BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE PILANI
Pilani Campus, Chemistry Department
Chemistry of Materials, CHEM F333, Semester II, 2016 - 17

COMPREHENSIVE Exam, 11 May 2017, 8.00 am

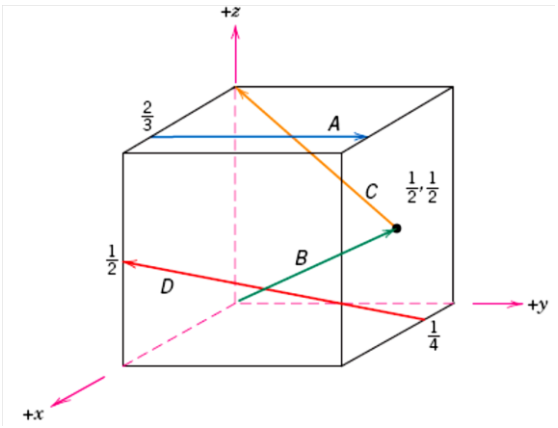
Maximum Marks: 80 **OPEN BOOK** **Duration: 180 min**

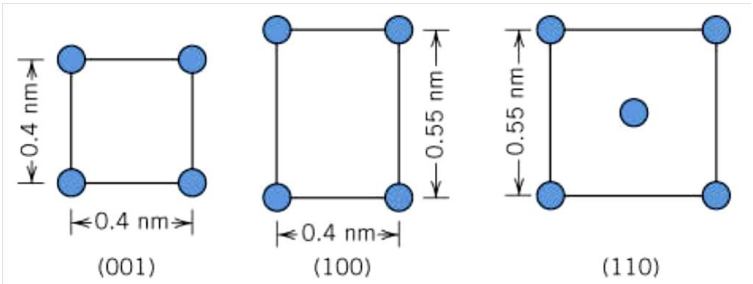
NOTE

1. **There are TWO pages in the question paper with EIGHT questions.**
2. **Use PEN only for both answering and drawing. NO PENCIL USE**

Answer all Questions

1. **(a)** A hypothetical metal has the BCC crystal structure, a density of 7.24 g/cm^3, and an atomic weight of 48.9 g/mol. Find the atomic radius of this metal.
(b) In the unit cell shown below, mention what the vectors A, B, C, D represent.
(c) Sketch the $(01\bar{1}1)$and $(2\bar{1}\bar{1}0)$planes in a hexagonal unit cell
(d) The accompanying figure shows three different crystallographic planes for a unit cell of a hypothetical metal. The circles represent atoms. Draw the unit cell. **[1+4+2+3 = 10]**





2. **(a)** Molybdenum (Mo) forms a substitutional solid solution with tungsten (W). Compute the number of molybdenum atoms per cubic centimeter for a molybdenum–tungsten alloy that contains 16.4 wt% Mo and 83.6 wt% W. The densities of pure molybdenum and tungsten are 10.22 and 19.30 g/cm^3, respectively
(b) Calculate the fraction of atom sites that are vacant for copper (Cu) at its melting temperature of 1084°C (1357 K). Assume energy for vacancy formation of 0.90 eV/atom.
(c) Describe pictorially the occurrence of atomic point defects. **[4+4+2 = 10]**

3. **(a)** Briefly explain the differences between **(i)** interdiffusion and self diffusion, and **(ii)** driving forces in steady state and non-steady state diffusion processes
(b) The diffusion coefficients for Ni in Fe are given at two temperatures, as in the adjacent table. **(i)** Determine the values of D_0 and the activation energy Q_d, **(ii)** What is the value of D at 1573 K?
(c) Describe shortly the process of diffusion in polymers **[4+4+2 = 10]**

T(K)	*D(m^2/s)*
1473	2.2×10^{-15}
1673	4.8×10^{-14}

4. **(a)** A steel alloy to be used for a spring application must have a modulus of resilience of at least 2.07 MPa (300 psi). What must be its minimum yield strength?
(b) The following true stresses produce the corresponding true plastic strains for a brass alloy: What true stress is necessary to produce a true plastic strain of 0.21?
(c) Define the four different hardness testing techniques for solid? **[3+3+4 = 10]**

True Stress (psi)	*True Strain*
60,000	0.15
70,000	0.25

5. **(a)** If ice homogeneously nucleates at - 40°C, Calculate the critical radius, given the latent heat of fusion and the surface free energy as -3.1×10^8 J/m^3 and 25×10^{-3} J/m^2 respectively.
(b) Describe the process of development of microstructures for equilibrium cooling of eutectic alloys
(c) What is the degree of freedom possible for a hypothetical "perfectly non-compressible" mixture having three components and two phases?
(d) Briefly describe an eutectoid reaction **[3+4+1+2 = 10]**

6. **(a)** How are glasses different from glass-ceramics?

NO SCRIBBLING ON THE QUESTION PAPER

(b) Compute the mass fractions of liquid in the following fireclay refractory materials at 1600°C: 25 wt% Al_2O_3–75 wt% SiO_2

(c) The modulus of elasticity for spinel ($MgAl_2O_4$) having 5 vol% porosity is 240 GPa (35×10^6 psi). Compute **(i)** the modulus of elasticity for the nonporous material. **(ii)** the modulus of elasticity for 15 vol% porosity.

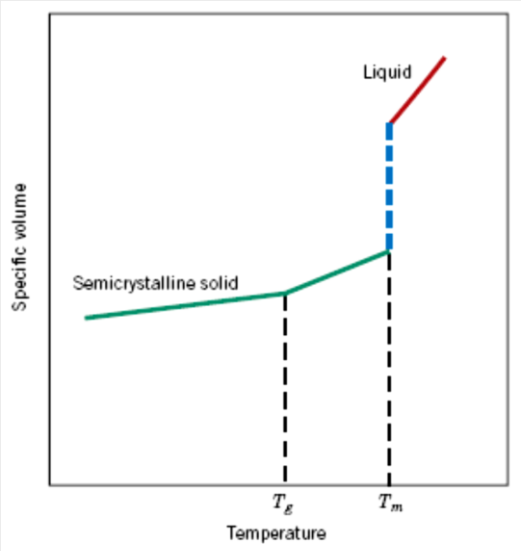
[2+3+3+2 = 10]

7. **(a)** Explain the phenomena in adjacent graph with respect to the variation in specific volume with temperature for a semicrystalline material.

(b) The following table lists molecular weight data for a polytetrafluoroethylene material. Compute the following:

(i) number-average molecular weight
(**ii**) weight-average molecular weight
(iii) degree of polymerization

Molecular Weight Range (g/mol)	x_i	w_i
10,000–20,000	0.03	0.01
20,000–30,000	0.09	0.04
30,000–40,000	0.15	0.11
40,000–50,000	0.25	0.23
50,000–60,000	0.22	0.24
60,000–70,000	0.14	0.18
70,000–80,000	0.08	0.12
80,000–90,000	0.04	0.07



(c) State the difference between thermosetting and thermoplastic polymers

(d) A random poly(styrene-butadiene) copolymer has a number-average molecular weight of 350,000 g/mol and a degree of polymerization of 5000. Compute the fraction of styrene and butadiene repeat units in this copolymer

[3+3+2+2 = 10]

8. **(a)** Nickel experiences corrosion in an acid solution according to the reaction

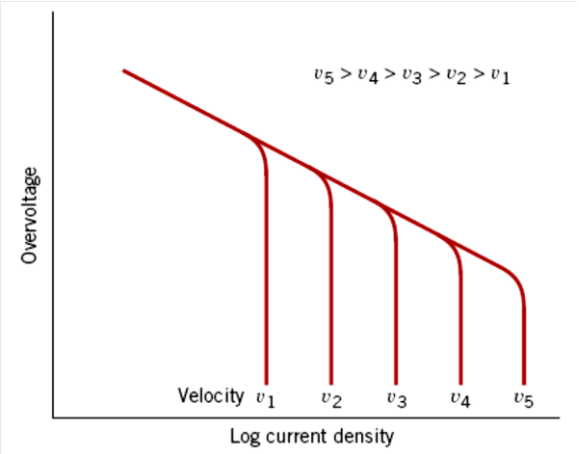
$$Ni + 2H^+ \longrightarrow Ni^{2+} + H_2$$

Assume the rates of both oxidation and reduction half reactions are controlled by activation polarization. Compute the rate of oxidation of Ni (in mol/ cm^2s), given the following activation polarization data:

(b) The influence of increasing solution velocity

For Nickel	*For Hydrogen*
$V_{(Ni/Ni^2)} = -0.25$ V	$V_{(H^+/H_2)} = 0$ V
$i_0 = 10^{-8}$ A/cm^2	$i_0 = 6 \times 10^{-7}$ A/cm^2
$\beta = +0.12$	$\beta = -0.10$

on the overvoltage-versus log-current density behavior for a solution that experiences combined activation–concentration polarization is indicated in adjacent figure. Based on this make a schematic plot of corrosion rate versus solution velocity for the oxidation of a metal, assuming activation polarization for the oxidation of the metal.



(c) Compare the Standard EMF series and Galvanic series citing at least two points of difference

(d) Mention the differences between the two techniques of cathodic protection

[3+3+2+2 = 10]

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