



# National Institute of Technology Goa

Programme Name: **B.Tech**

End Semester Examinations, July-2021

Course Name: Material Science

Date: **30/07/2021**

Duration: **3 Hours**

Course Code: PH150

Time: 09.30-12.30 P.M

Max. Marks: **100**

ANSWER ALL QUESTIONS

01. a) Draw the planes and directions of FCC structures (321), (102), (201) and (020). 4 (m)
- b) Determine the packing efficiency and density of sodium chloride from the following data: (i) radius of the sodium ion =  $1.02 \text{ \AA}$ , (ii) radius of chlorine ion =  $1.61 \text{ \AA}$  (iii) atomic mass of sodium = 22.29 amu and atomic mass of chlorine = 31.05 amu. 3 (m)
- c) Aluminium has FCC structure. Its density is  $2100 \text{ kg/m}^3$ . Find the unit cell dimensions and atomic diameter. Given at. weight of Al = 23.98. 3 (m)
02. a) Calculate the planar atomic densities of planes (100), (110) and (111) in FCC unit cell and apply your result for lead (FCC form). 3 (m)
- b) The force of attraction between ions of Na and Cl is  $2.02 \times 10^{-9} \text{ N}$  when the two ions just touch each other. Given: ionic radius of  $\text{Na}^+$  ion is  $1.1 \text{ \AA}$ ,  $e = 1.6 \times 10^{-19} \text{ C}$ ,  $\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2/\text{N} - \text{m}^2$ . Find the radius of  $\text{Cl}^-$  ion. 2 (m)
- c) The empty electron states are available immediately above the fermi level in a material. What type of material it is? And find the flux per unit potential gradient. 5 (m)
03. a) There are  $10^9 \text{ electrons/m}^3$ , which serves as carriers in a material. The conductivity of material is  $0.01 \text{ Ohm}^{-1}/\text{m}$ . Find the drift velocity of these carriers, when 0.17 Volt is applied across 0.27 mm distance with the material. Given:  $e = 1.602 \times 10^{-19} \text{ C}$  and  $m = 9.1 \times 10^{-31} \text{ kg}$ . 3 (m)
- b) Find the conductivity of copper at 300 K. The collision time for electron scattering in copper at 300 K is  $4 \times 10^{-14} \text{ sec}$ . Given that density of copper =  $8960 \text{ kg/m}^3$ , atomic weight of copper = 53.54 amu and mass of an electron =  $9.1 \times 10^{-31} \text{ kg}$ . 3 (m)
- c) If someone were to give you a poly crystalline material of  $\text{NaFePO}_4$ , how would you go about discovering the crystal structure, and what theory and principle would you use to do so? Explain your method with a neat sketch. 4 (m)
04. a) Calculate the resistance of a Cu wire 100 cm long and having cross-sectional area of 3 sq. mm at  $20^\circ\text{C}$ . Given, the resistivity of Al at  $20^\circ\text{C} = 2.66 \times 10^{-8} \text{ ohm-m}$ . 2 (m)
- b) The critical temperature of mercury is 5.2 K. Calculate the wavelength of a photon whose energy is just sufficient to break up Cooper pairs in mercury at  $T = 0$ . In what region of the electromagnetic spectrum are such photons found? 4 (m)
- c) What are type-I and type-II superconducting materials? Give three examples of each why type-II materials are preferred for applications of superconductivity. 4 (m)
05. a) Find the shortest wavelength of the x-rays emitted by an x ray tube operating at 30 KV 3 (m)
- b) A certain crystal has axial units  $x : y : z$  of 0.424:1:0.367. Find the Miller indices of crystal faces whose intercepts are 0.212:1:0.183. 3 (m)
- c) What are polar and non-polar dielectrics? Derive Clausius-Mosotti equation for a solid dielectric exhibiting electronic polarizability. 4 (m)

06. a) Find the total polarizability of CO<sub>2</sub>, if its susceptibility is  $0.985 \times 10^{-3}$  and density is  $1.977 \text{ kg/m}^3$  4 (m)
- b) A solid elemental dielectric having density of  $3 \times 10^{28} \text{ atoms/m}^3$  shows an electronic polarizability of  $10^{-40} \text{ F.m}^2$ . Assuming the internal electric field to be a Lorentz field, find the dielectric constant of the material. 4 (m)
- c) With usual notations show that  $P = \epsilon_0(\epsilon_r - 1) E$  2 (m)
07. a) Write a short note on Dia, Para, Ferromagnetic materials and their applications 5 (m)
- b) The index of refraction for LiF is 1.395, its density is  $2.635 \times 10^3 \text{ kg/m}^3$ , and its molecular weight is  $26 \times 10^{-3} \text{ kg/mol}$ . Recall that  $\epsilon_0 = 8.854 \times 10^{-12} \text{ C/V-m}$ .  
1: Calculate the total polarizability for LiF.  
2: Calculate the electronic contribution to the total polarizability.  
Combine your information to calculate the ionic polarizability,  $\alpha_i$  5 (m)
08. a) A magnetic material has a magnetization of  $3000 \text{ A/m}$  and a flux density of  $0.005 \text{ wb/m}^2$ . Calculate the magnetic force and the relative permeability of it 4 (m)
- b) Assume that iron atoms have magnetic moment of two Bohr magnetons. Calculate the Curie constant if its density is  $7150 \text{ kg/m}^3$  and atomic weight is 55.8 4 (m)
- c) If a material have  $\epsilon < 0$ ,  $\mu < 0$ , What will happen electromagnetic radiation fall on surface? Why? 2 (m)
09. a) The critical temperature of a superconductor at zero magnetic field is  $T_c$ . Determine the temperature at which the critical field becomes half of its value at 0K 4 (m)
- b) For a certain metal the critical magnetic field is  $4 \times 10^3 \text{ A/m}$  at 6K and  $2 \times 10^4 \text{ A/m}$  at 0K. Determine its transition temperature. 4 (m)
10. a) Explain Size effects in nano materials 4 (m)
- b) How to characterize nano materials? Explain any one method with neat sketch 4 (m)
- c) A material has completely filled electronic states and possess a small value of induced magnetic moment, when there is an applied magnetic field. What type materials they are? Find the susceptibility of that material? 4 (m)

\*\*\* All the best\*\*\*