Materials Science (MS31007) Mid-Semester Exam (Autumn 2011)

Departments: AE/BT/CE/CY/EX/GG/ME/NA 4th year B. Tech

Time: 2 hours Maximum marks: 60

Answer all the questions. All questions carry equal marks.

1. **Answer True or False (10 marks)**

(i) Ionic bonding is the result of the sharing of electrons of two atoms.
(ii) Atoms in the hydrogen molecule are held together by hydrogen bonding.
(iii) Metallic bonding is directional.
(iv) van der Waals bonding is the result of attraction between magnetic dipoles.
(v) A polymorphic material is one that is found naturally in many different shapes.
(vi) The Miller indices of all directions that are parallel to one another are identical.
(vii) Substitutional atoms occupy interstices in the parent lattice.
(viii) The Burgers vector of an edge dislocation is always perpendicular to the dislocation line.
(ix) Bronze is a Cu-Zn alloy
(x) Above the eutectic temperature, one cannot observe a solid phase for any composition in a binary phase diagram.

2. Calculate the force of attraction between a K^+ and O^{2-} ion whose centers are separated by a distance of 2.0 nm. **(5 marks)**

3. Cite the indices of the direction that results from the intersection of each of the following pairs of planes within a cubic crystal: (a) (110) and (111) planes; (b) (110) and $(1\bar{1}0)$; (c) $(10\bar{1})$ and (001) planes. **(5 marks)**

4. a. Aluminium crystallizes in the FCC structure. The density and atomic weight of Cu are 2699 kg/m^3 and 26.98, respectively. Calculate the lattice constant. **(5 marks)**

   b.Calculate the energy of vacancy formation in aluminium given that the equilibrium number of vacancies at 500°C is 7.57×10^{17} cm^{-3}. State any assumptions. **(5 marks)**

5. Calculate the molecular weight of polystyrene having degree of polymerization of 100,000. (b) Calculate the approximate chain length of one of the molecules. **(5 marks)**

6. Distinguish between pearlite and bainite. What is a martensitic transformation? **(5 marks)**

7. For both FCC and BCC crystal structures, the Burger's vector **b** may be expressed as

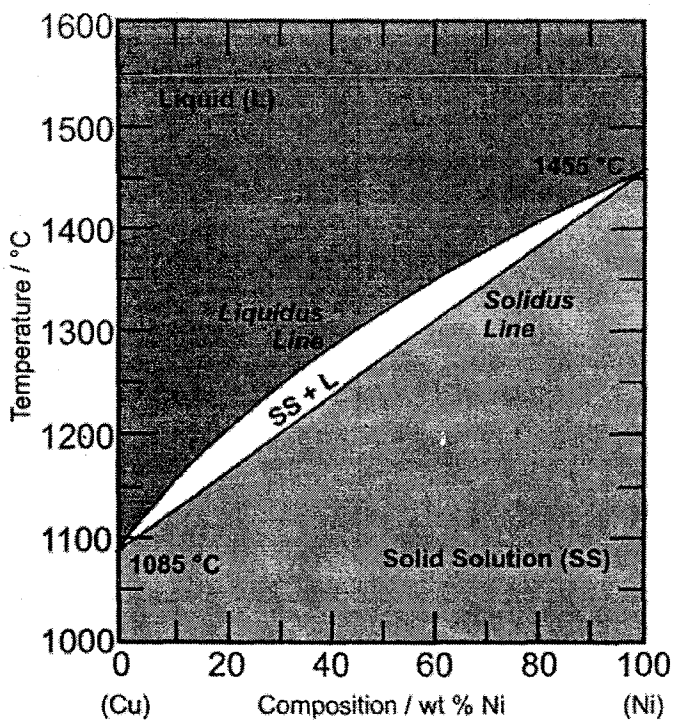
$$\mathbf{b} = \frac{1}{2}a[hkl]$$

where a is the unit cell length and $[hkl]$ is the crystallographic direction having the greatest linear atomic density. (a) What are the Burger's vector representations for FCC, BCC, and SC structures? (b) If the magnitude of the Burger's vector $|\mathbf{b}|$ is

$$|\mathbf{b}| = \frac{1}{2}a(h^2 + k^2 + l^2)^{\frac{1}{2}}$$

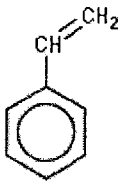
determine the values of $|\mathbf{b}|$ for aluminum (FCC) and tungsten (BCC). For aluminium, use the lattice constant calculated in Question 4a. Tungsten has a lattice constant of 3.160 Å. **(10 marks)**

8. Draw schematic ΔG_{mix} versus X_{Ni} curves for the Cu-Ni system shown in the Cu-Ni phase diagram at 1455, 1300, 1100, and 300◦C. Also, calculate the composition and amounts of each phase present in 1 kg of a 50:50 Cu:Ni alloy at 1300 °C. **(10 marks)**



Constants

Boltzmann constant: 8.65×10^{-5} eV/K
Permittivity in free space ε_o: 8.854×10^{-12} F/m
Charge on an electron: 1.602×10^{-19} C
Mass of electron: 9.11×10^{-31} kg
Planck's constant 6.626×10^{-34} J-s
Avogadro's number: 6.023×10^{23} /mole
C-C bond length: 0.154 Å
C=C bond length: 0.134 Å
Velocity of light in vacuum: 2.998×10^{8} m/s



styrene

Formulae

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

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