352001

COMBINED COMPETITIVE EXAMINATION (MAIN)

PHYSICS

Paper-II

Time : 3 Hours *Full Marks* : 200

Note : *(1) The figures in the right-hand margin indicate full marks for the questions.*

*(2) Attempt **five** questions in all.*

*(3) Question No. **1** is compulsory.*

(4) The symbols used in the question paper have their usual meanings.

(5) Relevant constants and their approximate values for use in the calculation :

Velocity of light, $c = 3\times10^{8}$ m/sec; *Planck's constant,* $h = 6.626\times10^{-34}$ m^2 kg/s;
Mass of electron, $m_e = 9.1\times10^{-31}$ kg; *Permeability of free space,* $\mu=4\pi\times10^{-7}$ NA^{-2}

1. Answer any ***ten*** questions from the following : 4×10=40

(a) Compare the Gauss law in electrostatics in vacuum with that in a dielectric medium.

(b) What kind of electrostatic situation is described by the Poisson's equation?

(c) An isolated metallic sphere of radius 1 metre is charged with 10^{-6} coulomb of charge. Describe the electrostatic effect on a person sitting inside the sphere.

(d) In an L-C-R circuit, the current manages to flow through the gap between the capacitor plates. How?

(e) What is the displacement current in the Maxwell's equations?

(f) Which physical quantity is signified by the magnitude of a Poynting vector?

(g) Discuss the assumptions made in the Bohr's theory of hydrogen atom.

(h) How do the Stokes and anti-Stokes lines appear in the Raman effect?

(i) Heisenberg's uncertainty principle is a fundamental principle and is not related to the error in the measuring instruments. Justify.

(j) Calculate the de Broglie wavelength for an electron at the speed of 2.2×10^{6} m/s.

(k) Explain conductors, insulators and semiconductors in terms of band gap energy.

(l) Explain the working principle of a thermistor.

2. Answer any ***eight*** questions from the following : 5×8=40

(a) Distinguish between the permittivity and permeability of free space.

(b) Establish the relationship between the electrostatic intensity and electrostatic potential for a given charge distribution.

(c) A beam of electromagnetic waves cannot pass through a metal surface. Why?

(d) The current changing at the rate of 1 mA/s through an induction coil induces an e.m.f. of 0.5 V in the coil. Calculate the self-inductance of the coil.

(e) Illustrate the distinctive properties of diamagnetic and ferromagnetic materials.

(f) Explain the quantum numbers associated with an electron in the Bohr's atomic model.

(g) Describe the physical significance of the wave packets associated with the Schrodinger equation.

(h) The semi-empirical mass formula is the sum of the different energy terms associated with the nucleus. Explain each of these energy terms.

(i) What will happen when the energy of the photon incident on a photoelectric material is just equal to the work function of the material?

(j) Discuss the P-N junction of the semiconductor under reverse bais.

3. Answer any ***five*** questions from the following : 8×5=40

(a) A stream of electrons, each moving at the speed of 10^6 m/s along a straight line, produces a current of 0.5 mA. Calculate the number of electrons passing per second through a point on the straight line.

(b) Discuss the distinctive properties of the hard and the soft X-rays.

(c) The root mean square of the potential difference in an alternating current circuit is 220 V. What does the statement mean?

(d) Explain with schematic diagram, the Balmar series of hydrogen spectrum in the Bohr's theory.

(e) Compare the penetrating and ionizing powers of the alpha, beta and the gamma rays.

(f) Describe the fundamental properties of superconducting materials.

4. Answer any ***four*** questions from the following : 10×4=40

(a) Establish that Maxwell's equations admit wave equations in the electric and magnetic fields.

(b) An electron is intended to be confined within the nucleus of an atom. Discuss the possibility of the confinement from the Heisenberg's uncertainty principle.

(c) Explain Compton effect. Is Compton effect a quantum mechanical effect?

(d) What is Radioactivity? Establish the radioactive decay formula for a given initial number of radioactive nuclei.

(e) Describe with a neat diagram, how Zener diode can stabilize fluctuations in the potential difference in a circuit.

5. Answer any ***two*** questions from the following : 20×2=40

(a) Obtain the condition for reasonance in an L-C-R series circuit connected with an alternating e.m.f. source of a given frequency.

(b) Deduce the form of the Schrodinger wave function for a particle moving inside the cubic box of sides L each.

(c) Describe the working principle of an electronic oscillator circuit with block diagram. Explain the conditions for sustained oscillations of the circuit.

6. Answer any ***four*** questions from the following : 10×4=40

(a) State Kirchhoff's circuit laws and explain with example. Can these laws be extended to AC circuits?

(b) Find the plane wave solutions to Maxwell's wave equation and establish that the electric and the magnetic fields of the wave remain mutually perpendicular.

(c) Describe the L-S and J-J coupling schemes for angular momenta. How do the couplings help in explaining the fine structure of atomic spectra?

(d) Explain the nuclear fission and nuclear fusion from the binding energy curve.

(e) Assuming three inputs and one output, draw the Truth Tables for the OR and the NOR logic gate circuits. Compare the properties of these logic gates.

7. Answer any ***two*** questions from the following : 20×2=40

(a) Find the expression of the magnetic induction at a distance R from an infinitely long straight conductor carrying a current I.

(b) Describe the Stern-Gerlach experiment. How is space quantization explained from the results of the experiment?

(c) Draw the circuit diagram of a full-wave rectifier and describe the rectification action performed by the circuit.

8. Answer the following questions : 40

(a) How are the elementary particles classified? Explain the properties of each class of elementary particles.

(b) What is receiver circuit? Explain the working of a super heterodyne receiver.

9. Answer the following questions : 40

(a) Give a detailed account of Zeeman effect and state the selection rule for requisite transitions.

(b) Describe strong, weak and electromagnetic interactions. Give a comparison of their relative strengths.

10. Answer the following questions : 40

(a) What are particle accelerators? Describe the working of a cyclotron accelerator.

(b) What is understood by modulation of signals? Detail the essential features of amplitude modulation and frequency modulation.

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