# PHYSICS

## PAPER – 1

## (THEORY)

***(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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*Answer* **all** *questions in **Part I** and **ten** questions from **Part II**, choosing **four** questions from Section **A**, **three** questions from Section **B** and **three** questions from Section **C**.*

*All working, including **rough** work, should be done on the same sheet as, and adjacent to, the rest of the answer.*

*The intended marks for questions or parts of questions are given in brackets [ ].*

*(Material to be supplied: Log tables including Trigonometric functions)*

*A list of useful physical constants is given at the end of this paper.*

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### PART I (20 Marks)

*Answer **all** questions.*

**Question 1**

**A.** Choose the correct alternative (a), (b), (c) or (d) for each of the questions given below: **[5]**

(i) A **short** electric dipole (which consists of two point charges, +q and –q) is placed at the centre O and inside a **large** cube (ABCDEFGH) of length L, as shown in ***Figure 1***. The electric flux, emanating through the cube is:

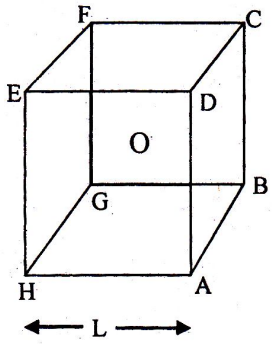


***Figure 1***

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**This Paper consists of 8 printed pages.**

(a) $q/4\pi\epsilon_0 L$

(b) zero

(c) $q/2\pi\epsilon_0 L$

(d) $q/3\pi\epsilon_0 L$

(ii) The equivalent resistance between points **a** and **f** of the network shown in ***Figure 2*** is:

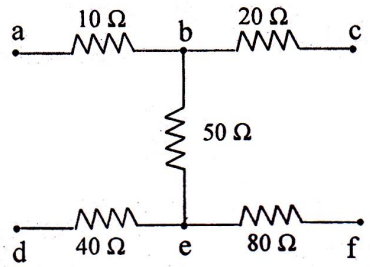


***Figure 2***

(a) 24 Ω

(b) 110 Ω

(c) 140 Ω

(d) 200 Ω

(iii) A moving electron enters a uniform and **perpendicular** magnetic field. Inside the magnetic field, the electron travels along:

(a) a straight line.

(b) a parabola

(c) a circle

(d) a hyperbola

(iv) A fish which is at a depth of 12 cm in water ($\mu = \frac{4}{3}$) is viewed by an observer on the bank of a lake. Its **apparent depth** as observed by the observer is:

(a) 3 cm

(b) 9 cm

(c) 12 cm

(d) 16 cm

(v) If $E_p$ and $E_k$ represent potential energy and kinetic energy respectively, of an orbital electron, then, according to **Bohr's theory**:

(a) $E_k = -E_p/2$

(b) $E_k = -E_p$

(c) $E_k = -2E_p$

(d) $E_k = 2E_p$

B. Answer **all** questions given below **briefly** and to the point: **[15]**

(i) What is meant by the term **Quantization of charge**?

(ii) A resistor **R** is connected to a cell of emf **e** and internal resistance **r.**
Potential difference across the resistor **R** is found to be **V**.
State the relation between **e, V, R** and **r**.

(iii) Three identical cells each of emf 2V and internal resistance 1Ω are connected in series to form a battery. The battery is then connected to a parallel combination of two identical resistors, each of resistance 6Ω. Find the current delivered by the battery.

(iv) State how **magnetic susceptibility** is **different** for the three types of magnetic materials, i.e. diamagnetic, paramagnetic and ferromagnetic materials.

(v) An emf of 2V is induced in a coil when current in it is changed from 0A to 10A in 0·40 sec. Find the **coefficient of self-inductance** of the coil.

(vi) How are electric vector $(\vec{E})$, magnetic vector $(\vec{B})$ and velocity vector $(\vec{c})$ oriented in an electromagnetic wave?

(vii) State *any two* methods by which ordinary light can be polarised.

(viii) A monochromatic ray of light falls on a **regular prism.** What is the relation between angle of incidence and angle of emergence in the case of **minimum deviation**?

(ix) What type of lens is used to correct **long-sightedness**?

(x) State any one **advantage** of using a reflecting telescope in place of a refracting telescope.

(xi) State **Moseley's law**.

(xii) Wavelengths of the first lines of the **Lyman series**, **Paschen series** and **Balmer series**, in hydrogen spectrum are denoted by $\lambda_L$, $\lambda_P$, and $\lambda_B$, respectively. Arrange these wavelengths in **increasing order**.

(xiii) What is the **significance** of **binding energy per nucleon** of a nucleus of a radioactive element?

(xiv) Write any one **balanced** equation representing **nuclear fission**.

(xv) What is the difference between **analogue** signal and **digital** signal?

## PART II (50 Marks)

*Answer **ten** questions in this part, choosing **four** questions*

*from Section **A**, **three** questions from Section **B** and **three** questions from Section **C**.*

## SECTION A

*Answer any **four** questions.*

**Question 2**

(a) Derive an expression for intensity of electric field at a point in **broadside position** or on an **equatorial line** of an electric dipole. **[4]**

(b) Two point charges of 10C each are kept at a distance of 3m in vacuum. Calculate their electrostatic potential energy. **[1]**

**Question 3**

(a) Four capacitors, $C_1$, $C_2$, $C_3$ and $C_4$ are connected as shown in ***Figure 3*** below. Calculate **equivalent** capacitance of the circuit between points X and Y. **[3]**

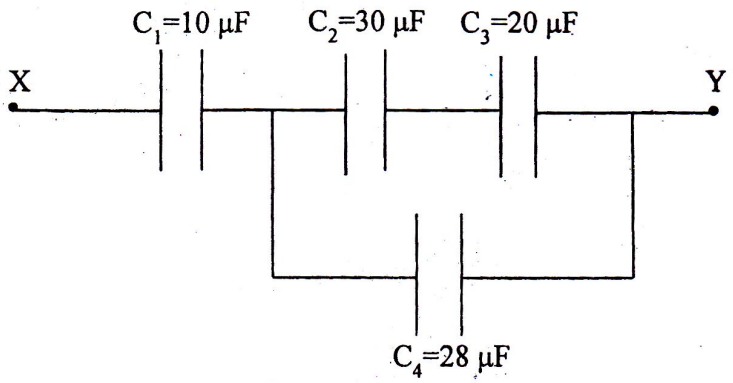


***Figure 3***

(b) Draw labelled graphs to show how **electrical resistance** varies with **temperature** for: **[2]**

(i) a metallic wire.

(ii) a piece of carbon.

**Question 4**

(a) Two resistors $R_1 = 400\ \Omega$ and $R_2 = 20\ \Omega$ are connected in **parallel** to a battery. If heating power developed in $R_1$ is 25 W, find the heating power developed in $R_2$. **[2]**

(b) With the help of a labelled diagram, show that the **balancing condition** of a **Wheatstone bridge** is: **[3]**

$$\frac{R_1}{R_2} = \frac{R_3}{R_4}$$ where the terms have their usual meaning.

**Question 5**

(a) A 10m long uniform metallic wire having a resistance of 20Ω is used as a potentiometer wire. This wire is connected in series with another resistance of 480Ω and a battery of emf 5V having negligible internal resistance. If an unknown emf ***e*** is balanced across 6m of the potentiometer wire, calculate: **[3]**

(i) the potential gradient across the potentiometer wire.

(ii) the value of the unknown emf ***e***.

(b) (i) Explain the term ***hysteresis.*** **[2]**

(ii) Name **three elements** of the earth's magnetic field which help in defining **earth's magnetic field** completely.

**Question 6**

(a) Obtain an expression for **magnetic flux density** B at the centre of a circular coil of radius **R**, having **N** turns and carrying a current **I**. **[3]**

(b) A coil of self inductance 2·5H and resistance 20Ω is connected to a battery of emf 120V having internal resistance of 5 Ω. Find: **[2]**

(i) The **time constant** of the circuit.

(ii) The current in the circuit in **steady state**.

**Question 7**

(a) ***Figure 4*** below shows a capacitor C, an inductor L and a resistor R, connected in series to an a.c. supply of **220 V.** **[4]**

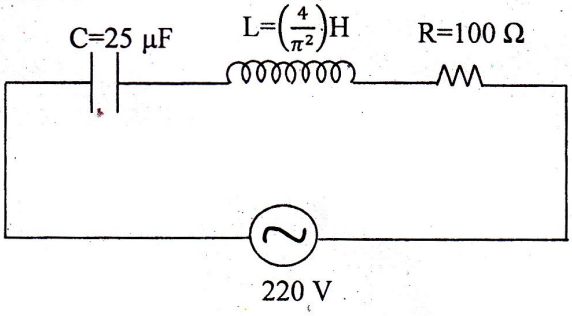


***Figure 4***

Calculate:

(i) The **resonant frequency** of the given CLR circuit.

(ii) Current flowing through the circuit.

(iii) Average power consumed by the circuit.

(b) In a series LCR circuit, what is the **phase difference** between $\mathbf{V_L}$ and $\mathbf{V_C}$ where $V_L$ is the potential difference across the inductor and $V_C$ is the potential difference across the capacitor? **[1]**

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## SECTION B

*Answer any **three** questions.*

**Question 8**

(a) On the basis of **Huygen's Wave theory of light**, show that angle of reflection is equal to angle of incidence. You must draw a labelled diagram for this derivation. **[4]**

(b) State any one difference between **interference of light** and **diffraction of light**. **[1]**

**Question 9**

(a) Laser light of wavelength 630 nm is incident on a pair of slits which are separated by 1·8mm. If the screen is kept 80 cm away from the two slits, calculate: **[3]**

(i) fringe separation i.e. fringe width.

(ii) distance of $10^{th}$ bright fringe from the centre of the interference pattern.

(b) Show graphically the intensity distribution in **Fraunhofer's single slit diffraction experiment**. Label the axes. **[2]**

**Question 10**

(a) A point object **O** is placed at a distance of 15cm from a convex lens **L** of focal length 10cm as shown in ***Figure 5*** below. On the other side of the lens, a convex mirror **M** is placed such that its distance from the lens is equal to the focal length of the lens. The final image formed by this combination is observed to **coincide** with the object **O**. Find the **focal length** of the **convex mirror**. **[3]**

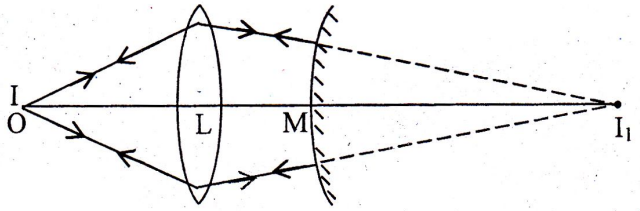


***Figure 5***

(b) What is **chromatic aberration**? How can it be minimised or eliminated? **[2]**

**Question 11**

(a) Draw a labelled ray diagram of an image formed by a **compound microscope**, when the final image lies at the **least distance of distinct vision (D)**. **[3]**

(b) With regard to an **astronomical telescope** of **refracting** type, state how you will increase its: **[2]**

(i) magnifying power

(ii) resolving power

## SECTION C

*Answer any **three** questions.*

**Question 12**

(a) In an experiment of **photoelectric effect**, the graph of maximum kinetic energy $E_K$ of the emitted photoelectrons versus the frequency $\nu$ of the incident light is a straight line **AB** as shown in ***Figure 6*** below: **[3]**

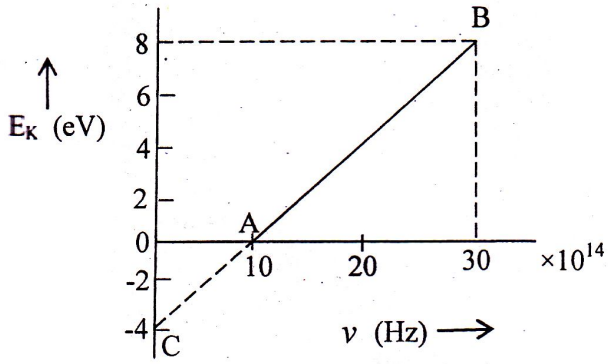


***Figure 6***

Find:

(i) Threshold frequency of the metal.

(ii) Work function of the metal.

(iii) Stopping potential for the photoelectrons emitted by the light of frequency $\nu = 30\times10^{14}$ Hz.

(b) (i) State how **de-Broglie wavelength** ($\lambda$) of moving particles varies with their linear momentum (p). **[2]**

(ii) State any one phenomenon in which moving particles exhibit wave nature.

**Question 13**

(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. **[3]**

(b) Using the constants given on page 8 of this Paper, find the **minimum wavelength** of the emitted X rays, when an **X ray tube** is operated at 50 kV. **[2]**

**Question 14**

(a) (i) Define **half-life** of a radioactive substance. **[3]**

(ii) Using the equation $N = N_0e^{-\lambda t}$, obtain the relation between **half-life (T)** and **decay constant** ($\lambda$) of a radioactive substance.

(b) With the help of a suitable **example** and an **equation**, explain the term ***pair production***. **[2]**

**Question 15**

(a) Draw a labelled diagram of a **full wave rectifier**. Show how output voltage varies with time, if input voltage is a **sinusoidal** voltage. **[3]**

(b) What is a NAND gate? Write its truth table. **[2]**

**Useful Constants and Relations:**

| | | | |
|---|---|---|---|
| 1. | Speed of Light in vacuum | (c) | $= 3{\cdot}0 \times 10^{8}\ ms^{-1}$ |
| 2. | Charge of a proton | (e) | $= 1{\cdot}6 \times 10^{-19}C$ |
| 3. | Planck's constant | (h) | $= 6{\cdot}6 \times 10^{-34}\ Js$ |
| 4. | Constant for Coulomb's law | $\left(\frac{1}{4\pi\epsilon_0}\right)$ | $= 9\times10^{9}\ mF^{-1}$ |
| 5. | Electron Volt | (1eV) | $= 1{\cdot}6 \times 10^{-19}\ J$ |