Introduction to Physical Metallurgy
(MT 401)

Full Marks: 70   **Time: 3 hrs**

Answer any SEVEN questions.
Use *single answer-script* for answering of all questions.
Figures on the right-hand side indicate full marks.

1. (a) Describe the principle of temperature measurement by thermoelectric method.
    (b) Name the principal thermocouples with their chemical composition.
    (c) How is a thermocouple calibrated?

    [4+3+3]

2. (a) Draw the $Fe-Fe_3C$ equilibrium diagram with proper labeling.
    (b) Write down the phase transformation reactions encountered in the system indicating the temperature and composition of their occurrence.
    (c) What is 'transformed' ledeburite?

    [5+3+2]

3. (a) Indicate the annealing and normalizing temperature ranges in the relevant portion of the $Fe-Fe_3C$ diagram and justify the choice.
    (b) Why is tempering necessary after hardening of steel? What structural changes occur on tempering?

    [5+5]

4. Differentiate between:
    (a) Process annealing and spheroidizing annealing
    (b) Strain hardening and precipitation hardening

    [5+2]

5. (a) Explain the terms *resolving power* of a lens and *empty magnification*.
    (b) Explain with line diagrams the *bright field* and *dark field* illumination in optical microscopy.

    [4+6]

6. (a) Discuss *Hume Rothery's rules* of solid solutions citing examples.
   (b) Explain the order-disorder phenomenon in solid solutions.

   [7+3]

7. (a) Differentiate between *edge dislocation* and *screw dislocation*.
   (b) With example discuss *Kirkendal effect*.

   [5+5]

8. (a) Derive *Fick's second law* of diffusion.
   (b) A hydrocarbon gas with C concentration of 1.0 wt. % is used for carburization of 0.2 wt. % plain C steel. Calculate how long it would take at 1000 °C to reach a C content of 0.6 wt.% at a distance of 1 mm from the surface.

   Given: $D_{c \text{ in } \gamma\text{-Fe at } 1273 K}$ = 2.98 x 10^{-11} m^2/s

Z = 0.40	erf(z) = 0.4284
Z = 0.45	erf(z) = 0.4755
Z = 0.50	erf(z) = 0.5205
Z = 0.55	erf(z) = 0.5633

   [5+5]

9. (a) Differentiate between *steady-state* and *non steady-state diffusion* with the help of appropriate diagram(s).
   (b) Prove that *interstitial diffusion* is much faster than the *substitutional diffusion*.
   (c) Briefly explain the *ring mechanism* of substitutional diffusion.

   [3+5+2]

10. (a) Classify *solids* based on atomic agreement.
    (b) Calculate the (theoretical) density of copper if lattice parameter, a = 3.61 A, and the atomic weight of copper is 63.5.
    (c) Discuss stacking fault in FCC crystal structure.
    (d) Draw $[1\bar{2}1]$ and $(\bar{2}11)$ in a cubic unit cell.

    [2+2+3+3]