BMEN 343 **NAME:**_____

ID #:_____

HOMEWORK #3 (85 PTS)

DUE: 16 October 2009 at the BEGINNING OF CLASS:
There are 2 pages (front and back) to this homework. Answers should be given neatly, in order, and in the space provided or in stapled attached pages if necessary. Show work for full credit. Put the final answer in a box when appropriate.

True or False:

1. **(2 pts)**	T	F	In order to form a substitutional solid solution with complete solubility, the elements should have the same valency.
2. **(2 pts)**	T	F	The driving force for steady-state diffusion is the concentration gradient.
3. **(2 pts)**	T	F	Heat treatment of an aluminum-silver diffusion couple (i.e. an Al bar in contact with a Ag bar) can lead to interdiffusion.
4. **(2 pts)**	T	F	For steady-state diffusion, diffusion flux is dependent on time.

Brief Answer

4. Name the principle elements of the following alloys (i.e. those present in highest amounts). Provide the answer in terms of the atomic symbol **and** "name" of each element (e.g. "Ag/silver"). (Note: not necessary to list %'s of each element in alloy)

a. Pewter (2 major components) **(2 pts)**:

b. Brass (2 major components) **(2 pts)**:

c. Stainless steel 316L (3 major components) **(3 pts)**:

d. Haynes-Stellite 25 or ASTM-F90: (4 major components) **(4 pts)**:

e. 55-Nitinol (2 major components) **(2 pts)**:

Problem Solving

Calculations 5-9: Answers should be completed on *separate pages* and ***stapled*** to this sheet. Show all work for full credit. Provide answers in a neat and orderly fashion. **Place a box around final answers.**

5. **(14 pts) (a)** For titanium (Ti), calculate the fraction of vacancies at **(i)** room temperature (25 °C) and at **(ii)** 950 °C. Assume the energy of vacancy formation is 1.2 eV/atom **(8 pts)**. **(b)** Based on the calculation, **one in how many sites** are vacant at **(i)** 25 °C and at (ii) 950 °C **(6 pts)**.

6. **(14 pts) (i)** Would you predict that more Pd (palladium) or more Co (cobalt) could be dissolved in Al (aluminum)? Consult the table below. *Explain your answer based on all 4 Hume-Rothery Rules for full credit* (**8 pts**). **(ii)** For Al-Pd and Al-Co, identify what each pair would form: (a) a substitutional solid of complete solubility, (b) a substitutional solid of incomplete solubility, or (c) an interstitial solid solution. **(6 pts)**

Element	*Atomic Radius (nm)*	*Crystal Structure*	*Electro-nega-tivity*	*Valence*
Cu	0.1278	FCC	1.9	+2
C	0.071			
H	0.046			
O	0.060			
Ag	0.1445	FCC	1.9	+1
Al	0.1431	FCC	1.5	+3
Co	0.1253	HCP	1.8	+2
Cr	0.1249	BCC	1.6	+3
Fe	0.1241	BCC	1.8	+2
Ni	0.1246	FCC	1.8	+2
Pd	0.1376	FCC	2.2	+2
Zn	0.1332	HCP	1.6	+2

7. **(12 pts)** What is the composition, in atom percent, of an alloy that consists of 100 lb_m Ti, 20 lb_m Al, and 5 lb_m V?

8. **(12 pts)** A sheet of steel (2.5 mm thick, cross-sectional area = 0.25 m^2) has nitrogen gas atmospheres on both sides at 1100 °C and is permitted to achieve a steady-state diffusion condition. For these conditions, the diffusion coefficient for nitrogen in steel is 1.2 x 10^{-7} m^2/s and the ~~diffusion flux is found to be 1.0 x 10^{-7} kg/m^2s~~. Also, the concentration of nitrogen in the steel at the *high*-pressure surface is 2.0 kg/m^3 and the concentration of nitrogen in the steel at the *low*-pressure surface is 0.5 kg/m^3. What is the number of kg of nitrogen that pass through the sheet per hour. Put a box around final answer.

9. **(12 pts)** How many hours of carburizing are required to achieve a carbon concentration of 0.5 wt% at a position 1.5 mm into an iron-carbon alloy that initially contains 0.2 wt% C. The surface concentration is to be maintained at 0.85 wt% C and the treatment is to be conducted at 900 °C. Use the diffusion data for γ-Fe in *Table 5.2*. Consult *Table 5.1* for tabulation of error function values. **SHOW CALCULATION OF D.**