PHYSICS
PAPER 1
(THEORY)

S2002491

Maximum Marks: 70
Time Allotted: Three Hours
Reading Time: Additional Fifteen Minutes

Instructions to Candidates

1. You are allowed an **additional fifteen minutes** for **only** reading the question paper.
2. You must **NOT** start writing during reading time.
3. This question paper has **12 printed pages.**
4. There are **twenty questions** in this paper. Answer ***all*** questions.
5. There are **four** sections in the paper: **A, B, C and D. Internal choices** have been provided in **two questions** each in **Sections B, C** and **D.**
6. **Section A** consists of one question having fourteen sub-parts of **one mark** each.
7. While attempting **Multiple Choice Questions** in Section A, you are required to **write only ONE option as the answer.**
8. **Section B** consists of **seven questions** of **two marks** each.
9. **Section C** consists of **nine questions** of **three marks** each.
10. **Section D** consists of **three questions** of **five marks** each.
11. The intended marks for questions are given in brackets [ ].
12. A list of useful constants and relations is given at the end of this paper.
13. A simple scientific calculator without a programmable memory may be used for calculations.

Instruction to Supervising Examiner

1. Kindly read **aloud** the Instructions given above to all the candidates present in the examination hall.

SECTION A– 14 MARKS

Question 1

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

(i) Three cells having emfs 3V, 1V and 4V are connected as shown in ***Figure 1*** below. Their internal resistances are **negligible**. The **equivalent** emf between the terminals P and Q is: **[1]**

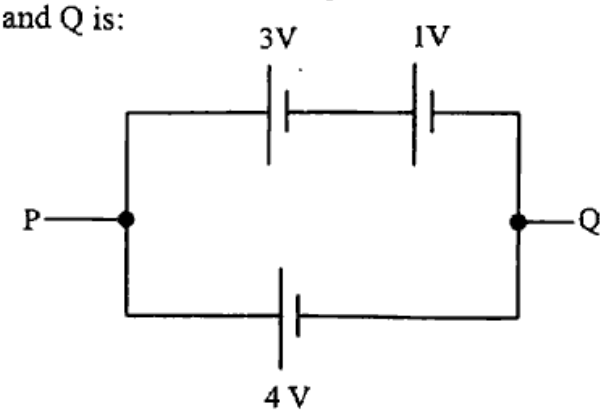


Figure 1

(a) 0V

(b) 4V

(c) 6V

(d) 8V

(ii) Magnetic field inside a **long current carrying** solenoid is B_0. If each of the current (I) and the number of turns (N) in this solenoid are doubled, magnetic field B_1 **inside** it becomes: **[1]**

(a) $B_1 = B_0/4$

(b) $B_1 = B_0/2$

(c) $B_1 = B_0$

(d) $B_1 = 4B_0$

(iii) Study the data given below. **[1]**

Material	Relative Permeability
P	0·9999906
Q	1·000021
R	600
S	280,000

The material **most** suitable to make **permanent magnets** is:

(a) P

(b) Q

(c) R

(d) S

(iv) de **Broglie wavelength** of moving particles **does not** depend on their: **[1]**

(a) velocity.

(b) mass.

(c) size.

(d) kinetic energy.

(v) If temperature of a block of a **semiconducting material** is increased, its resistance: **[1]**

(a) decreases.

(b) increases.

(c) remains constant.

(d) first increases and then decreases.

(vi) Given below are two statements marked, Assertion and Reason. Read the two statements and choose the correct option. **[1]**

Assertion: Phase difference between two overlapping waves to produce a bright band 0 is 2π, 4π, 6π, 8π,.....$(2m-1)\pi$.

Reason: When crest of one wave falls on crest of another wave, amplitude of the resulting wave decreases.

(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.

(vii) Given below are two statements marked, Assertion and Reason. Read the two statements and choose the correct option. **[1]**

Assertion: When a beam of white light is passed through a prism, it gets split into its constituent colours.

Reason: Refractive index of glass is different for different wavelengths of light.

(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.

(B) Answer the following questions briefly:

(i) What is the effect of increasing the temperature of a piece of metal on **relaxation time** of free electrons? **[1]**

(ii) Write an expression for **Lorentz force** in **vector** form. **[1]**

(iii) **Identify** the optical device shown in ***Figure 2*** below. **[1]**

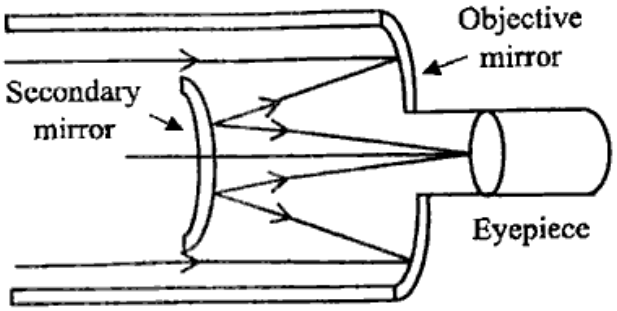


Figure 2

(iv) ***Figure 3*** below shows an optical pin kept in front of a lens mirror combination. It is found that the final image formed by the lens mirror combination **coincides** with the object pin. **[1]**

Draw the ray diagram showing the formation of the **final** image (I).

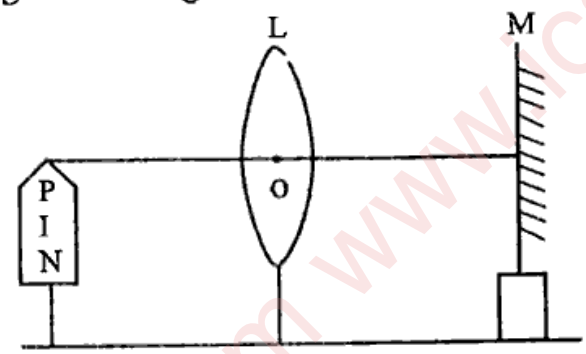


Figure 3

(v) How are energy ('E') and momentum ('p') of a photon related to each other? **[1]**

(vi) If radius of first **Bohr** orbit of an electron in hydrogen atom is 0·05nm, calculate the radius of its **third orbit**. **[1]**

(vii) State ***any one*** difference in the energy band diagram of a semiconductor and that of an insulator. **[1]**

SECTION B – 14 MARKS

Question 2 **[2]**

(i) Two resistors, $R_1 = 1\Omega$ and $R_2 = 2\Omega$ are connected in **parallel.** If the power developed in the **resistor** R_1 is 4W, find the power developed in the resistor R_2.

OR

(ii) In ***Figure 4*** shown below, **internal resistance of the battery is negligible. Calculate** the Ammeter Ⓐ reading, assuming its resistance to be negligible.

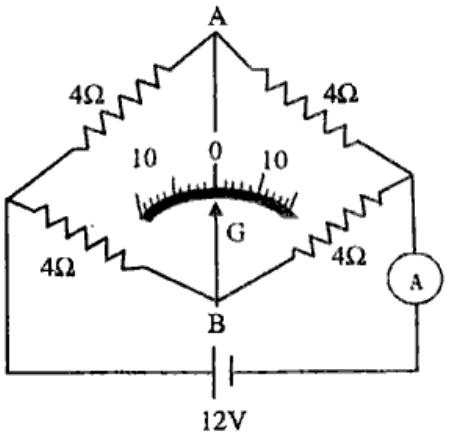


Figure 4

Question 3 **[2]**

Two **identical** capacitors, each of capacitance C are connected to a battery as shown in ***Figure 5*** below.

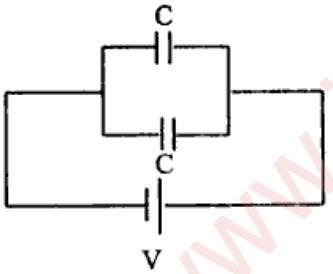


Figure 5

(i) Calculate the **equivalent** capacitance of the circuit.

(ii) What is the **equivalent** capacitance of the **circuit,** if the space between the two plates of one of the capacitors is completely filled with paper (of dielectric constant K= 2·5)?

Question 4 **[2]**

(i) (a) Three identical point charges, each equal to Q, are situated at the three vertices of an equilateral triangle MNO, having each side equal to *l*.
How much **electrostatic potential** energy is stored in this system?

(b) An electric dipole lies in a uniform electric field. When is **torque** acting on the dipole **maximum**?

OR

(ii) Two **Gaussian** surfaces, S_1 and S_2 are shown in ***Figure 6*** below.

(a) What is the ratio of electric flux emerging out of these two surfaces?

(b) What happens to this ratio if the space occupied by each Gaussian surface is doubled?

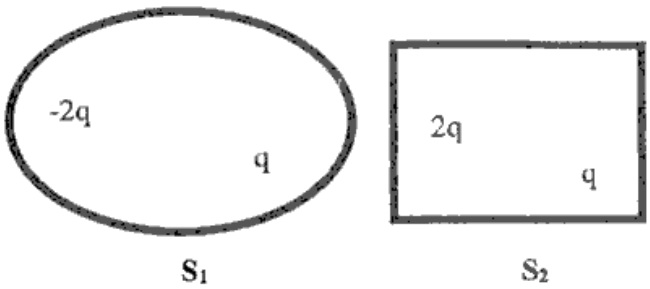


Figure 6

Question 5 **[2]**

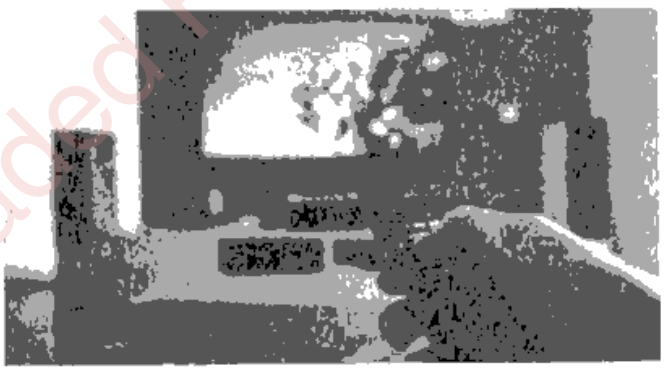
(i) How much **force per unit length** acts on a long current carrying conductor X due to a current flowing through another similar conductor Y, kept parallel to it in vacuum? (Derivation of the formula is **not** required.)

(ii) Use this expression to define an **ampere.**

Question 6 **[2]**

A parallel beam of monochromatic light of wavelength 450nm is incident **normally** on a rectangular slit of width 0·9μm. Calculate **angular width** of the central bright band.

Question 7 **[2]**



(i) **Name** the electromagnetic wave emitted by the remote control operating the TV set.

(ii) State ***any one*** property common to all electromagnetic waves.

Question 8 [2]

Intensity of monochromatic UV light incident on photocathode of a **photoelectric cell** is increased. What is its effect on:

(i) photocurrent?

(ii) kinetic energy of the most energetic photoelectron?

SECTION C – 27 MARKS

Question 9 [3]

Derive an expression for electric field intensity (E) at a point which lies on the **axis** of an electric dipole (having length $2l$ and dipole moment P) and which is it at a distance 'r' from its centre.

Question 10 [3]

(i) The potentiometer has a driver cell **D** of **emf** 6V and an internal resistance of 2Ω, as shown in ***Figure 7*** below.

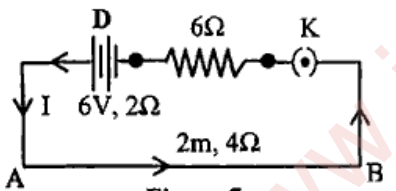


Figure 7

Calculate:

(a) the current flowing through potentiometer wire AB.

(b) the potential gradient across the wire AB.

OR

(ii) Two cells of emf 13V and 12V and negligible internal resistance are connected in the circuit shown in ***Figure 8*** below.

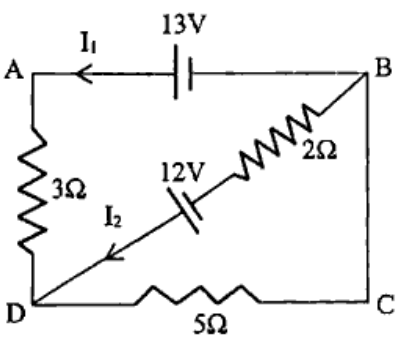


Figure 8

Using **Kirchhoff's laws**, calculate the current flowing through 5Ω resistor.

Question 11 [3]

(i) In a moving coil galvanometer, why is the magnetic field **made** radial?

(ii) You are provided with one low resistance R_L and one high resistance R_H and two galvanometers, G_1 and G_2. Draw diagrams to show how you will convert G_1 to a voltmeter and G_2 to an ammeter.

Question 12 [3]

(i) Using **Ampere's circuital law**, obtain an expression for magnetic field '**B**' at a point 'P' which is at a perpendicular distance 'r' from an infinitely long straight conductor, carrying a current 'I'.

OR

(ii) ***Figure 9*** below shows a metallic rod PQ resting on two parallel thick and smooth metallic rails CS and DR. There is a **uniform** magnetic field $\vec{B}$ which is perpendicular to the rails.

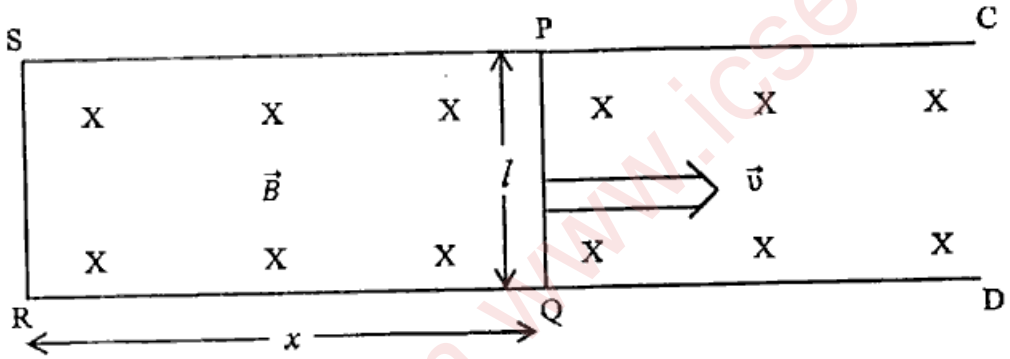


Figure 9

(a) How much magnetic flux is linked to the closed circuit PQRS?

(b) If the rod PQ is moved on the rails with a **constant velocity** v, how much emf will be induced in it?

(c) How much power has to be spent by an external agency to maintain the motion of the rod PQ on the rails? Write your answer in terms of B, l, v and resistance R of the rod PQ.

Question 13 [3]

Two convex lenses having focal length of 1·5cm and 5cm are placed coaxially to form a **compound microscope**. When a pin is kept at a distance of 1·6cm from the objective lens, a virtual magnified image is formed at a distance of 25cm from the eyepiece. Calculate the **length** of the microscope.

[3]

Question 14

With the help of a **labelled** diagram and **Huygen's wave theory,** prove:

When a parallel beam of light is incident obliquely on a ***plane mirror,*** *angle of reflection is equal to angle of incidence.*

[3]

Question 15

Shyam was performing a **double slit experiment** to determine wavelength of monochromatic light emitted by a laser. The examiner asked him some questions based on that experiment. Shyam answered those questions as per his understanding of the experiment.

State whether his answers are correct. If incorrect, write the correct answer.

(i) Examiner: What is meant by fringe width?

Shyam: It is the distance between centres of a bright band and the adjacent dark band.

(ii) Examiner: What happens to fringe width if blue light is replaced with red light?

Shyam: Fringe width increases.

(iii) Examiner: What will happen to the interference pattern if one of the slits is closed?

Shyam: The screen will be uniformly illuminated.

[3]

Question 16

(i) Two identical thin convex lenses, each having an optical power of 2D are kept in contact with each other. Calculate **focal length** of the combination.

(ii) ***Figure 10*** below shows a ray of monochromatic light incident **normally** on first surface **AB** of an **equilateral** glass prism ABC, whose adjacent surface **AC** is covered with a transparent liquid. If the emergent ray grazes the surface AC, calculate **refractive index** of the liquid.

(Refractive index of glass = 1·5)

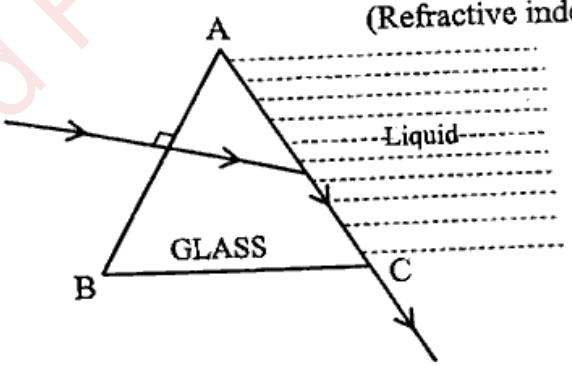
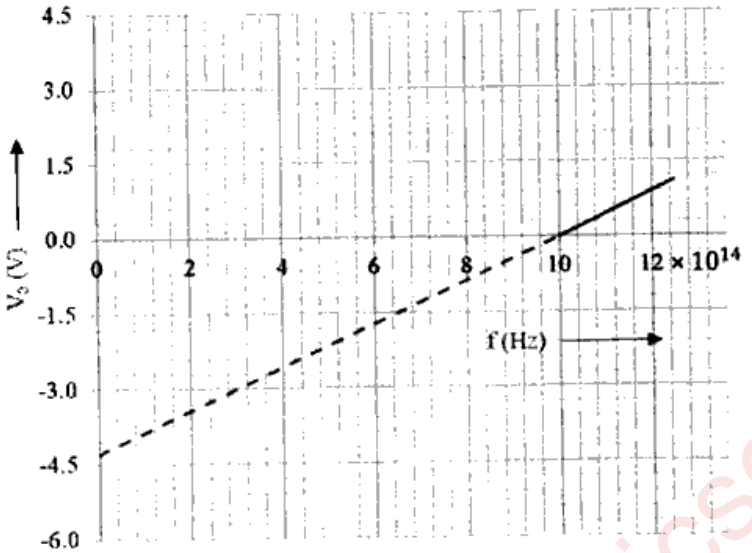


Figure 10

Question 17 [3]

The graph of **stopping potential** (V_0) versus **frequency** (f) of incident UV radiation incident on a metallic surface is shown below. Study the graph and answer the questions that follow.



(i) Find the value of **work function** of the metal.

(ii) Determine the value of **Planck's constant** 'h'.

SECTION D – 15 MARKS

Question 18 [5]

(i) A choke coil has a self-inductance of 0·5H and a resistance of 50Ω. It is connected to a 220V, 50Hz a.c. supply.

(a) Calculate rms value of the current flowing through the coil.

(b) What is the **phase difference** between the supply voltage and the current?

(c) What is the **power factor** for this circuit?

OR

(ii) (a) When current flowing through a solenoid increases from 0 to 10A in 0·2s, an emf of 20V is induced in it. Calculate the **coefficient of self-inductance (L)** of the solenoid.

(b) An **ideal** step-up transformer is shown in ***Figure 11*** below:

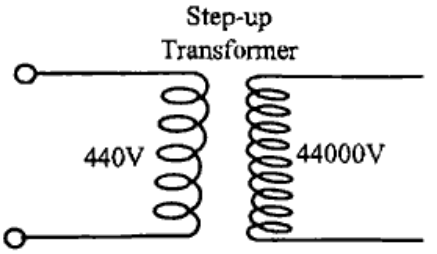


Figure 11

(1) Calculate its turns ratio.

(2) Which of the windings: primary or secondary, carries larger current? Give a reason for your answer.

(c) An ac source generates an emf 'e' given by

$$e = 311 \text{ Sin } (100 \pi t)V$$

Calculate **rms** value of the emf generated by the source.

Question 19 **[5]**

(i) (a) State **Bohr's postulate** of quantisation of angular momentum.

(b) Show how it can be obtained from **wave nature** of orbiting electrons.

(c) Plot a **labelled** graph showing variation of binding energy per nucleon of a nucleus **Versus** its mass number.

OR

(ii) (a) Write a **balanced** equation of a **nuclear fission** reaction taking place in a nuclear reactor.

(b) By performing necessary calculations, determine which one of the following nuclei is **more** stable:

$^{4}_{2}He$ nucleus having binding energy of 28.8MeV **Or** $^{9}_{4}Be$ nucleus having binding energy of 63MeV.

(c) (1) Draw **energy level diagram** of hydrogen atom showing at least four (lowest) energy levels.

(2) Show ***any one*** transition on this diagram which results in the emission of **light** energy.

Question 20 [5]

Read the following passage and answer questions which follow.

Discovery of semiconducting devices has revolutionised the field of electronics. Earlier, a computer known as first generation computer, was as big as a room! The radio sets used to be so bulky that they could not be taken on a picnic. Semiconducting devices, being light and compact, have changed all that. Now, computers have become so small in size that they are called laptops and palm tops. Semiconducting devices, that are widely used in electronic gadgets like a television, a radio, an amplifier etc, are diodes, transistors, FETs, ICs, logic gates etc. Diodes are of different types like light emitting diodes, photodiodes, Zener diodes etc. They perform various functions like converting an ac voltage to dc voltage, emit light etc.

(i) State ***any one*** advantage of a semiconducting device over an old electronic device.

(ii) What energy transformation takes place in an LED?

(iii) What is the **function** of a rectifier?

(iv) ***Figure 12*** below shows a rectifier.

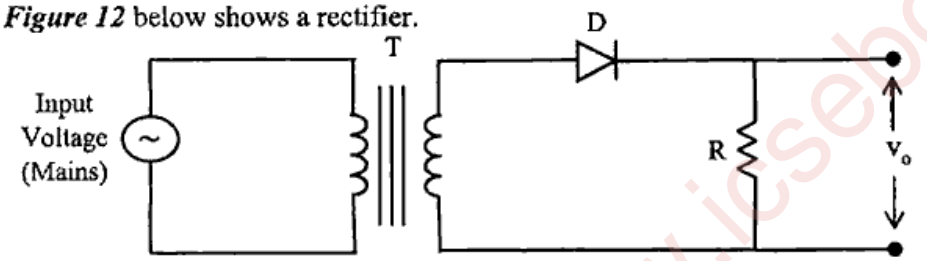


Figure 12

In case of the rectifier shown above, draw the graphs to show the waveform of:

(a) input voltage.

(b) output voltage.

USEFUL CONSTANTS AND RELATIONS

1.	Charge of a proton = Charge of an electron	e	=	$\pm 1{\cdot}6 \times 10^{-19}$ C
2.	Permeability of vaccum	μ_0	=	$4\pi \times 10^{-7}$ H/m
3.		$1\mu m$	=	$10^{-6}m$
4.		$1nm$	=	$10^{-9}m$