

JUNE 2005

Code: A-04
Time: 3 Hours

Subject: MATERIALS AND PROCESSES
Max. Marks: 100

NOTE: There are 11 Questions in all.

- Question 1 is compulsory and carries 16 marks. Answer to Q. 1. must be written in the space provided for it in the answer book supplied and nowhere else.
- Answer any THREE Questions each from Part I and Part II. Each of these questions carries 14 marks.
- Any required data not explicitly given, may be suitably assumed and stated.

Q.1 Choose the correct or best alternative in the following: (2x8)

a. Which one of the following is not the function of an oxide layer during IC fabrication?

- (A) to mask against diffusion or ion-implant.
- (B) to insulate the surface electrically.
- (C) to produce a chemically stable surface.
- (D) To increase the melting point of silicon.

b. The \underline{t} vector is parallel to the \underline{b} vector in a dislocation of type

- (A) screw.
- (B) edge.
- (C) mixed.
- (D) None of these.

c. In a single component system, the maximum number of phases that can coexist in equilibrium is

- (A) 2.
- (B) 3.
- (C) 4.
- (D) 5.

d. At 0°K , the probability of finding an electron at energy level E is unity, when

- (A) $E > E_F$.
- (B) $E \gg E_F$.

(C) $E < E_F$. (D) $E < 0$.

e. In a p-n junction in equilibrium with zero bias

- (A) no holes or electrons cross the junction.
- (B) only electrons cross the junction.
- (C) equal number of holes and electrons cross the junction in opposite direction.
- (D) only holes cross the junction.

f. Polarization of a dielectric on application of electric field is

- (A) passing of current through dielectric.
- (B) orientation or displacement of electrons locally.
- (C) breaking of insulation.
- (D) excitation of electrons.

g. A suitable material for audio and TV transformers is

- (A) ferrite. (B) Fe - 4% Si.
- (B) Fe - 30% Ni. (D) Pure Fe.

h. Which of the following is not the purpose of annealing

- (A) uniform grain structure.
- (B) shining and clean surface free of stress.
- (C) uniform structure free of internal stresses.
- (D) soft metallic structure.

PART I

Answer any THREE Questions. Each question carries 14 marks.

Q.2 a. Draw a schematic figure showing the structure of sodium chloride. Obtain an expression for the total lattice energy of an ionic crystal in terms of modelling constant and other parameters. (2 + 6)

b. Assume that the energy of two particles in the field of each other is

given by
$$U(r) = -\frac{a}{r} + \frac{b}{r^8}$$
. Where a and b are constants and r is the distance between the centres of the particles.

(i) Show that if the particles are pulled apart, the molecule will

$$r = \left(\frac{36b}{a} \right)^{\frac{1}{7}} = r_0 (4.5)^{\frac{1}{7}}$$

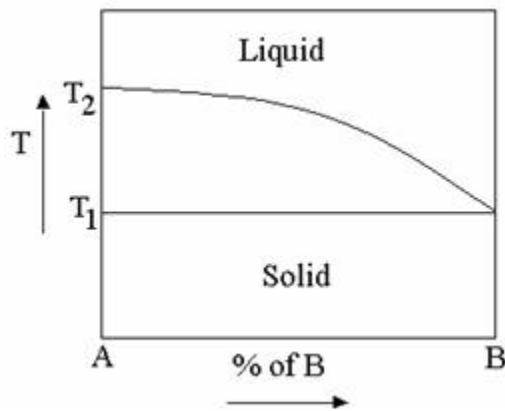
break as soon as

(ii) Prove that in the stable configuration, the energy of attraction is 8 times the energy of repulsion. (3 + 3)

Q.3 a. Describe with suitable diagrams edge dislocations and screw dislocations in crystal lattice. What is a Burger's vector? (6 + 2)

b. Show that the maximum radius of the sphere that can just fit into the void at the body centre of the fcc structure coordinated by the facial atoms is 0.414 r where r is the radius of the atom. (6)

Q.4 a. What type of information do you get about the alloy system AB from the equilibrium diagram as shown below: (8)



- b. How does the flux change with time and position along the diffusion direction under non-steady state conditions? What is the solution to the above conditions? (4 + 2)

Q.5 a. Explain drift velocity and relaxation time of free electrons in metals. How is the electrical conductivity in metals affected by temperature and alloying? (4 + 4)

- b. What is Fermi level? Show that the probability of occupancy of energy level E by an electron is

(i) negligible for $E \gg E_F$.

(ii) 0.5 for $E = E_F$.

(iii) almost unity for $E \ll E_F$ (3 + 3)

Q.6 a. Show that an intrinsic semiconductor contains equal number of holes in the valence band and electrons in the conduction band. (7)

- b. What is Hall effect? How would you determine the nature and concentration of carriers in a strongly extrinsic semiconductor? (2 + 5)

PART II

Answer any **THREE** Questions. Each question carries **14** marks.

Q.7 a. What is polarizability? What do you mean by local electric field? Examine the physical processes which give rise to different types of polarizations. (2 + 2 + 4)

- b. What is Piezoelectricity? What are different applications in which piezoelectricity is used? (2 + 4)

- Q.8** a. Differentiate hard and soft magnetic materials with suitable examples. **(8)**
- b. The speed of storing and reading out information from a computer core is less than a microsecond. Why is it necessary to use a ferrite for this application rather than a ferromagnetic alloy? **(6)**

Q.9 a. Describe a process of single crystal growth with a neat diagram. (7)

b. What are the characteristics of the structure obtained in a cast iron casting? Explain briefly. (7)

Q.10 a. Explain the difference between “annealing” and “normalizing” and need for each. (8)

b. What factors affect the choice of cooling rates for steels for hardening? (6)

Q.11 Write short notes on any **TWO** of the following:

(i) p-n junction as rectifier.

(ii) Properties and applications of PVC and mica.

(iii) Epitaxial

growth.

(7 + 7)