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S'12:2 FN:AN202/AD302 (1402)

MATERIALS SCIENCE AND ENGINEERING

Time : *Three hours*

Maximum Marks : *100*

Answer FIVE *questions, taking* ANY TWO *from* **Group A,** ANY TWO *from* **Group B** and ALL *from* **Group C.**

All parts of a question (a, b, etc.) should be answered at one place.

Answer should be brief and to-the-point and be supplemented with neat sketches. Unnecessary long answers may result in loss of marks.

Any missing or wrong data may be assumed suitably giving proper justification.

Figures on the right-hand side margin indicate full marks.

Group A

1. (*a*) What is the angle between [001] and [111] directions of cubic crystal ? Show that packing efficiency of a BCC crystal is 0.68. 2 + 4

(*b*) Find the equilibrium concentration of vacancies in aluminum at 300 K and 900 K. Enthalpy of formation of vacancies in aluminum, $\Delta H_f = 68$ kJ/mol, $R = 8.314$ J/mol K. 4

(*c*) Distinguish between Frenkel and Schottky defects. 5

(*d*) The diffusion coefficients for iron in nickel are given at following two temperatures :

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T (K)	D (m²/s)
1273	9.4×10^{-16}
1473	2.4×10^{-14}

Determine the values of D_0 and the activation energy Q_d. 5

2. (*a*) Explain Gibb's phase rule. Find the degree of freedom when FCC and BCC iron co-exist in equilibrium. 5

(*b*) Differentiate between edge and screw dislocations. 5

(*c*) In the Pb-Sn system, calculate the alloy composition at which the fraction of total α is 3 times the fraction of β phase at eutectic temperature, 182 °C, Pb with 19% Sn dissolved in it, Sn with 2.5% Pb dissolved in it, and liquid is in equilibrium. 5

(*d*) What is zone refining ? Discuss how is it done practically. 5

3. (*a*) Explain in brief different strengthening mechanisms in metals and alloys. 5

(*b*) State briefly the significance of secondary stage in an ideal creep curve. 4

(*c*) State the Griffith criterion for crack propagation in brittle solid. A sodium silicate glass has no surface defects as etching has removed them, but has cracks inside from 2 μm to 5 μm in length. Calculate the surface energy of glass, if fracture strength = 100 MN/m² and Young's modulus = 70 GN/m². 2 + 4

(*d*) What is the essential difference between brittle fracture and ductile fracture ? 5

4. (*a*) Deduce the relationship between true stress and engineering stress. 5

(*b*) Differentiate between the following : 5 + 5

(*i*) Hot and cold working
(*ii*) Recovery and recrystallisation

(*c*) Explain the Schmid's law. 5

Group B

5. (*a*) Discuss briefly the following case-hardening methods : (*i*) Nitriding, and (*ii*) cyaniding. 3 + 2

(*b*) Define hardenability and severity of quench. Mention the factors which affect hardenability. 2 + 3

(*c*) Define tempering. What are main aims of tempering ? 1 + 3

(*d*) What is age-hardening ? What are the main requirements for an alloy to depict age-hardening ? Mention the steps in the process of age-hardening. 1 + 2 + 3

6. (*a*) Define thermal stress. Briefly explain why thermal stresses may be introduced into a structure by rapid heating or cooling. 1 + 4

(*b*) A brass rod is to be used in an application requiring its ends to be held rigid. If the rod is stress-free at 20 °C, what is the maximum temperature to which

the rod may be heated without exceeding a compressive stress of 172 MPa ? Assume a modulus of elasticity of 100 GPa for brass. The magnitude of linear coefficient of thermal expansion is 20.0×10^{-6} /°C. 5

(*c*) Briefly explain why porosity decreases the thermal conductivity of ceramic materials. What may be the measures taken to reduce the likelihood of thermal shock of a ceramic materials ? 3 + 3

(*d*) What are glass ceramics ? What are the desirable characteristics of glass ceramics ? 2 + 2

7. (*a*) Differentiate between thermoplastic and thermosetting polymers with suitable examples. 6

(*b*) Distinguish between chain reaction and step reaction polymerizations. 6

(*c*) Define 'composites'. How can composite materials be classified ? Write the advantages of composite materials over traditional engineering alloys. 2 + 3 + 3

8. (*a*) Differentiate between hard and soft magnetic materials with suitable examples. 5

(*b*) Briefly explain diamagnetism, paramagnetism and ferromagnetism. 6

(*c*) Why does the conductivity of a semiconductor change with impurity content ? Compare this with the behaviour of metallic conductor. 5

(*d*) The resistivity of pure silicon at room temperature is 3000 Ωm. Calculate the intrinsic carriers concentration. Given the electron and hole mobilities are 0.14 m^2/Vs, and 0.05 m^2/Vs, respectively. 4

Group C

9. Answer the following in brief : 10 × 2

(*i*) The distance between (111) planes in FCC crystal structure is 2 Å. Find the lattice parameter and atomic diameter.

(*ii*) What is an eutectic reaction and eutectoid reaction ?

(*iii*) Define an isomorphous system with examples.

(*iv*) Define the terms 'anelasticity' and 'viscoelasticity'.

(*v*) What is Bauschinger effect ?

(*vi*) Define (*a*) Curie temperature, and (*b*) coercivity.

(*vii*) Define the glass transition temperature (T_g).

(*viii*) What is tempered glass ?

(*ix*) Calculate the room-temperature electrical conductivity of silicon that has been doped with $10^{23}\ m^{-3}$ of arsenic atoms. The electron mobility, $\mu_e = 0.07\ m^2/V.s$.

(*x*) Define any one high temperature material with an examples.