*NOTE: various graphs, some from your textbook, have been included at the end of this assignment. They may or may not be useful. If you do use them in your work, be sure to copy them into your homework – mark on them appropriately, and **cite** them.*

1) The following are often used as prefixes or suffixes in technical vocabulary in medicine, physics, engineering, etc. For each of these, determine the origin (Latin or Greek), "translate" it into English, and provide a common example of its use. Example:
REF: I used http://wordinfo.info/words/index/info/search_box/index for the following answers.

   Homo
   Latin origin meaning: human beings, mankind; literally, "man"; however, it generally also includes, "woman" or "women". As in *homo sapiens*
   Also in Greek: Greek origin meaning: same, equal, like, similar, common; one and the same. As in homogenized milk (milk that has been processed to prevent the cream from separating).

   Provide a similar description/answer for the following: hetero, poly, iso, trop, plast, morph, hyper, hypo, meta, eu, pro, pre oid, ic, ous, ite
   You may use the same link I referenced above or other sources, but you MUST cite your sources (like I have).
ANS: …you have the ability to look these up….

2) **The following (a through l) are to be graded as single problems each.**
   For lead-tin (Pb-Sn) alloy, answer the following questions. Clearly mark the phase diagram to help communicate your answers where appropriate. Use a straight edge (your ID card may be pretty straight). You may use the space below to answer the questions. Note, the phrase "slowly cooled" is meant to imply that equilibrium has been attained.

   a) What critical but basic assumption is necessary to answer the following types of questions regarding reading a phase diagram? **ANS: the system is at equilibrium.** (That is why the phrase "slowly cooled" is normally injected into these questions – slow cooling generally allows equilibrium to be attained.)

   b) What is the eutectic composition and the eutectic temperature for Pb-Sn? **ANS:** As shown on the attached phase diagram the **eutectic composition is 62%Sn and 38%Pb** and the **eutectic temperature is 183°C.**

   c) Regardless of temperature, what is the maximum amount of tin that can be dissolved in lead (α phase)? What is the maximum amount of lead that can be dissolved in tin (β phase)? **ANS:** as shown on the attached phase diagram, up to **18.3%Sn can be dissolved in** α and up **to 2.2% Pb can be dissolved in** β.

   d) Cite the phases that are present and the composition of each phase: **ANS:** see attached phase diagram
      i) $C_0 = 10\%Sn, 90\%Pb, 200°C$
      ii) $C_0 = 30\%Sn, 70\%Pb, 180°C$
      iii) $C_0 = 90\%Sn, 10\%Pb, 180°C$
      iv) $C_0 = 62\%Sn, 38\%Pb, 190°C$

v) $C_0 = 62\%Sn, 38\%Pb, 180°C$

For problem 2d):

Composition (at% Sn) / Temperature (°C) vs Composition (wt% Sn) phase diagram (Pb-Sn)

2d)
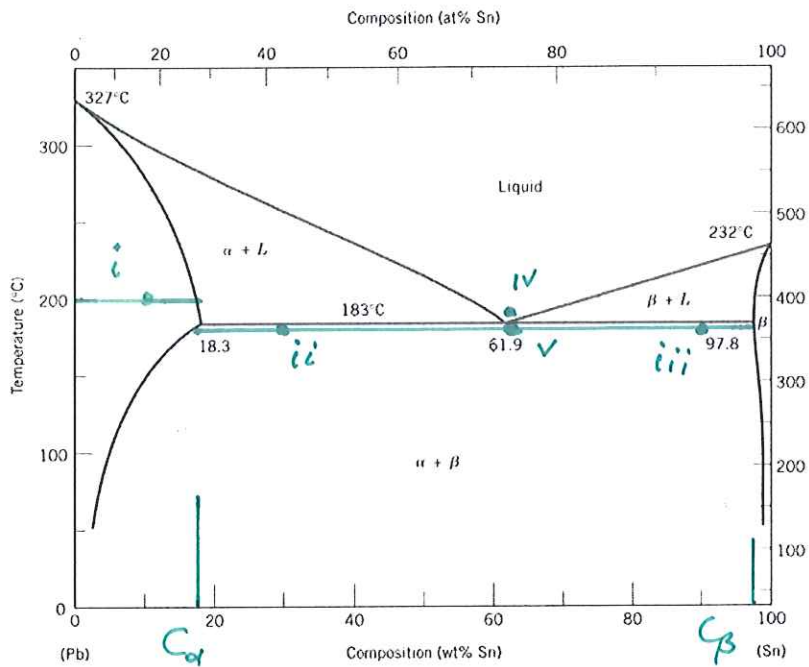
i) $C_0 = 10\% Sn, 200°C$
   α only. $C_\alpha = C_0 = 10\%Sn, 90\% Pb$

ii) $C_0 = 30\% Sn, 180°C$
   $C_\alpha \cong 17\% Sn, 83\%Pb$
   $C_\beta = 98\% Sn, 2\%Pb$

iii) $C_0 = 90\% Sn, 180°C$
   $C_\alpha \cong 17\% Sn, 83\% Pb$
   $C_\beta = 98\% Sn, 2\% Pb$

iv) $C_0 = 62\% Sn, 190°C$
   $C_L = 62\% Sn, 38\% Pb$

v) $C_0 = 62\% Sn, 180°C$
 $C_\alpha \cong 17\% Sn, 83\% Pb$
   $C_\beta = 98\% Sn, 2\% Pb$

e) If the microstructure of a Pb-Sn alloy at 185°C is composed of 75wt% α and 25wt% liquid, approximately what is the overall composition of the alloy? See attachment

f) If an alloy composed of 30wt% Sn and 70wt% Pb is slowly cooled from liquid to 185°C, what phases would be present and what is their composition? ANS: as shown on the attached phase diagram, two phases exist (α and liquid). The **liquid is about 61% Sn** (39%Pb) and **α is about 18%Sn** (82%Pb).

g) If an alloy composed of 30wt% Sn and 70wt% Pb is slowly cooled from liquid to 185°C, how much of each phase will be present?

Composition (at% Sn) / Temperature (°C) vs Composition (wt% Sn) phase diagram (Pb-Sn)
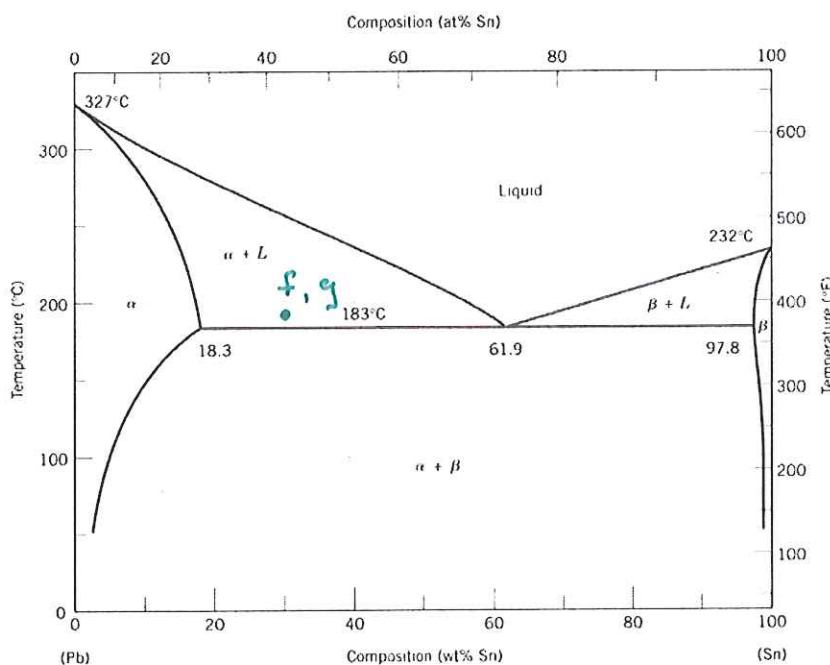
g) $wt\% \alpha = \dfrac{C_L - C_0}{C_L - C_\alpha}$

$C_L = 61\% Sn, \quad C_\alpha = 18\% Sn$
$C_0 = 30\% Sn$

$wt\% \alpha = \dfrac{61 - 30}{61 - 18} \times 100\% = 72\%$

$wt\% L = 100\% - wt\% \alpha = 28\%$

Assignment 9 Solutions

FROM Pb-Sn Phase Diagram:
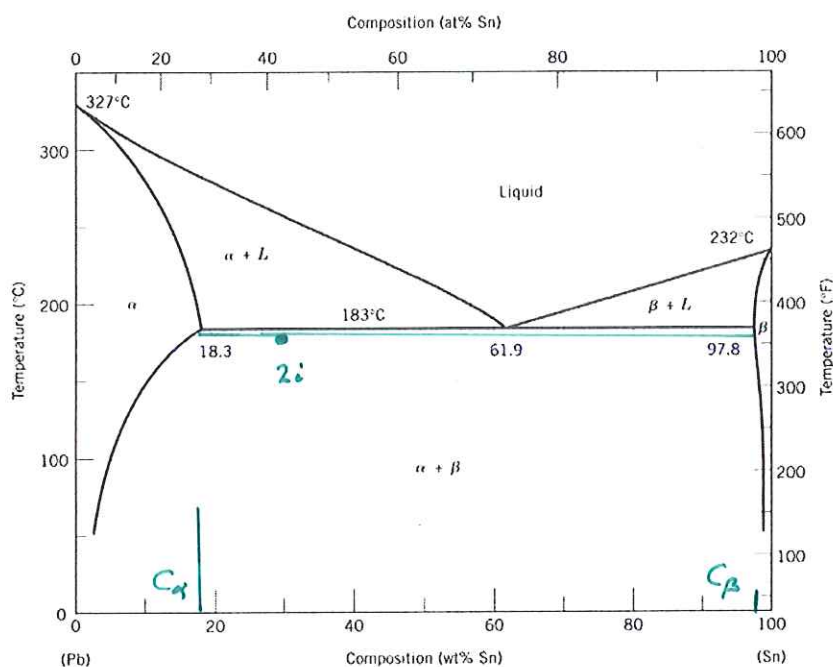
2e) Given Pb-Sn at 185°C, .75 wt% α, 25 wt% L

Find C_0.

$$wt\%\alpha = \frac{C_0 - C_L}{C_\alpha - C_L} = 0.75 \quad (given)$$

$$\Rightarrow \quad C_0 = C_L + (wt\%\alpha)(C_\alpha - C_L)$$

at 185°C, $C_\alpha = 18\%$ Sn $\quad C_L = 62\%$ Sn

$$C_0 = 62 + (0.75)(18 - 62) = \underline{29\% \text{ Sn}}, \underline{71\% \text{ Pb}}$$

h) If an alloy composed of 30wt% Sn and 70wt% Pb is slowly cooled from liquid to 180°C, what phases would be present and what is their composition? **ANS: as shown on the attached phase diagram, two phases exist (α and β). β is about 98% Sn (2%Pb) and α is about 18%Sn (82%Pb).**

i) If an alloy composed of 30wt% Sn and 70wt% Pb is slowly cooled from liquid to 180°C, what would the weight percentage be of α and β?

j) If an alloy composed of 30wt% Sn and 70wt% Pb is slowly cooled from liquid to 180°C, what would the weight percentage be of the microstructures referred to as primary α and of eutectic structure? Hint: consider problem (g) above – the α is happy being α at 185°C and at 180°C, so it remains (primary α) but the liquid upon solidification goes through the eutectic reaction resulting in a eutectic microstructure.

Composition (at% Sn)

Temperature (°C) / Temperature (°F)

Composition (wt% Sn)

(Pb) ... (Sn)

327°C, 300, 200, 100, 0 / 600, 500, 400, 300, 200, 100

Liquid, α + L, α, 183°C, 18.3, 2i, 61.9, β + L, 97.8, β, α + β, 232°C, C_α, C_β

2i) $wt\% \alpha = \dfrac{C_\beta - C_o}{C_\beta - C_\alpha} \times 100\%$

$C_\beta = 98\% \, Sn, \quad C_\alpha = 18\% \, Sn, \quad C_o \approx 30\% \, Sn$

$wt\% \alpha = \dfrac{98-30}{98-18} = 85\%$

$wt\% \beta = 100\% - wt\% \alpha = 15\%$

j) REF 2g) where at $C_o = 30\% \, Sn$ at 185° (Teutectic⁺) was 72% α and 28% liquid. When cooled to 180°C, $L \rightarrow \alpha + \beta$ eutectic microstructure forms.

∴ 72% is primary α
28% is eutectic structure

k) What is one common application of Pb-Sn alloy? Are electronics companies in the United States allowed to use Pb-Sn alloys? What about companies in Europe? **ANS: lead-tin has been a commonly used alloy for solder due to its relatively low liquidus temperature. However, there are health concerns with lead (and to a lesser extent tin) due to radioactive isotope alpha decay. Companies in the US are allowed to use Pb-Sn solder, but are given tax incentives to use lead-free solder. Europe have outlawed the use of lead-containing solder in electronics (since 2006). Source:** must cite! https://en.wikipedia.org/wiki/Solder#Lead-free_solder. } ANS

l) Sketch the appearance of the microstructure in part (j) labeling and describing the various constituents.

primary α grains (no "zebra" stripes)

eutectic (layers of α & β)