Jashore University of Science and Technology

Department of Physics

Bachelor of Science with Honours in Physics

2nd semester of 3rd year (2022 – 2023)

Course code: PHY 3205 **Course title: Solid State Physics I**

Assignment no.: 1 **Date: 19 January 2025**

Deadline for submission: 03 February 2025, 10:00 PM

1. Derive an expression for the attractive interaction between atoms in a solid composed of inert gases. Provide a detailed explanation of the underlying physical principles and assumptions.

2. What is the Madelung constant? Derive its expression for a one-dimensional ionic crystal and discuss its significance in determining the lattice energy of ionic solids.

3. List and briefly describe the key properties of the following: (i) Covalent crystals, (ii) Metals and (iii) Hydrogen bonds.

4. Derive the dispersion relation for lattice vibrations in a one-dimensional crystal with a monatomic basis. Discuss the physical meaning of the acoustic phonon branch obtained from the relation.

5. Establish the dispersion relation for lattice vibrations in a one-dimensional crystal with two atoms per primitive basis. Discuss how it gives rise to acoustic and optical phonon modes and their distinctive properties.

6. Establish the Debye T^3 law for the heat capacity of solids at low temperatures. Define the Debye temperature and explain its significance in this model.

7. How does the Einstein model of heat capacity explain the temperature dependence of the specific heat of solids at high and low temperatures, and how does it differ from the classical Dulong-Petit law?

8. Explain the concept of the density of states (DOS) in the context of a solid. How can the DOS be calculated in 3D?

9. Explain the Fermi-Dirac distribution function with a proper sketch of the distribution. How does it describe the occupation of energy states in a system of fermions?

10. What is Fermi energy? Derive the expression for the Fermi energy (E_F) of a free electron gas:

$$E_F = \frac{\hbar^2}{2m}\left(\frac{3\pi^2 N}{V}\right)^{2/3}.$$