3.091 Fall Term 2002

Homework #7

1.(a) In a diffractometer experiment a specimen of thorium is irradiated with tungsten L_α radiation. Calculate the angle, θ, of the 4th reflection.

(b) Suppose that the experiment described in part (a) is repeated but this time the incident beam consists of neutrons instead of x-rays. What must the neutron velocity be in order to produce reflections at the same angles as those produced by x-rays in part (a)?

2. A Debye-Scherrer powder diffraction experiment using incident copper K_α raditation gave the following set of reflections expressed as 2θ: 38.40°; 44.50°; 64.85°; 77.90°; 81.85°; 98.40°; 111.20°.

(a) Determine the crystal structure.

(b) Calculate the lattice constant, a.

(c) Assume that the crystal is a pure metal and on the basis of the hard-sphere approximation calculate the atomic radius.

(d) Calculate the density of this element which has an atomic weight of 66.6 g/mol.

3. The following diffractometer data (expressed as 2θ) were generated from a specimen irradiated with silver K_α radiation: 14.10; 19.98; 24.57; 28.41; 31.85; 34.98; 37.89; 40.61.

(a) Determine the crystal structure.

(b) Calculate the lattice constant, a.

(c) Assume that the crystal is a pure metal and on the basis of the hard-sphere approximation calculate the atomic radius.

(d) At what angle, θ, would we find the first reflection if, instead of K_α radiation, we used silver L_α radiation to illuminate the specimen?

4. What is the maximum wavelength (λ) of radiation capable of second order diffraction in platinum (Pt)?

5. What acceleration potential (V) must be applied to electrons to cause "electron diffraction" on {220} planes of gold (Au) at $\theta = 5°$?

6. How can diffraction on {110} planes of palladium (Pd) be used to isolate K_α radiation from the "white" spectrum of x-rays emitted by an x-ray tube with a copper (Cu) target? (Rationalize your answer and provide and appropriate schematic drawing.)

7. In iridium, the vacancy fraction, n_V/N, is 3.091×10^{-5} at 1234°C and 5.26×10^{-3} at the melting point. Calculate the enthalpy of vacancy formation, ΔH_V.

8. At 10°C below the melting point of aluminum, 0.08% of the atom sites are vacant. At 484°C only 0.01% are vacant. Determine the energy of vacancy formation (ΔH_V) for aluminum.

9. A formation energy of 2.0 eV is required to create a vacancy in a particular metal. At 800°C there is one vacancy for every 10,000 atoms.

(a) At what temperature will there be one vacancy for every 1,000 atoms?

(b) Repeat the calculation, but this time with an activation energy of 1.0 eV. Note the big change in the temperature interval necessary to obtain the same change in vacancy concentration.

10. Give the Miller indices (of planes) and the direction indices of four (4) slip systems in Cu.

11. Identify three (3) types of crystal defects in solids and suggest for each of these one materials property that is adversely affected by its presence and one that is improved.

12. The energy of vacancy formation in palladium (Pd) is 1.5 eV. At 888°C there is one vacancy for every million (10^6) atom sites. Is it possible to achieve a vacancy fraction of one vacancy for every thousand (10^3) atom sites by simply raising the temperature? Be sure to check that the required temperature does not exceed the melting point of Pd.