

GUJARAT TECHNOLOGICAL UNIVERSITY**BE - SEMESTER-IV EXAMINATION – SUMMER 2025****Subject Code:3142111****Date:19-05-2025****Subject Name:Phase Transformations****Time:10:30 AM TO 01:00 PM****Total Marks:70****Instructions:**

1. Attempt all questions.
2. Make suitable assumptions wherever necessary.
3. Figures to the right indicate full marks.
4. Simple and non-programmable scientific calculators are allowed.

		MARKS
Q.1	(a) What is the phase from a thermodynamic perspective?	03
	(b) Classify the phase transformation in materials.	04
	(c) Describe the three diffusional processes. Compare it with non-diffusional processes with analogy.	07
Q.2	(a) Define Gibbs free energy, entropy, and enthalpy.	03
	(b) Illustrate the mechanism of vacancy diffusion.	04
	(c) What is Fick's Law of diffusion? Explain Fick's First Law and how it differs from Fick's Second Law.	07
	OR	
	(c) Explain the atomic model of diffusion and the role of crystal defects.	07
Q.3	(a) How alloying elements are affecting the nature of the TTT curve?	03
	(b) What is diffusion and why does it occur in metals and alloys?	04
	(c) Elaborate on the phenomena of grain growth. Describe the total rate of transformation in terms of the rate of nucleation and the rate of growth.	07
	OR	
Q.3	(a) Which type of effects can be observed when materials are underage, and peak aged?	03
	(b) Name two reasons why interstitial diffusion is typically faster than vacancy diffusion.	04
	(c) Explain the precipitation phenomena from a solid solution.	07
Q.4	(a) Draw a Bain distortion model.	03
	(b) List the sequence of preferential sites where the rate of heterogeneous nucleation increases as ΔG^* decreases.	04
	(c) Derive the relationship between heterogeneous and homogeneous nucleation for different cases: • Case I: The product particle only makes point contact with the foreign surface ($\theta = 180^\circ$). • Case II: The product particle completely wets the foreign surface ($\theta = 0^\circ$). • Case III: The product particle is hemisphere-shaped ($\theta = 90^\circ$).	07
	OR	
Q.4	(a) How self-diffusion is different from the inter-diffusion process?	03
	(b) Explain the Kirkendall effect.	04
	(c) Compute r^* and ΔG^* for the homogeneous nucleation of the solidification of Ni. Apply the critical radius equation and activation free energy equation to compute the critical radius and free energy, respectively. The melting temperature for nickel, found inside the front	07

cover is 1455°C; also values of ΔH_f ($-2.53 \times 10^9 \text{ J/m}^3$) and γ (0.255 J/m^2) are given in the problem statement, and the supercooling value is 319°C (or 319 K).

- Q.5** **(a)** What is Spinodal decomposition? **03**
 (b) What do you mean by ordered and disordered transformation? **04**
 (c) Consider one such alloy that initially has a uniform carbon **07**
 concentration of 0.25 wt. % and is to be treated at 950 °C (1750 °F). If
 the concentration of carbon at the surface is suddenly brought to and
 maintained at 1.20 wt. %, how long will it take to achieve a carbon
 content of 0.80 wt. % at a position 0.5 mm below the surface? The
 diffusion coefficient for carbon in iron at this temperature is 1.6×10^{-11}
 m^2/s ; assume that the steel piece is semi-infinite.
- OR**
- Q.5** **(a)** What is the influence of ordering on the properties? **03**
 (b) What are the general characteristics of martensitic transformation? **04**
 (c) Explain the mechanism of age hardening with an example. **07**
