Roll No:

MOTILAL NEHRU NATIONAL INSTITUTE OF TECHNOLOGY ALLAHABAD, PRAYAGRAJ

Department of Applied Mechanics

Mid -Term Examination

Materials Science and Engineering (AMN 12401)

B. Tech. II Semester

Duration: 1.5 hrs (90 min) ***Maximum Marks***: 25

Attempt all the following questions. Draw a suitable diagram wherever necessary. Useful data is given at the end of the question paper.

1. Write short notes on following 6

   (a) Frank read source (b) Structure of diamond

2. Differentiate the following 6

   (a) Tilt and Twist boundary (b) Edge dislocation and Screw dislocation

3. Using schematic diagram (s) determine the ideal c/a ratio for Hexagonal Closed Packed (HCP) crystal structure. 2

4. What is Miller Indices? Give the following answer 5

   (a) A plane intersects the coordinate axis at X=2/3, Y=1/3 and Z=1/2 what is the Miller index of this plane?

   (b) Determine the planer density and packing fraction for FCC nickel in the (111) planes, giventhat the lattice constant of nickel is 3.5167 Å.

5. The listed diffraction angles (Table-I) for the first three peaks (first order) of the X-Rays diffraction pattern for some metal. Monochromatic radiation having a wavelength of 0.1542 nm was used 6

   (a) Determine whether this metals crystal structure is FCC, BCC or neither FCC or BCC and explain the reason for your choice.

   (b) If the crystal structure is either FCC or BCC, identify which of the metals in the Table II gives this diffraction pattern.

Table I	
Peak order	**Diffraction angle (2θ), θ is in degree**
I^st	*38.6*
II^nd	*55.7*
III^rd	*70*

Table II		
Metal	**Crystal structure**	**Atomic radius (nm)**
Aluminium	FCC	0.1431
Chromium	BCC	0.1249
Iron	BCC	0.1241
Tantalum	BCC	0.1430

Useful Data:

1. Sin (0.3368) = 0.3305, Sin (0.4861) = 0.4672, Sin (0.6108) = 0.5735, here θ is in radian.

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End -Term Examination

Materials Science and Engineering (AMN 12401) 35

B. Tech. II Semester

Duration: 2.5 hrs (150 min) ***Maximum Marks***: 50

Attempt all the following questions. Draw a suitable diagram wherever necessary.

1. Define the following 5

   (a) Fatigue life

   (b) Creep curve

   (c) Yield point Phenomena in mild steel

   (d) Endurance limit

   (e) Gibbs phase rule

2. Differentiate the following 10

   (a) True Stress and True Strain

   (b) Peritectoid and Eutectoid reaction

   (c) Resilience and Toughness

   (d) Materials Science and Materials Engineering

   (e) Space lattice and crystal structure

3. **(a)** Draw the isothermal transformational diagram (or time-temperature transformation, TTT diagram) for an iron-carbon alloy of eutectoid composition and label all its parts. Briefly describe the various micro-constituents that occur in this diagram. 4

   (b) How martensite phase is obtained from single phase Austenite? Describe the mechanism and conversion of its geometry from Austenite (FCC) to martensite (BCT) structure. 4

4. Derive the Ficks II law. For a steel alloy it has been determined that a carburizing heat treatment of 10 hours duration will raise the carbon concentration to 0.45 at a point 2.5 mm from the surface. Estimate the time necessary to achieve the same concentration at a 5 mm position for an identical steel and at the same carburizing temperature. 6

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5. Explain the Bragg's law of diffraction and extinction rules for allowed reflections in X-ray diffraction. Would you expect NiO to have cesium chloride, sodium chloride or zinc blende structrure? Based on your answer, determine (a) the lattice parameter (b) the density and (c) the packing factor. Given data: *Atomic mass of Ni = 58.71 g/mol, Atomic mass of oxygen = 16 g/mol, Ionic radius of* Ni^{2+} *= 0.069 nm, Ionic radius of* O^{2-} *= 0.132 nm.* **6**

6. **(a)** For homogeneous nucleation, derive the relations for the critical radius and the activation energy for the formation of a stable nucleus. **4**

(b) For the solidifications of pure gold (Au), calculate the critical radius (r^*) and the activation energy (ΔG^*) if nucleation is homogeneous. Given data: latent heat of fusion for Au (ΔH_f) = -1.16x10^9, surface free energy for Au = 0.132 J/m2, melting temperature for Au = 1064°C, super cooling (ΔT) = 230 K. Also calculate the number of atoms found in a nucleus of critical size. Assume a lattice parameter of 0.413 nm for solid gold at its melting temperature. [R = 8.314J/mol-K, N_A (Avogadro's number) = 6.023×10^{23} mol^{-1}]. **6**

7. Draw a neat sketch of iron-iron carbide phase diagram and answer the following:-

(a) Explain the various invariant reactions taking place in iron-iron carbide system.

(b) Compute the mass fractions of ferrite and cementite in pearlite. **5**