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Total Pages : 05

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May 2026

M. Sc. (Physics) (Fourth Semester)

Materials Science (PHP-204-V)

Time : 3 *Hours*] [*Maximum Marks* : 75

Note : It is compulsory to answer all the questions (1.5 marks each) of Part A in short. Answer any *four* questions from Part B in detail. Different sub-parts of a question are to be attempted adjacent to each other.

Part A

1. (a) Explain, why Frenkel defects are more common in ionic crystals with large differences in ionic sizes. **1.5**

(b) A crystal has vacancy formation energy 1 eV. Estimate, how the vacancy concentration changes qualitatively when temperature increases from 500 K to 1000 K. **1.5**

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(c) What is meant by grain boundary energy ? 1.5

(d) Discuss the difference between engineering stress and true stress and explain, why true stress becomes important during large deformation. 1.5

(e) Justify the following statement "Work hardening increases the strength but decreases the ductility". 1.5

(f) A crystal is subjected to a tensile stress of 80 MPa along a direction making 45° with the slip plane normal and 30° with the slip direction. Calculate the resolved shear stress acting on the slip system. 1.5

(g) Explain the role of exchange interaction in producing ferromagnetism. 1.5

(h) If the Curie constant of a paramagnetic material doubles, explain, how the magnetic susceptibility changes at a fixed temperature. 1.5

(i) Explain, why dielectric constant often increases near a ferroelectric phase transition. 1.5

(j) The dielectric constant of a material is 4 and the number density of atoms is 2×10^{28} m^{-3}, calculate the electronic polarizability. 1.5

Part B

2. (a) Explain the formation and thermodynamic stability of Frenkel and Schottky defects in ionic crystals. Discuss how these defects influence density, electrical neutrality and ionic conductivity of solids. 10

(b) Show, how the Burgers vector is related to lattice distortion around an edge dislocation. 5

3. (a) Explain the stress-strain curve of a ductile metal. Discuss the physical mechanisms occurring in the following regions :

Elastic deformation, Yield point, Plastic deformation, Necking and fracture. Relate these stages to dislocation motion and multiplication. **10**

(b) Analyse the role of grain boundaries as barriers to dislocation motion. **5**

4. (a) Explain the concept of Larmor precession and its significance in magnetic resonance. **8**

(b) Explain, why diamagnetic susceptibility is negative and nearly temperature independent. **7**

5. (a) If the applied electric field is 2×10^6 V/m, estimate the polarization. Explain briefly the physical meaning of polarization in dielectrics. **7**

(b) Derive and explain the Clausius-Mossotti relation and discuss its physical significance. **8**

6. (a) Weiss theory of ferromagnetism is based on the concept of ferromagnetic domains spontaneously magnetized due to the presence of Weiss field. Explain the nature and origin of Weiss field. **7**

(b) Explain the Frank-Read mechanism for dislocation multiplication and why is it important for plastic deformation ? **8**

7. (a) Find the minimum diameter of a steel wire, which is used to raise load of 4000 N if the stress in the rod is not to exceed 95 MN/m^2. **7**

(b) During a phase transition, energy is absorbed or released without a change in temperature. What kind of phase transition is this ? Explain. **8**

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