Problem 1: Recovered exam problem from 3.012 (2017)

5. Interpreting binary phase diagrams [20 pts]

Pure Ag and Cu both crystalize in the FCC structure. This is the binary phase diagram of the copper-silver system at atmospheric pressure:
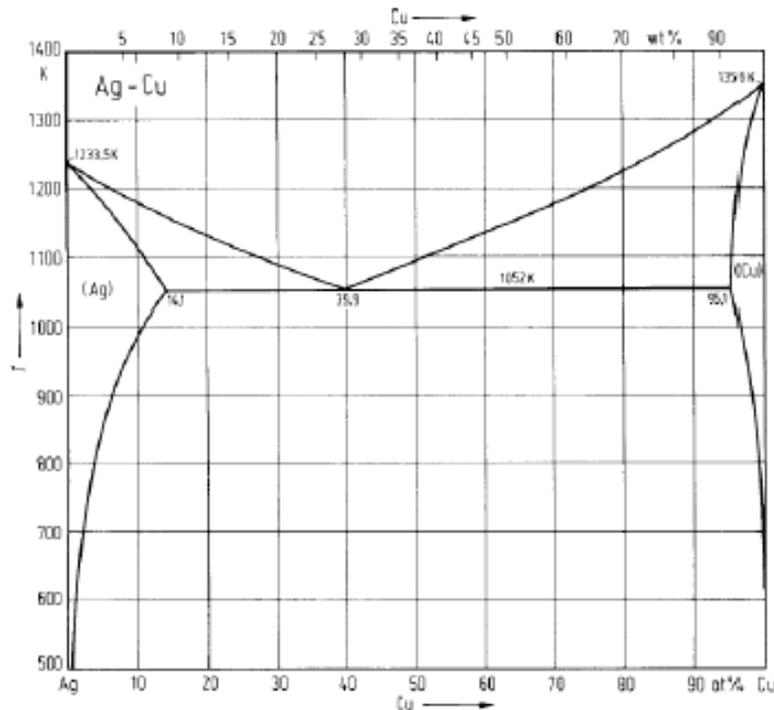
(a) List all of the 1-phase regions in this phase diagram. [1 pt]

(b) List all of the 2-phase regions in this phase diagram. [1 pt]

(c) What is the maximum solid solubility for Cu disolved in Ag? [2 pts]

(d) Consider a system with overall composition 20 at% Cu. Describe the equilibrium condition at 1200, 1100, and 900 K. In each case write the composition and phase fraction for each phase. [4 pts]

(e) Is there a 3-phase coexistence "region"? If so, how many degrees of freedom are there in this 3-phase condition, and are they all apparent in this plot? [2 pts]

(f) Draw a Gibbs free energy-composition diagram showing all relevant phases and common tangents at 1100 K. Your plot does not have to be quantitatively accurate, but it should be qualitatively consistent with the above phase diagram. You don't need to draw portions of free energy curves that don't matter for determining equilibrium -- for instance, you can cut off the L phase curve for very Cu-rich conditions. [4 pts]

(g) Imagine that the liquid phase didn't exist. Sketch the resulting phase diagram. [2 pts]

(h) The entropy of fusion for copper is 9.768 J/K·mol. Assuming that the L phase behaves as an ideal solution, what is the chemical potential of copper in a 50% solution at 1200 K relative to pure copper at the same temperature? [4 pts]

3.020 Thermodynamics of Materials
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