December 2005

Code: A-04
Subject: MATERIALS AND PROCESSES
Time: 3 Hours
Max. Marks: 100

NOTE: There are 9 Questions in all.

- **Question 1 is compulsory and carries 20 marks. Answer to Q. 1. must be written in the space provided for it in the answer book supplied and nowhere else.**
- **Out of the remaining EIGHT Questions answer any FIVE Questions. Each question carries 16 marks.**
- **Any required data not explicitly given, may be suitably assumed and stated.**

Q.1 Choose the correct or best alternative in the following: (2x10)

a. The number of atoms present in the unit cell of hcp structure is

(A) 2. **(B)** 4.
(C) 6. **(D)** 7.

b. Metallic bond is not characterized by

(A) ductility. **(B)** high conductivity.
(C) directionality. **(D)** opacity.

c. Frankel and Schottky imperfections are

(A) dislocations in ionic crystals.
(B) grain boundaries in covalent crystals.
(C) vacancies in ionic crystals.
(D) vacancies in co-valent crystals.

d. The Einstein relationship between the diffusion constant, D_n and mobility, μ_n for electron is

(A) $\frac{D_n}{\mu_n} = \frac{2K_B T}{e}$. **(B)** $\frac{D_n}{\mu_n} = \frac{e}{K_B T}$.

(C) $\frac{D_n}{\mu_n} = \frac{K_B T}{e}$. **(D)** $\frac{D_n}{\mu_n} = K_B T - E$.

Where T is the temperature and K_B is Boltzmann's constant.

e. If the Fermi energy of silver at 0° K is 5 electron volt, the mean energy of electron in silver at 0° K is

(A) 6 electron volt. **(B)** 12 electron volt.
(C) 1.5 electron volt. **(D)** 3 electron volt.

f. The Fermi level in an n-type semiconductor at 0° K lies

(A) below the donor level.
(B) half way between the bottom of conduction band and donor level.
(C) exactly in the middle of band gap.
(D) half way between the top of valence band and the acceptor level.

g. Hard magnetic material is characterized by

(A) high coercive force and low residual magnetic induction.
(B) low coercive force and high residual magnetic induction.
(C) only low coercive force.
(D) high coercive force and high residual magnetic induction.

h. Piezoelectric effect is the production of electricity by

(A) chemical effect. **(B)** pressure.
(C) varying field. **(D)** temperature.

i. Electromigration in metallization refers to the diffusion (under the influence of current) of

(A) Al. **(B)** Cu in Al-Cu alloy.
(C) Si. **(D)** Na.

j. Fine grain sizes are obtained by

(A) slow cooling. **(B)** increasing nucleation rate.
(C) decreasing growth rate. **(D)** fast cooling.

Answer any FIVE Questions out of EIGHT Questions.
Each question carries 16 marks.

Q.2 a. Why a covalent bond is directional? Describe the salient features of ionic and metallic bonded crystals. **(3+7)**

b. Obtain the Miller indices of a plane which intercepts at a, $b/2$, 3c in a simple Cubic unit cell. Draw a neat diagram showing the plane. (Where a, b, c are lattice parameters). **(4+2)**

Q.3 a. What is tie-line rule? Explain. Show that, for correct mass balance, the relative amount of two co-existing phases or micro constituents must be as given by the lever rule. **(3+5)**

b. What are the different types of point defects? How are they caused? **(6+2)**

Q.4 a. State and explain Fick's laws of diffusion. What are the factors influencing the diffusion coefficient? **(8+2)**

b. How do temperature and impurities affect electrical resistivity of metals? **(6)**

Q.5 a. Define mobility of a carrier of current. How is it related to the Hall coefficient? Is the mobility of an electron in the conduction band of a semiconductor the same as the mobility of an electron (or hole) in the valence band? Give reasons for your answer. **(10)**

b. The resistivity of pure silicon at room temperature is 3000 ohm-m. Mobilities of electrons and holes in silicon are 0.14 $m^2v^{-1}s^{-1}$ and 0.05 $m^2v^{-1}s^{-1}$ respectively. Calculate the intrinsic carrier density of silicon at room

temperature. **(6)**

Q.6 a. What are properties of an ideal electrical insulating material? What are the various products and applications of mica? **(3+5)**

b. What is dielectric strength? Explain the various causes & processes which give rise to different types of dielectric break down. **(2+6)**

Q.7 a. What are the most important properties of permanent magnetic materials? Explain. **(6)**

b. What are ferrites? Where are they used? Give examples. Differentiate magnetically soft ferrites and magnetically hard ferrites. **(2+4+4)**

Q.8 a. What is the basis of classification of hot and cold working? What are the advantages and disadvantages of cold working over hot working? **(4+5)**

b. What are the functions of oxide layer in a high quality IC? Explain. **(7)**

Q.9 a. Explain the process of extrusion. What are its applications? **(8)**

b. What are the objectives of heat treatment processes? Describe the hardening process and explain its various stages. **(8)**