

**Answer all the questions. All questions, except Q.1, carry 7 marks each.**

1. Write **short** notes on each of the following **(2 marks each)**:
  - a) Madelung constant
  - b) Polymorphism and allotropy
  - c) Schottky and Frenkel defects
  - d) Single Crystalline, Polycrystalline and Amorphous materials
  - e) Polydispersity Index of a polymer
2. a. Draw a schematic of the binding energy versus distance curve for a general material. What all information about a material can be deduced from such a curve? **(5 Marks)**  
  
b. Using a Lennard-Jones potential with  $m=6$  and  $n=12$ , determine the separation distance,  $r$ , at which the maximum force,  $F_{\max}$  occurs in terms of the equilibrium bond distance,  $r_0$ . **(5 Marks)**
3. Copper crystallizes in the FCC structure. The density and atomic weight of Cu are  $8960 \text{ kg/m}^3$  and  $63.54$ , respectively. Calculate the lattice constant. **(5 Marks)**
4. a. The first ionization energy of sodium is  $498 \text{ kJ/mol}$  and the electron affinity of chlorine is  $-354 \text{ kJ/mol}$ . Justify why sodium chloride should form. **(5 Marks)**  
  
b. Use diagrams to illustrate how close packed structures can be formed and calculate the packing density (atomic volume by unit cell volume) for an fcc structure. **(5 Marks)**
5. Distinguish between thermoplastic and thermosetting polymers? What are co-polymers and what are the different types of co-polymers? **(5 Marks)**
6. a. Calculate the energy of vacancy formation in aluminium given that the equilibrium number of vacancies at  $500^\circ\text{C}$  is  $7.57 \times 10^{17} \text{ cm}^{-3}$ . State any assumptions. **(5 Marks)**  
  
b. Describe with suitable diagrams edge and screw dislocations in a crystal lattice. What are mixed dislocations? **(5 Marks)**
7. a. How can composites be classified on the basis of the matrix used? Give an example of each type. **(5 Marks)**  
  
b. The heart of materials science is the structure-property relationships. Explain how the periodic table reflects this statement. **(5 Marks)**

**Constants**

Boltzmann constant:  $8.65 \times 10^{-5} \text{ eV/K}$   
Avogadro's number:  $6.023 \times 10^{23} \text{ /mole}$   
Permittivity in free space  $\epsilon_0$ :  $8.854 \times 10^{-12} \text{ F/m}$   
Charge on an electron:  $1.602 \times 10^{-19} \text{ C}$   
Mass of electron:  $9.11 \times 10^{-31} \text{ kg}$   
Planck's constant  $6.626 \times 10^{-34} \text{ J-s}$   
Velocity of light in vacuum:  $2.998 \times 10^8 \text{ m/s}$   
Lattice parameter of Aluminium:  $4.04958 \text{ \AA}$   
Structure of Aluminium: FCC  
Atomic Weight of Aluminium:  $26.98 \text{ g/mol}$   
Bond formation energy in NaCl:  $-515 \text{ kJ/mol}$

**Formulae**

$$n = N \exp\left(-\frac{E_v}{k_B T}\right)$$

$$U = -\frac{a}{r^m} + \frac{b}{r^n}$$

$$2d \sin \theta = \lambda$$