The University of Western Ontario
Department of Physics and Astronomy

P2800 Fall 2008

Homework Assignment #3 (October 9, 2008)

Due date October 28, 2008

Problems:

1. X-rays pf an unknown wavelength are diffracted by a gold sample. The 2Θ angle was 64.582° for the {220} planes. What is the wavelength of the X-rays used? (The lattice constant of gold =0.40788 nm; assume first-order diffraction, $n = 1$).

2. A sample of *bcc* metal with the lattice parameter a = 0.33nm was placed in a X-ray diffractometer using incoming x-rays with $\lambda = 0.1541$nm. Using Braggs law (assume first order diffraction, n=1) predict positions of the diffraction peaks (in 2Θ) corresponding to {110}, {210}, {230}, {321} and {431} planes. Which of these peaks will be observable?

3. Name and briefly describe three different AFM operation modes. In which mode separation between the probe and the surface is the highest?

4. The distance between atoms in a crystal are in a ~1-2 Å range, so waves with approximately this wavelength are required to explore the crystal structure. Using de Broglie law ($\lambda = h/p$), calculate the energies of (a) neutrons (m=1.675×10-24kg), (b) electrons (m=0.911×10-28kg) and (c) X-rays required for the structural studies?

5. The diffusivity of Mn atoms in the *fcc* iron lattice is 1.5×10^{-14}m^2/s at 1300°C and 1.50×10^{-15}m^2/s at 400°C. Calculate the activation energy in kJ/mol for this case in this temperature range. (R=8.314 J/(mol K).

6. Classify the mechanism of diffusion in first 11 solute/solvent pairs given in the Table below (interstitial or substitutional). Compare the diffusivity values and draw a conclusion.

Table 5.2 Diffusivities at 500°C and 1000°C for selected solute-solvent diffusion systems

Solute	Solvent (host structure)	Diffusivity (m^2/s) 500°C (930°F)	1000°C (1830°F)
1. Carbon	FCC iron	(5×10^{-15})*	3×10^{-11}
2. Carbon	BCC iron	10^{-12}	(2×10^{-9})
3. Iron	FCC iron	(2×10^{-23})	2×10^{-16}
4. Iron	BCC iron	10^{-20}	(3×10^{-14})
5. Nickel	FCC iron	10^{-23}	2×10^{-16}
6. Manganese	FCC iron	(3×10^{-24})	10^{-16}
7. Zinc	Copper	4×10^{-18}	5×10^{-13}
8. Copper	Aluminum	4×10^{-14}	10^{-10} M†
9. Copper	Copper	10^{-18}	2×10^{-13}
10. Silver	Silver (crystal)	10^{-17}	10^{-12} M
11. Silver	Silver (grain boundary)	10^{-11}	
12. Carbon	HCP titanium	3×10^{-16}	(2×10^{-11})

7. A stress of 2.34 MPa is applied in the [001] direction of a unit cell of the *fcc* copper single crystal. Calculate the resolved shear stress on the (-111) plane in the following directions: (a) [101], (b) [110], (c) [111] and (d) [0-11]

8. Calculate the engineering stress on a 0.8 cm diameter rod that is subjected to a force of 1500 kg?

9. What is the difference between the slip and twining mechanisms of plastic deformation of metals?

10. By what mechanism do grain boundaries strengthen metals?