[This question paper contains 8 printed pages.]

5992 *Your Roll No.* .....

B.Sc. (H) ELECTRONICS / Ist Sem. B

Paper – ELHT–102

(Engineering Materials)

(Admissions of 2010 and onwards)

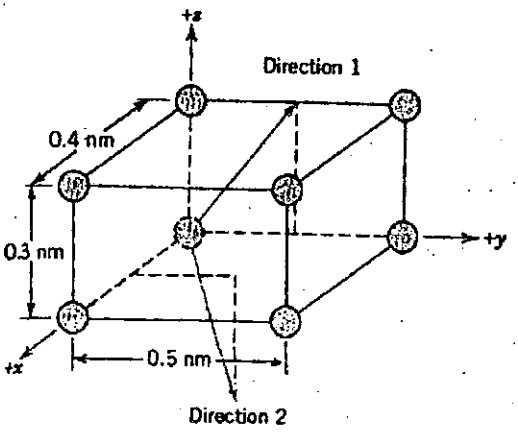
Time : 3 Hours *Maximum Marks : 75*

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt **Five** *questions in all including Q. No.* **1** *which is compulsory.*
Use of scientific calculators is allowed.

1. Attempt any **five** : (5×3)

(a) What are the indices for the directions indicated by the two vectors in the sketch below ?



P.T.O.

(b) A steel bar 100 mm long having a square cross section 20 mm on an edge is pulled in tension with a load of 89,000 N and experiences an elongation of 0.10 mm. Assuming that the deformation is entirely elastic, calculate the elastic modulus of the steel.

(c) At room temperature the electrical conductivity and the electron mobility for copper are 6.0×10^7 $(\Omega\text{-m})^{-1}$ and 0.0030 $m^2/V\text{-s}$, respectively. (i) Compute the number of free electrons per cubic meter for copper at room temperature. (ii) What is the number of free electrons per copper atom ? Assume atomic weight value for Cu is 63.55 g/mol and density of 8.9 g/cm^3.

(d) For aluminium (atomic weight = 26.98 gm), the heat capacity at constant volume C_V at 30K is 0.81 J/mol-K, and the Debye temperature is 375 K. Estimate the specific heat at 50 K.

(e) The magnetic susceptibility of iron measured at 900°C is 2.5×10^{-4}. Given the Curie constant as 3.25×10^{-2} K^{-1}, find the Curie temperature of iron.

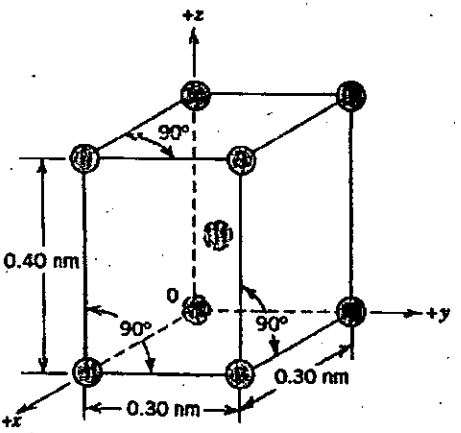
(f) What is the motivation behind the development of nanomaterials ? Justify.

2. (a) Below is a unit cell for a hypothetical metal.

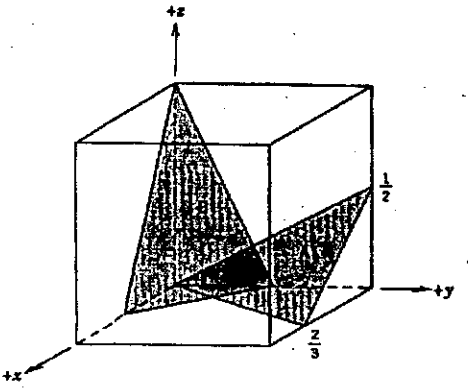
(i) To which crystal system does this unit cell belong ?

(ii) What would this crystal structure be called ?

(iii) Calculate the density of the material, given that its atomic weight is 141 g/mol. (5)



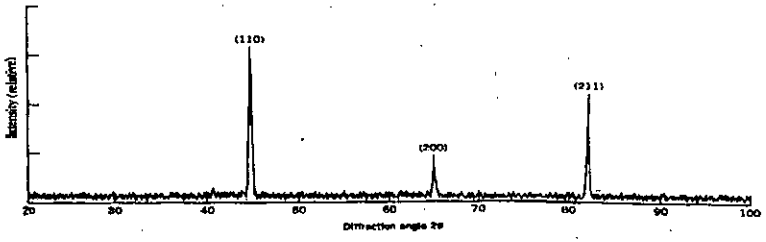
(b) (i) Determine the Miller indices for the planes shown in the following unit cell :



P.T.O.

(ii) What are the various types of crystalline defects ? (5)

(c) Derive Bragg's law for X-ray diffraction. Figure shows an x-ray diffraction pattern for α-iron taken using a diffractometer and monochromatic x-radiation having a wavelength of 0.1542 nm; each diffraction peak on the pattern has been indexed. Compute the interplanar spacing for (211) indexed set of plane; also determine the lattice parameter. (5)



3. (a) Derive an expression for critical resolved shear stress. (5)

(b) A cylindrical specimen of steel having original diameter of 12.8 mm is tensile tested to fracture and found to have an engineering fracture strength of 460 MPa. If the cross-sectional diameter at fracture is 10.17 mm, determine

(i) The ductility in terms of percent reduction in area

(ii) The true stress at fracture (5)

(c) Briefly discuss the following terms Yield strength, tensile strength, toughness, hardness, creep. (5)

4. (a) In terms of electron energy band structure, discuss reasons for the difference in electrical conductivity between metals, semiconductors, and insulators. Briefly tell what is meant by the drift velocity and mobility of a free electron. Show that the two Ohm's law expressions, $J = \sigma E$ and $V = IR$, are equivalent. (5)

(b) Will each of the following elements act as a donor or an acceptor when added to the indicated semiconducting material and why ? Assume that the impurity elements are substitutional. (5)

Impurity	Semiconductor
P	Si
Si	GaAs
Ge	InP
Al	Si
Cd	GaAs

(c) Explain Hall Effect. Discuss its importance and derive the expression for Hall coefficient. Some hypothetical metal is known to have an electrical

resistivity of 4×10^{-8} (Ω-m). Through a specimen of this metal that is 25 mm thick is passed a current of 30 A; when a magnetic field of 0.75 tesla is simultaneously imposed in a direction perpendicular to that of the current, a Hall voltage of -1.26×10^{-7} V is measured. Compute (i) the electron mobility for this metal, and (ii) the number of free electrons per cubic meter. (5)

5. (a) Derive an expression for the specific heat of solids on the basis of Debye model and discuss the variation of Debye specific heat with temperature. (5)

(b) Briefly explain why the thermal conductivities are higher for crystalline than noncrystalline ceramics and why metals are typically better thermal conductors than ceramic materials. For each of the following pairs of materials, decide which has the larger thermal conductivity. Justify your choices.

(i) Pure copper; aluminum bronze (95 wt% Cu-5 wt% Al).

(ii) Fused silica; quartz. (5)

(c) What is thermoelectricity ? Explain the Seeback, Thomson and Peltier effects. (5)

6. (a) What is meant by local field in a solid dielectric ? Deduce an expression for the local field in a solid dielectric and hence obtain Clausius-Mosotti equation. (5)

(b) Explain with a neat sketch the frequency and temperature dependence of dielectric properties of an insulator. (5)

(c) The dielectric constant for a soda-lime glass measured at very high frequencies (on the order of 10^{15} Hz) is approximately 2.3 while at relatively low frequencies (1 MHz) is 6.9. What fraction of the dielectric constant at relatively low frequencies (1 MHz) is attributed to ionic polarization ? Neglect any orientation polarization contributions. (5)

7. (a) Distinguish between Diamagnetic, Paramagnetic and Ferro-magnetic materials. Mention their properties. What happens when these materials are placed in a magnetic field ? (5)

(b) The saturation magnetization of cobalt is 14.48×10^5 A/m. Given the density of cobalt as 8900 Kg/m^3 and its atomic weight as 59, calculate the spin magnetic moment of a cobalt atom in terms of Bohr's magnetron. (5)