Name: **Enrolment No:**	UPES UNIVERSITY OF TOMORROW

UPES

End Semester Examination, December 2023

Course: Phase Transformations in Materials **Semester: V**

Program: B. Tech AMNT **Time: 03 hrs.**

Course Code: MEMA3008 **Max. Marks: 100**

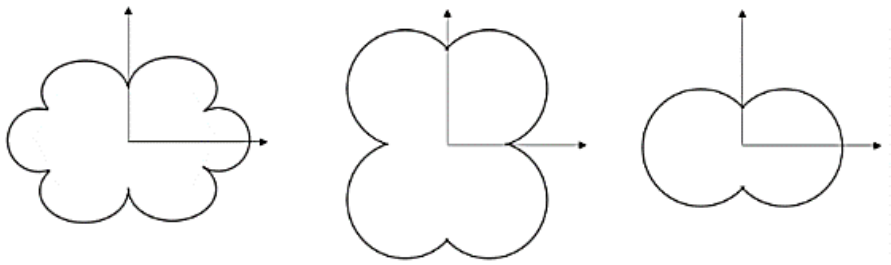
Instructions:

i. *There are three sections viz. Section A, Section B and Section C. Section A carries 20 marks, Section B carries 40 marks and Section C carries 40 marks*

ii. *Attempt all the questions in Section A, B and C*

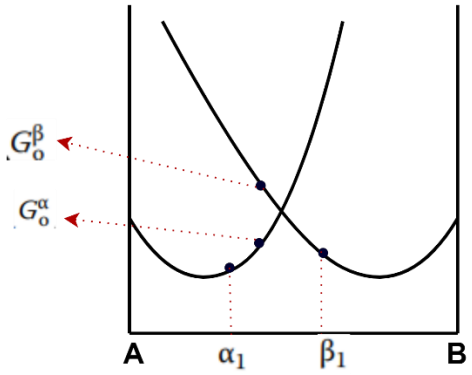
iii. *Make appropriate assumptions wherever required*

SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Plot the variation of ΔG_{mix} for an ideal solution at high and low temperature?	**4**	**CO1**
Q 2	Discuss the effect of undercooling on critical radius of crystal formed during solidification?	**4**	**CO2**
Q 3	Estimate the number of spherical clusters in 1mm3of copper at its melting point that contain a) 10 atoms and b) 60 atoms. The atomic volume of liquid copper is 1.6x10-29m3, γ_{SL} is 0.177 J/m^2, k =1.38x10^{-23} J/K and Tm is 1356 K. Hint: Consider that at the melting temperature, the free energies per unit volume of the liquid and the solid are the same.	**4**	**CO3**
Q 4	Sketch the equilibrium crystal shapes based on the Wulff plots below: 	**4**	**CO1**
Q 5	Explain the effect of melting rate on Homogenous nucleation rate?	**4**	**CO1**

SECTION B
(4Qx10M= 40 Marks)

Q 6	Copper (FCC crystal structure) is normally alloyed with additional elements in order to increase its strength. For an alloy with a composition of Cu (75 wt%) and Ag (25 wt%), when the first solid nucleates from the liquid, spherical clusters of radius 'r' form with interfaces having an interfacial energy of 250 mJ/m^2. Assuming that the latent heat of melting, L_T is 4.8x10^8 J/m^3, determine the critical radius for	**10**	**CO3**

	nucleation if the sample is cooled from the single-phase liquid region to a temperature of 900 °C		
Q 7	If the atoms are arranged in a homogenous phase, the free energy will be lowest at α, i.e., G_o^{α} per mole. The system can lower its free energy when atoms separate into two phases with composition α_1 and β_1. Show this point on the curve where system reduces its free energy by separating in two phases.  Discuss the other ways by which a system can reduce its free energy and show this transformation in the form of a curve.	**10**	**CO2**
Q 8	Discuss the effect of contact angle on heterogenous nucleation? Develop energy equation for heterogenous nucleation?	**10**	**CO1**
Q 9	A diffusion couple including inert wires was made by plating pure copper on to a block of α-brass with a composition Cu-30 wt% Zn. After 56 days at 785°C the marker velocity was determined as 2.6×10^{-8}. Microanalysis showed that the composition at the markers was $X_{Zn} = 0.22$, $X_{Cu} = 0.78$, and that $\frac{\partial X_{Zn}}{\partial x}$ was 0.089 mm^{-1}. From an analysis of the complete penetration curve Dα at the markers was calculated as $4.5 \times 10^{-13} m^1 s^{-1}$. Use this data to calculate D_{In}^{α} and D_{Cu}^{α} in brass at 22 atomic % Zn. How would you expect D_{In}^{α} , D_{Cu}^{α} and Dα to vary as a function of composition?	**10**	**CO3**
SECTION-C (2Qx20M=40 Marks)			
Q 10	Demonstrate the evolution of Eutectic Phase diagram using Gibbs free energy curve? (Discuss all the intermediate phases)	**20**	**CO2**
Q 11	Classify diffusional transformations and illustrate each using a phase diagram. ***OR*** Discuss the factors on which 'C' curve of TTT diagram depends? Also explain the formation of Pearlite, Bainite and Martensite formation using TTT diagram?	**20**	**CO1**