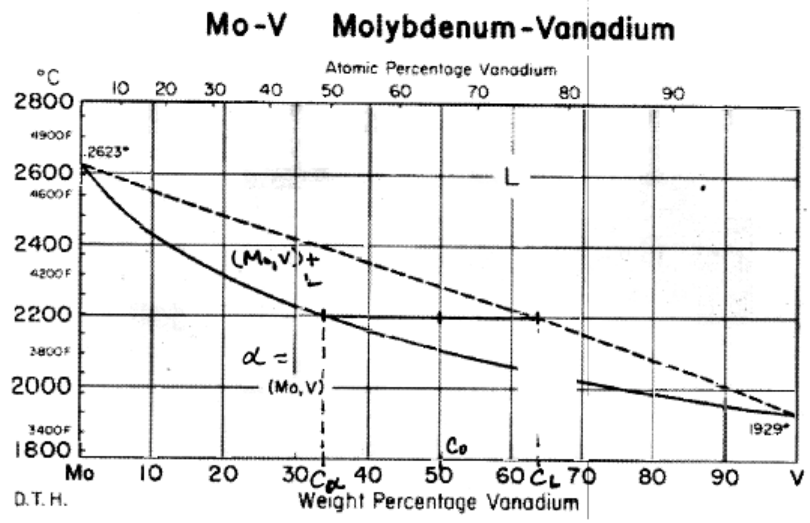
SCI 1410: materials science & solid state chemistry

HOMEWORK 6.
solutions

Use the binary, isomorphous, molybdenum-vanadium phase diagram for Problems 2-4. Note: the dashed curve in the phase diagram indicates that there is some error or uncertainty in the location of the liquidus line; the uncertainty in the liquidus line should not affect your calculations.

(Mo,V) IS A SOLID SOLUTION OF Mo AND V.

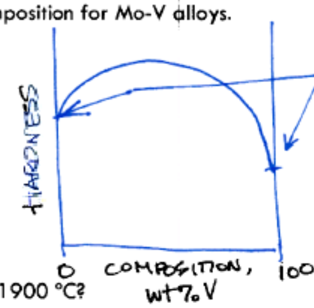


3. For a 50 wt% vanadium alloy at 2200 °C, determine the following:
   a. Phases present (Mo,V) + L OR α + L
   b. Compositions of the phases $C_\alpha \approx 34$ wt% V $C_L \approx 64$ wt% V
   c. Percent or fractions of the phases

$$W_{(Mo,V)} \text{ or } W_\alpha = \frac{C_L - C_o}{C_L - C_\alpha} \approx \frac{64-50}{64-34} = \underline{0.47} \qquad W_L = \frac{C_o - C_\alpha}{C_L - C_\alpha} \approx \frac{50-34}{64-34} = \underline{0.53}$$

2. Sketch the expected trend in hardness as a function of composition for Mo-V alloys.

   (Mo,V) IS A SOLID SOLUTION, SO WE EXPECT SOLID SOLUTION STRENGTHENING.



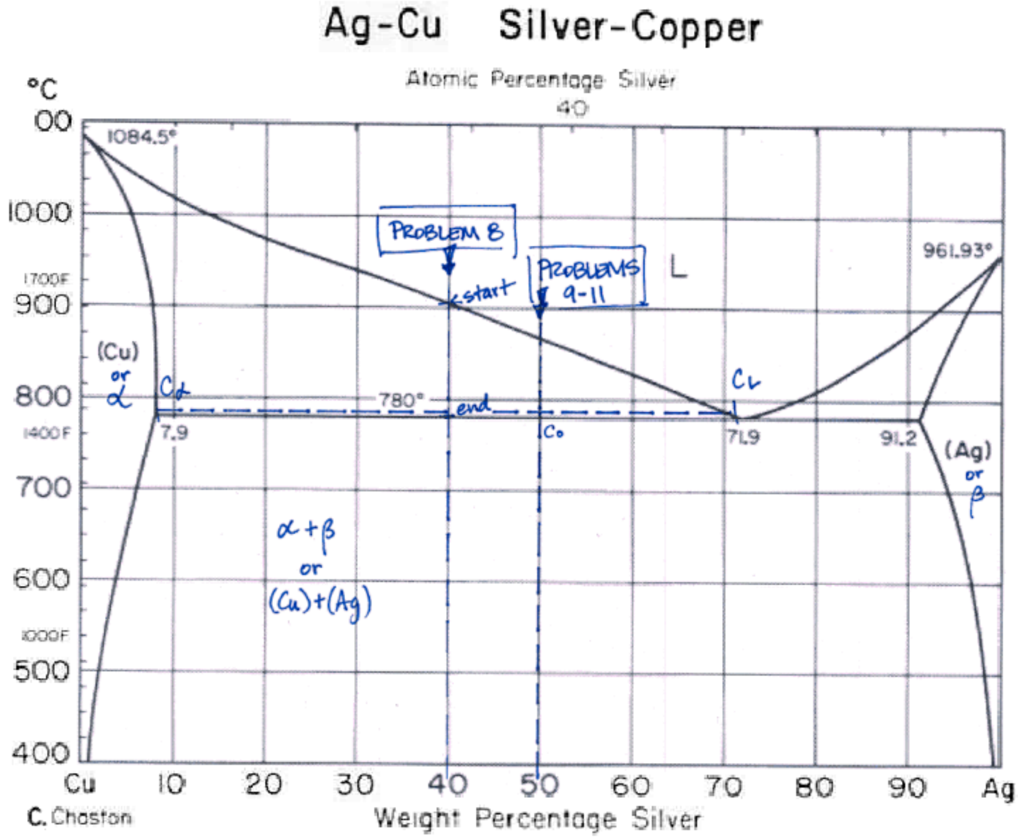
LOWEST HARDNESS VALUES AT PURE COMPONENTS.
V EXPECTED TO BE SOFTER (LOWER T_M INDICATES WEAKER METALLIC BONDING).

4. What is the solubility limit of molybdenum in vanadium at 1900 °C?

   Mo & V ARE COMPLETELY SOLUBLE ... NO LIMIT!

NOTE: I recognize that you have not yet been assigned reading on solid solution strengthening (this will come in the next assignment), so you may have had some trouble with the hardness vs. composition curve.

Use the following silver-copper phase diagram for Problems 5-9.



5. What are the solubility limits of Ag in (Cu) and Cu in (Ag)? Recall that (Cu) and (Ag) are the same as α and β, respectively.
   The solubility limit of Ag in (Cu) is **7.9 wt. % Ag**. The solubility limit of Cu in (Ag) is **8.8 wt.% Cu**. Note that these solubility limits are found at the ends of the eutectic line (780 °C).

6. For equilibrium solidification of a Cu-Ag alloy containing 40 weight percent Ag,
   a. State the temperature at which solidification begins. **Solidification starts at about 905 °C.**
   b. State the temperature at which solidification is complete. **Solidification is complete at 780 °C (eutectic line).**

7. For a Cu-Ag alloy of 50 wt.% Ag,
   a. Determine the phases present, compositions of the phases, and relative amounts (weight fractions) of the phases at a temperature just ***above*** the eutectic temperature.

   • α + L PHASES (OR (Cu)+L PHASES)

   $C_\alpha \cong 7.9$ wt% Ag $C_L \cong 71.9$ wt% Ag

   • $W_\alpha = \dfrac{71.9-50}{71.9-7.9} = 0.342$ $W_L = \dfrac{50-7.9}{71.9-7.9} = 0.658$

   $W_\alpha = 34.2\%$ $W_L = 65.8\%$

   b. Determine the phases present, compositions of the phases, and relative amounts of the phases when solidification is just complete (at a temperature just ***below*** the eutectic temperature).

   • $\alpha+\beta$ PHASES

   • $C_\alpha = 7.9$ wt% Ag , $C_\beta = 91.2$ wt% Ag

   • $W_\alpha = \dfrac{91.2-50}{91.2-7.9} = 0.495$ $W_\beta = \dfrac{50-7.9}{91.2-7.9} = 0.505$

   $W_\alpha = 49.5\%$ $W_\beta = 50.5\%$

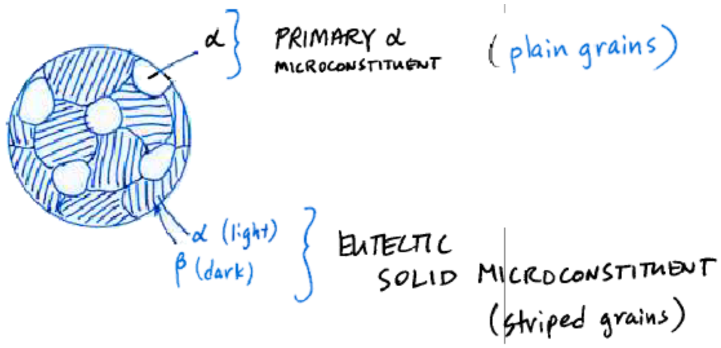
8. For a 50 wt.% Ag alloy, determine the fractional amounts of ***microconstituents*** when solidification is just complete.

MICROCONSTITUENTS ARE (i) EUTECTIC SOLID AND (ii) PRIMARY α

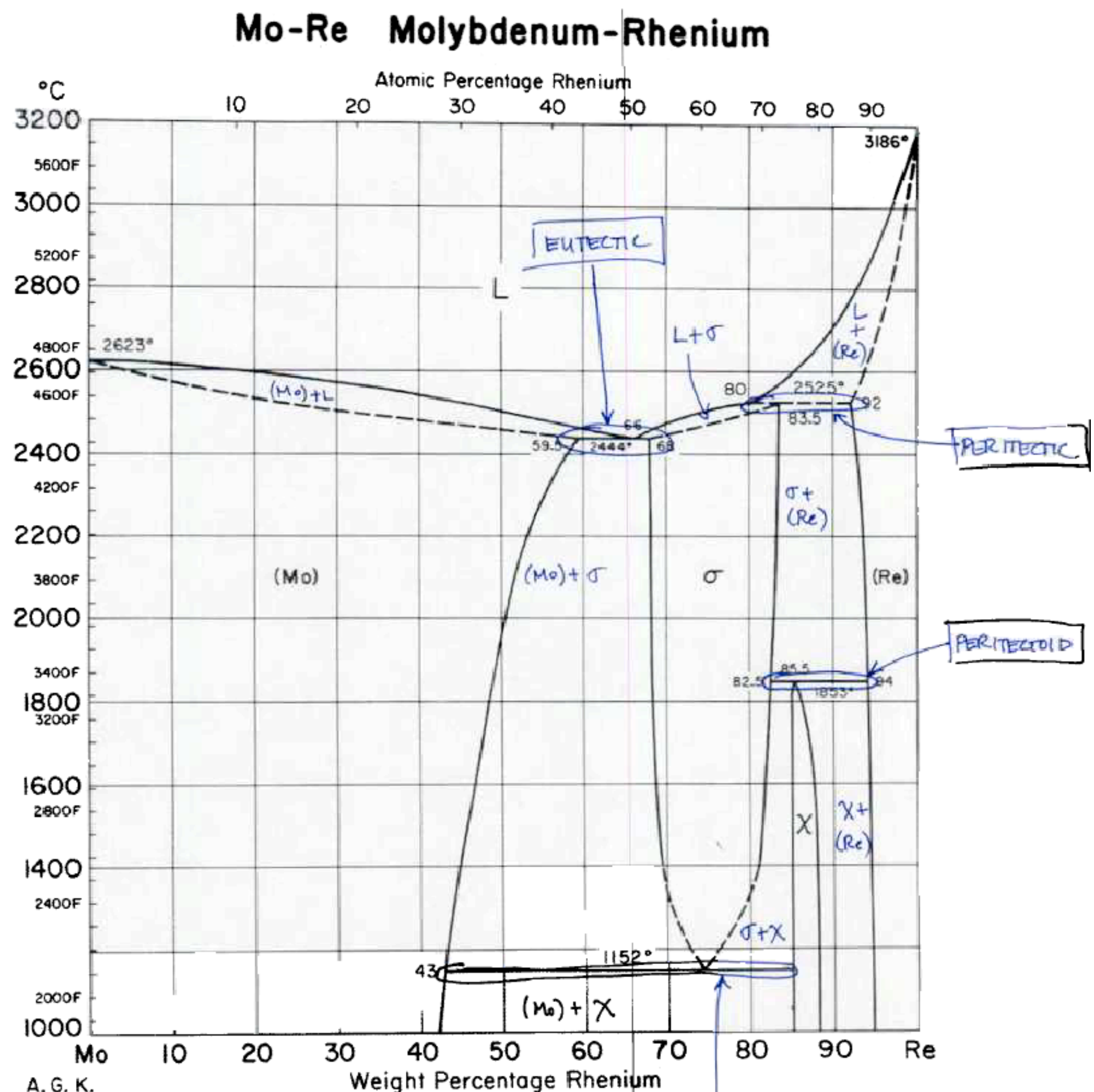
$W_{\text{EUTECTIC SOLID AT JUST BELOW } T_E} = W_{L \text{ AT JUST ABOVE } T_E} = 0.658 = \underline{65.8\%}$

$W_{\text{PRIMARY } \alpha \text{ AT JUST BELOW } T_E} = W_{\alpha \text{ AT A TEMP. JUST ABOVE } T_E} = 0.342 = \underline{34.2\%}$

9. Sketch the 50 wt.% silver alloy at a temperature just below the eutectic temperature. Label both the phases and the microconstituents.



10. The molybdenum-rhenium phase diagram is provided below. Note that all the single-phase regions labeled.
    b. Label all two-phase regions.
    c. Specify the temperatures and compositions for all 3-phase equilibria in this system. For each 3-phase equilibrium, write the reaction upon cooling.
    d. Assuming no phase transformations occur at lower temperatures, specify the strengthening mechanisms that are possible for an alloy of Mo with 18 wt. % Re.
    e. BONUS (don't you love how I give bonus questions for homework that isn't graded?): How would you actually form an alloy of Mo with 10 wt. % Re? Could you make it in one of our mat sci lab furnaces?



EUTECTIC: L (66wt%Re) → (Mo)(59.5wt%Re) + σ(68wt%Re)

PERITECTIC: L(80wt%Re) + (Re)(92wt%Re) → σ(83wt%Re)

PERITECTOID: σ(82.5wt%Re) + (Re)(94wt%Re) → χ(85.5 wt%Re)

EUTECTOID: σ(74wt%Re) → (Mo)(43wt%Re) + χ(85%Re)