INDIAN INSTITUTE OF SPACE SCIENCE AND TECHNOLOGY
THIRUVANANTHAPURAM

End Semester Examination – July 08, 2022
CH 121- Materials Science and Metallurgy
Semester-II

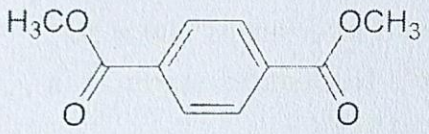
Time: 2 h **Max. Marks: 50**

Note: Draw neat sketches wherever necessary. State assumptions if any. You are advised to answer only to the question asked.Provide step-by-step calculations in the numerical problems. Answer all questions. Clearly write the question numbers.

Polymer Science

1. Mr. Raahil and Mr. Saathwick were asked to prepare polystyrene with PDI=1. Raahil used benzoyl peroxide (BPO) as the initiator, while Saathwick used BuLi as the initiator for polymerization. Who will be able to achieve the goal? Justify your answer with the support of the reasons and mechanisms that would have operated in the reactions. Please write the mechanism of both the reactions. (5 marks)

2. A polyester was prepared by melt polycondensation of ethylene glycol ($OHCH_2CH_2OH$) and dimethyl terephthalate. Analysis of the whole reaction product showed that it contained 6×10^{-5} mols of hydroxyl groups. Find out the degree of polymerization and number average molar mass of the polymer, if 2 g of ethylene glycol was used for the reaction and the reactants were taken in 1:1 molar ratio. (5marks)



dimethyl terephthalate

Materials Science

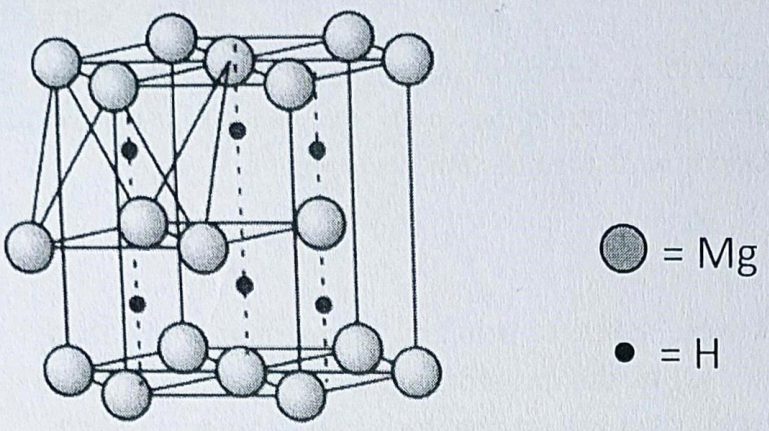
3. Define sintering (of ceramics)? Discuss various stages in ceramics sintering. (3 marks

4. What are intermediates and modifiers in commercial glass? Explain their roles by taking soda-lime-silica glass as an example. (2 marks)

5. The α-graphite has an *hcp* crystal structure. The density of graphite is 2.18 g/cm^3. The atomic radius of a carbon atom is 0.72 Å. (i) Calculate the interplanar spacing of the graphite layers. (ii) Find out the peak position corresponding to these layers (planes) in the XRD spectrum. (6 marks)

(atomic mass of carbon = 12 g/mol, Avogadro's number = 6.02×10^{23} atoms/mol, wavelength of Cu Kα radiation = 1.54 Å. *hint*: for an isosceles triangle, base b = 2a cos β, *cos* 30 = 0.866)

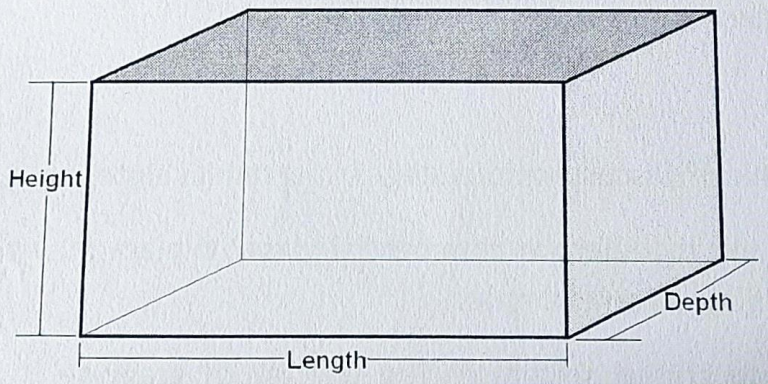
6. Representation of hydrogen incorporation in magnesium metal is given below. (4 marks)
(i) Deduce the miller indices of the planes where hydrogens are present (consider only the planes parallel to the basal plane). (ii) Name the type of voids that hydrogen goes in (iii) Give the Kroger-Vink notation representing this material.



Metallurgy

7. Explain Hume-Rothery rules for the formation of solid solutions (4 marks)

8. In hypothetical situation, the solid clusters that form during the solidification of an iron (Fe) melt takes up a parallelopiped (cuboid) shape with one side (length) given by 'a', the other side (height) by 'b' and yet another side (depth) by 'c', where b=2a and c = 3a, calculate the critical size (a*) and the critical energy required (ΔG^*) for homogeneous nucleation. Determine the number of atoms to nucleate homogeneously~~, and heterogeneously.~~ Assume that the radius of the iron atom is 1.265 A°, Surface energy of the solid-liquid interface is 204×10^{-7} J/sq.cm and the heat of fusion (ΔH) is 1737 J/cm^3. Nucleation starts at a temperature of 1119°C. (Melting temperature of iron =1539°C) (8 marks)



9. A forging industry requires raw material with a grain size of approximately 50 μm. The raw material supplier understands the grain size only by means of ASTM grain size number. What will be the ASTM grain size number that corresponds to grain diameter of 50 μm so that it can be communicated to raw material supplier. Provide proper calculations arriving at a particular ASTM grain size number (7 marks)

10. It is known that Lead –Tin alloys are used for soldering applications. One of the company 'delta industry' requires that the alloy to have at least 90% of the eutectic mixture at the eutectic temperature so that it melts easily. Other company 'lambda industry' requires these solders to be strong and they concluded that these alloys to have at least 90% eutectic mixture at room temperature. Determine the composition range of the alloys that are suitable for alpha industry and beta industry. Assume the room temperature solubility of tin in lead is 4% by weight and lead in tin is 1% by weight. *(6 marks)*