Name: **Enrolment No:**	

UPES

End Semester Examination, December 2023

Course: Automotive Materials **Semester: III**

Program: B.Tech (ADE) **Time : 03 hrs.**

Course Code: MEAD2006 **Max. Marks: 100**

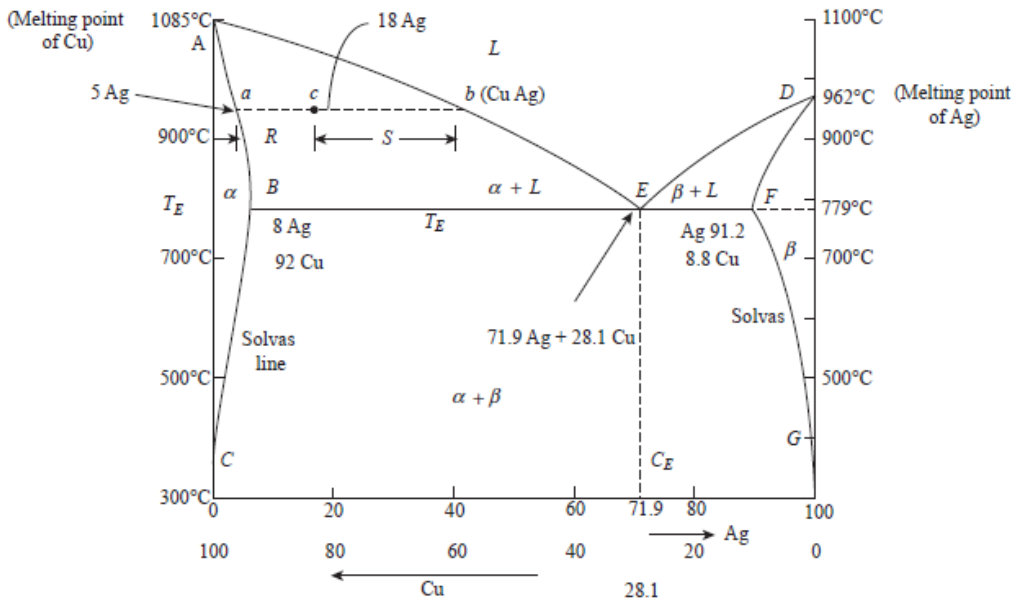
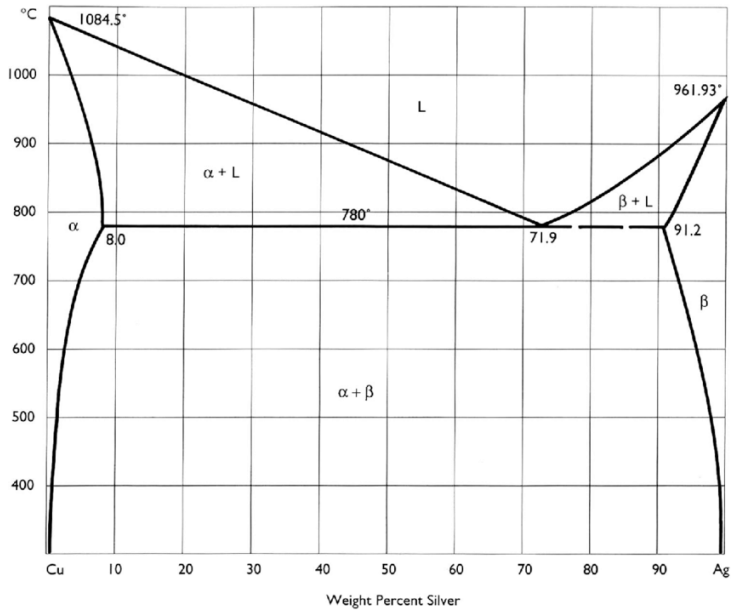
Instructions: Assume suitable values of variables/parameters if not given in the problem.

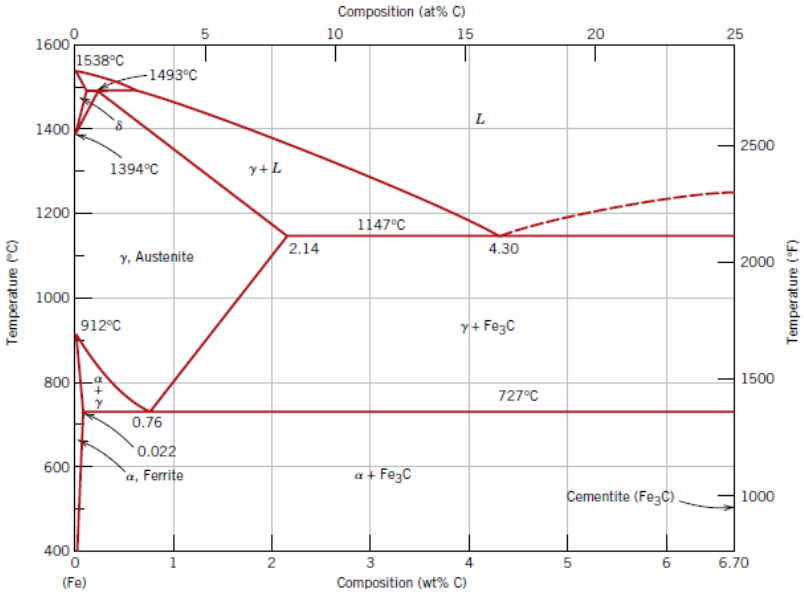
SECTION A
(5Qx4M=20Marks)

S. No.		Marks	CO
Q 1	Explain the following: (i) Crystalline (single/poly) and amorphous materials, (ii) Space lattice and Unit cells	**4**	**CO1**
Q 2	State the following: (i) Crystal systems and Bravais lattices, (ii) Allotropy or Polymorphism	**4**	**CO1**
Q 3	Differentiate BCC, FCC and HCP crystal structures and give an example for each structure.	**4**	**CO1**
Q 4	Iron has an atomic radius of 0.124 nm (1.24 Å) and a BCC structure with an atomic weight of 55.85 g/mol. Calculate the density of iron.	**4**	**CO2**
Q 5	Explain the purpose of the heat treatment process in steels.	**4**	**CO2**

SECTION B
(4Qx10M= 40 Marks)

Q 6	Describe the following mechanical properties of materials: (a) Yield and Ultimate Tensile Strength (b) Engineering and True stress, strain (c) Ductility, Resilience, Toughness and Hardness	**10**	**CO1**
Q 7	Analyze the phase diagram shown below and answer the following question. (i) Write the eutectic reaction present in this diagram with phase compositions (ii) If 18% Ag alloy composition is cooled from the shown temperature (962°C) to just below the eutectic temperature (779°C), calculate the fraction of pro-eutectic and eutectic α phase in the final alloy composition.	**10**	**CO2**

			
Q 8	Explain the homogeneous and heterogeneous nucleation process and derive the expression to obtain the critical radius for homogeneous nucleation.	**10**	**CO3**
Q 9	(a) Determine the degree of freedoms (DOFs) of (i) only liquid phase, (ii) α+β phase and (iii) liquid, α, β phases in equilibrium for the Cu-Ag phase diagram shown below. (b) Write the eutectic reaction with phase compositions present in the phase diagram. 	**4+6**	**CO3**

SECTION-C (2Qx20M=40 Marks)			
Q 10	Analyze the Fe-Fe_3C phase diagram shown below and answer the following questions: (i) Write the maximum solubility of carbon in α and δ ferrite and austenite with corresponding temperatures. Also, write eutectoid, eutectic and peritectic temperatures. (ii) Write all the invariant reactions present in this diagram with their phase compositions. (iv) Sketch and explain the microstructure evolution of eutectoid, hypo eutectoid and hypereutectoid steel.  **Iron-carbon phase diagram**	**20**	**CO4**
Q 11	**(a)** A sheet of steel 2.5 mm thick has nitrogen atmospheres on both sides at 900°C and is permitted to achieve a steady-state diffusion condition. The diffusion coefficient for nitrogen in steel at this temperature is 1.85×10^{-10} m^2/s, and the diffusion flux is found to be 1.0×10^{-7} kg/m^2s. Also, it is known that the concentration of nitrogen in steel at high-pressure surfaces is 2 kg/m^3. How far into the sheet from this high-pressure side will the concentration be 0.5 kg/m^3? Assume a linear concentration profile. **(b)** Determine the carburising time necessary to achieve a carbon concentration of 0.30 wt% at a position 4 mm into an iron-carbon alloy that initially contains 0.10 wt% C. The surface concentration is to be maintained at 0.90 wt% C, and the treatment is to be conducted at 1100°C. The diffusion coefficient of carbon in γ - Fe is 2.3×10^{-5} m^2/s. Use the following data, as per requirement:	**8+12**	**CO4**

	OR (a) Explain Fick's first and second laws of diffusion. (b) At 950°C, a 0.8% carbon steel is decarburized for a duration of 4 hr in an atmosphere equivalent to 0% carbon at the surface of the steel. Determine the minimum depth up to which post-machining is to be done if the carbon content at the surface after-machining should not be below 0.6%. The diffusion constant of Carbon in Iron at the specified temperature is 1.38×10^{-11} m^2/s. **Use the following information, as per the requirement for Question 11:** $\frac{C_x - C_0}{C_s - C_0} = 1 - \text{erf}\left(\frac{x}{2\sqrt{Dt}}\right)$, erf (0.81) = 0.75, erf (0.778) = 0.722		