Ref. No.: Ex/PG/MET/PE/T/124A/2025

M.E. METALLURGICAL ENGINEERING FIRST YEAR
SECOND SEMESTER EXAM 2025

Subject: Phase Transformation of Materials

Time: Three Hours **Full Marks:** 100

Answer the following questions (Q1 or Q2; any two from Q3, Q4 and Q5; Q6 or Q7; Q8 or Q9)

1. **(a)** Define Phase and Degree of Freedom. On what basis a phase diagram is drawn. What is understood by studying a phase diagram? **[CO1]** 2+2+2+2 = 8

(b) What is a binary isomorphous system? What conditions are to be satisfied for forming a binary isomorphous system? By giving an example describe the procedure to obtain the binary isomorphous phase diagram. Find the degree of freedom in the two-phase region of a binary isomorphous system and justify the result. **[CO1]** 2+2+6+2 = 12

OR

2. (a) What is the difference between a solid solution and a mixture? What is the purpose for forming solid solution? State the rules for formation of extensive binary solid solution. **[CO1]** 4+3+3 = 10

(b) From a single phase of a system when does precipitation occur? How will you ascertain the formation of precipitates? Is there any advantage or disadvantage due to the formation of such precipitates? Discuss. **[CO1]** 2+3+5 = 10

3. (a) Why does phase change of any system does not occur at the equilibrium temperature and what is required for the commencement of the phase change? Find the necessary relationship between desired parameter and the experimental parameter for phase change to occur from liquid to solid state of a system. **[CO2]** 4+4 = 8

(b) Draw and discuss the formation of composition profile both in the solid and liquid phase during solidification of a binary isomorphous alloy and the related supercooling. **[CO2]** 12

4. (a) What is pearlite? What microstructural parameter characterize pearlite and how is it defined? How can this parameter be varied to the desired level? What is the influence of this parameter on mechanical properties? **[CO2]** 2+2+2+2 = 8

(b) Discuss the mechanism including effect of temperature for pearlitic transformation. **[CO2]** 12

5. (a) Give an account for recrystallization annealing. **[CO2]** 8

(b) What kind of alloys ameanable to precipitation strengthening and give an example of such an alloy. State the steps involved for processing an alloy to be precipitation strengthened. **[CO2]** 2+1=3 = 6

(c) Discuss the mechanism involved in coarsening of the precipitates. **[CO2]** 6

[Turn over

6. (a) What is bainite? How is bainite differ from pearlite? Why is bainitic transformation called an 'intermediate transformation'? Justify whether bainite can be formed on continuous cooling from austenite in plain-carbon steel? **[CO3]** 2+3+3+4 = 12

(b) Discuss the reason for the presence of austenite in the microstructure following bainitic transformation. **[CO3]** 8

OR

7. (a) Give an account for martensitic transformation in steel. **[CO3]** 14

(b) Given that the lattice parameter of austenite (a_o) varies with carbon as - a_o = 3.548 + 0.044 Wt% C, and lattice parameter of martnsite varies as - a = 2.861 – 0.013 Wt% C; c = 2.861 + 0.116 Wt% C. Find the dimensional change associated with the formation of martensite. **[CO3]** 6

8. (a) What is the purpose of tempering of steel? Why does hardening-tempering process known a very important heat treatment process? Discuss the underlying phenomena responsible for the general nature of tempering curve in case of plain-carbon steel. **[CO4]** 2+2+6 = 10

(b) Define hardenability of steel. Justify the criterion used in describing the hardenability. Discuss the factors affecting hardenability of steel. **[CO4]** 2+4+6 = 10

OR

9. (a) Describe the procedure for obtaining the T-T-T curve of a plain-carbon steel. **[CO4]** 8

(b) Justify the selection of hardening temperature for hypereutectoid steel. **[CO4]** 4

(c) What is Martempering? What is the advantage and disadvantage if this process is followed? What should be the characteristics of the steel suitable for Martempering. **[CO4]** 3+2+3 = 7