

**BIRLA INSTITUTE OF TECHNOLOGY, MESRA, RANCHI**  
(MID SEMESTER EXAMINATION MO/2023)

CLASS: B. TECH  
BRANCH: MECHANICAL AND PIE

SEMESTER : III  
SESSION : MO/2023

**SUBJECT: PE214 METALLURGICAL AND MATERIALS ENGINEERING**

TIME: 02 Hours

FULL MARKS: 25

**INSTRUCTIONS:**

1. The question paper contains 5 questions each of 5 marks and total 25 marks.
2. Attempt all questions.
3. The missing data, if any, may be assumed suitably.
4. Tables/Data handbook/Graph paper etc., if applicable, will be supplied to the candidates

- |   |       | CO  | BL  |
|---|-------|-----|-----|
| Q.1(a) I. A unit cell cannot have 100% atomic packing density - explain the statement with a simple diagram.  | [1+1] | CO1 | BL2 |
| II. Determine the total number of atoms per unit cell for body centered cubic structure with the help of a diagram  |       |     |     |
| Q.1(b) A crystalline solid has a cubic unit cell with one atom per lattice point. If the lattice parameter, $a = 4.0786 \text{ \AA}$ and atomic radius, $r = 1.442 \text{ \AA}$ , determine whether the crystal structure is simple cubic, body centered cubic or face centered cubic.                          | [3]   | CO1 | BL3 |
| Q.2(a) I. Name the different types of defects in crystalline solids with respect to the dimension of the defect and state which is the most relevant for explaining deformation of crystalline solids.  | [1+1] | CO1 | BL1 |
| II. State the Hume Rothery's rules for formation of substitutional solid solutions  |       |     |     |
| Q.2(b) I. Explain why ceramic solids are not suitable for processing by rolling or forging.   | [1+2] | CO1 | BL2 |
| II. Discuss the most important difference between a twin boundary and a grain boundary with a schematic microstructure.   |       |     |     |
| Q.3(a) Temperature is a state function, but mechanical strain is not - justify this statement with proper logic.  | [2]   | CO2 | BL3 |
| Q.3(b) Discuss the invariant transformations (describing the suitable reactions) that occur on cooling below the following isothermal temperatures in plain carbon steel referring to the iron-cementite phase diagram: (i) $1147^\circ\text{C}$ and (ii) $727^\circ\text{C}$                                   | [3]   | CO2 | BL2 |
| Q.4(a) Draw a schematic binary (A-B) phase diagram with labelling showing:  | [2]   | CO2 | BL4 |
| I. partial solubility of B in A but no solubility of A in B and   |       |     |     |
| II. a eutectic transformation at an intermediate composition.   |       |     |     |
| Q.4(b) I. Compute the mass fractions of ferrite and cementite in pearlite.  | [2+1] | CO2 | BL3 |
| II. Draw the microstructure of pearlite with proper labelling.  |       |     |     |
| Q.5(a) What is strain hardening? Why does it arise?   | [2]   | CO2 | BL2 |
| Q.5(b) Select the correct choice:   | [1x3] | CO3 | BL2 |
| I. In isothermal transformation, the time to start the transformation is called _____ (nucleation/kinetic/formation/incubation) time, and the same at a higher temperature (above the nose or knee) at a higher temperature is _____ (lower/cannot be determined/higher/same) than that at a lower temperature. |       |     |     |
| II. The basic difference between Fick's First Law and Second Law are related to _____ (polymorphism/diffusion/osmosis/solidification) and for determining _____ (temperature range/composition of alloy/steady and non-steady state/activation barrier of diffusion).   |       |     |     |
| III. The characterization technique appropriate for determining crystal structure of a phase in a crystalline solid is _____ (SEM/AFM/XRD/XRF) and the technique for determining micro-composition of a phase is _____ (TEM/XRD/SPM/EDS).   |       |     |     |

:::22/09/2023 E:::