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.*

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

(a) Write Coulomb's law in vector form.

(b) How is the Coulomb force between two charges affected by the presence of a third charge?

(c) Electric lines of force never cross. Why?

(d) Two point charges of q and $4q$ coulombs are fixed at a distance of 12 cm from each other. Sketch the lines of force and locate the neutral point, if any.

(e) A spherical rubber balloon carries a charge that is uniformly distributed over its surface. As the balloon is blown up, how does $\vec{E}$ vary for points *(i)* inside the balloon, *(ii)* on the surface of the balloon and *(iii)* outside the balloon?

(f) Does the relation $E = mc^2$ suggest that mass can be converted to energy only when it is in motion?

(g) What is thermal neutron?

(h) Why are the total energies E_n of hydrogen atom negative?

(i) Is Bohr's atomic model consistent with the uncertainty principle? Explain your answer.

(j) What do you mean by forward bias and reverse bias?

(k) Why are transistors and semiconductor diodes metal coated?

(l) How much energy will be released if an electron in third orbit of H-atom jumps to second orbit?

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

(a) What do you mean by a point charge?

(b) For what order of distance, Coulomb law is true?

(c) Can a metal surface of radius 1×10^{-2} m hold a charge of 1 C?

(d) An electron enters along the electric line of force. Discuss its motion.

(e) Why is the divergence of magnetic induction $\vec{B}$ always zero?

(f) State Pauli's exclusion principle.

(g) What is Raman effect?

(h) State the difference between soft X-ray and hard X-ray.

(i) What is the effect of temperature on the conductivity of a semiconductor?

(j) What is the electron configuration in various orbits of silicon and germanium?

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

(a) Of the three vectors in the equation $\vec{F} = q\vec{v} \times \vec{B}$, which pairs are always at right angles? Which may have any angle between them?

(b) State Kirchhoff's laws. Why is it preferred over Ohm's law for complicated circuits?

(c) State Lenz's law and explain.

(d) State photoelectric effect and explain.

(e) The threshold wavelength for lithium is 800 Å. What does it mean?

(f) The base region of a transistor is made very thin as compared with emitter and collector region. Why?

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

(a) State Biot-Savart law and explain by drawing diagram (use SI units).

(b) Show that electromagnetic waves are transverse in nature.

(c) State Compton's effect. Explain with neat diagram.

(d) Give explanation of Moseley's law from Bohr's theory.

(e) The half-life of radon is 4 days. After how many days only 1/10th of radon sample be left behind?

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

(a) Obtain the Poynting's theorem for the conservation of energy in an electromagnetic field.

(b) The wave function of a square well potential extending from $x = 0$ to $x = L$ is $\psi(x) = \sqrt{30}x(x-L)/L^{i}$. Show that the function is normalized.

(c) Distinguish between ionic, covalent and metallic bonds.

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

(a) For a charged particle moving in both electric and magnetic fields, show that the total force acting on is $\vec{F} = q\vec{E} + q(\vec{v} \times \vec{B})$. The symbols have their usual meanings.

(b) Explain the properties of alpha and beta particles.

(c) Write down the expressions for the current in a critically damped *L-C-R* circuit.

(d) Find an expression for the RMS value of the output current in a full-wave rectifier.

(e) State Zeeman effect.

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

(a) State Maxwell's equations for electromagnetic field and obtain the wave equations for $\vec{E}$ and $\vec{B}$ in homogeneous isotropic non-conducting medium.

(b) Obtain a general expression for *(i)* the radii of Bohr's orbit and *(ii)* the orbital frequencies for electrons occupying them stating the assumption made.

(c) What is Zener diode? Explain the characteristic and applications of Zener diode.

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8. Answer the following questions :

(a) Discuss Einstein's photoelectric equation. What do you mean by threshold frequency and stopping potential? Mention their relation with work function.

(b) What is distinction between Raman effect and Rayleigh scattering? Distinguish between Stokes and anti-Stokes lines in Raman spectra.

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9. Answer the following questions :

(a) What is the binding energy of nucleus? Show how this concept of binding energy is related to the stabilities of atomic nucleus.

(b) Obtain an expression of mean lifetime of a radioactive element in terms of its half-lifetime.

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10. Answer the following questions :

(a) Explain the difference between the band structure of a semiconductor and that of a metal. Why does a semiconductor act as an insulator at 0 K and why its conductivity increases with increasing temperature?

(b) Write down Schrödinger equation for a particle in one dimension. Find the discrete energy levels and the normalized eigenfunction of a particle in one dimensional infinite square well potential.

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