Donald P. Shiley School of Engineering
EGR 221 Materials Science
Assignment 4, Fall 2015

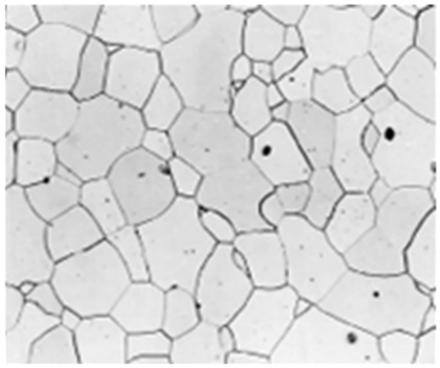
1) Who was Linus Pauling and why "should" someone studying science or engineering in Portland know who he is?
2) In Greek, what does the word "*plasma*" mean? In physics, what is *plasma*?
3) What is brass? What is bronze? When were they each first used? How are they each used in modern industry?
4) Information for various elements is shown in the table below. Which of the elements in table would you expect to form with *copper*:
   a) A substitutional solid solution with complete solubility
   b) A substitutional solid solution with partial (incomplete) solubility
   c) An interstitial solid solution (which is never complete solubility)

Element	**Atomic Radii (nm)**	**Crystal Structure**	**Atomic Weight (amu)**
Cu	***0.128***	***FCC***	***63.55***
C	0.071	Not BCC, HCP, FCC	12.011
Fe	0.124	BCC	55.85
Ni	0.125	FCC	58.69
O	0.060		16.00
Pb	0.137	FCC	207.2
Zn	0.1332	HCP	65.41

In materials science, we often discuss the "composition" of an alloy. Usually we express this in terms of "mass percentage" or "weight percentage" (effectively, the same thing). For example, alpha brass has a composition of 65%Cu and 35% Zn – so if I have 100kg of alpha brass it contains 65kg of copper and 35 kg of zinc. On occasion, we express composition as atomic percentage. Since no two elements have the same atomic weight, atomic percentage is different than mass percentage. Here's a simple problem to help you develop the ability to convert between these two different methods of expressing composition:

5) According to modern cosmology, after about 20 minutes "post-big bang" (in other words, when the universe was a mere 20 minutes old) all of the protons and neutrons to ever exist, existed. Only two elements were formed – hydrogen and helium (and they were too hot to hold onto electrons so they were completely ionized plasma). ---*where did the other elements come from? That's another story*…. But in the beginning, for every 12 ionized hydrogen nuclei (aka "free protons") there was one ionized helium nucleus (2N+2P). Therefore, the composition of the universe was (and largely remains today) 92.3% (12/13) hydrogen and 7.7% (1/13) helium – by atomic percentage. If ionized helium is four times more massive than a single hydrogen ion, calculate the composition of the universe by mass. Include a sketch (this will help you visualize your answer). (No, don't worry about dark matter, etc.).

6) A) Determine the ASTM grain size number in the micrograph below. B) Also determine the average grain diameter for this same sample. The image was taken at 100X magnification.



7) For an FCC single crystal, would you expect the surface energy for a (100) plane to be greater or less than that for a (111) plane? Why?

8) Briefly explain the difference between self-diffusion and interdiffusion.

9) Briefly explain the concepts of "steady state" and "transient" (aka non-steady state) as they apply to diffusion.

10) What is the diffusion coefficient (D) and what does its magnitude tell you about diffusion?

11) a) Compute the diffusion coefficient (D) of nitrogen in FCC iron at 950°C (iron is FCC above 912°C and BCC below that temperature).
    b) Compute the diffusion coefficient (D) of nitrogen in BCC iron at100°C.
    c) Compare these two answers –how much greater is the diffusion rate at 950°C than 100°C?

12) a) What is nitriding? Very briefly, describe the process and explain its benefits (why is it done). Is nitriding commonly performed on non-ferrous materials?
    b) What is carburization (aka carburizing) and explain its benefits. Is carburizing commonly performed on non-ferrous materials?
    c) Are either of these process (nitriding, carburizing) performed at room temperature?
    d) Could either of these processes be used to enhance the performance of a knife?