2023

QUESTION PAPER

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PHYSICS PAPER 1

(THEORY)

Maximum Marks: 70
Time Allowed: Three hours
*(Candidates are allowed **additional 15 minutes** for **only** reading the paper.*
*They must **NOT** start writing during this time.)*

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*This paper is divided into **four** sections – **A, B, C** and **D**.*
*Answer **all** questions.*
***Section A** consists of **one** question **having sub-parts** of **one** mark each.*
***Section B** consists of **seven** questions of **two** marks each.*
***Section C** consists of **nine** questions of **three** marks each, and*
***Section D** consists of **three** questions of **five** marks each.*
Internal choices have been provided in two questions each in Section B, Section C and Section D.
The intended marks for questions are given in brackets [ ].
All working, including rough work, should be done on the same sheet as and adjacent to the rest of the answer.
Answers to sub parts of the same question must be given in one place only.
A list of useful physical constants is given at the end of this paper.
A simple scientific calculator without a programmable memory may be used for calculations.

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) A hollow sphere of radius **R** has a point charge **Q** at its centre. **Electric flux** emanating from it is **φ**. If both the charge and the radius of the sphere be doubled, **electric flux** emanating from the sphere will: **[1]**

(a) remain the same.

(b) become 2 φ

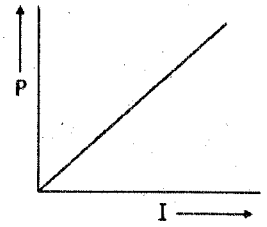
(c) become 4 φ

(d) become 8 φ

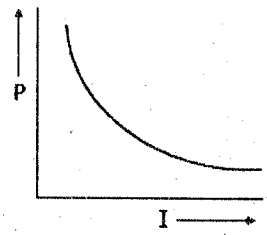
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(ii) An electric current (**I**) flowing through a metallic wire is gradually increased. **[1]**
The graph of heating power (**P**) developed in it **versus** the current (**I**) is:

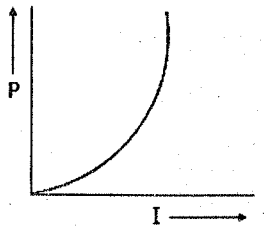
(a)



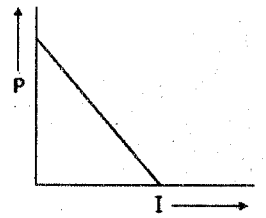
(b)



(c)



(d)



(iii) A circular coil has radius 'r', number of turns 'N' and carries a current 'I'. **[1]**
Magnetic flux density 'B' at its **centre** is:

(a) $B = \mu_o NI$

(b) $B = \mu_o NI/2r$

(c) $B = \mu_o NI/4\pi r$

(d) $B = \mu_o NI/4r$

(iv) If an object is placed at a distance of 10cm in front of a **concave mirror** of **[1]**
focal length 20cm, the image formed will be:

(a) real and 20cm in front of the mirror.

(b) real and 6·67cm in front of the mirror.

(c) virtual and 20cm behind the mirror.

(d) virtual and 6·67cm behind the mirror.

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

(a) Cylindrical wavefronts

(b) Plane wavefronts

(c) Spherical wavefronts

(d) All types of wavefronts

(vi) **Matter waves** are: [1]

(a) waves associated with moving particles.

(b) waves associated with stationary particles.

(c) waves associated with any charged particles.

(d) waves associated with electrons only.

(vii) With an increase in the temperature, electrical **conductivity** of a semiconductor: [1]

(a) decreases.

(b) increases.

(c) does not change.

(d) first increases and then decreases.

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

(i) What is meant by an **equipotential** surface? [1]

(ii) In case of metals, what is the relation between **current density** (J), **electrical conductivity** (σ) and **electric field intensity** (E)? [1]

(iii) What is meant by " **Motional emf** " ? [1]

(iv) What is meant by a **microscope** in normal use? [1]

(v) In a single slit **Fraunhofer diffraction experiment**, how does the **angular width** of central maximum change when the slit width is **increased**? [1]

(vi) Name the type of **nuclear reaction** that takes place in the core of the Sun. [1]

(vii) What **type** of semiconductor is obtained when a crystal of silicon is doped with a **trivalent** element? [1]

SECTION B – 14 MARKS

Question 2 [2]

(i) Calculate **equivalent capacitance** of the circuit shown in ***Figure 1*** given below:

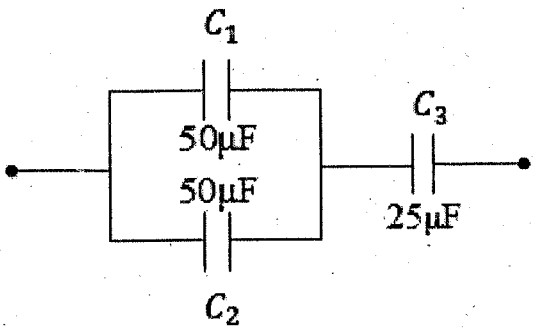


Figure 1

OR

(ii) Calculate **electric potential** at a point P which is at a distance of 9cm from a point charge of 50μC.

Question 3 [2]

(i) Write **balancing condition** of a **Wheatstone bridge**.

(ii) Current 'I' flowing through a metallic wire is related to drift speed v_d of free electrons as follows:

$$I = nAev_d$$

State what the symbol 'n' stands for.

Question 4 [2]

When an **electric current** is passed through a wire or a coil, a **magnetic field** is produced. Is the reverse phenomenon possible i.e., can a **magnetic field** produce an **electric current**? Explain with the help of an **appropriate example**.

Question 5 [2]

(i) A long straight wire **AB** carries a current of 5A. **P** is a proton travelling with a velocity of 2×10^6 m/s, parallel to the wire, 0·2m from it and in a direction opposite to the current, as shown in ***Figure 2*** below. Calculate the **force** which magnetic field of the current carrying conductor AB exerts on the proton.

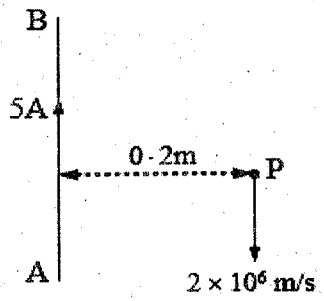


Figure 2

OR

(ii) A moving coil galvanometer of resistance 55Ω produces a **full scale deflection** for a current of 250 mA. How will you convert it into an **ammeter** having a range of 0 – 3A?

Question 6 [2]

(i) State how vectors $\vec{E}, \vec{B}$ and $\vec{c}$ are oriented in an **electromagnetic** wave.

(ii) Name the electromagnetic wave / radiation which is used to **study** crystal structure.

Question 7 [2]

Name ***any two*** phenomena which take place in the formation of a **rainbow**.

Question 8 [2]

With reference to semiconductor physics, answer the following questions.

(i) What is meant by "**Forbidden band**" of energy levels?

(ii) In which material "**Forbidden band**" is absent?

SECTION C – 27 MARKS

Question 9 [3]

Show that **intensity of electric field** at a point in **broadside position** of an **electric dipole** is given by:

$$E = \left(\frac{1}{4\pi \in_o}\right)\frac{p}{\left(r^2 + l^2\right)^{3/2}}$$

where the terms have their usual meaning.

Question 10 [3]

(i) Eight **identical** cells, each of emf 2V and internal resistance 3Ω, are connected in **series** to form a row. **Six** such rows are connected in **parallel** to form a battery. This battery is now connected to an external resistor **R** of resistance 6Ω. Calculate:

(a) emf of the battery.

(b) internal resistance of the battery.

(c) current flowing through **R**.

OR

(ii) In the circuit shown in ***Figure 3*** below, E_1 and E_2 are batteries having **emfs** of 25V and 26V. They have an internal resistance of 1Ω and 5Ω respectively. Applying **Kirchhoff's laws** of electrical networks, calculate the currents I_1 and I_2.

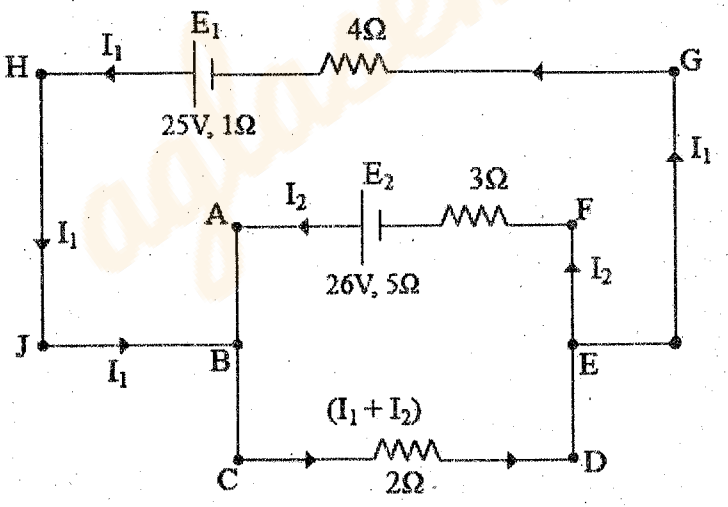


Figure 3

Question 11 [3]

Using **Ampere's circuital law**, obtain an expression for **magnetic flux density 'B'** at a point near an **infinitely** long and straight conductor, carrying a current I.

Question 12 [3]

Using **Huygen's wave theory of light**, show that the angle of incidence is equal to the angle of reflection. Draw a **neat** and **labelled** diagram.

Question 13 [3]

(i) For any prism, obtain a relation between **angle of the prism** (A), **angle of minimum deviation** (δ_m) and **refractive index of its material** (μ or n).

OR

(ii) Obtain an expression for **refraction** at a **single convex spherical surface** i.e., the relation between μ_1 (rarer medium), μ_2 (denser medium), object distance u, image distance v and the radius of curvature R.

Question 14 [3]

(i) What is the **essential** condition for obtaining a **sustained interference**?

(ii) In **Young's double slit experiment**, the distance of the 4th bright fringe from the centre of the interference pattern is 1·5mm. The distance between the slits and the screen is 1·5m and the wavelength of light used is 500nm. Calculate the **distance** between the two slits.

Question 15 [3]

Monochromatic light of wavelength 396nm is incident on the surface of a metal whose **work function** is 1·125eV. Calculate:

(i) the energy of an incident photon **in eV**.

(ii) the maximum kinetic energy of photoelectrons **in eV**.

Question 16 [3]

Name ***any two*** essential parts of a nuclear reactor. State the function of ***any one*** of them.

Question 17 [3]

Draw a labelled circuit diagram of a **full wave rectifier**. Show graphically how the **output voltage** varies with **time**.

SECTION D – 15 MARKS

Question 18 [5]

(i) A 60Ω resistor, a 1·0 H inductor and a 4μF capacitor are connected in **series** to an ac supply generating an emf **e = 300 Sin (500t) V**. Calculate:

(a) **impedance** of the circuit.

(b) **peak value** of the current flowing through the circuit.

(c) **phase difference** between the current and the supply voltage.

OR

(ii) (a) An ac generator generates an emf which is given by **e = 311 Sin (240πt) V**. Calculate:

(1) **frequency** of the emf.

(2) **r.m.s. value** of the emf.

(b) The **primary** coil of a transformer has 60 turns whereas its **secondary** coil has 3000 turns.

(1) If a 220V ac voltage is applied to the **primary** coil, how much emf is induced in the **secondary** coil?

(2) If a current of 5A flows in the **primary** coil, how much current will flow in a load in the **secondary** coil? **State** the **assumption** you have made **regarding the transformer**, in this calculation.

Question 19 [5]

(i) (a) Name the **series** of lines of hydrogen spectrum which lies in the

(1) ultraviolet region.

(2) visible region.

(b) How much is the **angular momentum** of an electron when it is orbiting in the **second Bohr orbit** of hydrogen atom?

(c) With reference to **Nuclear Physics**, answer the following questions.

(1) What is meant by **"Isotopes"**?

(2) Define **1u** (where **u** stands for unified atomic mass unit).

OR

(ii) (a) Using **Bohr's Theory** of hydrogen atom, obtain an expression for the **velocity** of an electron in n^{th} orbit of an atom.

(b) What is meant by **"binding energy per nucleon"** of a nucleus? State its **physical significance**.

Question 20 **[5]**

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

There are two types of lenses: Converging lenses and Diverging lenses, depending on whether they converge or diverge an incident beam of light. They are also called convex or concave lenses. Lenses are usually made of glass. Convex lenses are more popular as they form a real image of an object. They are widely used in our daily life, for instance, in microscopes, telescopes, projectors, cameras, spectacles etc. Microscopes are used to view small and nearby objects whereas telescopes are used to see distant objects.

(i) State ***any one*** factor on which focal length of a lens depends.

(ii) Give an example where a convex lens behaves like a diverging lens.

(iii) What type of lens is used in a camera?

(iv) Write an expression for **magnifying power** of a **compound microscope** when its final image lies at the least distance of distinct vision (D).

(v) State ***any one*** difference between a **reflecting** telescope and a **refracting** telescope.

Useful Constants & Relations:

1	Constant for Coulomb's law	$(1/4\pi\varepsilon_0)$	9×10^9m/F
2	Permeability of vacuum	(μ_0)	$4\pi \times 10^{-7}$H/m
3	Speed of light in vacuum	c	3×10^8m/s
4	Planck's Constant	h	$6{\cdot}6 \times 10^{-34}$Js
5	Charge of a proton	e	$1{\cdot}6 \times 10^{-19}$C
6		1eV	$1{\cdot}6 \times 10^{-19}$J
7		1nm	1×10^{-9}m