The candidates shall limit their answers precisely within the answer-book (40 pages) issued to them and no supplementary/continuation sheet will be issued.

Note: Candidates are required to attempt five questions in all selecting one question from each of the section A, B, C & D of the question paper and all subparts of the questions in Section-E. Use of non-programmable calculator is allowed.

SECTION - A

1. (a) What are Miller Indices? Derive formula for the distance between two adjacent planes in a cubic crystal. (10)

(b) State and explain Bragg’s law of X-ray diffraction. (5)

(c) Find packing fraction of body centred cubic structure. (5)

2. (a) Derive an expression for Fermi energy and density of states of a free electron gas in three dimensions. (10)

(b) What is free electron gas model of metals? Which properties of solids are explained by free electron gas model. (10)

SECTION - B

3. (a) Discuss Kronig-Penny model for electron energy in solids and show how it explains the forbidden bands. (12)

14615/1650 [P.T.O.]
(b) Prove that the effective mass of an electron in an energy bend is given by \( m^* = \frac{\hbar^2}{\alpha^2 E / \alpha k^2} \) \hspace{1cm} (8)

4. (a) On the basis of band theory of solids, distinguish between metals, insulators and semiconductors. \hspace{1cm} (10)

(b) What are Brillouin zones. Derive an expression for Brillouin zone for bcc lattice. \hspace{1cm} (10)

SECTION - C

5. (a) What is photoconductivity? How does it arise? Mention a few applications of the phenomenon. \hspace{1cm} (10)

(b) Define photovoltaic effect. How this effect can explain the working of photovoltaic cells. \hspace{1cm} (10)

6. (a) Explain the origin of diamagnetism in materials. Obtain an expression for diamagnetic susceptibility using the Langevin’s theory. \hspace{1cm} (10)

(b) Give difference between type I and type II super conductors using the Meissner effect. Discuss one application of super-conductivity. \hspace{1cm} (10)

SECTION - D

7. (a) What are Einstein’s A and B coefficients? Show that in the optical region the number of spontaneous emission far exceeds the number of stimulated emission. \hspace{1cm} (10)

(b) Write short notes on population inversion and quality factor. \hspace{1cm} (5+5=10)

8. (a) What is an optical fibre? Give basic principal of optical fibre communication. How are optical fibres classified on the basis of mode and refractive index profile? \hspace{1cm} (12)

(b) What are advantages of optical fibres? \hspace{1cm} (8)
9. Explain in Brief:

(i) What is the cause of hydrogen bonding? (1½)

(ii) In diamond crystal structure, what is the number of nearest neighbours? (1½)

(iii) Define Fermi energy. (1½)

(iv) Differentiate between thermionic emission and photoelectric emission. (1½)

(v) What do you mean by forbidden energy gap? (1½)

(vi) How does Fermi energy vary with temperature? (1½)

(vii) Explain photoluminescence. (1½)

(viii) Differentiate between paramagnetism and ferromagnetism. (1½)

(ix) Define magnetisation and susceptibility. (1½)

(x) Do you think energy conservation is violated in a LASER? (1½)

(xi) Which property of a LASER beam make it useful in ICBMs? (1½)

(xii) A laser beam has a band width of 2800Hz. Find its coherence length. (2)

(xiii) What is dispersion in optical fibres? (1½)