PHYSICS (PAPER-1)

SECTION A – 14 MARKS

Question 1

(A) In questions (i) to (vii) given below, choose the correct alternative (a), (b), (c) or (d) for each of the questions.

(i) If potential difference between the two ends of a metallic wire is doubled, **drift speed** of free electrons in the wire: **[1]**

(a) remains same.

(b) becomes double.

(c) becomes four times.

(d) becomes half.

(ii) A **metre bridge** is balanced with a known resistance (R) in the left hand gap and an unknown resistance (S) in the right hand gap. Balance point is found to be at a distance of $\boldsymbol{l}$ cm from the left hand side. When the battery and the galvanometer are interchanged, balance point will **[1]**

(a) shift towards left.

(b) shift towards right.

(c) remain same.

(d) shift towards left or right depending on the values of R and S.

(iii) **Lorentz force** in **vector** form is: **[1]**

(a) $F = B\, q\, v \sin\theta$

(b) $\vec{F} = q\,(\vec{v} \times \vec{B})$

(c) $\vec{F} = q\,(\vec{B} \times \vec{v})$

(d) $\vec{F} = \vec{v}\ (q \times \vec{B})$

(iv) **Assertion:** When an electric current is passed through a moving coil galvanometer, its coil gets deflected. **[1]**

Reason: A circular coil produces a uniform magnetic field around itself when an electric current is passed through it.

(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) Assertion is false and Reason is true.

(v) When a ray of **white** light is incident obliquely on the first surface of a prism, then **[1]**

(a) red colour is deviated most.

(b) green colour is deviated most.

(c) yellow colour is deviated most.

(d) violet colour is deviated most.

(vi) The **de-Broglie** wavelength (λ) associated with a moving electron having kinetic energy (E) is given by: **[1]**

(a) $\frac{2h}{\sqrt{2mE}}$

(b) $\frac{2\sqrt{2mE}}{h}$

(c) $\frac{h}{\sqrt{2mE}}$

(d) $\sqrt{2mhE}$

(vii) The **majority** charge carriers in a ***P***-type semiconductor are **[1]**

(a) electrons.

(b) holes.

(c) protons.

(d) ions.

(B) Answer the following questions **briefly**.

(i) In an electric dipole, what is the **locus** of a point having zero potential? **[1]**

(ii) Three identical cells each of emf 'e' are connected in **parallel** to form a battery. What is the emf of the battery? **[1]**

(iii) Three bulbs $\mathbf{B_1}$(230V, 40W), $\mathbf{B_2}$(230V, 60W) and $\mathbf{B_3}$(230V, 100W) are connected in **series** to a 230V supply. Which bulb glows the brightest? **[1]**

(iv) Explain the meaning of the following statement: **[1]**
Curie temperature for soft iron is 770°C.

(v) What type of wavefronts are associated with a **point source** of light? **[1]**

(vi) What is '**Pair production**'? **[1]**

(vii) In semiconductor physics, what is the **function** of a rectifier? **[1]**

Comments of Examiners

(A) (i) Most of the candidates attempted this question incorrectly. They marked option (a) or option (c) as the answer instead of option (b). However, some candidates chose the correct option.

(ii) A large number of the candidates answered options (a) or (b) instead of option (c). The idea of the balancing length remains the same was probably unclear or the candidates assumed it had to change left or right since the galvanometer and battery were interchanged.

(iii) Most of the candidates answered this question correctly. Some candidates chose the incorrect option (c) instead of option (b) due to a lack of understanding of vector form.

(iv) Most of the candidates selected option (a) instead of option (c) due to lack of practice for assertion and reason-based questions as they failed to interpret the reason statement.

(v) Most of the candidates answered it correctly. However, some of the candidates were found to lack an understanding of the visible spectrum and optical medium behaviour. However, very few candidates chose (a) as the option.

(vi) Since options (a) and (c) were good distractors, the candidates made mistakes due to a lack of understanding. The majority of the candidates selected the correct option.

(vii) This question was correctly answered by most of the candidates. However, some candidates chose protons as they were confused between positive charge, holes, and protons.

(B) (i) The candidates were not able to answer it correctly as they were not able to understand the difference between a point and a locus. Most candidates did not interpret the term **'locus.'** Some candidates mentioned equipotential surfaces as a response.

Suggestions for teachers

- Explain the concept of drift velocity and its application in a broader perspective.
- Provide clarity on the concept of a meter bridge (Wheatstone Bridge).
- Regularly update and adopt a better approach to applications.
- A hands-on experience of the circuit may make the concept very easy to grasp for students.
- Demonstrate the result in the lab or diagrammatically compare the balancing condition.
- Clarify the dot and cross-products in vectors.
- Explain the difference in magnitude and vector form.
- Provide a broader perspective on visible spectrum and optical medium behaviour and clarify the idea of the dispersion of light through prism.
- Link the concept of bending to different wavelengths travelling at different speeds.
- Teach different forms of de-Broglie wavelength in terms of momentum, Kinetic energy, and accelerating potential.
- Explain semiconductors in more detail and elaborate the concept of positive charge as deficiency of electron.
- Use the term hole from the beginning of the first chapter electric charges, so that students understand proton cannot be exchanged.
- Elucidate on the details of doping and the formation of majority and minority charge carriers.
- Point out the difference between a point and a locus and explain perpendicular bisector with examples.
- Teach equatorial line and perpendicular bisector are the locus of points with zero potential.
- Avoid broadside position term in discussion of zero potential in case of an electric dipole.
- Emphasise on the correct symbol to be used as 'e'.

(ii) The candidates applied the concept of series, parallel resistances and not the cells, hence most of the candidates answered it as **'3e'** instead of **'e.'** Many candidates did not follow the rubric of the question paper, they used symbols like E, €. Some candidates were confused between series and parallel combinations of cells and provided responses as **'3e.'**

(iii) Several candidates applied the concept of parallel circuits instead of series, hence went wrong in giving a correct answer as they answered as B_3 and not B_1. Some candidates showed substantial working steps to arrive at the correct answer.

(iv) A number of candidates instead of mentioning the change in the magnetic behaviour of soft iron explained the change in crystal lattice from face centred cubic (fcc) to body centred cubic (bcc). However, some candidates responded that it would melt. Some candidates were confused and mentioned paramagnetic becomes diamagnetic. A few numbers of candidates were confused between Curie's temperature and Curie's law.

(v) A large number of candidates answered it correctly. However, a few candidates wrote **'circular'** as a response and a few drew a circle marking the center.

(vi) Several candidates misinterpreted the question, they wrote example of energy converted to matter. Some candidates did not write the keywords 'photon/energy/neutral boson' creating a pair of electron and positron.

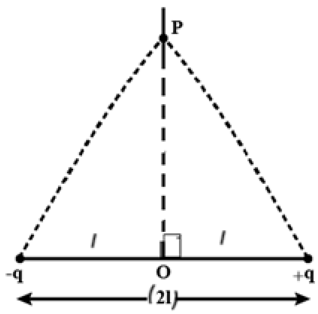
(vii) Majority of the candidates answered this question correctly. Some candidates were confused between the utility of the transformer and the rectifier. A few candidates drew waveforms as answers.

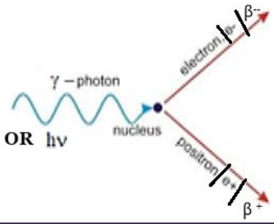
Suggestions for teachers

- Demonstrate with examples and detailed explanation about series and parallel combinations in cells that are not in regular use.
- Highlight the concept of PD constant in parallel and algebraic addition only in case of cells in series using illustration in class with pencil cells and a digital multimeter.
- Use demonstrations and examples to explain series combinations are not usual combinations.
- Clearly differentiate the concept of bulbs in series and parallel.
- Teach the properties of dia, para and ferro in terms of susceptibility and permeability.
- Clearly highlight the dependence on temperature for dia, para and ferro.
- A graphical treatment susceptibility versus temperature will give a broader understanding on temperature dependence and magnetic materials.
- Clearly explain the shape of the wavefronts to avoid response of circular/plane.
- Ensure students practice different cases of reflection and refraction of wavefronts through lenses, mirrors, and prism.
- Teach using an example of energy being converted into matter.
- Clearly state the difference between AC and DC.
- Elaborate on the full wave rectifier article with proper waveforms to explain how AC is received in households and the need to convert AC to DC for certain devices.
- Provide examples of mobile chargers and LED lamps.

MARKING SCHEME

Question 1

(A)	(i)	(b) or becomes double.
	(ii)	(c) or remain same.
	(iii)	(b) or $\vec{F} = q\,(\vec{v} \times \vec{B})$
	(iv)	(c) or Assertion is true but Reason is false.
	(v)	(d) or violet colour is deviated most.
	(vi)	(c) or $h/\sqrt{2mE}$
	(vii)	(b) or holes.
(B)	(i)	Perpendicular bisector OR Right bisector OR Equatorial line / Plane / axis.  Minimum diagram *(Broadside position is not acceptable)*
	(ii)	EMF of the battery = e OR Ɛ OR E
	(iii)	(Bulb) B_1 OR the bulb with the lowest power.
	(iv)	It means at a temperature of 770℃ (and more), soft iron becomes paramagnetic. OR When soft iron is heated to this temperature, it loses its (ferro) magnetic properties.
	(v)	Spherical (Diagram may be accepted only if the word Sphere / spherical is there, as circular is not accepted.)
	(vi)	Creation of (a gamma photon to) an electron-positron pair from gamma rays. OR Creation of a particle-antiparticle pair from neutral boson. OR When gamma rays having energy of more than or equal to 1·02MeV falls on a heavy substance, it is found that a pair of electron and positron is formed. (This phenomenon is called **Pair production).**

		OR Production of an electron-positron pair from a gamma ray / neutral Boson. (or radiation) OR Conversion of a gamma ray photon into an electron–positron pair. OR hν OR $\gamma \rightarrow {}^{0}_{-1}e + {}^{0}_{1}e$ OR $h\nu \text{ or } \gamma \longrightarrow \beta^{-} + \beta^{+}$ OR 
	(vii)	It converts AC to DC (voltage or current). OR It converts alternating current to a direct / unidirectional current or voltage.

SECTION B – 14 MARKS

Question 2

[2]

(i) A hollow sphere of radius R has a point charge **q** at its centre. **Electric flux** emanating from the sphere is X. How will the electric flux change, if at all, when

(a) radius of the sphere is **doubled**?

(b) charge q is **replaced** by an electric dipole?

OR

(ii) In case of an **infinite line charge**, how does intensity of electric field at a point change, if at all, when

(a) charge on it is **doubled**?

(b) distance of the point is **halved**?

Comments of Examiners

(i) (a) Almost all candidates answered this question incorrectly: 'Flux does not depend on radius.' This concept was not clear to many candidates. Some candidates misinterpreted the question as referring to an electric field instead of electric flux, leading to an incorrect or opposite response.

(b) The concept of the Gauss's theorem was not well understood by some candidates. The formula $\emptyset = \frac{\Sigma Q}{\epsilon_0}$ was not conceptualised properly. Most candidates interpreted this question correctly, stating that the net charge is zero, and, therefore, the flux is zero. A few candidates mistakenly mentioned that the flux is constant.

OR

(ii) (a) Most of the candidates answered this part correctly. However, some candidates did not interpret the term 'infinite line charge' correctly and, as a result, did not apply the concept of linear charge density.

(b) Some candidates answered this question correctly, while others provided only part of the answer. The formula was not substituted correctly. Some candidates did not connect the stem of the question with this subpart and likely assumed a point charge, stating that the result is inversely proportional to r^2 and, hence, four times the value.

Suggestions for teachers

- Elaborate explicitly on Gauss's Theorem and its applications.
- Explain the concept of electric flux and Gauss theorem with a single charge, an electric dipole and various charge distributions.
- Elucidate clearly that the product of electric field and area is constant, and hence a larger Gaussian surface will have a weak field, and vice versa.
- Clarify the idea that charge is a scalar quantity, and thus the additive nature of charge results in a net charge of zero for an electric dipole.
- Clarify that the infinite line charge is an application of Gauss's theorem.
- Teach the derivation of the expression for the electric field, considering a cylindrical wavefront.
- Explain the concepts of different charge densities and emphasise graphical treatment.
- Instruct students to quote the working formula before attempting the question. This will minimise misinterpretation and help students write answers in the correct format.
- Emphasise that when a question asks whether something "is doubled or halved," the response should be "constant," "doubles," or "halves" and avoid using terms like "increasing" or "decreasing."

MARKING SCHEME

Question 2

(i)	(a)	Electric flux **remains the same / No Change / Remains 'X'** as before because electric flux doesn't depend on the size of the sphere.
	(b)	Electric flux **becomes zero** because the net charge enclosed by the sphere now becomes zero and hence flux becomes zero.
		OR
(ii)	(a)	The intensity of the electric field will **become double** as E is directly proportional to linear charge density which depends on its charge.
	(b)	The intensity of the electric field will **become double** as it is inversely proportional to the distance.

Question 3 [2]

(i) What is meant by the statement: "**Relative permittivity** of water is 81"?

(ii) Can a body be given a charge of $2 \cdot 2 \times 10^{-19}$ C? Give a reason for your answer.

Comments of Examiners

(i) Most of the candidates answered this question correctly, but some candidates related it to the refractive index, while others referred to permeability. Therefore, a clear distinction should be made between permittivity and permeability. Additionally, some candidates presented the answer in symbolic ratio format and used nonstandard notations.

(ii) Some candidates answered correctly, while others were unaware of the quantization of charge. A few candidates were uncertain about the concept of the basic charge and responded, "yes possible." Very few candidates failed to provide a reason for their answer.

Suggestions for teachers

- Provide rigorous practice on basic concepts related to Class IX.
- Establish a clear distinction between permittivity and permeability.
- Teach the concept of relative permittivity (or dielectric constant) of media in the context of electric force, and reiterate it in the form of a ratio of fields or capacitance.
- Provide more questions of this type to help candidates understand the expectations of using correct notations and making correct statements with key terms.
- Explain the concept of quantization of charge, the basic value (or fundamental unit) of charge, the additive nature of charge, and the integral multiples of the basic value of charge.
- Solve similar problems to build clarity about the value of charge that can be given or withdrawn from a body.

MARKING SCHEME

Question 3

(i)	It means the permittivity of water is 81 times that of a vacuum or $\epsilon_r = \frac{\epsilon_{water}}{\epsilon_{vacuum\ or\ air}} = 81$ OR The force / Electric field intensity / Electric potential between any two charged particles becomes $^1/_{81}$ times when they are immersed in water. (This is because the binding force of attraction between oppositely charged ions of the substance in water becomes 1/81 of the force between these ions in air.) OR The Capacitance between the plates becomes 81 $times$. *(Statement or formula accepted.)*
(ii)	No. According to the principle of Quantisation of charges $Q = \pm ne$, and the given charge is not an exact multiple of the elementary charge (e). OR

	Q is not quantised. OR Solved numerically to that the result is not an integer.

Question 4

[2]

(i) What **type** of transformer is used in a mobile phone charger?

(ii) Why is the **core of a transformer** made of soft iron and not of steel?

Comments of Examiners

(i) Almost all the candidates answered correctly, except those who could not understand the question. A few candidates mentioned 'rectifier' as a response, while a few others wrote 'step transformer.'

(ii) A number of candidates answered this part incorrectly. The majority of the candidates were confused by this question and wrote conflicting answers, such as 'greater coercivity' and 'greater susceptibility.' Many candidates only mentioned heat loss.

Suggestions for teachers

- Establish the correlation between concepts of physics and their applications in devices used on a daily basis.
- Clearly explain the working of a transformer, its types, principles, and uses.
- Give more examples from daily life.
- Distinguish between step-up and step-down transformers using relevant examples.
- Discuss in detail terms like magnetic field induction, magnetic field intensity, susceptibility, permeability, hysteresis, coercivity, and retentivity.
- Explain the hysteresis graph and the properties required for making electromagnets, permanent magnets, and the core of transformers.

MARKING SCHEME

Question 4

(i)	Step down (transformer).
(ii)	Sort iron has greater permeability / Susceptibility. OR Soft iron has less coercivity and greater /more retentivity, as a result the flux linkage increases. OR To minimise the loss of power / Energy due to hysteresis. OR To minimise the Hysteresis loss. OR The area of the hysteresis loop is less for soft iron. OR The intensity of magnetisation increases.

Question 5

[2]

(i) Name the electromagnetic radiation whose frequency is 10^{11} Hz.

(ii) What is the speed of radio waves in **vacuum**?

Comments of Examiners

(i) A large number of candidates answered this part correctly, but some candidates confused it with radio-waves, ultraviolet and infrared.

(ii) Majority of the candidates answered this question correctly. However, some of the candidates did not mention the unit, and a few candidates mentioned the velocity of sound waves in air instead of light.

Suggestions for teachers

- Provide rigorous practice and explanation of the electromagnetic spectrum and its applications.
- Discuss the electromagnetic spectrum, including its frequency and wavelength ranges.
- Highlight sources, uses and properties of each part of the spectrum.
- Elucidate and provide practice on the electromagnetic spectrum and its applications, irrespective of the wavelength or frequency, since they all travel at the same speed in a vacuum.

MARKING SCHEME

Question 5

(i)	Microwaves
(ii)	3×10^8 m/s or equivalent OR speed of light.

Question 6

[2]

Draw a **labelled** graph showing the variation in **intensity of diffracted light** with diffracting angle in a single slit **Fraunhofer diffraction** experiment.

Comments of Examiners

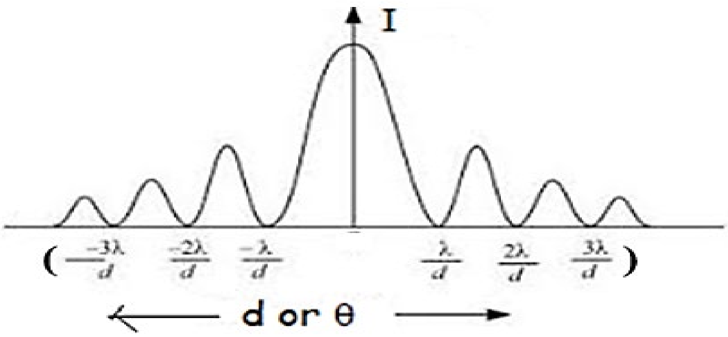
Many candidates answered this question correctly, except for those who did not study at all. The common errors identified were that candidates marked the X- axis incorrectly. Some candidates did not show a clear variation in intensity as they moved away from the centre. Very few candidates drew a diffraction intensity variation diagram.

Suggestions for teachers

- Practice graphs-based questions along with explanation related to the importance of the shape and labelling the axis of a graph.
- Emphasise 60 percent variation is expected in the secondary maxima.
- Encourage students to label the axis in symbolic or in full words and mark at least two maxima and two minima.

MARKING SCHEME

Question 6



The correct shape of the graph with two maxima on each side

Correct labelling with one axis correctly marked.

Question 7

[2]

(i) ***Figure 1*** below is the Energy level diagram for Hydrogen atom. Study the transitions shown and answer the following questions.

(a) State the type of spectrum obtained.

(b) Name the series of spectrum obtained.

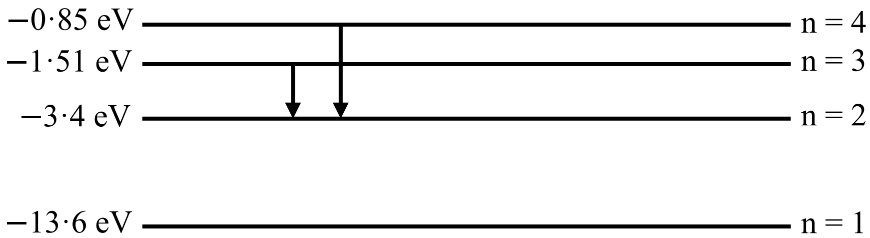


Figure 1

OR

(ii) In a **nuclear reactor**, state the use of the following:

(a) Graphite rods

(b) Cadmium rods

Comments of Examiners

(i) (a) This question was answered incorrectly by most of the candidates. Candidates were not aware of the absorption and emission spectrum. Many candidates mentioned the hydrogen spectrum as a response, while a few mentioned the line spectrum.

(b) Those who opted for this question answered this part correctly. Very few candidates mentioned the Lyman series as a response.

OR

(ii) (a) Most of the candidates confused 'Graphite rods' with the control rod. Some candidates confused it with cadmium and incorrectly implied that it controls the rate of reaction. A large number of candidates provided a 'moderator' as a response. Some candidates stated that it slows down the neutrons.

(b) Most candidates answered it correctly, but the use was not explained properly. No

Suggestions for teachers

- Emphasise the hydrogen atom spectrum as both emission and absorption spectra.
- Provide rigorous practice and discuss the various series in the hydrogen spectrum, using the energy level diagram and Rydberg formula.
- Highlight Lyman series $n_1 = 1$ in the UV region, Balmer series $n_1=2$ in the visible region, and the others in the Infrared region.
- Encourage students to solve numerical on the shortest, longest, and other wavelengths of hydrogen spectra.
- Emphasise the role and need for a moderator in a nuclear fission reactor. State that heavy water is the best moderator, along with other examples such as cadmium and D_2O.
- Give regular practice on these types of questions from time to time.
- Emphasise the role and need for control rods in a nuclear fission reactor.
- Provide another example, such as Boron rods.

MARKING SCHEME

Question 7

(i)	(a)	Emission (spectrum) or line (spectrum) OR Emission line (spectrum).
	(b)	Balmer (series).
		OR
(ii)	(a)	They **act as a moderator**, OR they **slow down the fast-moving neutrons**.
	(b)	It **absorbs the neutrons** OR it controls the rate of the nuclear fission reaction or it **acts as control rods**.

Question 8

[2]

With reference to a semiconductor diode, define the following terms:

(i) depletion region

(ii) potential barrier

Comments of Examiners

(i) Most of the candidates provided incorrect answers. Some candidates defined the concept, while others explained it through diagrams, but they did not state that it contains immobile ions/charge carriers (which should be a part of the definition). Most candidates missed key terms like "immobile charges" or "no mobile charges." Many candidates failed to clearly state that it is the gap between the p-n junction diode.

(ii) Candidates understood the question but could not express it properly. Most candidates attempted this question incompletely. Some mentioned 'the barrier created in the p-n junction diode,' while others wrote 'obstructs the flow of charge.' However, very few candidates provided the complete answer.

Suggestions for teachers

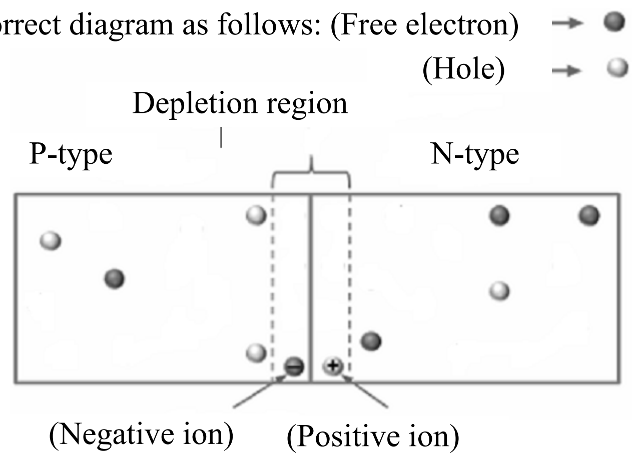
- Discuss the formation of a p-n junction diode and elaborate on the diffusion of charges across the junction due to the potential difference, leading to the creation of immobile ions and their tendency to accumulate at the junction.
- Emphasise the concept of the external potential difference (PD) needed to break the depletion layer.
- Highlight the obstruction created by the depletion layer.
- Teach that the width of the depletion layer is proportional to the height of the potential barrier.

MARKING SCHEME

Question 8

(i)	Depletion region: It is a charge-free region between 'p' and 'n' regions of a semiconductor diode. OR It is a (narrow) space between p and n regions that doesn't contain mobile charge carriers. OR It is a (narrow) region between p region & n region of a semiconductor diode which is devoid / absent of charge carriers or free electrons & holes and has immobile ions only. OR A (small) space near the junction of a junction diode that does not contain charge carriers or free electrons & holes. OR

<table>
<tr><td></td><td>Correct diagram as follows:



</td></tr>
<tr><td>(ii)</td><td>Potential barrier: The **potential difference / voltage developed across the depletion region** due to diffusion of charge carriers (is called the 'Potential barrier').
OR
The potential barrier created throughout the P-N junction is due to the diffusion of electrons and holes. **Potential barrier (normally) does not allow charge flow through the junction** and this resistance to the flow of charge is called the potential barrier.
OR
It is the potential difference / voltage developed across the depletion region.</td></tr>
</table>

SECTION C – 27 MARKS

Question 9

[3]

Obtain an expression for **equivalent** capacitance **C** when three capacitors C_1, C_2 and C_3 are connected in **series**.

Comments of Examiners

A large number of candidates did not provide a circuit diagram in their solution. The basic concept that potential varies ($V=V_1+V_2+V_3$) and that the charge remains the same was not clear to most of the candidates. Most candidates expressed the final step as $\{C = 1/C_1+1/C_2+1/C_3\}$ instead of $1/C$.

OR

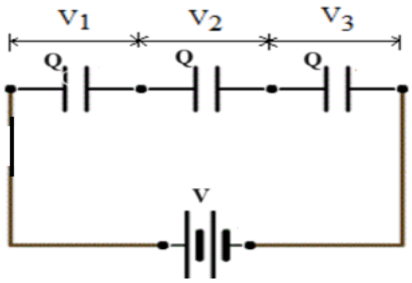
Some candidates got confused between series and parallel combinations. Several candidates made an error in the last step $Cs= 1/C_1 + 1/C_2 + 1/C_3$.

Suggestions for teachers

- Provide more practice with derivations and emphasise the importance of diagrams and how the derivations correspond to the diagrams.
- Teach the series and parallel combinations of capacitors with properly labelled circuit diagrams.
- Emphasise the need to consider different capacitors, not identical ones, and clearly mark 'Q' as constant in series and 'V' as constant in parallel.
- Emphasise clearly that potential difference (PD) add in series and charge (Q) adds in parallel.

MARKING SCHEME

Question 9



Correct diagram with **V_1, V_2, V_3 / Q / C_1, C_2, C_3** written on the diagram.

$$V = V_1+V_2+V_3$$

$$\frac{Q}{C} = \frac{Q}{C1} + \frac{Q}{C2} + \frac{Q}{C3} \quad \textbf{[Eqn A]}$$

So,

$$\frac{1}{C} = \frac{1}{C1} + \frac{1}{C2} + \frac{1}{C3}$$

(If equation A is written directly then the first equation is even implied in the diagram or in the equations.)

Question 10

[3]

(i) ***Figure 2*** below shows two batteries **E_1** and **E_2** having emfs of 18V and 10V and internal resistances of 1Ω and 2Ω respectively. **W_1**, **W_2** and **W_3** are uniform metallic wires AC, FD and BE having resistance of 8Ω, 6Ω and 10Ω respectively. **B** and **E** are **midpoints** of the wires **W_1** and **W_2**. Using **Kirchhoff's laws** of electrical circuits, calculate the current flowing in the wire **W_3**.

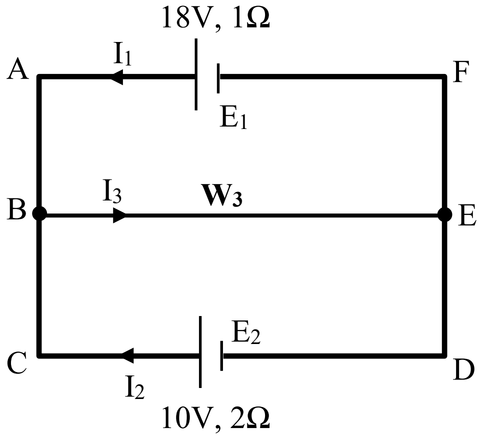


Figure 2

(ii) ***Figure 3*** below shows a **potentiometer** circuit in which the **driver cell D** has an emf of 6V and internal resistance of 2Ω. The potentiometer wire **AB** is 10m long and has a resistance of 28Ω. The series resistance $\mathbf{R_s}$ is of 20Ω.

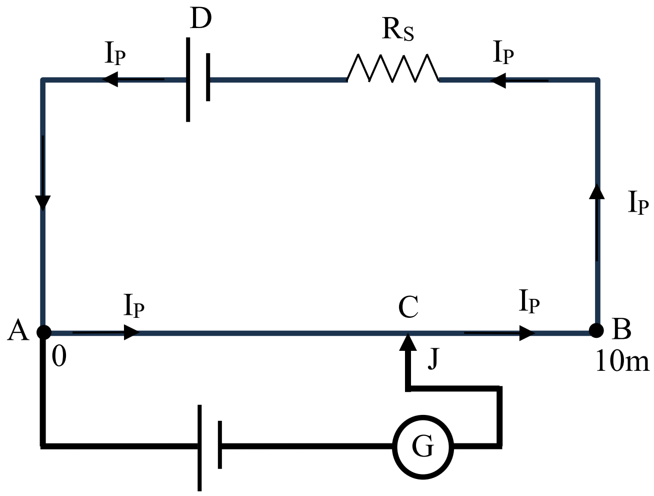


Figure 3

Calculate:

(a) The current $\mathbf{I_p}$ flowing in the potentiometer wire AB when the jockey (J) **does not touch** the wire AB.

(b) emf of the cell **X** if the **balancing length** AC is 4·5m.

Comments of Examiners

(i) Candidates were unable to frame the correct equations, and those who succeeded could not reach the correct inference. A common error noted was the application of Kirchoff's second law in the loops. Many candidates seem to understand the concept, but due to a lack of practice in writing and solving linear equations, they made errors. A few candidates did not interpret the question correctly and used Ohm's law in the two loops, resulting in vague answers.

OR

(ii) (a) Most candidates answered incorrectly because they failed to take into consideration all the resistance, especially the resistance of wire AB, while using V = IR.

(b) Several candidates could not determine the potential in wire AB, so they could not apply the formula $V_1/V_2 = L_1/L_2$ properly. Some candidates were not able to interpret the concept of balancing length and calculated null point incorrectly.

Suggestions for teachers

- Teach the division of current and the implementation of Kirchhoff's second law.
- Practice questions that apply only the first law in closed circuits. After sufficient practice in marking current correctly and ensuring that the current entering the circuit is equal to the current leaving the circuit, introduce the second law as the conservation of energy and state the law clearly.
- Give additional practice in solving complex linear equations.
- Clearly state that any complex value of current can be a possible answer.
- Teach the concept of Ohm's law for a single external resistor without considering the internal resistance of a cell, then introduce internal resistance, followed by the addition of the resistance of the wire.
- Provide rigorous practice with direct application-based problems, including variations of practical topics.

MARKING SCHEME

Question 10

<table>
<tr><td>(i)</td><td colspan="2">

[By Kirchhoff's loop rule] in the loop ABEFA OR loop 1,

$$4I_1 + 10I_3 + 3I_1 + 1I_1 = 18$$

[Similarly, applying Kirchhoff's loop rule to the] loop CBEDC OR loop 2,

$$4I_2 + 10I_3 + 3I_2 + 2I_2 = 10$$

Note: Kirchoff's loop rule may be applied to the loop ABCDEFA also.

OR Third possible equation in loop ACBFA OR loop 3

$$4I_1 + 3I_1 + 1I_1 - 4I_2 - 3I_2 - 2I_2 = 18 - 10$$

Substituting, $I_3 = I_1 + I_2$

$$9I_1 + 5I_2 = 9$$
$$10I_1 + 19I_2 = 10$$
$$8I_1 - 9I_2 = 8$$

in the above equations and solving, we get,

$(I_1 = 1A \text{ and } I_2 = 0)$

Current through W_3 or $I_3 = 1A$ *[e.c.f. is implied]*

(Correct unit at any one place or any other alternative method)

</td></tr>
<tr><td colspan="3">

OR

</td></tr>
<tr><td>(ii)</td><td>(a)</td><td>

By applying Ohm's law to the primary circuit of the potentiometer, we get,

$$Ip = \frac{\varepsilon}{(R+r)} =/ \frac{\varepsilon}{(R+r)} = / \frac{\varepsilon}{(R_p + R_s + r)} /$$

$$= \frac{6}{(28+20+2)}$$

$$= (6 / 50)$$

$$= 0{\cdot}12A$$

</td></tr>
<tr><td></td><td>(b)</td><td>

$Vp = Ip \times Rp =/ 0{\cdot}12 \times 28 = 3{\cdot}36V$ [or even implied]

K = potential gradient = $Vp / L = 3{\cdot}36/10 = 0{\cdot}336Vm^{-1}$ [or even implied]

[e.c.f.]

Now, $Ex = K \times l = 0{\cdot}336 \times 4{\cdot}5 = 1{\cdot}512V \sim 1 \cdot 5V$ ……… *[e.c.f.]*

OR

Any alternative correct method.

</td></tr>
</table>

Question 11

[3]

Using **Biot-Savart law,** show that **magnetic flux density 'B'** at the centre of a current carrying circular coil of radius R is given by:

$$B = \frac{\mu_0 I}{2R}$$

where the terms have their usual meaning.

Comments of Examiners

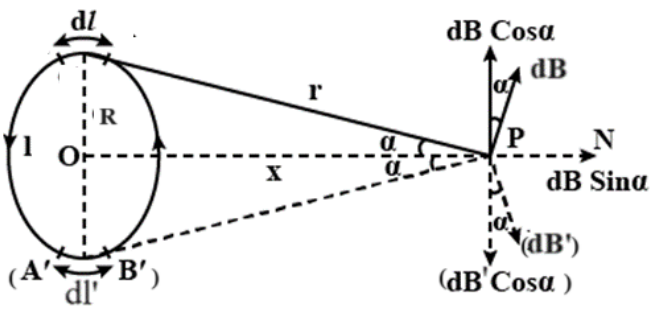
It was noted in some of the answers that the diagram, or their basic components were missing (for instance, $\theta = 90^0$). Otherwise, the approach to the derivation was correct. Several candidates were unable to distinguish between Ampere's circuital law and Biot–Savart's law.
Some candidates made errors in the diagram. For e.g., I was not connected, dl was not marked, the sample was not chosen, or the direction of **B** was not marked. Some candidates failed to show the limits of integration and $\theta = 90^0$.
A few candidates mentioned the derivation for an axial line of the coil and simplified it for the centre.

Suggestions for teachers

- Guide students to mark all vector symbols in the diagram.
- Teach the concept of definite integration within the limits of integration in Physics.
- Avoid summation, as it is not the idea of Biot Savarts law.
- Encourage students to use the symbols provided in the questions.
- Avoid changing R to r/a/*x*, as the final step is printed in the question.

MARKING SCHEME

Question 11



Correct diagram - In the diagram if Idl is marked (I may be ignored).

By Biot Savart Law written and (sin 90 =1)

OR

$$dB = \left(\frac{\mu_0}{4\pi}\right)\frac{Idl}{r^2}$$

Magnetic flux density B due to the whole coil

B = $\int dB \, sin\alpha$

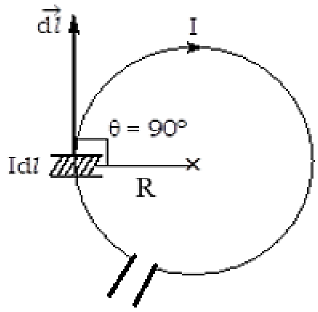
$= \int \left(\frac{\mu_0}{4\pi}\right) \frac{Idl}{r^2} \frac{R}{r}$

$= \left(\frac{\mu_0}{4\pi}\right) \frac{I\,R}{r^3} \int_0^{2\pi R} dl$

$= \frac{\mu_0}{4\pi} \frac{IR}{(x^2+R^{2)3/2}} . 2\pi R$

$= \frac{\mu_0 I}{2R}$ (for $x = 0$)

(Any other alternative method to be accepted)



Correct diagram *(it exactly looks 90^0. Complete circular loop also accepted)*

Consider a circular coil of radius 'R' and carrying a current I in the clockwise sense. To find the magnetic induction at the center O of the coil, we divide the circular coil into a very large number of elements, each of length d*l*.

Consider the element of length d*l* at point P. The magnitude of magnetic induction (dB) at the center (O) of the coil due to this element is given by the Biot-Savart's law as,

$$dB = \frac{\mu 0}{4\pi} \frac{Idl \sin\theta}{R^2}$$

where, θ is the angle between the element and the radius vector 'R'.

In this case, θ = 90°.

∴ $\sin\theta = 1$

∴ $dB = \frac{\mu 0}{4\pi} \frac{Idl}{R^2}$

If we consider all the elements, we find that in each case, θ = 90° and each element is at the same distance 'R' from the centre.

Hence, the magnetic induction due to the entire coil is given by,

$B = \int dB$

∴ $B = \int \frac{\mu 0}{4\pi} \frac{Idl}{R^2}$

∴ $B = \frac{\mu 0}{4\pi} \frac{I}{R^2} \int_0^{2\pi R} dl = \frac{\mu 0}{4\pi} \frac{I\,2\pi R}{R^2}$

Alternate Step:

$B = \sum dB$

∴ $B = \sum \frac{\mu 0}{4\pi} \frac{Idl}{R^2}$

∴ $B = \frac{\mu_0}{4\pi} \frac{I}{R^2} \Sigma\, dl = \frac{\mu_0}{4\pi} \frac{I}{R^2}\ 2\pi R$

$B = \frac{\mu_0 I}{2R}$

'a' OR 'r' may be accepted instead of R.

Question 12

[3]

Figure 4 below shows an **infinitely long** metallic wire YY′ which is carrying a current **I′**. **P** is a point at a perpendicular distance **r** from it.

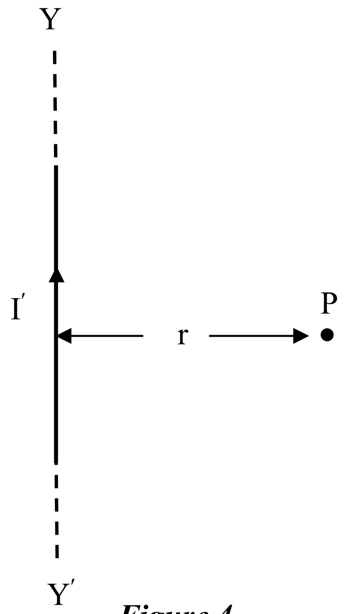


Figure 4

(i) What is the **direction** of magnetic flux density **B** of the magnetic field at the point P?

(ii) What is the **magnitude** of magnetic flux density **B** of the magnetic field at the point P?

(iii) Another metallic wire MN having length ***l*** and carrying a current **I** is **now** kept at the point P. If the two wires are in vacuum and parallel to each other, how much **force** acts on the wire MN due to the current **I′** flowing in the wire YY′?

Comments of Examiners

(i) Several candidates were not familiar with the direction rules. Additionally, those who understood the directions were unable to express them in the correct language resulting in incorrect answers. Most candidates wrote 'inward' but did not provide a complete response such as 'perpendicular/normally inward.'

(ii) Some answers were correct, but a few candidates failed to consider I' instead of I, as it is a common notation for current. Some candidates calculated the magnitude incorrectly.

(iii) A number of candidates were found to be confused in this part of the question. Many used the formulas F= q v B, instead of F= I B l, rather than $F = \frac{\mu_0}{4\pi}\frac{2II'L}{r}$.

Some candidates misinterpreted the question and used the formula F = Bil sin θ. Additionally, most candidates did not use the symbols provided in the question and instead wrote the product of current as $I_1\ I_2$.

Suggestions for teachers

- Ask students to regularly memorise vectors and diagrams related to directions.
- Teach the convention for marking magnetic fields with symbols and encourage its consistent use in numericals.
- Reiterate that mentioning only 'inward' or 'outward' is not a complete answer; the plane of the paper is a mandatory part of the response.
- Encourage students to use the symbols provided in the question paper.

MARKING SCHEME

Question 12

(i)	Perpendicular/ Normally into the plane of the paper, pointing into the paper. OR A correct symbol: $\otimes$ Directed along $-\hat{k}$ or – Z axis, away from the observer.
(ii)	$B = [\mu_0/4\pi][\frac{2I'}{r}]$ OR $B = \frac{\mu_0}{2\pi}\frac{I'}{r}$
	(F = BIl) $F = [\mu_0/4\pi][\frac{2II'}{r}]l$ OR $\frac{\mu_0 II' l}{2\pi r}$

Question 13

[3]

(i) Using **Huygen's wave theory**, show that (for refraction of light):

$$\frac{Sini}{Sinr} = \text{Constant}$$

where terms have their usual meaning. You must draw a neat and **labelled** diagram.

OR

(ii) In **Young's double slit experiment**, show that:

$$\beta = \frac{\lambda D}{d}$$

where the terms have their usual meaning.

Comments of Examiners

(i) A large number of candidates answered the question correctly. However, some candidates misunderstood the question and proved the Law of Reflection instead of the Law of Refraction. In some cases, the diagram was also missing. Very few candidates mentioned reflection, while the majority drew a diagram of refraction. Some candidates lost marks in the diagram for not labelling the direction of light and not marking the angles 'i' and 'r'. The values of sin i and sin r were not written correctly, and the right-angled triangles were labelled incorrectly. The rarer and denser mediums were not marked.

(ii) While most candidates answered correctly, their steps were not up to the mark as some key steps were missing. Many candidates lost marks for drawing an incomplete/unlabelled diagram. Some candidates did not quote the path difference step correctly, and a few did not show the calculation of fringe width correctly.

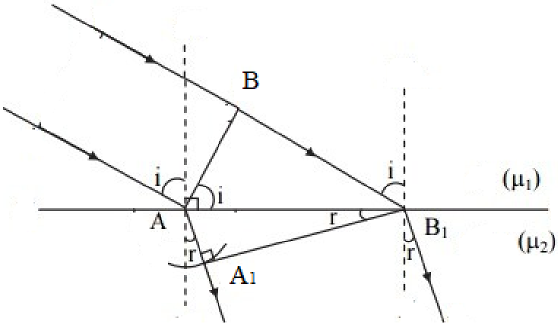
Suggestions for teachers

- Elucidate the importance of the diagram and its application in the derivation.
- Teach how to draw a simple diagram with correct labels.
- Emphasise the importance of substituting 'sin *i*' and 'sin *r*' correctly.
- Use the definition to reach the last step.
- Explain in detail the importance of the diagram and its application to the derivation.
- Emphasise the need to draw neat and well-labelled diagrams.
- Highlight important and mandatory steps in the derivation, and ensure students practice derivations regularly.

MARKING SCHEME

Question 13

(i)



Correct diagram with 'i' and 'r' at one place and arc drawn or wavefront shown at right angle and at least one arrow to indicate path of light.

Sin i = $\frac{BB_1}{AB_1}$ and sin r = $\frac{AA_1}{AB_1}$

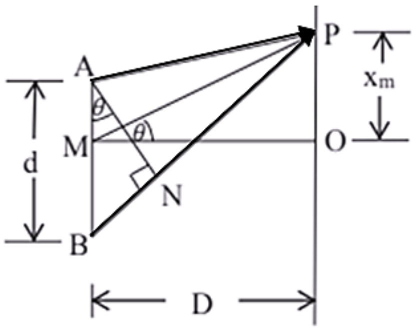
$$\frac{\sin i}{\sin r} = \frac{ct}{Vt} = \frac{c}{V} = n/r/\mu\ /const$$

OR

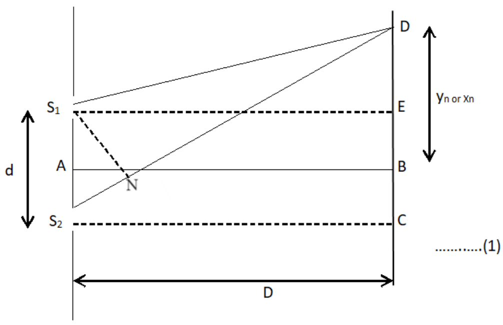
Any other alternative method

OR

(ii)



OR



(Diagram for Alternative method)

$$\sin\theta = \frac{BN}{AB} = \frac{m\lambda}{d} \quad \text{and} \quad \tan\theta = \frac{OP}{OM} = \frac{x_m}{D}$$

Since, θ is small,

$$\tan\theta \cong \sin\theta$$

$$\frac{x_m}{D} = \frac{m\lambda}{d}$$

$$\beta = \frac{\lambda}{d}D$$

Or equivalent method is accepted.

	$S_1D^2 = S_1E^2 + DE^2$ $= D_2 + (y - dy_2)^2$ $S_1D^2 = D^2 + y^2 - \frac{2yd}{2} + \frac{d^2}{4}$ $S_2D^2 = S_2C^2 + \left(y + d/2\right)^2$ $= D^2 + y^2 + yd + \frac{d^2}{4}$ $S_2D - S_1D = \frac{\not{2}yd}{\not{2}D}$ Path difference $= \frac{yd}{D}$ $\beta_{bright} \frac{y_n d}{D} = n\lambda$ / $y_n = \frac{n\lambda D}{d}$ For Bright fringe $y_{n+1} = \frac{(n+1)\lambda D}{d}$ $\beta - y_{n+1} - y_n = \frac{\lambda D}{d}$ Similarly OR $\frac{y_n d}{D} = (2n+1)\frac{\lambda}{2}$ $y_n = \frac{(2n+1)\lambda D}{2d}$ **Or** For dark fringe; $y_{n+1} = \frac{[2(n+1)+1]\lambda D}{2d}$ $\beta_{dark} = y_{n+1} - y_n = \frac{\lambda D}{d}$

Question 14

[3]

Figure 5 below shows a ray of monochromatic light LM incident on the first surface AB of a **regular (equilateral) glass prism** ABC. The emergent ray grazes the adjacent surface AC. Calculate the **angle of incidence.** (Refractive Index of glass = 1·5)

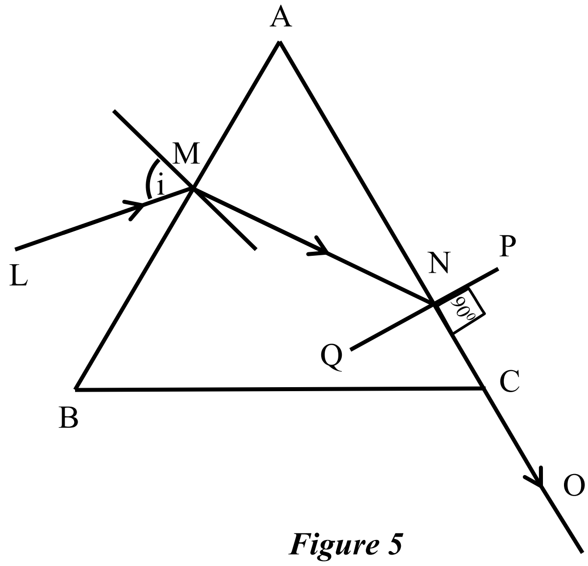


Figure 5

Comments of Examiners

Most of the candidates answered this question incorrectly. Some candidates quoted the critical angle as 42^0 without performing the calculation. A few candidates used the prism formula. Many candidates rounded off intermediate steps, which led them to deviate from the expected answer. Additionally, some candidates missed the units. Moreover, rounding of values in every step also resulted in an answer outside the expected range.

Suggestions for teachers

- Provide students with rigorous practice related to numericals with variations.
- Teach the formation of angles at different interfaces and ray diagrams properly in class.
- Emphasize to students the importance of reading numerical questions carefully.
- State the formula, show the substitution, and provide answers with the correct number of decimal places and units.

MARKING SCHEME

Question 14

$\sin c = \frac{1}{\mu} =/ \frac{1}{1.5}$

$\therefore$ c = 41·8° or 42° ……with working.

$\because$ ($r_1 + r_2 = A$)/

$\therefore r_1 + 41{\cdot}8^o = 60^o$)

$\therefore r_1 = 18{\cdot}2^o$ or $r_1 = 18^o$ …………………………………………*[e.c.f.]*

$\left(\frac{\sin i}{\sin r_1}\right) = / \left(\frac{\sin i}{\sin 18.2^o}\right) = 1 \cdot 5$

$\therefore$ sin i = 1·5 × sin (18·2°) = ·46850

$\therefore$ i = 27·93° or 27·61° or 28 ° …………………………………*[e.c.f.]*

Degree written at any one place.

Question 15

[3]

A student is performing an experiment to determine **focal length** of a convex lens by using lens formula i.e., by **no parallax** method. The examiner gives some instructions to the student. The student responds to each instruction as per her understanding of the experiment.

State whether the student's response is correct or incorrect. Give a reason for your answer

(i) EXAMINER: Image formed by the lens is **magnified**. Reduce the size of the image. STUDENT moves the lens towards the object pin.

(ii) EXAMINER: Plot a graph of (1/v) **against (**1/u).
STUDENT takes (1/v) on Y axis and (1/u) on X axis.

(iii) EXAMINER: Write the relation between the **optical power** (P) and the **focal length** (f) of the convex lens.
STUDENT writes P = 2f.

Comments of Examiners

(i) Most of the candidates answered this question correctly but failed to provide the correct reason. Some candidates did not provide any reason at all and struggled to give an appropriate explanation. Some explained the error, while others discussed how to achieve greater magnification.

(ii) The majority of candidates answered correctly but failed to provide the correct reason. Some candidates missed the reason entirely. Although almost all candidates provided the correct response, they struggled to offer an appropriate explanation.

(iii) A large number of candidates answered correctly but failed to provide the correct reason. Some candidates did not mention any reasons at all. A few candidates, however, mentioned R = 2f.

Suggestions for teachers

- Emphasize elaborating on the incorrect response by clearly stating what is wrong, then quoting the correct steps to successfully execute the examiner's instructions.
- Teach the concept of dependent and independent variables.
- Emphasize the interpretation of graphs, as it is part of the optical bench practical.
- Slope and intercepts imply an answer and must include units.
- Provide rigorous practice with these kinds of questions, as they require more attention.
- Instruct students to identify the error and state the correct relation.

MARKING SCHEME

Question 15

(i)	Incorrect; as the image will be more magnified. Since, $m = \frac{v}{u}$, if 'u' decreases 'm' will increase.
(ii)	Correct; as $1/_v$ dependent variable is on y-axis and $1/_u$ independent variable is on x-axis. $1/_v$ and $1/_u$ are correctly plotted as per convention/condition.
(iii)	Incorrect; as the power P = $\frac{1}{f(m)}$

Question 16

[3]

(i) In an experiment on photo electric effect, how does **stopping potential** change, if at all, when **intensity** of incident monochromatic UV radiation is increased?

(ii) Ultraviolet light is incident on metals P, Q and R, having work functions 8eV, 2eV and 4eV respectively.

(a) Which metal has **lowest** threshold frequency for photoelectric effect?

(b) For which metal is the value of E_{max} **minimum**?

(Note: E_{max} is maximum kinetic energy of the emitted photoelectrons.)

Comments of Examiners

(i) Most of the candidates knew the relation, so the answer was correct. However, some candidates mentioned stopping potential increases or decreases.

(ii) (a) Most candidates attempted this question correctly. Some of the candidates were found to be confused about frequency and wavelength; thus, they answered ambiguously. A few candidates mentioned 2 eV as the correct response. The incorrect answer given was P/R.

(b) Some of the candidates answered ambiguously because they were confused about frequency and wavelength. A number of candidates mentioned P as the answer but failed to support it with any reasoning.

Suggestions for teachers

- Teach the relationship between work function and frequency.
- Provide more practice for numerical problems.
- Offer more rigorous practice with variations.
- Instruct students to provide a reason for their responses. Data mentioned in the question should be substituted to obtain a result, followed by stating the response.

MARKING SCHEME

Question 16

(i)	No change, (As stopping potential does not depend upon the intensity of incident light.)	
(ii)	(a)	(Metal) Q
	(b)	($E_{max} = h\nu - w$ thus, metal) P

Question 17

[3]

(i) What is meant by **forward biasing** of a semiconductor diode?

(ii) Draw a **labelled** characteristic curve (I-V graph) for a semiconductor diode during **forward bias**.

Comments of Examiners

(i) Most of the candidates answered this question correctly, either through a definition or a diagram. A few candidates made an error and quoted the definition of reverse biasing. However, some other candidates provided incomplete answers, such as 'p-type is connected to positive.'

(ii) Majority of the candidates answered it correctly, but the shape was not up to the mark. Some candidates started the graph from the origin. The common errors made by them were:

- Axis not labelled correctly.
- Voltage cut not marked.
- Axis reversed.
- Curve is not drawn appropriately.

Suggestions for teachers

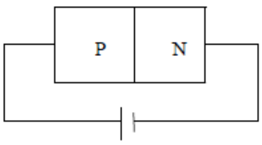
- Draw and present a circuit diagram/block diagram to discuss FB.
- Graphs should be practiced more, with detailed explanations on the importance of the shape and the labeling of the axes.
- Proper instruction on graph plotting should be carried out in class.
- Practice I-V graphs for FB and RB.
- State the importance and significance of the cut-in voltage for FB and the knee voltage for RB.
- Draw graphs marking current (I) in mA and voltage (V) in volts. Mark the cut-in voltage for Ge at 0.3 V and Si at 0.7 V.

MARKING SCHEME

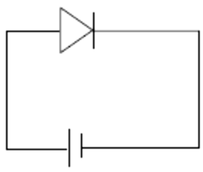
Question 17

(i) Forward bias: It means p region of a semiconductor diode is connected to positive terminal and n region is connected to negative terminal of a cell / battery.

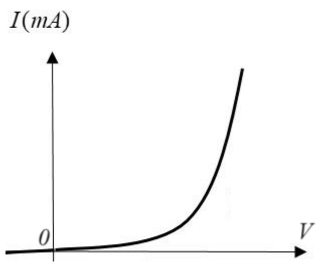
OR



OR



(ii)



(Correct shape of the graph to be ensured.)
(Any one axes to be labelled correctly.)

SECTION D – 15 MARKS

Question 18 [5]

(i) (a) A 220V, 50Hz ac source is connected to a coil having coefficient of self-inductance of 1H and a resistance of 400Ω. Calculate:

(1) the **reactance** of the coil.
(2) the **impedance** of the coil.
(3) the **current** flowing through the coil.

(b) Draw a **labelled** graph showing variation of **impedance (Z)** of a series LCR circuit Vs **frequency (f)** of the ac supply. Mark the resonant frequency as $\mathbf{f_0}$.

OR

(ii) (a) When current flowing through a solenoid decreases from 5A to 0 in 20 milliseconds, an emf of 500V is induced in it.

(1) What is this phenomenon called?
(2) Calculate **coefficient of self-inductance** of the solenoid.

(b) (1) **RMS** value of an alternating current flowing in a circuit is 5A. Calculate its **peak** value.

(2) State ***any one*** difference between a direct current (dc) and an alternating current (ac).

Comments of Examiners

(i) (a) Most candidates answered correctly; however, some mistakenly considered the circuit to be an L-C-R circuit rather than an L-R circuit. A few candidates incorrectly mentioned the reactance as 400 Ω or failed to include units in their answers. Many candidates did not apply the formula correctly; some misinterpreted the question as relating to resonance and quoted Z=R=400 ohm, while others made calculation errors or incorrectly added X_L +R. In part (3), most candidates used V=IR instead of the correct formula V=IZ. While most candidates understood the concept of Ohm's law, they used the wrong substitution to find the current. Additionally, a few candidates did not express the final answer in amperes (A).

(b) A large number of candidates drew graph correctly but failed to mark f_0. Some of the common errors made by them included the axis not being marked correctly, axis reversed, f_o not marked, shape not sketched correctly, curve touching axis, etc.

OR

(ii) (a) Some candidates incorrectly referred to 'induction' instead of the correct term 'self-induction,' while others confused it with 'self-inductance' or 'mutual induction.' Only a few candidates accurately identified the phenomenon as self-induction, and many simply wrote 'induction' or 'mutual induction.' A small number of candidates did not attempt this part of the question, possibly due to difficulty in interpreting it. In part (2), while many candidates used the correct formula, most failed to account for the time being given in milliseconds (10^{-3} s). Some candidates applied the wrong formula to calculate the self-inductance, and a few overlooked the time unit entirely. Additionally, many candidates did not provide the correct units in their final answers.

(b) Most of the candidates answered it correctly but some candidates used the formula $I_0 = \frac{I_{rms}}{\sqrt{2}}$. A few candidates applied the formula in the reverse manner.

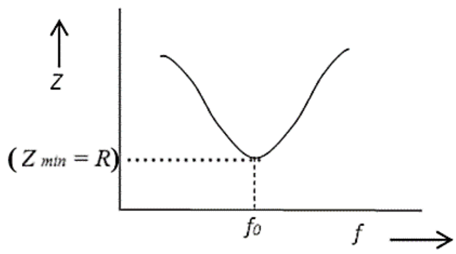
Suggestions for teachers

- Draw an impedance triangle and practice a few numericals where R(base) and (X_L - X_C) (height) are given as sides of a right -angled triangle, and candidates use the Pythagoras theorem (or the Parallelogram law) to find the impedance (hypotenuse).
- Emphasise that the current in LCR, LR, LC or CR is a ratio of E/Z only at resonance, I = E/R.
- Discuss the difference between calculating I_{rms} and I_0.
- Provide practice for graphs with explanation on the importance of the shape and labelling the axis of a graph
- Show examples of Z calculated for f= 0, f = f_R and f= ∞ , plot the graph marking these points. Mark the axis with units and show corresponding Z = R, f = f_0.
- Provide regular practice of newly introduced terms and formulae.
- Introduce the idea of delay in growth of current when a DC battery is switched ON. Due to increase in current magnetic flux increases and due to Lenz's law an induced emf is generated opposite to growth of current. Emphasise this is observed when DC battery is switched OFF as well.
- Introduce conversion of units well.
- Teach flux is proportional to current in the solenoid hence L is a constant of proportionality. Introduce units of L and factors on which L depends.
- Practice numerical on evaluating L when e, dt and dI is stated.
- Clearly distinguish between I scalar in DC circuit, average current zero in AC circuit for a full cycle, actual current flowing in AC as I_{rms} value and peak value of AC.
- Teach the relation between I_{rms} and I_0 with proper integration steps.
- Differentiate AC as SHM of electrons about the mean position and DC as a pulsating current.
- Discuss AC follows sine or cosine variation whereas DC is constant in time.

Many candidates answered part (2) correctly; however, some made distinctions based on their use, which was not appropriate. A few candidates drew waveforms without labels, while others drew input/output waveforms for a full-wave rectifier.

MARKING SCHEME

Question 18

(i) (a)	
	(1) $X_L = 2\pi f L$ /= 2 × 3·14 × 50 ×1 = 100 π Ω OR 314 Ω
	(2) $Z = \sqrt{(X_L)^2 + R^2}$ / $= \sqrt{(314)^2 + (400)^2} = \sqrt{(258596}$ = 508·6 OR 509 Ω *[e.c.f.]*
	(3) I = E / Z = / 220 / 509 = 0·43A to 0·44 A *[e.c.f.]*
(b)	 (Axes labelled correctly). i.e. (Z on Y axis &) f *on* X axis With **only f_0 marked correctly** Correct shape *If axis is interchanged check accordingly.*
OR	
(ii)(a)	(1) Self-Induction
	(2) $e = L\frac{dI}{dt}$ $500 = \frac{L \times (5-0)}{20 \times 10^{-3}}$ ∴ L = 2H
(b)	(1) $I_0 = \sqrt{2} \, . \, I_{rms}$ $= \sqrt{2} \times 5$ = 7·07 A
	(2) DC has a fixed value whereas AC varies with time. OR DC is unidirectional whereas in AC, direction of current continuously changes. OR AC can be transferred to long distances as compared to DC.

	OR Power loss in AC is less as compared to DC. OR Shown graphically with correct axis and shape.

Question 19

[5]

(i) (a) On the basis of **Bohr's theory**, derive an expression for the **radius** of the **n^th^** orbit of an electron of hydrogen atom.

(b) Calculate the energy released in the following nuclear fusion reaction:

$$^{2}_{1}H + ^{2}_{1}H \rightarrow ^{4}_{2}He + \text{energy}$$

Mass of $^{2}_{1}H$ = 2·014102u

Mass of $^{4}_{2}He$ = 4·002604u

OR

(ii) (a) Calculate **mass defect** and **binding energy** of $^{20}_{10}Ne$ nucleus, given

Mass of $^{20}_{10}Ne$ = 19·992397u,

Mass of $^{1}_{1}H$ = 1·007825u,

Mass of $^{1}_{0}n$ = 1·008665u.

(b) State the **Bohr's postulate** of angular momentum of an electron.

(c)

(1) What is the **velocity** of an electron in the **3^{rd}** orbit of hydrogen atom if its velocity in the 1^{st} orbit is v_0?

(2) Radius of the 1^{st} orbit of hydrogen atom is r_0. What will be the **radius** of the **4^{th}** orbit?

Comments of Examiners

(i) (a) Most of the candidates attempted this part correctly; however, some candidates failed to mention the steps. Moreover, some candidates did not obtain the final formula for the H atom. The maximum errors were observed in simplifying the radius expression. Some candidates left the answer in the form of K, and did not substitute Z=1 for the hydrogen atom.

(b) Majority of the candidates left the answer in terms of a mass difference, stating it to be nuclear energy. Additionally, the units were incorrect in various places. Some candidates made calculation errors in the numerical part. Very few candidates made conceptual errors, such as not identifying (the mass of reactants – the mass of products). Some candidates considered only one reactant in the calculation. Some candidates calculated the answers in joules and did not use 931 MeV as a conversion factor, or instead used 931.5 MeV.

OR

(ii) (a) Most of the candidates calculated the mass defect correctly but could not solve binding energy. Other candidates were unable to frame the correct equation, so they failed to calculate the mass defect. Some candidates made calculation and substitution errors in this numerical. Errors were induced due to rounding off digits. A few candidates converted Δm answer into kg, which was not needed, since the conversion factor of 931 MeV is to used in the next step. A few candidates used 931.5 instead of 931, as stated in the question paper.

Suggestions for teachers

- Encourage students to read the questions properly and utilise the reading time efficiently to avoid any errors.
- Emphasise Bohr's postulate for the hydrogen atom Z =1 is a mandatory substitution. Impress K needs to be substituted in the derivation of radius.
- Solve simple substitution based numerical on $r \alpha n^2$ to illicit radius increases as higher shell numbers are taken.
- Practice terms of a mass difference stating it to be nuclear energy and also the units and their related numerical.
- Explain the concept of energy released and absorbed as exothermic and endothermic reaction properties.
- Emphasise the use of factor 931 MeV as given in the question paper as a convenient step to express mass difference into energy associated.
- related to the concept of mass difference, explaining it as nuclear energy, along with the units and the corresponding numerical calculations.
- Teach the concept of mass defect and Binding energy and BE/nucleon with lower, middle order and higher order mass numbers.
- Impress on not rounding off digits since students are using a scientific calculator.
- Discuss and emphasise on the use of conversion factor 931 MeV or 931.5 Mev.
- Discuss BE/nucleon vs. mass number graph to illicit mass defect can never be negative, the significance of the curve and characteristics.
- Provide regular practice of the terms of a mass difference stating it to be nuclear energy and also the units and their related numerical.
- Teach the angular momentum condition as a quantization condition where 'n' is an integral multiple and 'h' is Planck’s constant.
- Ensure to provide more practice towards theoretical analysis with formulas and relations.
- Emphasise quoting the relationship between 'v' and 'n', showing substitution, and then answering.

(b) Almost all candidates answered correctly, while some candidates did not know it completely. However, some candidates mentioned expressions instead of worded statements and did not explain the symbols used. A few candidates mentioned the first postulate.

(c) 1. The relation was not learned properly, so some candidates expressed it as 3VO rather than Vo/3. Many candidates misinterpreted the question and substituted the expression for velocity with n=3. Some candidates, without showing v α 1/n , quoted the correct answer.

2. Some candidates expressed it as r0/4 rather than 16r0. Many candidates quoted r α n and gave the wrong answer. Some candidates substituted the radius expression for n= 4 and quoted a response.

MARKING SCHEME

Question 19

(i) (a)	$mvr = \frac{nh}{2\pi}$ Or $m^2v^2r^2 = \frac{n^2h^2}{4\pi^2}$ $\frac{mv^2}{r} = \frac{1}{4\pi\epsilon_0}\frac{Ze^2}{r^2}$ Dividing (i) by (ii) $r = \frac{n^2h^2\epsilon_0}{\pi m Z e^2}$ For Z = 1 $r = \frac{n^2h^2\epsilon_0}{\pi m e^2}$
(b)	$\Delta m = 2 \times$ Mass of ${}_1^2H -$ Mass of ${}_2^4He$ Δm = 4·028204u − 4·002604u = 0·025600 E = 0·025600 × 931 = (23·83 MeV to 23·85 MeV) = 3·813 × 10 -12J *[e.c.f.]*
OR	
(ii)(a)	$\{\ \Delta m = ZM_H + (A-Z)M_N\ \} - \{{}_Z^AX\}$ = {10 × 1·007825 + 10 × 1·008665} – {19·992397} = {10·07825 + 10·08665} – {19·992397} $\Delta m = 0 \cdot 172u \quad or \quad 2 \cdot 58635\ x\ 10^{-28}kg$ B.E. = $\Delta m \times 931\ Mev = 0 \cdot 172 \times 931$ $= (160 \cdot 1MeV\ to\ 160 \cdot 7\ MeV) \quad or \quad 2 \cdot 5696 \times 10^{-11}J$ *[e.c.f.]*
(b)	Electrons revolve around the nucleus only in those orbits in which their angular momentum is an integral multiple of h/2π, where h is the Planck's constant (6·6 x 10^{-34} Js) that is L or $mvr = \frac{nh}{2\pi}$. 'n' is a positive integer. L or $mvr = nh$, where h is $\frac{h}{2\pi}$

(c)	1.	$(v_n \propto \frac{1}{n}; /\therefore \frac{v_1}{v_3} = \frac{3}{1} =>) v_3 = \frac{v_0}{3}$
	2.	$(r_n \propto n^2; /\therefore \frac{r_1}{r_4} = \frac{1^2}{4^2} =>) r_4 = 16r_0$

Question 20

[5]

Read the passage given below and answer the questions that follow.

There are two types of optical instruments: Microscopes and Telescopes.

Microscopes are used to magnify very tiny objects whereas telescopes are used to study distant objects. Both of them deploy convex lenses. In his telescope, **Newton** used a large parabolic mirror to collect light from the stars and reduce aberrations.

(i) Rohit observed the launch of **Chandrayan 3** with the help of an optical instrument. Name the instrument used by him.

(ii) State ***any one*** advantage of a reflecting telescope over a refracting telescope.

(iii) Which instrument is used to study the structure of a virus?

(iv) What is the ability of an optical instrument to form enlarged images called?

(v) What is the **difference** between a compound microscope and an astronomical telescope (refracting type), as far as their **lenses** are concerned?

Useful Constants & Relations:

1.	Charge of a proton	e	$1{\cdot}6 \times 10^{-19}$ C
2.	Speed of light in vacuum	c	3×10^8 ms^{-1}
3.		1u =	931MeV

Comments of Examiners

(i) Almost all the candidates answered this question correctly, except for parts (ii) and (v). Very few candidates answered incorrectly, as they quoted 'microscope' instead of 'telescope.'

(ii) Most of the candidates answered this part incorrectly. Some mentioned factors such as more magnification, higher resolving power, ease of handling, and low cost.

(iii) A large number of candidates answered correctly. Very few candidates mentioned 'telescope' instead of 'microscope'.

(iv) This part was mostly answered correctly. However, few candidates mentioned 'Power' as an answer.

(v) The candidates did not notice that the difference required was only in terms of 'Lenses.' Many candidates responded with:
   - A compound microscope is used to magnify tiny objects/viruses, while a telescope is used to view distant/celestial objects.
   - In a compound microscope, the objective lens is small and the eyepiece is large, whereas in a telescope, the objective lens is large and the eyepiece is small.
   - A ray diagram was drawn for both the compound microscope and the telescope.

Suggestions for teachers

- Discuss in class to ensure that students notice and take interest in space missions launched by ISRO.
- Clearly state and explain the advantages of different types of telescope.
- Encourage students to write about the quality of the image only in terms of brightness.
- Discuss spherical and chromatic aberrations in lenses as a ray diagram and emphasise that the detailed description not needed.
- Emphasise reading the passage carefully, as the words used in the question are part of the passage itself.
- Discuss the magnification of lenses and mirrors to understand the idea enlarged image.
- Emphasise with example M= +5 and M= -5 convey image is 5 times enlarged, its inverted in case of M= -5. The Minus sign indicates position/erect/inverted.
- Teach magnifying power of optical instrument is not same as power of a lens.
- Teach students to quote differences pertaining to a single point viz. compare the size of objective lens in compound microscope and telescope or compare the eyepiece lens in each case.
- Encourage students to clearly make distinction in the question quoting to mention differences and not differences in terms of lenses and not utility/use.

MARKING SCHEME

Question 20

(i)	Telescope
(ii)	The image formed by reflecting telescope is more distinct or clear. OR The image formed by reflecting telescope is brighter. OR The magnification of reflecting telescope can be much larger but refracting telescope has a limitation due to distortion. OR It is free from chromatic aberration or spherical aberration.
(iii)	Compound Microscope OR Electron Microscope OR Microscope.
(iv)	Magnifying power OR Magnification.
(v)	In a compound microscope, focal length OR aperture of objective is less than focal length OR aperture of eye piece whereas in a telescope the focal length of objective is greater than focal length of eye piece.

Note: For questions having more than one correct answer/solution, alternate correct answers/solutions, apart from those given in the marking scheme, have also been accepted.