Birla Institute of Technology and Science Pilani (Rajasthan)
CHEM F333: Chemistry of Materials

Comprehensive Exam	**Part II (Open Book)**	**I Semester 2023-2024**
Max. Marks: 50	**Time: 135 minutes**	**Date: 06.12.2023**

Note: There are **two** questions in all. **Answer all parts of a question together.**

Q. 1 (a) An XRD experiment was performed with monochromatic x-radiation having a wavelength of 1.54 Å on a FCC crystal with lattice parameter = 3.61 Å. What are the Miller indices of the planes with highest Bragg angle? **(4)**

(b) Suppose one Schottky defect is present in every tenth unit cell of MgO. MgO has the sodium chloride crystal structure and a lattice parameter of 0.396 nm. Calculate **(i)** the number of anion vacancies per cm^3 and **(ii)** the density of the ceramic. **(4)**

(c) Iron containing 0.05% C is heated to 912 °C in an atmosphere that produces 1.20% C at the surface and is held for 24 h. Calculate the carbon content at 0.05 cm beneath the surface if **(i)** the iron is BCC and **(ii)** the iron is FCC. Explain the difference. **(4)**

(d) A cylindrical metal specimen 15.4 mm in diameter and 290 mm long is to be subjected to a tensile stress of 26 MPa; at this stress level the resulting deformation will be totally elastic.
(i) If the elongation must be less than 0.090 mm which of the metals (Aluminium, magnesium, brass, copper, nickel and titanium) are suitable candidates? Why?
(ii) If, in addition, maximum permissible diameter decrease is 1.3×10^{-3} mm when tensile stress of 27 MPa is applied, which metals that satisfy the criterion in part (a) are suitable candidates? Why? **(4)**

(e) The density and associated percent crystallinity for two polytetrafluoroethylene materials are:

ρ (g/cm^3)	2.229	2.345
Crystallinity (%)	52.2	75.3

(i) Compute the densities of totally crystalline and totally amorphous polytetrafluoroethylene.
(ii) Determine the percent crytallinity of a specimen having a density of 2.35 g/cm^3. **(4)**

(f) Cadmium (At. Wt. =112.41 g/mol) has an HCP crystal structure and a density of 8.65 g/cm^3.
(i) What is the volume of its unit cell in cubic meters? **(ii)** If the c/a ratio is 1.593, compute the values of c and a. **(5)**

Q. 2 (a) Consider a Pb–35% Sn alloy. Determine **(i)** if the alloy is hypoeutectic or hypereutectic, **(ii)** the composition of the first solid to form during solidification, **(iii)** the amounts and compositions of each phase at 184°C, **(iv)** the amounts and compositions of each phase at 182°C, **(v)** the amounts and compositions of each microconstituent at 182°C, and **(vi)** the amounts and compositions of each phase at 25°C. **(5)**

(b) Briefly explain why **(i)** there is no bainite transformation region on the continuous cooling transformation diagram for an iron–carbon alloy of eutectoid composition.
(ii) Fine pearlite forms for the moderate cooling of austenite through the eutectoid temperature, whereas coarse pearlite is the product for relatively slow cooling rates. **(4)**

(c) A half-cell produced by dissolving copper in water produces an electrode potential of 0.32 V. Calculate the amount of copper to be added to 1000 ml of water to produce this potential. **(4)**

(d) Which of metallic coatings (zinc, lead, tin, cadmium, aluminum, and nickel) will provide protection to steel even when the coating is locally disrupted? Explain. **(4)**

(e) Calculate electrical resistivity of copper in a Cu–Ni alloy containing 1.80 at% Ni at 100 °C. **(4)**

(f) An alloy of nickel and cobalt is to be produced to give a magnetization of 2×10^6 A/m. The crystal structure of the alloy is FCC with a lattice parameter of 0.3544 nm. Determine the atomic percent cobalt required, assuming no interaction between the nickel and cobalt. **(4)**

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