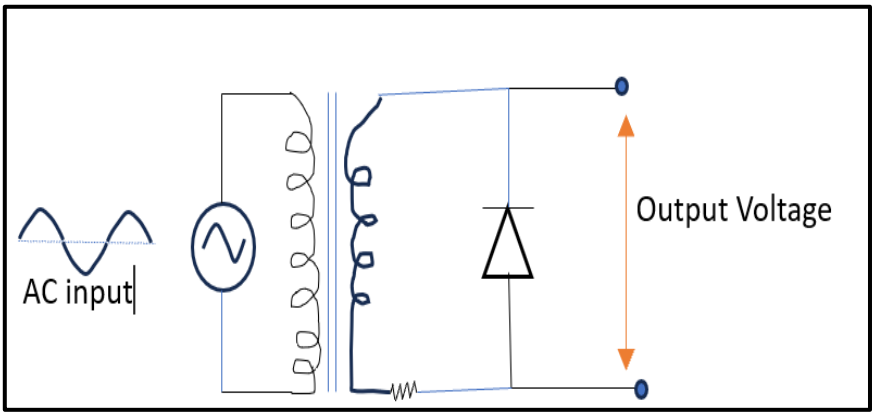
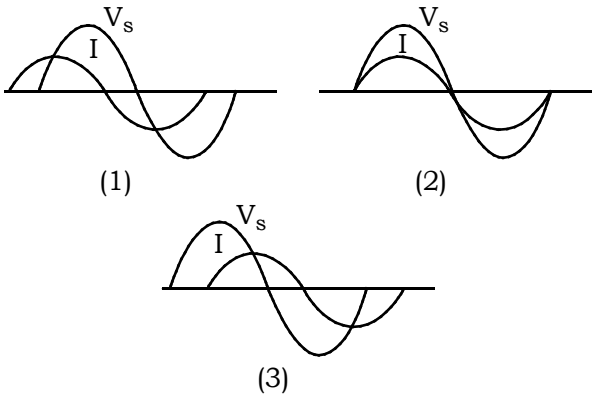
COMPETENCY-FOCUSED PRACTICE QUESTIONS

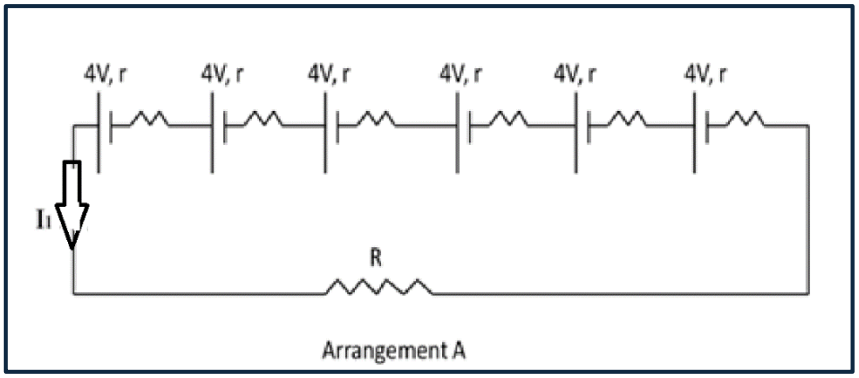
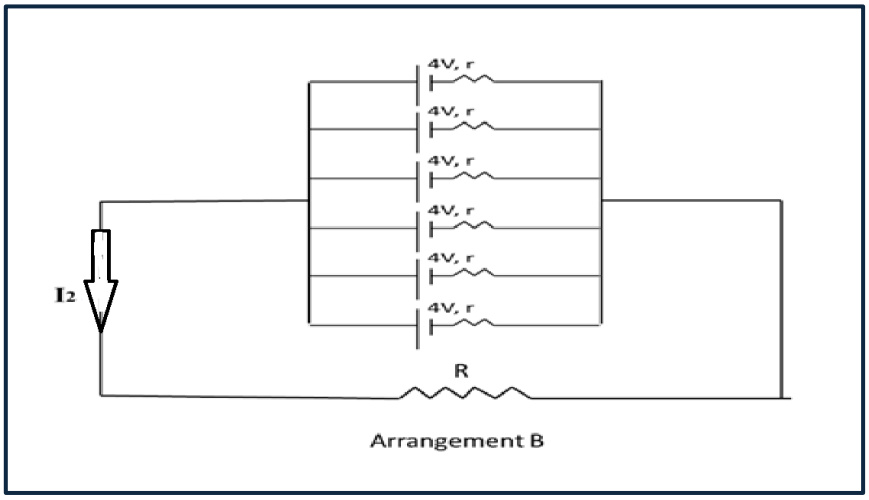
ISC-CLASS XII

Physics

I: Multiple Choice Questions (1 Mark Each)

S.No.	Questions
1.	***[Optics]*** Three lenses L_1, L_2, and L_3 are specified in the given table below. To construct an astronomical telescope, which one of the following is to be used as an eyepiece and as an objective? **Lens** | **Aperture (cm)** | **Power (D)** L_1 | 8 | 3 L_2 | 1 | 10 L_3 | 1 | 6 (a) L_1, L_2 (b) L_2, L_1 (c) L_2, L_3 (d) L_3, L_1 **(Analysis)**
2.	***[Magnetic Effects of Current and Magnetism]*** An ideal Moving Coil Galvanometer (MCG) cannot be used as an ammeter to measure the value of current in a given circuit. The following reasons are: (i) it has a high current sensitivity value. (ii) for a minimal amount of current the galvanometer deflection will be maximum. (iii) it has a low least count. (a) (i) and (ii) (b) (i) and (iii) (c) (ii) and (iii) (d) (i), (ii), and (iii) **(Analysis)**

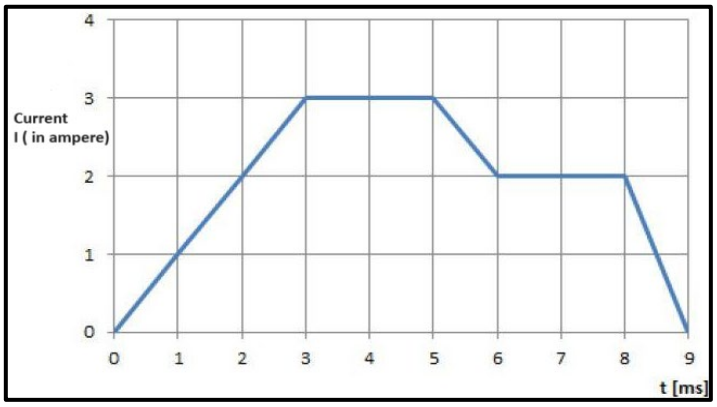
S.No.	Questions
3.	***[Electronic Devices]*** What will be the output for the given circuit?  (a) Zero (b)  (c)  (d)  **(Understanding)**
4.	***[Electromagnetic Induction and Alternating Currents]*** The graphs shown below are for three different Inductance, Capacitance, and Resistance (LCR) circuits. Identify their nature based on the phase difference between V_S and I.  (a) Inductive, Capacitive, and Resistive. (b) Capacitive, Resistive, and Inductive. (c) Resistive, Capacitive, and Inductive. (d) Inductive, Resistive, and Capacitive. **(Understanding)**

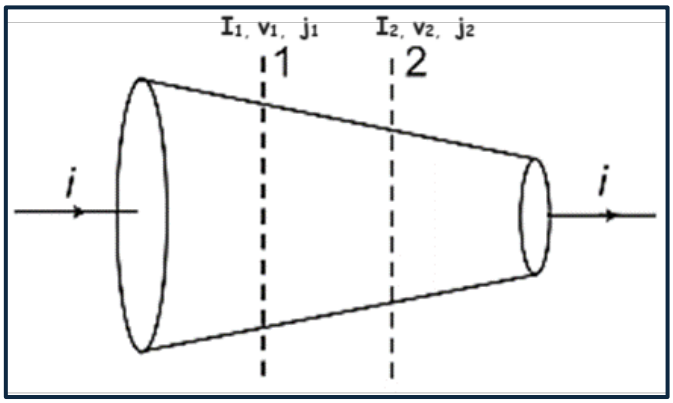
S.No.	Questions
5.	***[Current Electricity]*** Sheetal had 6 identical cells, each of electromotive force (emf) 4 V and internal resistance 'r'. She connected them to an external resistor 'R' in two different arrangements as shown and measured the current as 'I_1' and 'I_2' respectively.   If 'I_2' is found to be greater than 'I_1', then which relation is *true*? (a) R > r (b) R = r (c) R < r (d) R = 6r **(Application)**
6.	***[Magnetic Effects of Current and Magnetism]*** Lorenz's force is: (a) the vector sum of electrostatic and magnetic force acting on a moving charged particle. (b) the sum of electrostatic and magnetic force acting on a moving charged particle. (c) electrostatic force acting on a charged particle only. (d) the magnetic force acting on a moving charged particle only. **(Understanding)**

S.No.	Questions
7.	***[Magnetic Effects of Current and Magnetism]*** A charged particle is moving with velocity '$\vec{v}$' in a magnetic field of induction $\overrightarrow{'B'}$. The force on the particle will be maximum when: (a) '$\vec{v}$' and $\overrightarrow{'B'}$ are at an angle of 45°. (b) '$\overrightarrow{v'}$ and $\overrightarrow{'B'}$ are perpendicular. (c) $\overrightarrow{v'}$ and $\overrightarrow{'B'}$ are in the same direction i.e., at an angle of 0^0. (d) '$\overrightarrow{v'}$and $\overrightarrow{'B'}$ are in opposite directions i.e., at an angle of 180^0. **(Analysis)**
8.	***[Magnetic Effects of Current and Magnetism]*** Ampere's circuital law states that: (a) the line integral of a magnetic field along the boundary of the closed loop is equal to μ_0 times the total current passing near the surface. (b) the line integral of a magnetic field along the boundary of the closed loop is equal to μ_0 times the total current passing through the surface. (c) the surface integral of the magnetic field over the closed loop is equal to μ_0 times the total current passing through the surface. (d) the surface integral of the magnetic field over the closed loop is equal to μ_0 times the total current passing near the surface. **(Recall)**
9.	***[Electromagnetic Induction and Alternating Currents]*** The magnetic induction at any point due to a long straight wire carrying a current is: (a) inversely proportional to the distance from the wire. (b) inversely proportional to the square of the distance from the wire. (c) does not depend on distance. (d) proportional to the distance from the wire. **(Recall)**
10.	***[Atoms and Nuclei]*** The energy of an electron in the ground state of a hydrogen atom is −13.6 eV. What will be the ratios of energies in the first orbit to that in the second orbit, if the radius of the first orbit is r_1 and the second radius is r_2? (a) $r_1^2 : r_2^2$ (b) $r_1 : r_2$ (c) $r_2 : r_1$ (d) $r_2^2 : r_1^2$ **(Application)**

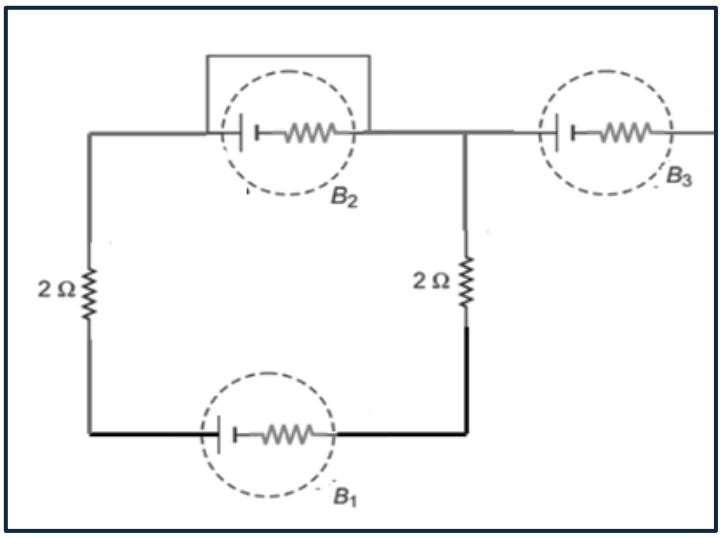
S.No.	Questions
11.	***[Atoms and Nuclei]*** Which of the following is **NOT** a limitation of Bohr's theory? (a) It does not include the electrical forces between electrons which necessarily appear in multi-electron atoms. (b) The model is unable to explain the relative intensities of the frequencies in the spectrum. (c) In a hydrogen atom, an electron revolves in certain stable orbits without the emission of radiant energy. (d) It cannot explain the characteristic line spectra of atoms of different elements. **(Analysis)**
12.	***[Dual Nature of Radiation and Matter]*** It was found that certain metals like Zinc, Cadmium, Magnesium, etc. are photosensitive only to ultraviolet light. However, some alkali metals such as Lithium, Sodium, and Potassium, were photosensitive even to visible light. If ultraviolet light of the same frequency and the same intensity is incident on Zinc and Sodium metal, then which of the following quantities may be the same? (a) Kinetic energy of the photoelectrons emitted by the two metals. (b) Photoelectric current flowing through the two metals. (c) Stopping potential. (d) The potential energy of the photoelectrons emitted by the two metals. **(Analysis)**
13.	***[Electromagnetic Induction and Alternating Currents]*** An alternating current (a.c.) voltage source at 50 Hz is applied to a series combination of resistor A of resistance 'P' and component B of reactance 'Y'. The phase angle is $+\frac{\pi}{4}$. Which of the following is *true*? (a) B is a capacitor and Y = 2P. (b) B is an inductor and Y = 2P. (c) B is a capacitor and Y = P. (d) B is an inductor and Y = P. **(Analysis)**

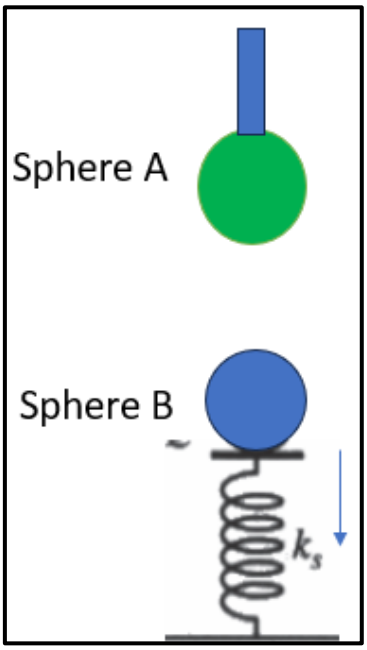
S.No.	Questions
14.	***[Electromagnetic Induction and Alternating Currents]*** Consider an alternating current (a.c.) source whose angular frequency (ω) changes constantly but has a fixed peak voltage 'V'. This source is connected to an ideal capacitor (C) and electric bulb of resistance 'R'. When (ω) starts to reduce gradually, then which of the following condition happens? (a) The bulb starts to dim. (b) The bulb starts to glow brighter than before. (c) The brightness of the bulb is independent of changes in (ω). (d) The bulb will fuse out. **(Application)**
15.	***[Electromagnetic Waves]*** The speed of electromagnetic waves in free space is given by (in usual notations): (a) $\sqrt{\epsilon_0\mu_0}$ (b) $\frac{1}{\sqrt{\epsilon_0\mu_0}}$ (c) $\sqrt{\epsilon\mu}$ (d) $\frac{1}{\sqrt{\epsilon\mu}}$ **(Recall)**
16.	***[Electromagnetic Waves]*** Which of the following statement is *true*? (a) According to both Maxwell's electromagnetic theory and Huygens's wave theory, light is treated as a wave in nature and requires a medium to travel. (b) According to both Maxwell's electromagnetic theory and Huygens's wave theory, light is treated as a particle in nature and requires a medium to travel. (c) According to both Maxwell's electromagnetic theory and Huygens's wave theory, light is treated as a wave in nature and does not require a medium to travel. (d) According to Maxwell's electromagnetic theory, light is treated as a wave in nature and requires no medium to travel. However, according to Huygens's theory, light is treated as a wave in nature and requires a medium to travel. **(Recall)**

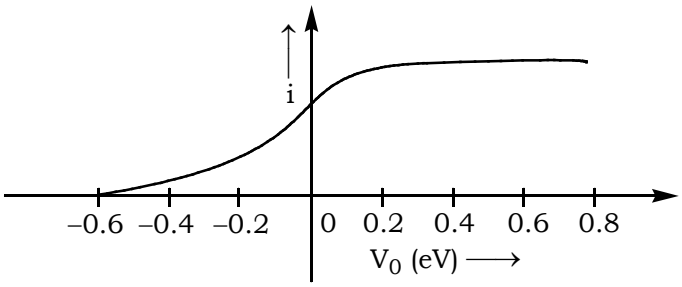
S.No.	Questions
17.	***[Current Electricity]*** The current passing through a wire varies with time as provided below.  The charge passing through the wire from 0s to 5s is: (a) 12.5 mC (b) 9 mC (c) 4.5 mC (d) 10.5 mC **(Evaluate)**

S.No.	Questions
18.	***[Current Electricity]*** A current I is flowing through a wire of non-uniform cross-section as shown in the figure. Which of the following options gives the correct variation of current (i), drift velocity (v), and current density (j) across the wire?  **(Evaluate)**

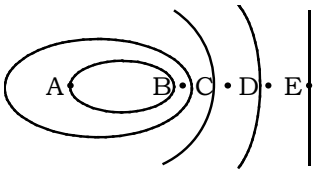
S.No.	Current	Current density	Drift velocity
(a)	$I_1 > I_2$	$j_2 = j_1$	$v_2 < v_1$
(b)	$I_1 = I_2$	$j_2 > j_1$	$v_2 > v_1$
(c)	$I_1 < I_2$	$j_2 < j_1$	$v_2 = v_1$
(d)	$I_1 = I_2$	$j_2 = j_1$	$v_2 = v_1$

S.No.	Questions
19.	***[Current Electricity]*** Each of the batteries connected in the circuit is of electromotive force (emf) 4V and internal resistance of 1 ohm. What is the potential difference across the battery B_2?  (a) 0 V (b) 2.67 V (c) 4 V (d) 1.33 V **(Application)**

S.No.	Questions
20.	***[Electrostatics]*** A non-conducting sphere A, attached to an insulated handle is given a charge +q. It is brought near a non-conducting sphere B, having a charge +Q, placed on a platform attached to a spring and placed at a vertical distance R from sphere B. The spring compresses by a distance d_1. Now, if sphere B is replaced by a similar conducting sphere and sphere A is brought vertically at the same distance from B, without touching it, the spring compresses by a distance d_2.  Choose the *correct* option based on the above situation and diagram: (a) $d_2 > d_1$ (b) $d_2 < d_1$ (c) $d_2 = d_1$ (d) insufficient information to compare d_2 and d_1. **(Application)**

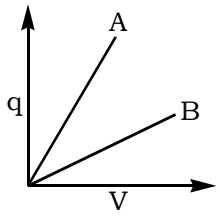
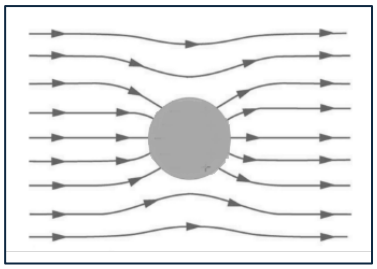
S.No.	Questions
21.	***[Dual Nature of Radiation and Matter]*** The work function of caesium metal is 2.04 eV and a graph between the variation of photoelectric current with a collector plate potential of caesium, for incident radiation is given below. If the frequency of the incident radiation is doubled, which of the following combinations is *correct?*  **S.No. / Work function / Stopping potential** (a) 2.04eV -0.6 V (b) 4.08 eV -0.6V (c) 4.08eV −3.24V (d) 2.04eV −3.24V **(Analysis)**

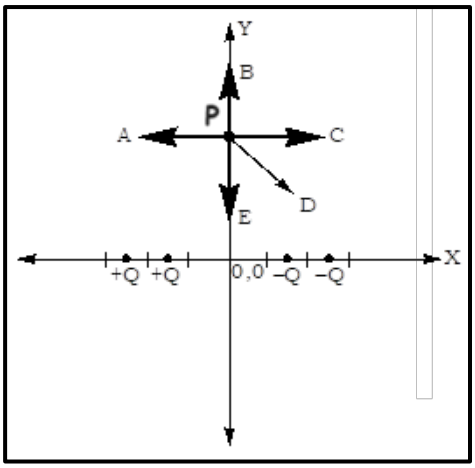
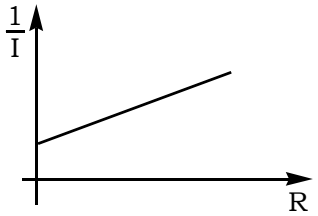
II. Assertion-Reason Questions (1 Mark Each)

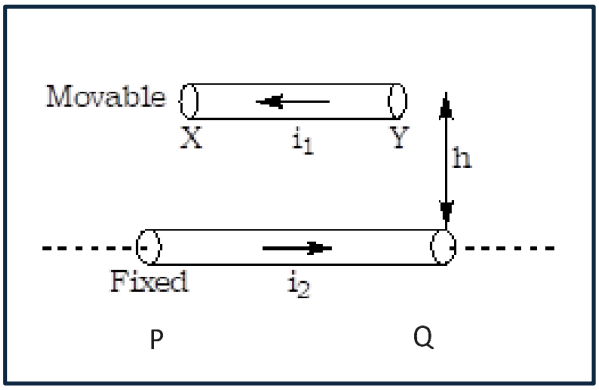
S.No.	Questions
22.	*[Electrostatics]* The diagram below shows the equipotential surfaces in a given region of space. The potential difference between any two consecutive surfaces is equal. There are five points marked in the space, namely A, B, C, D, and E as shown.  **Assertion (A):** The electric field strength is greatest at point A and reduces from A to E. **Reason (R):** The potential difference in a region of space is equal to the negative electric field gradient in that region. (a) Both Assertion and Reason are true, and Reason is the correct explanation for Assertion. (b) Both Assertion and Reason are true, but Reason is not the correct explanation for Assertion. (c) Assertion is true, and Reason is false. (d) Both Assertion and Reason are false. **(Analysis)**
23.	*[Magnetic Effects of Current and Magnetism]* **Assertion (A):** In a ferromagnetic material, all the atomic magnets have dipole moments in the same direction. **Reason (R):** It is due to strong exchange coupling between neighbouring atoms in a domain. (a) Both Assertion and Reason are true, and Reason is the correct explanation for Assertion. (b) Both Assertion and Reason are true, but Reason is not the correct explanation for Assertion. (c) Assertion is false, and Reason is true. (d) Both Assertion and Reason are false. **(Understanding)**

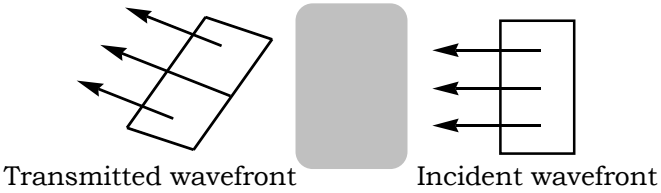
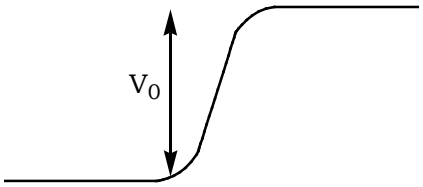
S.No.	Questions
24.	***[Optics]*** **Assertion (A):** The graph for 'v' versus 'u' of a concave mirror forming real images, falls within the second quadrant. **Reason (R):** For concave mirrors, according to the sign convention for real images, 'u' is negative, and 'v' is positive. (a) Both Assertion and Reason are true, and Reason is the correct explanation for Assertion. (b) Both Assertion and Reason are true, but Reason is not the correct explanation for Assertion. (c) Assertion is true, and Reason is false. (d) Both Assertion and Reason are false. **(Application)**
25.	***[Atoms and Nuclei]*** **Assertion (A):** The wave nature of matter is what prevents atoms from collapsing and gives atoms their sizes. **Reason (R):** Only those orbits where the circumference of the orbit is an integral multiple of de Broglie wavelength exist or are "allowed." And it is not possible lower than the lowest orbit in an atom. (a) Both Assertion and Reason are true, and Reason is the correct explanation for Assertion. (b) Both Assertion and Reason are true, but Reason is not the correct explanation for Assertion. (c) Assertion is true, and Reason is false. (d) Both Assertion and Reason are false. **(Analysis)**

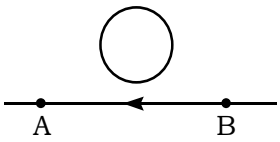
III: Very Short Answer Questions (1 Mark Each)

S.No.	Questions
26.	***[Electrostatics]*** The given graph shows the variation of charge on plates (q) versus the potential difference (V) between the plates of two capacitors C_1 and C_2. Both the capacitors have the same plate area but the plate separation of C_1 is twice that of C_2. Which graph corresponds to C_1?  **(Analysis)**
27.	***[Electrostatics]*** A hollow sphere made of material 'X' is placed in a region of electric field. The pattern of electric field lines around the sphere is observed to be like the figure shown below.  Plot the resistivity versus temperature graph for the material of the sphere. **(Analysis)**

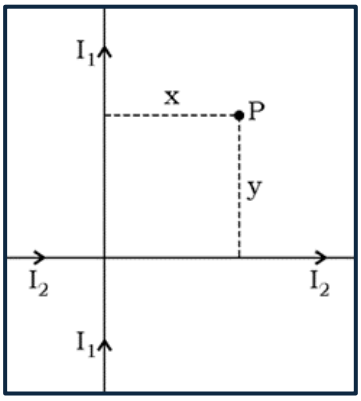
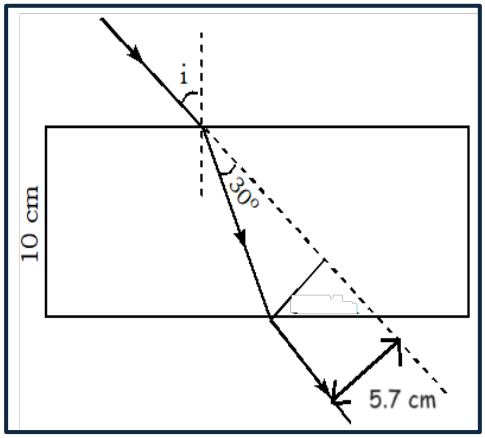
S.No.	Questions
28.	***[Electrostatics]*** Four charges +Q, +Q, −Q, and –Q are placed in an arrangement as shown. The direction of the net electric field at a point 'P' (on the diagram) is best indicated by which of the following vectors: A, B, C, D, or E?  **(Understanding)**
29.	***[Electrostatics]*** Using a cell of electromotive force (e.m.f.) ε and internal resistance 'r', a student designs an electrical circuit to calculate current 'I' through a variable resistor 'R'. The student plots her findings on a graph as shown.  What does the slope of the graph indicate? **(Evaluate)**

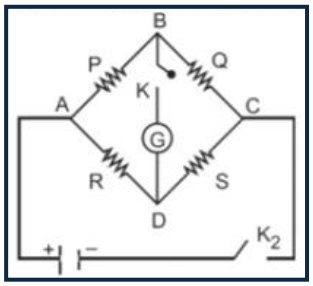
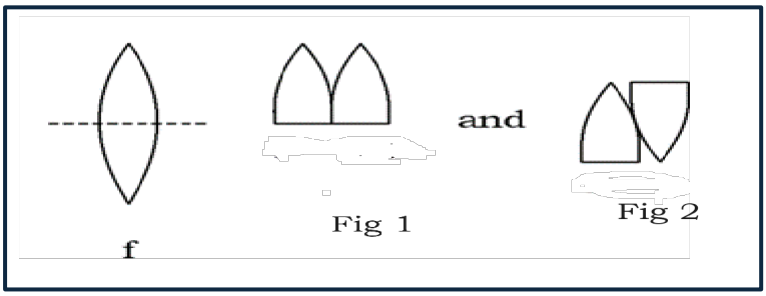
S.No.	Questions
30.	***[Magnetic Effects of Current and Magnetism]*** A finite-length **Movable** wire (**XY**) carrying current $\mathbf{i_1}$ is kept parallel to another infinite-length **Fixed** wire (**PQ**) carrying current $\mathbf{i_2}$ **above** it. In this setup, the **Movable** wire (**XY**) is **stationary** as depicted below.  Redraw a new setup such that the Movable wire (**XY**) remains **stationary** and is placed parallel **below** the **Fixed** wire (**PQ**) carrying current $\mathbf{i_2}$. Label the direction of current $\mathbf{i_1}$ in the **Movable** wire (**XY**). **(Create)**
31.	***[Magnetic Effects of Current and Magnetism]*** A charge 10 μC enters a region of the uniform magnetic field with a velocity (4i + 5j) m/s and experiences a force (5i−Cj) N. Find the value of 'C'. **(Analysis & Evaluate)**
32.	***[Magnetic Effects of Current and Magnetism]*** A galvanometer of resistance 3G can carry a maximum current of 25 mA. Calculate the value of shunt resistance to be used so that it works as an ammeter to read the current up to 0.1 A. **(Application)**
33.	***[Magnetic Effects of Current and Magnetism]*** In the X - Y plane, a magnetic field of 4 T is applied along the Y-axis. Calculate the magnetic force on a proton, if it moves at 3×10^6 m/s along the +Y-axis. **(Application)**
34.	***[Optics]*** How is the refractive index of the material of a prism dependent on the angle of incidence? **(Understanding)**

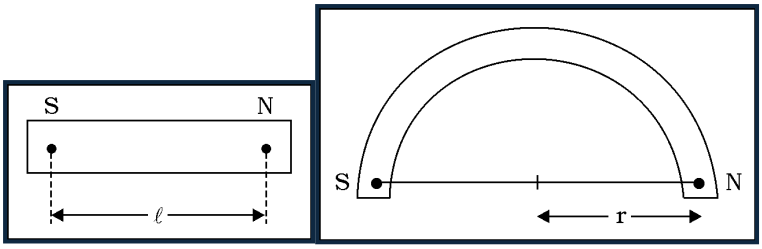
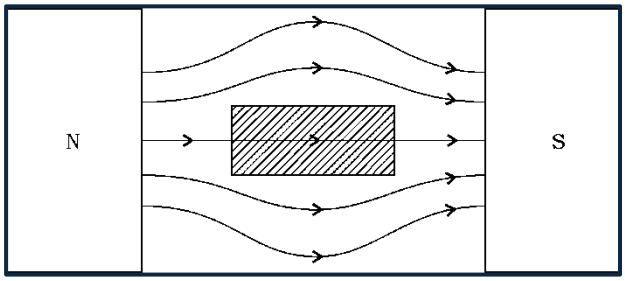
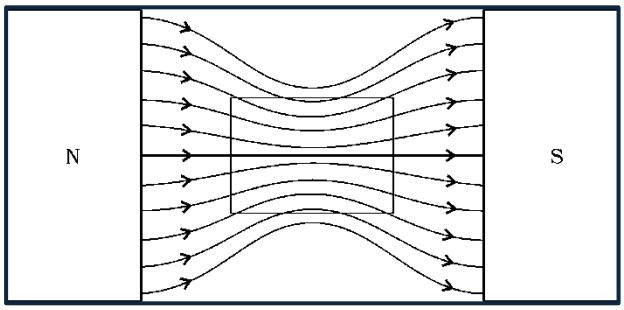
S.No.	Questions
35.	***[Optics]*** If you had to construct an optical fibre using the two materials, which would you prefer for the core and the cladding? X: with a refractive index of 1.4905 or Y: of refractive index of 1.337? **(Analysis)**
36.	***[Optics]*** A lens forms the image of an object as shown in the figure. Identify the type of lens.  **(Application)**
37.	***[Optics]*** Redraw the diagram with the correct orientation of the obscured (hidden) optical device, so that when a plane wavefront is incident upon it, the transmitted wavefront matches the depicted figure.  **(Create)**
38.	***[Electronic Devices]*** A light-emitting diode (LED) is connected in forward biasing. If its potential barrier is given by 'V_0' when no biasing is there, as shown in the diagram, then draw the diagram showing the new position of potential barrier.  **(Understanding)**
39.	***[Dual Nature of Radiation and Matter]*** An electron is revolving around the nucleus of a hydrogen atom. If the radius of the first orbit is 0.53×10^{-10} m, calculate the de Broglie wavelength of the moving electron in the orbit. **(Application)**

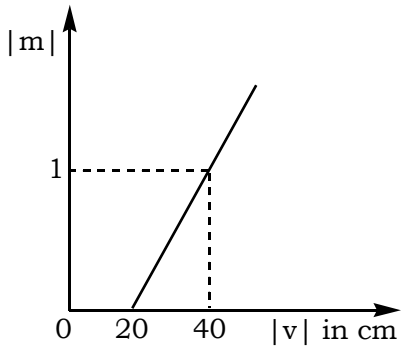
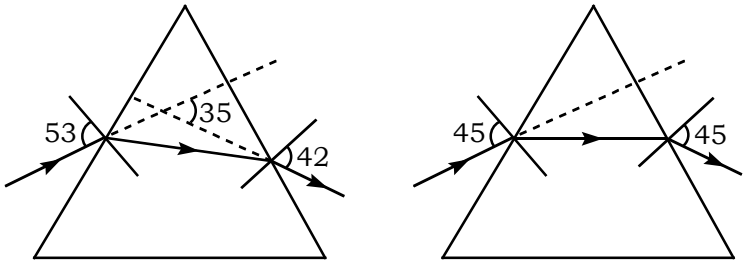
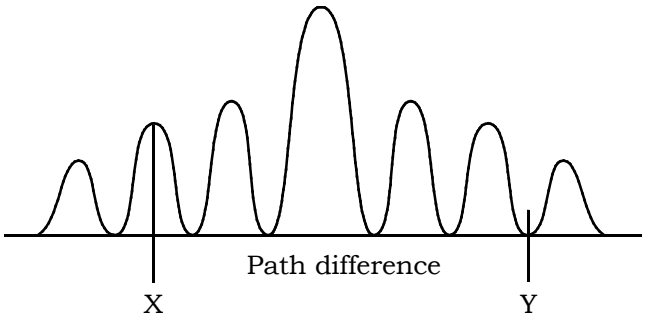
S.No.	Questions
40.	***[Atoms and Nuclei]*** A 9.2 eV electron beam is used to bombard gaseous hydrogen at room temperature. What series of wavelengths will be emitted if any? **(Application)**
41.	***[Dual Nature of Radiation and Matter]*** Calculate the wavelength of a photon needed to ionize a hydrogen atom. **(Application)**
42.	***[Atoms and Nuclei]*** The kinetic energy of an α-particle incident on a gold foil is doubled. How does the distance of the closest approach change? **(Application)**
43.	***[Magnetic Effects of Current and Magnetism]*** The electric current flowing in a wire in the direction B to A is decreasing. What is the direction of the induced current in the metallic loop kept above the wire, as shown in the figure?  **(Analysis)**
44.	***[Magnetic Effects of Current and Magnetism]*** A circular coil of radius 8 cm and 20 turns rotates about its vertical diameter with an angular speed of 50 s^{-1} in a uniform horizontal magnetic field of magnitude 3×10^{-2} T. Obtain the average electromotive force (e.m.f.) induced in the coil in each rotation. **(Evaluate)**
45.	***[Electromagnetic Induction and Alternating Currents]*** Give the expression for the power factor in an LR circuit in terms of the resistance 'R' and inductive reactance 'X_L'. **(Recall)**

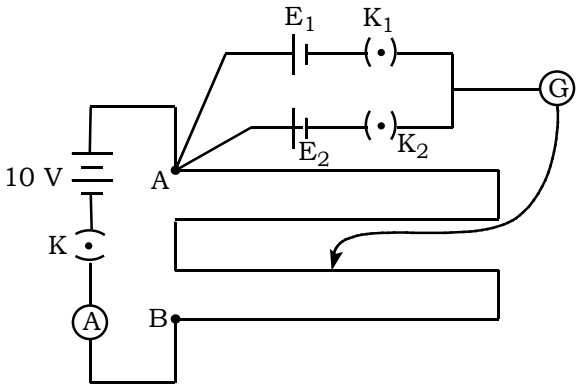
IV: Short Answer Questions (2 Marks Each)

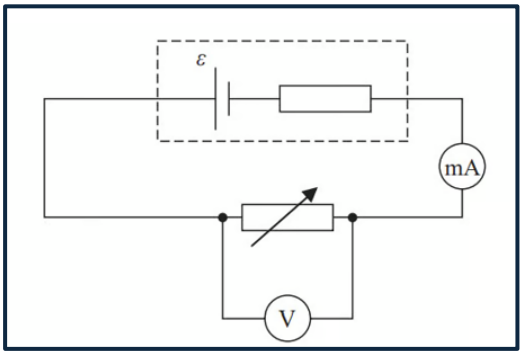
S.No.	Questions
46.	***[Electromagnetic Induction and Alternating Currents]*** Two long wires carrying current are kept crossed (not touching each other) as shown in figure. If resultant magnetic induction at P is zero, then find the relation between I_1 and I_2.  **(Application)**
47.	***[Optics]*** Which material is used to make this glass slab? Material | Refractive Index Zircon | 1.96 – 2.01 Sapphire | 1.76 – 1.77 Peridot | 1.65 – 1.69 Tourmaline | 1.62 – 1.64  **(Analysis)**

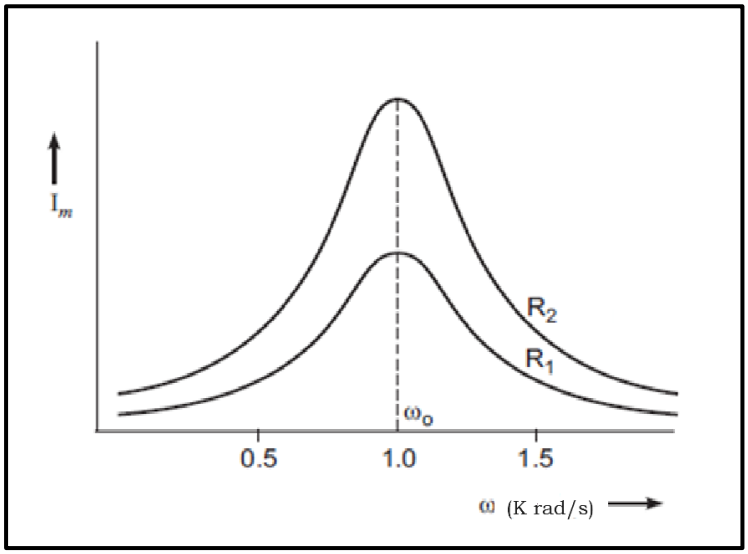
S.No.	Questions
48.	***[Electrostatics]***  In a Wheatstone bridge, three resistances P, Q, and R are connected in the three arms, and the fourth arm is formed by two resistances S1 and S2 connected in parallel. Evaluate the new condition for the bridge to be balanced. **(Create)**
49.	***[Optics]***  A thin convex lens of focal length **f** is cut into parts and then combined as shown in Fig 1 and Fig 2. Evaluate the focal length of the combination, in: (a) figure 1 (b) figure 2 **(Evaluate)**
50.	***[Dual Nature of Radiation and Matter]*** A changing electric field produces a magnetic field and vice versa, resulting in an electromagnetic wave. If a charged particle is passed through a crossed field, under what circumstances will this charge experience no deviation? Also, obtain a formula that proves that electromagnetic (e.m.) waves carry both energy and momentum. **(Analysis)**

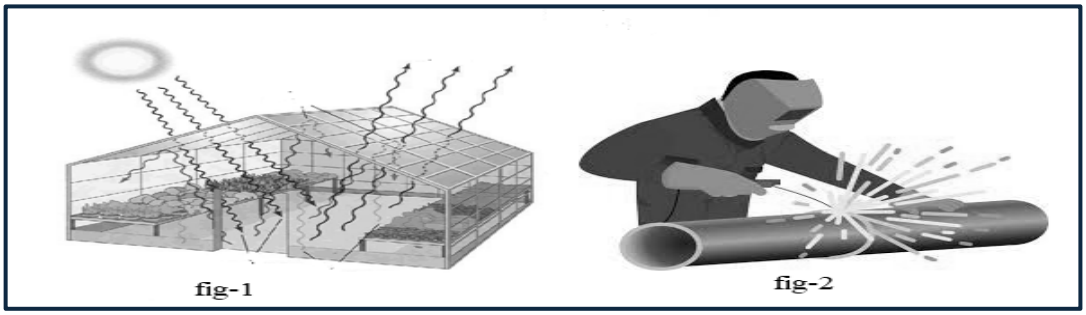
S.No.	Questions
51.	***[Electromagnetic Induction and Alternating Currents]*** The first diagram depicts a bar magnet of pole strength 'm' and separation between the poles 'ℓ'. If the magnetic moment in the first diagram is 'M', then the new magnetic dipole moment in the second diagram is:  Diagram 1 Diagram 2 **(Analysis)**
52.	***[Electromagnetic Induction and Alternating Currents]*** Observe the two diagrams and state which diagram corresponds to diamagnetic and ferromagnetic.  Figure 1  Figure 2 **(Understanding)**

S.No.	Questions
53.	***[Electromagnetic Induction and Alternating Currents]*** A long straight wire in the horizontal plane carries a current of 50 A in the north-to-south direction. Give the magnitude and direction of 'B' at a point 2.5 m east of the wire. **(Application)**
54.	***[Optics]***  (a) Name the type of mirror used here. (b) What is its focal length? **(Application)**
55.	***[Optics]***  Calculate the refractive index of the material of the prism. **(Evaluate)**
56.	***[Optics]*** Give the values of X and Y in terms of λ and the corresponding phase difference.  **(Application)**

S.No.	Questions
57.	***[Current Electricity]*** Two cells of electromotive forces (e.m.f.s.) approximately 5 V and 10 V are to be accurately compared using a potentiometer of length 400 cm. The student sets up the circuit as shown in the diagram. However, he is not able to measure the ratio of e.m.f.s correctly. Analyse the circuit shown and spot a minimum of *two* errors in the circuit. Explain with proper reasoning.  **(Analysis)**
58.	***[Electrostatics]*** A student wants to place three charges '−q', 'Q', and '−q' in such a way that the potential energy of the system is zero. The three charges are arranged in a straight line at an equal distance from each other. Calculate the ratio of 'Q' to 'q' for such an arrangement. **(Evaluate)**

S.No.	Questions
59.	***[Current Electricity]*** The student sets up an experiment in the lab to determine the internal resistance of a cell by graphical method. The setup of the circuit is done as shown below using a cell of e.m.f. 'E' and internal resistance 'r', a variable resistor 'R', and a milliammeter. A voltmeter 'V' is connected to the circuit as shown.  (a) Draw the nature of the graph so determined. What does the Y-intercept of the graph represent? (b) How can internal resistance be calculated from the graph? **(Evaluate)**
60.	***[Dual Nature of Radiation and Matter]*** Images produced by positron emitters have become important in recent years. When the emitted positron (β^+) encounters an electron, mutual annihilation occurs, producing two γ-rays. These rays have identical 0.511 MeV energies and they move directly away from one another, allowing detectors to determine their point of origin accurately. The system is called positron emission tomography (PET). It requires detectors on opposite sides to simultaneously (i.e., at the same time) detect photons of 0.511-MeV energy and utilises computer imaging techniques similar to those in SPECT and computed tomography (CT) scans. Its resolution of 0.5 cm is better than that of Single-photon emission computed tomography (SPECT); the accuracy and sensitivity of PET scans make them useful for examining the brain's anatomy and function. (a) Why two 'γ' photons are produced? (b) Why energy of each produced 'γ' photon is 0.511 MeV? **(Application)**
61.	***[Atoms and Nuclei]*** In the first atomic bomb, the energy released was equivalent to about 30 kilotons of Trinitrotoluene (TNT), where a ton of TNT releases an energy of about 4×10^9 J. Estimate the amount of mass converted into energy in this event. **(Application)**

S.No.	Questions
62.	***[Atoms and Nuclei]*** Draw a graph showing the variation of binding energy (in eV) versus the first five principal quantum numbers in a hydrogen atom. **(Application)**
63.	***[Electromagnetic Induction and Alternating Currents]*** An inductor-resistor circuit (LR) series circuit connected to an alternating current (a.c.) source of 220 V, 50 Hz, the resistor value is 11 ohms, and the power factor is $\frac{1}{\sqrt{2}}$. Calculate the value of inductance in the circuit. **(Recall)**
64.	***[Electromagnetic Induction and Alternating Currents]*** The graph here shows a variation of I_{rms} with angular frequency 'ω' for two different LCR circuits. Which of the *two* will have: (a) lower power factor. (b) calculate resonance frequency for the two different LCR circuits.  **(Application)**

S.No.	Questions
65.	***[Electromagnetic Waves]*** Analyse the figures given below and mention the significance of electromagnetic waves in each case.  fig-1 fig-2 **(Understanding)**

V. Long Answer Questions (3 Marks Each)

S.No.	Questions
66.	***[Magnetic Effects of Current and Magnetism]*** A synchrotron uses a combination of solenoid and toroid to generate high magnetic fields. Charged particles like electrons and protons can be accelerated to very high energies using a synchrotron. A synchrotron adjusts the magnetic field such that the particles are kept in a circular orbit. It is used to study high-energy particle collisions. (a) If the magnetic field is parallel to the positive Y-axis and the charged particle is moving along the positive X-axis, which way would the Lorentz force be for: (i) an electron. (ii) a proton. (b) An electron does not suffer any deflection while passing through a region of uniform magnetic field. What is the direction of the magnetic field? **(Application)**
67.	***[Optics]*** Both students i.e. Student 1 and Student 2, had an intention of stargazing at night and knew that a telescope would be required for viewing distant stars. Student 1 visited a shop to purchase the necessary equipment for stargazing and purchased two lenses X and Y, the former being thicker and the latter thinner. On the other hand, Student 2 opted for a different approach. He decided to build his telescope by combining a concave mirror of focal length 25 cm and a plane mirror, along with a convex lens of focal length 5 cm. (a) Which lens would Student 1 use as an objective, X or Y? (b) Give *any one* advantage of the telescope of Student 2 over the telescope of Student 1. (c) What is the length of the telescope of Student 1 when the final image is formed at infinity, assuming she uses the same eyepiece as Student 2 but achieves twice the magnifying power? **(Understanding)**

<table>
<tr><th>S.No.</th><th>Questions</th></tr>
<tr><td>68.</td><td>[Electrostatics]

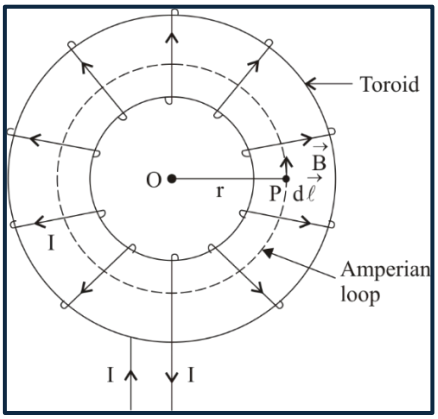
A student starts working on a problem on Gauss' theorem to calculate the flux and hence the electric field at a given point due to a system of discreet charges. The teacher gives him certain instructions and the student responds to each instruction as per her understanding of the concept. State whether the student's response is correct or incorrect. Give a reason for your answer.
(a) Examiner: Draw a Gaussian surface for the given system of charges.
Student: Draws a symmetric surface passing through the point at which the electric field is to be calculated.
Examiner: Suggest a way to double the flux through the given surface.
Student: Doubles the surface area of the Gaussian surface.
(c) Examiner: Calculate the electric flux of a point charge of 2 μC, placed 5 cm above the centre of a square plate of side 10 cm, through the given plate.
Student: As the charge is not enclosed by the surface, the flux through the surface is zero.
(Application)</td></tr>
<tr><td>69.</td><td>[Electromagnetic Induction and Alternating Currents]

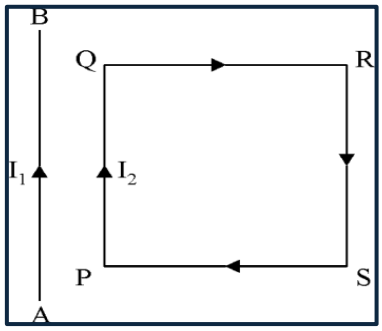
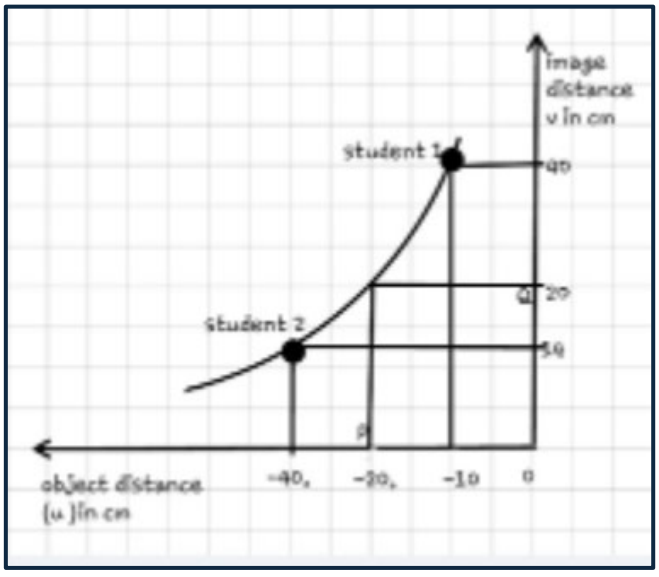
A student was given a frequency generator, a source, an inductor, a capacitor, a resistor and an ammeter. After connecting the circuit correctly, the student tabulated the readings as shown below.

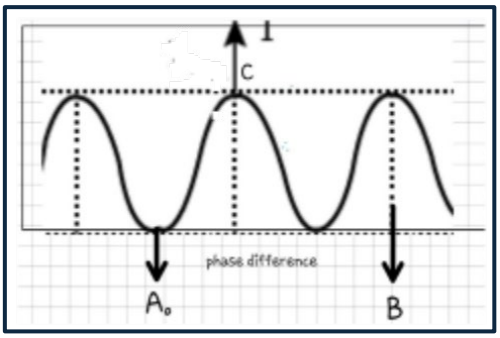
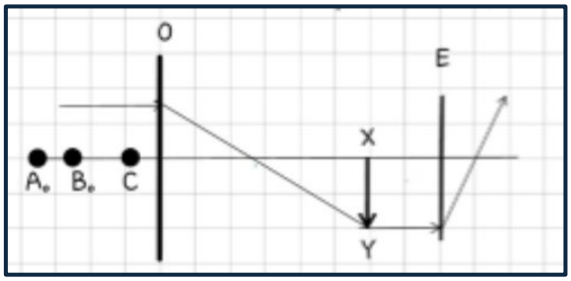
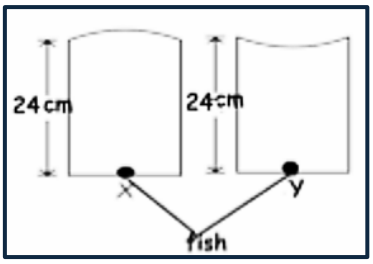
<table>
<tr><th>S.No.</th><th>Frequency(kHz)</th><th>Ammeter reading (mA)</th></tr>
<tr><td>1</td><td>1.20</td><td>13.8</td></tr>
<tr><td>2</td><td>1.38</td><td>16.3</td></tr>
<tr><td>3</td><td>1.71</td><td>19.4</td></tr>
<tr><td>4</td><td>2.08</td><td>22.0</td></tr>
<tr><td>5</td><td>2.39</td><td>19.5</td></tr>
<tr><td>6</td><td>2.57</td><td>17.6</td></tr>
<tr><td>7</td><td>2.79</td><td>16.0</td></tr>
<tr><td>8</td><td>3.10</td><td>14.5</td></tr>
</table>
(a) What is the resonant frequency of the circuit?
(b) Plot the graph for the given data using proper axes.

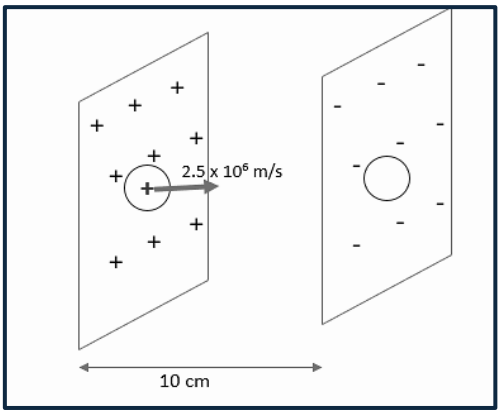
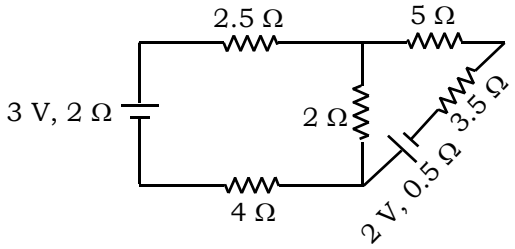
(Evaluate)</td></tr>
</table>

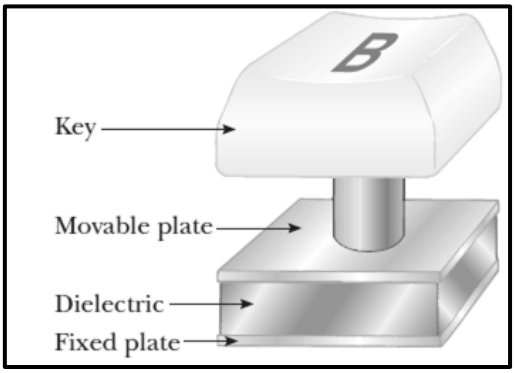
S.No.	Questions
70.	***[Atoms and Nuclei]*** Nuclear binding energy is the energy required to separate an atomic nucleus into its constituent protons and neutrons, or, equivalently, the energy that would be liberated by combining individual protons and neutrons into a single nucleus. For example, the nucleus of the hydrogen isotope deuterium, which is composed of one proton and one neutron, can be separated by supplying 2.23 million electron volts (MeV) of energy. Conversely, when a slowly moving neutron and proton combine to form a deuterium nucleus, 2.23 MeV energy is liberated in the form of gamma rays. (a) Why is the energy needed to separate an atomic nucleus into its constituents? (b) In the case of two atoms $_3X^6$ and $_3Y^7$, which atom is likely to be more stable and why? (c) Calculate mass defect when a neutron and a proton combine to form a deuterium nucleus. **(Application)**
71.	***[Magnetic Effects of Current and Magnetism]*** A circular coil of 20 turns and a radius of 10 cm is placed in a uniform magnetic field of 0.10 T normal to the plane of the coil. If the current in the coil is 5 A, what will be: (a) the total torque on the coil? (b) the total force on the coil? (c) average force on each electron in the coil due to the magnetic field. (The coil is made of copper wire of a cross-sectional area of 10^{-5} m^2, and the free electron density in copper is given to be about 10^{29} m^{-3}). **(Evaluate)**

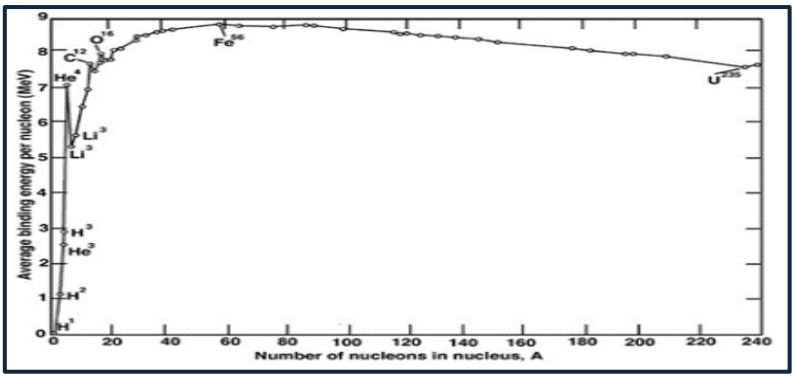
S.No.	Questions
72.	***[Magnetic Effects of Current and Magnetism]*** A toroid is a hollow non-conducting circular ring, on which a large number of turns of a conducting wire are closely wound. If a ***solenoid is bent into a circular shape and the ends are joined, we get a toroid***. Consider a toroid having centre O, number of turns N and each carrying a current I.  By Ampere's law, in the case of a toroid: **STEP 1:** $\oint \vec{B} \cdot d\vec{l} = \mu_0$ (Total current) = μ_0__I (Rewrite STEP 1 and fill in the blank with an appropriate substitution) **STEP 2**: B___ = μ_0NI (Rewrite STEP 2 and fill in the blank with an appropriate substitution) $\therefore \quad B = \frac{\mu_0 NI}{2\pi r} = \mu_0 I\left[\frac{N}{2\pi r}\right]$ If n is the number of turns per unit length, then $n = \frac{N}{2\pi r}$ **STEP 3:** $\boxed{B = \mu_0 \_\_\_ I}$ (Rewrite STEP 3 and fill in the blank with an appropriate substitution) **(Application)**
73.	***[Magnetic Effects of Current and Magnetism]*** An electron emitted by a heated cathode and accelerated through a potential difference of 2 kV, enters a region with a uniform magnetic field of 0.15 T. Determine the radius and the trajectory of the electron if the field is: (a) transverse to its initial velocity. (b) makes an angle of 30° with the initial velocity. **(Application)**

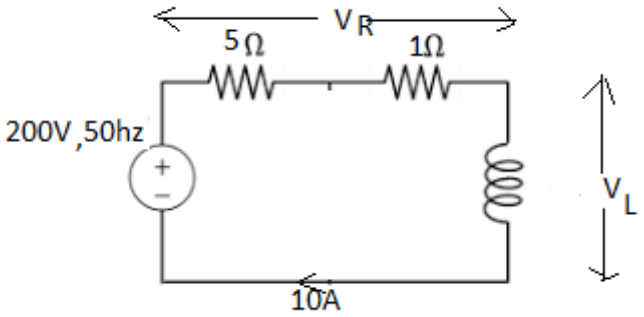
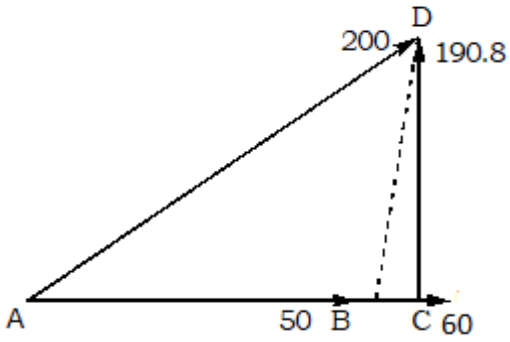
S.No.	Questions
74.	***[Magnetic Effects of Current and Magnetism]*** In the figure, the straight wire AB is fixed while the loop PQRS is free to move.  Give a reason for your response in each sub-part. (a) What is the force experienced by arms QR and SP? (b) What is the nature of force experienced by arms PQ and RS? (c) In which direction, does the loop begin to move? **(Application)**
75.	***[Optics]*** The teacher is demonstrating the experiment of the focal length of a convex lens using the u-v method. After the teacher takes readings P and Q. He/she assigns two students (Student 1 and Student 2) to take the subsequent readings, assuming that the teacher is right.  (a) What is the focal length of the given lens? (b) How should Student 2 adjust the screen to obtain an accurate reading? (c) What error do you observe in the readings of Student 1? **(Analysis)**

S.No.	Questions
76.	***[Optics]***  (a) If the graph depicts intensity versus phase difference for double-slit interference. What do points A and B symbolise? (b) If the waves have amplitudes 1:3, then find the ratio of intensities at A and C. **(Understanding)**
77.	***[Optics]***  (a) Identify *two* errors in the student's attempt to draw a ray diagram of a compound microscope. (b) Which position A, B, or C, is optimal for placing the object? **(Analysis)**
78.	***[Optics]*** For a science project, two fish tanks with lids were constructed as shown in the figure. Tank X has a lid with a convex shape, while Tank Y has a lid with a concave shape and no space between the lid and the liquid. Both tanks have the same height of 24 cm and are made of glass with a refractive index of 1.5. The radius of curvature of both lids is 40 cm. Which tank appears to have the fish positioned higher? Support the answer with necessary calculations.  **(Understanding)**

S.No.	Questions
79.	***[Electrostatics]***  An alpha particle is made to move through two plates 10 cm apart. The speed with which it enters the gap in the first plate is 2.5×10^{6} m s^{-1}. The particle exits the second plate with a velocity of 5×10^{6} m s^{-1}. (a) Calculate the potential difference between the plates. (b) Calculate the electric field between the plates. (c) Name a device where this principle is used. **(Application)**
80.	***[Electrostatics]*** For the given electrical circuit, calculate the current through each branch using Kirchhoff's laws.  **(Application)**

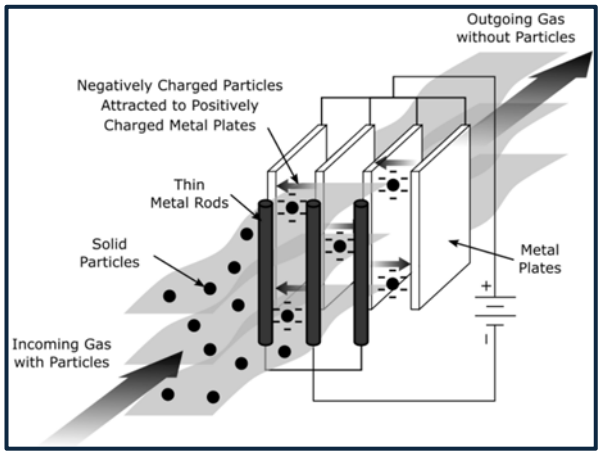
S.No.	Questions
81.	***[Electrostatics]*** The computer's keyboards make use of capacitors at the base of their keys (as shown in the diagram).  Each key is connected to a movable plate, which represents one side of the capacitor. The fixed plate on the keyboard's bottom represents the capacitor's other side. External electronic circuits recognize each key in its capacitance when pressed. (a) How would the capacitance of the capacitor so formed change, when the key is pressed? (b) If the plate area is 2 cm^2 and the plate separation is 1 mm, calculate the charge density on the plate, if the potential difference between the plates is 3 V. The plates are separated by a dielectric of K = 5. (c) Sketch a graph showing the variation of electric field E between the plates with distance 'd' from the first plate till the second plate. **(Understanding & Application)**
82.	***[Atoms and Nuclei]*** Given two nuclei $_{29}Cu^{64}$ and $_{13}Al^{27}$. (a) Calculate the ratio of the radii. (b) What will be the ratio of their densities? (c) Compare their nuclear density to the density of water. **(Application & Analysis)**

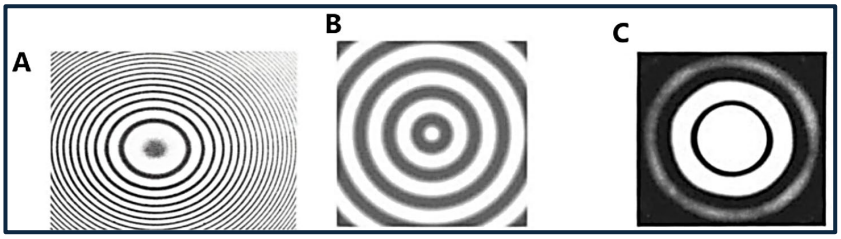
S.No.	Questions
83.	***[Atoms and Nuclei]*** A graph showing the variation of binding energy per nucleon with mass number is given below. In the graph mark regions where nuclei are:  (a) Prone to fusion. (b) Prone to fission. (c) Give a reason for your marking. **(Analysis)**
84.	***[Atoms and Nuclei]*** The energy of the thermal neutrons required for the fission of U^{235} nuclei is of the order of 0.025 eV. However, the neutrons produced in the fission of U^{235} possess quite large energy as compared to the energy of thermal neutrons. As these neutrons escape the U^{235} block without causing the fission of U^{235} nuclei. Due to this, in a nuclear reactor, it is important that the energy of neutrons is absorbed, and some neutrons are also absorbed. Name the substance: (a) used to absorb the energy of the neutrons. (b) used for absorbing neutrons. (c) write condition when U^{235} is said to be of critical size. **(Application)**
85.	***[Atoms and Nuclei]*** The Lyman series spectrum of an atom contains wavelengths of 176.7 nm and 137.5 nm. The energy of the ground level of the atom is -10 eV. Determine the ratio of kinetic energies of electrons in the first excited state and the second excited state. **(Application)**
86.	***[Atoms and Nuclei]*** (a) Calculate the angular momentum of a 'γ' photon which is emitted when an electron jumps from the 3^{rd} energy state to the 2^{nd} energy state in a hydrogen atom. (b) A charged particle of energy, [$E = \frac{1}{2}mv^2$] bombards a heavy target of charge Ze, then shows with the help of a graph how the distance of the closest approach varies with the mass of the particle. **(Application)**

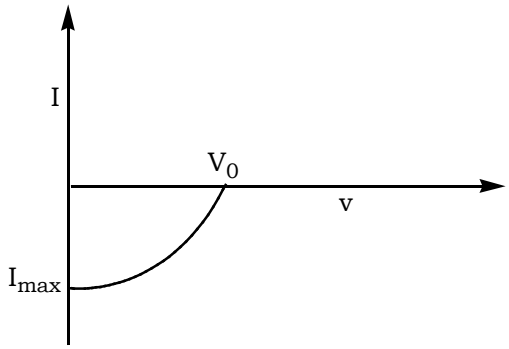
S.No.	Questions
87.	***[Electromagnetic Induction and Alternating Currents]*** An arc lamp takes 10 A at 50 V. Calculate the impedance of a choke of 1-ohm resistance to be connected in series with an arc lamp so that the lamp may be used on 200 V, 50 Hz supply. Use the data from the circuit diagram and the phasor voltage triangle and calculate the total active power and the power factor. AB – drop across arc lamp BC – drop across 1-ohm resistance of the choke CD – drop across the inductor BD – total drop across the choke   **(Application)**
88.	***[Electromagnetic Induction and Alternating Currents]*** Power Corporation of India wanted to transmit power of 11 kW from tower 1 to tower 2 at 220 V or 22000 V. Which of the *two* voltages is better for transmission of alternating current (a.c.) power? Support the answer with a mathematical calculation. **(Application)**

<table>
<tr><th>S.No.</th><th>Questions</th></tr>
<tr><td>89.</td><td>[Electromagnetic Induction and Alternating Currents]
Match the following:
<table>
<tr><td>1.</td><td>$\omega L > \frac{1}{\omega C}$</td><td>(i)</td><td>The current is in phase with voltage V.</td></tr>
<tr><td>2.</td><td>$\omega L < \frac{1}{\omega C}$</td><td>(ii)</td><td>The current lags in phase with voltage V.</td></tr>
<tr><td>3.</td><td>$\omega L = \frac{1}{\omega C}$</td><td>(iii)</td><td>The current leads in phase with voltage V.</td></tr>
</table>
(Analysis)</td></tr>
<tr><td>90.</td><td>[Electromagnetic Induction and Alternating Currents]
In an inductance-capacitance-resistance (LCR) series circuit, which is connected to an alternating current (a.c.) source of a frequency (v), its signal voltage (v) is equal to v_x for an instantaneous time between 0 and half its time period (T) and equal to zero during the next half period.
(a) Suppose the frequency of the source is gradually increased, what happens to inductance and capacitance?
(b) Calculate the root mean square (r.m.s.) voltage of the signal.
(c) If $X_C = 2X_L = R$, calculate the total impedance of the circuit.
(Evaluate)</td></tr>
</table>

VI: Very Long Answer Questions (5 Marks Each)

S.No.	Questions
91.	*[Electrostatics]* **Electrostatic precipitators:** Electrostatic precipitators are devices used to remove particles, such as dust and ash, from a flowing gas using the force of an induced electrostatic charge. It consists of two sets of electrodes: positive and negative. The negative electrodes are in the form of a wire mesh, and the positive electrodes are plates. These electrodes are vertically placed and alternate to each other. High Direct Current (DC) voltage is fed to the discharge electrodes, generating a negative electric field around them. The gas-borne particles such as ash are ionised by the corona effect. When the polluted gas passes through the electric field, the particles become charged and are attracted to oppositely charged collector plates, where they adhere until they are removed.  Answer the following questions. (a) Name *any two* electrostatic processes involved in the working of an electrostatic precipitator. (b) If the medium between the mesh and the plates is filled with a dielectric medium of dielectric constant K = 10, what will happen to the efficiency of working of the device? (c) What is the strength of the electric field between two parallel conducting plates separated by 2 cm and having a potential difference (voltage) between them of 1.50×10^4 V? (d) Name any other device used in day-to-day life, based on the principle of the electrostatic precipitator. **(Analysis)**

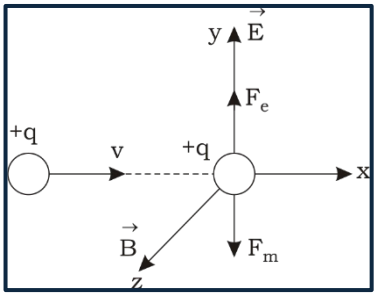
S.No.	Questions
92.	***[Optics]*** Student 1 and Student 2 conducted experiments using coherent sources of light, with Student 1 using a single slit and Student 2 using a double slit.  Answer the following questions. (a) Identify the patterns resulting from Student 1 and Student 2 experiments. (b) Give *two* reasons that assisted you in recognizing the patterns. (c) Upon utilizing a monochromatic source of light of 500 nm wavelength, Student 1 observed that the distance between the initial minimum and the centre of the fringe matched the width of the slit. Calculate the distance of this initial minimum from the centre of the fringe, given that the screen is situated 1 m away from the slit. (d) Student 2 observes 10 fringes within a specific portion of the screen using the same monochromatic source of light. If he were to immerse his entire experimental setup in a liquid of refractive index 5/3, what alteration should he make to the distance of the screen to maintain the same number of fringes? **(Analysis)**

S.No.	Questions
93.	***[Electronic Devices]*** A solar cell is a junction diode. A very thin layer of p-type semiconductor is grown on a relatively thicker n-type semiconductor, having a few finer electrodes on the top of the p-type semiconductor layer. These electrodes do not obstruct light from reaching the thin p-type layer. Just below the p-type layer, there is a p-n junction. We also provide a current-collecting electrode at the bottom of the n-type layer. Similarly, the holes in the depletion can quickly come to the p-type side of the junction. Once, the newly created free electrons come to the n-type side, cannot further cross the junction because of the barrier potential of the junction. Similarly, the newly created holes once come to the p-type side cannot further cross the junction because of the same barrier potential of the junction. As the concentration of electrons becomes higher on one side, the p-n junction will behave like a small battery cell. A voltage is set up which is known as photovoltage. If we connect a small load across the junction, there will be a tiny current flowing through it. The IV characteristic of solar cells is given below:  Answer the following questions. (a) Is the principle of a solar cell the same as that of a photodiode? (b) What is the suitable band gap of the semiconductors used as solar cell materials? (a) 0 to 0.5 eV (b) 0.5 to 1 eV (c) 1.1 to 2 eV (d) 0 to 0.8 eV (c) What does V_0 represent in the characteristic curve? (d) Is I_{max} independent of the intensity of incident radiation? (e) Why do holes in the depletion region quickly come to the p-side? **(Analysis & Evaluate)**

S.No.	Questions
94.	***[Electromagnetic Waves]*** **Read the passage and answer the questions carefully.** A joint family stayed happily in a town. As a family, they watched the Asian games that took place in Hangzhou, China from September 23 to October 8, 2023. During advertising breaks, one of the parents made popcorn in the microwave oven for the family. One day, the grandparent tripped and fell on her elbows, and she was rushed to the hospital. However, the parent used Google Maps to find the way to the hospital. The orthopaedic with the help of an X-ray machine, imaged her ankle to confirm that the grandparent had a hairline fracture and treated her appropriately. As the grandparent was healed, the family decided to go on a pilgrimage in their car. There was unexpected fog and mist during their night journey, but they were still able to click clear pictures using their camera. Since they were thousands of kilometres away, the family was able to communicate with their relatives using mobile phones once a day. After a weeklong trip, the family resumed their daily activities. Based on the above situation, answer the questions that follow. (a) Popcorns are made in the microwave oven. Name *one* property of the waves in the oven that is used to make popcorn. (b) Why are X-rays not used to image the flesh of the body, but can photograph the bone? (c) Name the electromagnetic (e.m.) wave used for Google mapping to find the way to the hospital. (d) Name the type of wave that carries information from one mobile phone to another for thousands of kilometres. (e) What is the reason that the family was able to click clear pictures on camera despite fog? **(Understanding)**

S.No.	Questions
95.	***[Magnetic Effects of Current and Magnetism]***

The diagram depicts $\vec{v}$, $\vec{E}$ and $\vec{B}$ are mutually perpendicular.



If direction of $\vec{E}$ is indicated with $\hat{j}$, direction of $\vec{B}$ is indicated with $\hat{k}$ then direction of $\vec{v}$ is indicated as …….

The force value in each case is stated. State the value of E and B as equal to zero or not equal to zero in each case.

(a) The value of resultant F = 0 if E = 0 and B …… (choose B = 0 **OR** B ≠ 0)

(b) The value of resultant F may be zero (if θ = 0° or 180°) if B ≠ 0 and E …… (choose E = 0 **OR** E ≠ 0)

(c) F = 0 (if $\left|\vec{F}_e\right| = \left|\vec{F}_m\right|$ and their directions are opposite) if E ≠ 0, B …… (choose B = 0 **OR** B ≠ 0)

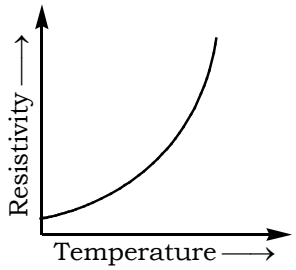
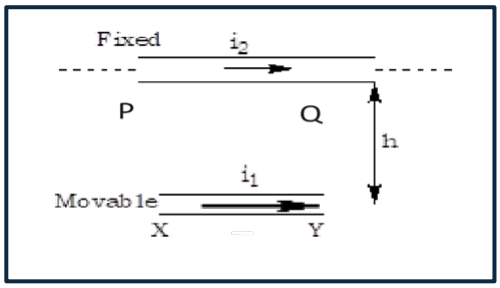
(d) F ≠ 0 (because $\vec{v}$ ≠ constant) if E ≠ 0, B …… (choose B = 0 OR B ≠ 0)

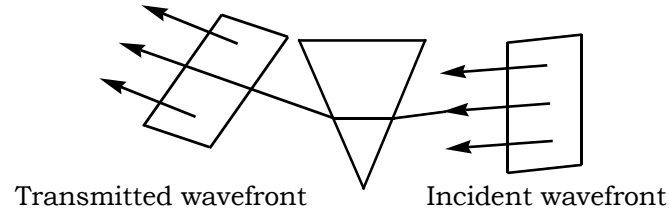
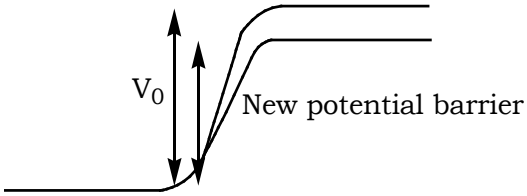
(Analysis)

ANSWER KEY

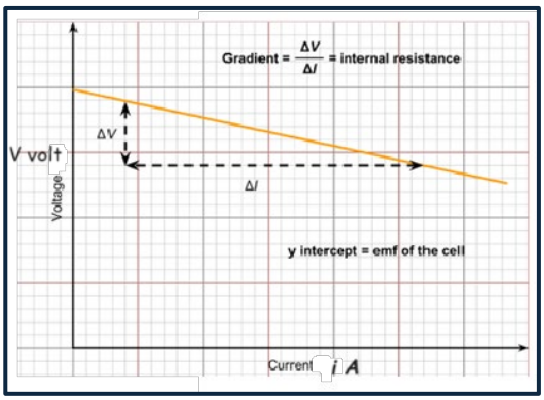
S.No.	Expected Answers
1.	(b) L_2, L_1 **Explanation:** The objective should have a large aperture and large focal length, while the eyepiece should have a small aperture and small focal length.
2.	(a) (i) and (ii)
3.	(b)  During the first half diode is in reverse biasing so it does not conduct, and we get the same voltage in output. But in the second half, it is in forward bias, so it conducts, hence the circuit is shortened, and we do not get any voltage in output.
4.	(b) Capacitive, Resistive and Inductive.
5.	(c) $R < r$
6.	(a) The vector sum of electrostatic and magnetic force acting on a moving charged particle. **Explanation:** As Lorenz force is given by, $\vec{F} = q(\vec{E} + \vec{v} \times \vec{B}) = q\vec{E} + q(\vec{v} \times \vec{B})$ $\vec{F} = \vec{F_E} + \vec{F_B}$
7.	(b) '$\vec{v}'$ and $\overrightarrow{'B'}$ are perpendicular. **Explanation:** Since $F = q('\vec{v}' \times \overrightarrow{'B'})$ or $\lvert F \rvert = qvB \sin\theta$ 'F' will be the maximum when $\theta = 90°$.
8.	(b) The line integral of a magnetic field along the boundary of the closed loop is equal to μ_0 times the total current passing through the surface. **Explanation:** According to Ampere's circuital law, $\oint \vec{B} \cdot \vec{d\ell} = \mu_0 I$
9.	(a) inversely proportional to the distance from the wire. **Explanation:** $B = \frac{\mu_0 I}{2\pi r}$ or $B \propto \frac{I}{r}$

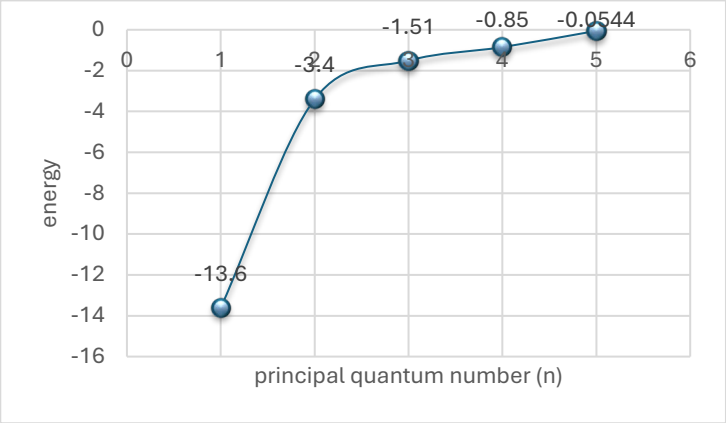
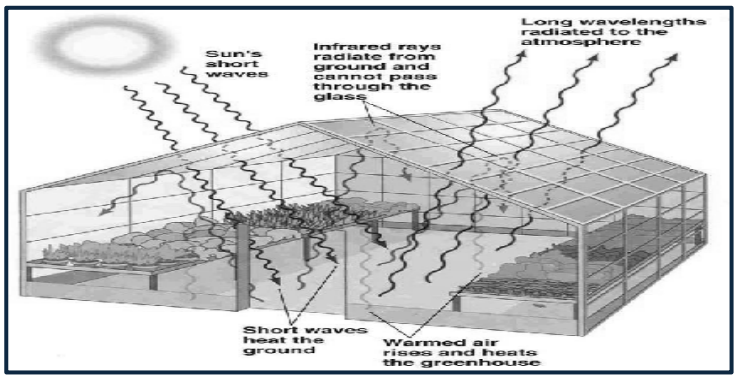
S.No.	Expected Answers
10.	(c) r_2: r_1 Solution: E= $-\frac{e^2}{8\pi\varepsilon_0 \ r}$
11.	(c) In a hydrogen atom, an electron revolves in certain stable orbits without the emission of radiant energy.
12.	(b) Photoelectric current flowing through the two metals.
13.	(c) B is a capacitor and Y = P.
14.	(a) The bulb starts to dim.
15.	(b) $\frac{1}{\sqrt{\in_0\mu_0}}$
16.	(d) According to Maxwell's electromagnetic theory, light is treated as a wave in nature and requires no medium to travel. However, according to Huygens's theory, light is treated as a wave in nature and requires a medium to travel.
17.	(d) 10.5mC. **Explanation:** Under the graph
18.	(b) **Current:** $I_1=I_2$; **Current density:** $j_2 > j_1$; **Drift velocity:** $v_2 > v_1$
19.	(a) 0 V. **Explanation:** As the battery is short-circuited, the potential difference is 0 V.
20.	(b) $d_2 < d_1$ Electrons on the conducting sphere will be attracted to the excess positive charges on Sphere A and move closer to Sphere A. This leaves the opposite side of the conducting sphere more positively charged which results in less electric repulsion between the spheres and as a result, less compression in the spring.
21.	(d) **Work function:** 2.04 eV; **Stopping Potential:** -3.24V.
22.	(d) Both Assertion and Reason are false.
23.	(c) Assertion is false, and Reason is true.
24.	(d) Both Assertion and Reason are false.
25.	(a) Both Assertion and Reason are true, and Reason is the correct explanation of Assertion.

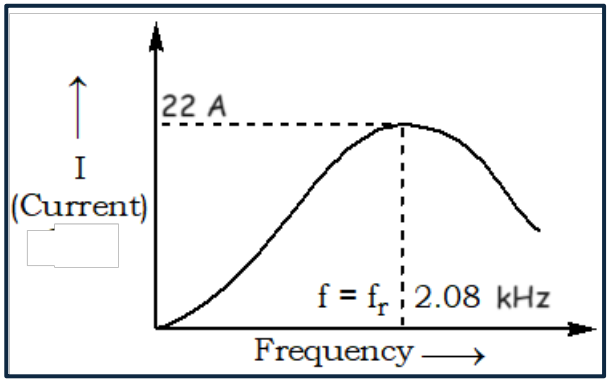
S.No.	Expected Answers
26.	Slope = qV = C. The higher slope corresponds to higher capacitance. Also, $C \propto \frac{1}{d}$. The lesser the value of 'd', the more the capacitance. Hence, graph 'B' corresponds to 'C_1'.
27.	Conductor 
28.	C
29.	$Slope = \frac{1}{\varepsilon}$
30.	
31.	As we know magnetic force is always perpendicular to the velocity of the charge particle, given as $\vec{F} = q(\vec{v} \times \vec{B})$. As $\vec{F}$ is perpendicular to $\vec{v}$, we use $\vec{F} \times \vec{v} = 0$ **F.v** = 0 $(5\hat{i} - C\hat{j}) \cdot (4\hat{i} + 5\hat{j}) = 0$ 20 – 5C = 0 $C = \frac{20}{5} = 4$
32.	G
33.	Zero
34.	It is independent of the angle of incidence.

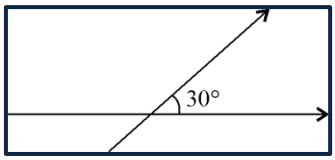
S.No.	Expected Answers
35.	X: refractive index of 1.4905: Core Y: refractive index of 1.337: Cladding
36.	Convex lens
37.	
38.	
39.	According to Bohr's quantization condition, $2\pi r = n\lambda$. $\therefore \quad \lambda = 2\pi r$, since n = 1 $\lambda = 2 \times 3.14 \times 0.53 \times 10^{-10}$ $= 3.328 \times 10^{-10}$ m.
40.	No series. (At room temperature electrons remain present in the ground state.)
41.	$\lambda = \frac{hc}{E} = \frac{6.6 \times 10^{-34} \times 3 \times 10^{8}}{13.6 \times 1.6 \times 10^{-19}} = 909.9 \times 10^{-10}$ m
42.	K.E. $\propto \frac{1}{r_0}$, where 'r_0' is the distance of closest approach. So, when the kinetic energy is doubled, the distance of the closest approach is halved.
43.	By right-hand thumb rule, the magnetic field of the current in wire AB acts on the loop in a direction perpendicular to the plane of paper and inwards. By Lenz's law, the induced current should oppose the decrease in flux, i.e., it should also produce inward flux. So, the induced current flows in the clockwise direction.
44.	$\varepsilon = NBA\omega \sin \omega t = \varepsilon_0 \sin \omega t$ Since the average value of sin ωt over a cycle is zero, therefore, $\varepsilon_{av} = 0$.
45.	$\cos \theta = \frac{R}{\sqrt{R^2 + X_L^2}}$

S.No.	Expected Answers
46.	$\vec{B_P} = \vec{B_{1(in)}} + \vec{B_{2(out)}}$ $B_P = B_1 - B_2 = \frac{\mu_0}{4\pi}\frac{2I_1}{x} - \frac{\mu_0}{4\pi}\frac{2I_2}{y}$ The resultant magnetic field induction at point P is 0. $0 = \frac{\mu_0}{4\pi}\frac{2I_1}{x} - \frac{\mu_0}{4\pi}\frac{2I_2}{y}$ $\frac{\mu_0}{4\pi}\frac{2I_1}{x} = \frac{\mu_0}{4\pi}\frac{2I_2}{y}$ $\therefore \quad \frac{I_1}{I_2} = \frac{x}{y}$
47.	Lateral disp $= \frac{t\sin(i-r)}{\cos r} \rightarrow \cos r = \frac{10\times0.5}{5.7} = 0.8772 \rightarrow r = 28.69°$ Refractive index $= \frac{\sin i}{\sin r} = \frac{\sin 58.69}{\sin 28.69} = 1.77$ The material is sapphire.
48.	$\frac{P}{Q} = \frac{R}{S} = \frac{R(S_1 + S_2)}{S_1 S_2}$
49.	(a) F = f/2 (b) F = ∞
50.	When the velocity of the charged particle is E/B. Then, $p = \frac{E}{c}$ proves that e.m. waves carry both energy and momentum.
51.	$M = m \times \ell$ After bending, the new separation between the poles = 2r. Now, $\pi r = \ell$ $\therefore \quad r = \frac{\ell}{\pi}$ New dipole moment, $M_1 = m \times 2r = m \times \frac{2\ell}{\pi}$ $\therefore \quad M_1 = \frac{2M}{\pi}$
52.	Figure 1 – Diamagnetic Figure 2 – Ferromagnetic

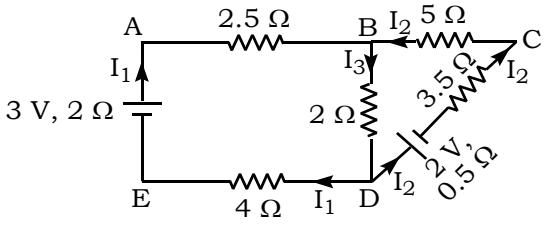
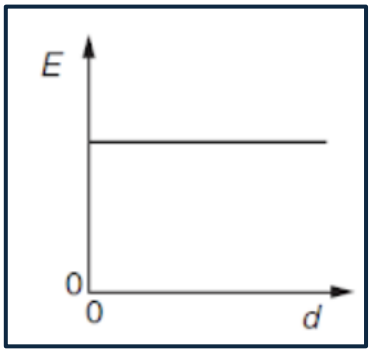
S.No.	Expected Answers
53.	I = 50 A, r = 2.5 m $B = \frac{\mu_0}{4\pi}\frac{2I}{r} = \frac{4\pi \times 10^{-7} \times 50}{2\pi \times 2.5} = 4 \times 10^{-6}$ T Applying the right-hand thumb rule, we find the magnetic field will be perpendicular outward at a point 2.5 m east of the power line.
54.	(a) Concave mirror; (b) 20 cm
55.	From the first diagram, I + e = A + d A = 53 + 42 – 35 = 60° From the second diagram, the angle of minimum deviation = 2i – A = 30° $\text{Refractive index} = \frac{\sin\frac{A+d}{2}}{\sin\frac{A}{2}} = \frac{\sin 45}{\sin 30} = 1.414$
56.	X – 2nd order maxima = $-\frac{5\lambda}{2}$, Phase difference = $-\frac{5\lambda}{2} \times \frac{2\pi}{\lambda} = -5\pi$ Y – 3rd minima $= 3\lambda$ Phase difference $= 3\lambda \times \frac{2\pi}{\lambda} = 6\pi$
57.	(i) The electromotive force (emf) of the battery must be greater than 10 V, so that the potential difference across the wire is more than the e.m.f.s of the cell to be compared. Otherwise, the balance length for 10 V cannot be determined. (ii) A series variable resistant/rheostat must also be added to the primary circuit to minimize the current drawn from the cell and adjust the potential drop across the potentiometer.
58.	$-\frac{kqQ}{x} - \frac{kQq}{x} + \frac{kqq}{2x} = 0$ **or** $\frac{-2kqQ}{x} = \frac{-kqq}{2x}$ Solving we get, Q: q = 1: 4
59.	(a)  Y-intercept gives the emf of the cell. (b) The slope of the graph = internal resistance.

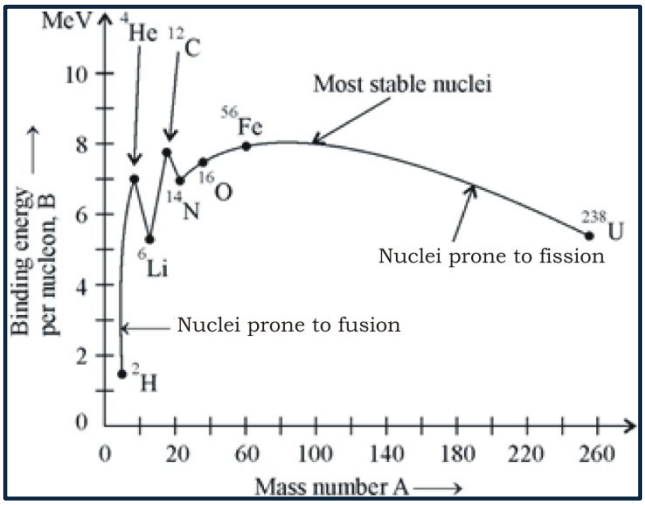
S.No.	Expected Answers
60.	(a) Two 'γ' photons are produced to conserve momentum. (b) Using $E = mc^2$ it can be shown that energy equivalent to mass of an electron is equal to 0.511 MeV.
61.	Using $E = mc^2$ $4 \times 10^9 \times 30 \times 10^3 = m \times (2.99792 \times 10^8)^2$ $m = \frac{4 \times 10^9 \times 30 \times 10^3}{(2.99792 \times 10^8)^2} = 1.33 \times 10^{-3}$ kg
62.	
63.	$\cos\phi = \frac{1}{\sqrt{2}} = \frac{R}{Z}$; $Z = 11\sqrt{2}$, $L = 0.035$ H
64.	(a) For R_1; (b) 0.1592 Hz & 159.2 Hz
65.	Figure. 1 – Infrared rays:  Figure. 2 UV rays: Welders to protect their eyes from intense UV use welding glasses.
66.	(a) (i) −ve Z-axis for an electron. (ii) +ve Z-axis for a proton. (b) The direction of motion of the electron should be parallel to the magnetic field direction.

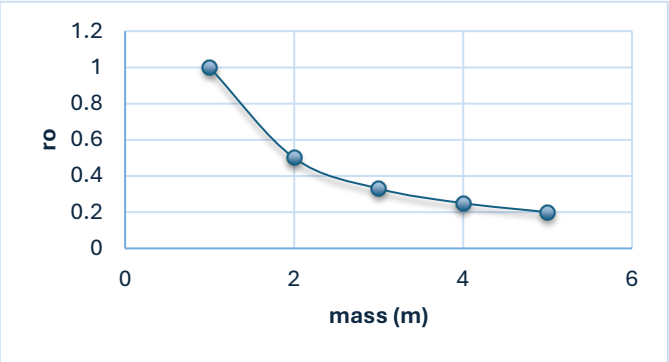
S.No.	Expected Answers
67.	(a) Y (b) Free of chromatic aberration / Image formed is brighter / Free from spherical aberration. *(anyone relevant point)* (c) Magnifying power of telescope of student 2 = $\frac{f_0}{f_e}$ =5 Hence, the magnifying power of the telescope of student 1= 10. Since f_e = 5 cm, hence f_0 =50 cm. Length = 50 + 5 = 55 cm.
68.	(a) Response is correct. The Gaussian surface is an imaginary closed surface around a charge. (b) Response is incorrect. The electric flux does not change with the area of the Gaussian surface. (c) Response is incorrect. The total flux through the square plate = $\frac{1}{6}\left(\frac{2 \times 10^{-6}}{\varepsilon_0}\right)$ = 3.77×10^4 Nm^2 /C. *(Reason is to be given for both correct as well as incorrect responses.)*
69.	(a) 2.08 kHz (b) 
70.	(a) Nuclear binding energy is also energy needed to bind nucleons together in the nucleus. Therefore, energy is needed to break the nucleons' infinite distance apart OR energy is needed to work against the strong nuclear forces. (b) $_3Y^7$ is more stable as it has a greater number of neutrons as compared to $_3X^6$, therefore nuclear force is greater than the electrostatic force of repulsion between protons. (c) $E = \Delta m \cdot c^2$ 2.23 MeV = Δm × 931.5 MeV $\Delta m = \frac{2.23}{931.5}$ = 0.00239398 u

S.No.	Expected Answers
71.	$N = 20, r = 10 \times 10^{-2}$ m, B = 0.10 T (a) τ = zero (b) F_{total} = zero (c) $F = ev_dB = e\frac{I}{neA}B = 5 \times 10^{-25}$ N
72.	STEP 1: μ_0**N**I STEP 2: B **2πr** = μ_0NI STEP 3: B = μ_0**n**I
73.	(a) K.E. $= \frac{1}{2}mv^2 = eV$ $v = \sqrt{\frac{2\,eV}{m}} = 2.65 \times 10^7$ m/s $\frac{mv^2}{r} = qvB \sin\theta$ $\therefore \quad r = \frac{mv}{qB} = 9.95 \times 10^{-4}$ m [Circular] (b)  $\frac{mv^2}{r'} = qvB \sin\theta$ $\therefore \quad r' = (2r) = 2 \times 9.95 \times 10^{-4}$ m. [Spiral]
74.	(a) No. The force is experienced since they are aligned perpendicular to the current carrying conductor AB. (b) There is a force of attraction between AB and PQ and a force of repulsion between AB and SR. (c) PQ is closer to AB than SR, so the force of attraction is stronger than the force of repulsion. So, the loop begins to move towards AB.
75.	(a) Focal length by using the teacher's reading $= \frac{1}{20} + \frac{1}{20} = \frac{2}{20} = \frac{1}{10}$ $\Rightarrow$ f = 10 cm (b) He should move his screen 3 cm farther from the lens. (c) Student 1 has kept his lens at F, the image would be at infinity.

S.No.	Expected Answers
76.	(a) $A = -\pi$, $B = 2\pi$ (b) $I_{min} : I_{max} = (3 - 1)^2 : (3 + 1)^2 = 1 : 4$
77.	(a) Eyepiece is of shorter focal length / Image XY isn't between optical centre and F / Objective is having a larger aperture. *(any two relevant points.)* (b) A
78.	$H(X) \rightarrow \frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R} = \frac{1}{H(X)} - \frac{3/2}{-24} = \frac{1 - \frac{3}{2}}{-40}$ $H(X) = -20$ cm $H(Y) \rightarrow \frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R} = \frac{1}{H(Y)} - \frac{3/2}{-24} = \frac{1 - \frac{3}{2}}{40}$ $H(Y) = -13.33$ cm
79.	(a) By conservation of energy, Change in K.E. + Change in P.E. = 0 or $\Delta K + q\Delta V = 0$ $\Delta V = -\frac{\Delta K}{q} = -\frac{\frac{1}{2}m(v^2 - u^2)}{q}$ $= \frac{\frac{1}{2} \times 6.64 \times 10^{-27} \times (25 - 6.25) \times 10^{12}}{3.2 \times 10^{-19}}$ $= -1.95 \times 10^5$ V (b) $E = \frac{\Delta V}{d} = 1.95 \times 10^6$ V/m (c) Particle accelerator/Linear accelerators/Atom smashers.

S.No.	Expected Answers
80.	 $I_3 = I_1 + I_2$ In loop 1 (ABDEA): $-2.5I_1 - 2I_3 - 4I_1 - 2I_1 + 3 = 0$ or $-10.5I_1 - 2I_2 = -3$ or $-10.5I_1 + 2I_2 = 3$ ...(i) In loop 2 (BCDB): $2I_1 + 11I_2 = -2$ … (ii) Solving (i) and (ii) we get: $4I_1 + 22I_2 = -4$ $-115.5I_1 + 22I_2 = -33$ Subtracting, $-111.5I_1 = -37 \Rightarrow I_1 = 0.33$ A $11I_2 = -2 - 0.66 \Rightarrow I_2 = -0.24$ A $I_3 = 0.33 - 0.24 \Rightarrow I_3 = 0.09$ A
81.	(a) When key is pressed, the distance between the plates decreases and hence, the capacitance increases. (b) $C = \frac{K\varepsilon_0 A}{d} = \frac{5\times8.85\times10^{-12}\times2\times10^{-4}}{10^{-3}} = 8.85$ pF $Q = CV = 26.55$ pC Charge density $= \frac{Q}{A} = 13.28 \times 10^{-8}$ C/m^2 Alternately: $E = \frac{\sigma}{K\varepsilon_0}$ or $\sigma = EK\varepsilon_0 = (\varepsilon_0 KV/d)$ (c) Graph: 

S.No.	Expected Answers
82.	(a) $R \propto A^{1/3}$ $\frac{r_1}{r_2} = \frac{64^{1/3}}{27^{1/3}}$ $\frac{r_1}{r_2} = \frac{4}{3}$ $r_1 : r_2 = 4:3$ (b) $d_1 : d_2 = 1:1$ Nuclear density is constant. (c) $2.3 \times 10^{14}:1$
83.	(a) & (b)  (c) **Nuclear fission:** Binding energy per nucleon is smaller for heavier nuclei than middle ones. When a heavier nucleus splits into lighter nuclei, the binding energy per nucleon changes from about 7.6 MeV to 8.4 MeV. **Nuclear fusion:** The binding energy per nucleon is small for light nuclei. So, when two light nuclei combine to form a heavier nucleus, the higher binding energy per nucleon of the latter results in the release of energy.
84.	(a) Heavy water/graphite rods. (b) Cadmium rods. (c) If the number of neutrons produced per second is equal to the number of neutrons lost per second in the block.

S.No.	Expected Answers
85.	$\lambda = \frac{hc}{\Delta E}$ $E_2\text{-}E_1 = \frac{6.6\times10^{-34}\times3\times10^{8}}{176.7\times10^{-9}\times1.6\times10^{-19}}$ eV $E_2 - E_1 = 7eV$ $E_2 = -10eV + 7\ eV = -3\ eV$ Since K = -E, therefore $K_2 = 3\ eV$ ΔE for next spectral line = 9 eV Similarly, $E_3 = -10\ eV + 9\ eV = -1\ eV$, therefore $K_3 = 1\ eV$. and $K_2:K_3 = 3:1$
86.	(a) $\Delta L \approx -1.06\times10^{-34}$ kg m/s (Using $\Delta L = \frac{h(3-2)}{2\pi}$) This negative value indicates that the angular momentum of the electron decreases during the transition. Finally, we can determine the angular momentum of the emitted photon using the principle of conservation of angular momentum. Since the angular momentum of the electron decreases by 1.06×10^{-34} kg m/s, therefore the angular momentum of the emitted photon must be equal in magnitude but opposite in direction. Therefore, the angular momentum of the emitted photon is approximately 1.06×10^{-34} kg m/s. (b) $r_0 \propto \frac{1}{m}$ Graph: 

S.No.	Expected Answers
87.	Total resistance in the circuit $= \frac{50}{10} + 1 = 6$ ohms $V_R = 10 \times 6 = 60$ V $V_L = \sqrt{200^2 - 60^2} = 190.8$ V BD $= (10^2 + 190.8^2)^{1/2} = 191.06$ V $Z = \frac{191.06}{10} = 19.106$ ohms Power factor $= \cos\theta = \frac{60}{200} = 0.3$ Total active power $= EI \cos\theta = 200 \times 10 \times 0.3 = 600$ W
88.	$i_1 = \frac{P}{V} = 50$ A, Power loss is 2500R watt $i_2 = 0.5$ A, power loss is 0.25R watt Comparing the two, the second mode is preferred.
89.	1 – (ii), 2 – (iii), 3 – (i)
90.	(a) Inductive reactance increases and capacitive reactance decreases. (b) $\frac{V_x}{\sqrt{2}}$ (c) $Z = \frac{R\sqrt{5}}{2}$
91.	(a) Ionisation, electrostatic attraction, electric discharge. (b) On introducing the dielectric between the mesh and plates, the electric field between the plates reduces. Hence, the ionisation of gas molecules/dust particles reduces and the efficiency of the device decreases. (c) $E = \frac{V}{d} = \frac{1.50 \times 10^4}{2 \times 10^{-2}} = 7.5 \times 10^5$ N/C (d) Air purifier/Electrostatic air cleaner.

S.No.	Expected Answers
92.	(a) Student 1– Pattern C; Student 2 – Pattern B. (b) Student 1- Utilisation of a single slit results in a diffraction pattern, characterized by a wider central maximum and diminishing fringe widths as they extend. Conversely, Student 2- Utilisation of double slits yields an interference pattern, as evidenced by uniform fringe widths across the pattern. Pattern C conforms to a diffraction pattern due to its wider central maximum and progressively decreasing fringe widths, while pattern B exhibits equal fringe widths indicative of an interference pattern. (c) Distance of the first minimum of the diffraction pattern from the centre, $y = \frac{\lambda D}{d}$ Let $y = d = x$ $x^2 = \lambda D = 500 \times 10^{-9} \times 1$ $x = 70.7 \times 10^{-5}$ m (d) New wavelength $= \frac{\lambda}{n}$ $500 \div \frac{5}{3}$ D has to be increased 5/3 times as fringe width $= \frac{\lambda D}{d}$.
93.	(a) Yes. (b) Option c – 1.1 to 2 eV (c) Maximum potential when the solar cell is in an open circuit. (d) No. (e) Due to potential barriers.
94.	(a) The microwaves are reflected within the metal interior of the oven where they are absorbed by food. (b) X-rays penetrate through the flesh and rebound back from the bone. (c) Radio waves. (d) Radio waves. (e) The basis of this camera is the use of infrared imaging.
95.	(a) B = 0 (b) E = 0 (c) B ≠ 0 (d) B = 0

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