

**South Dakota School of Mines and Technology**  
**Department of Materials and Metallurgical Engineering**

Met 321

HQ 1

4/29/2009

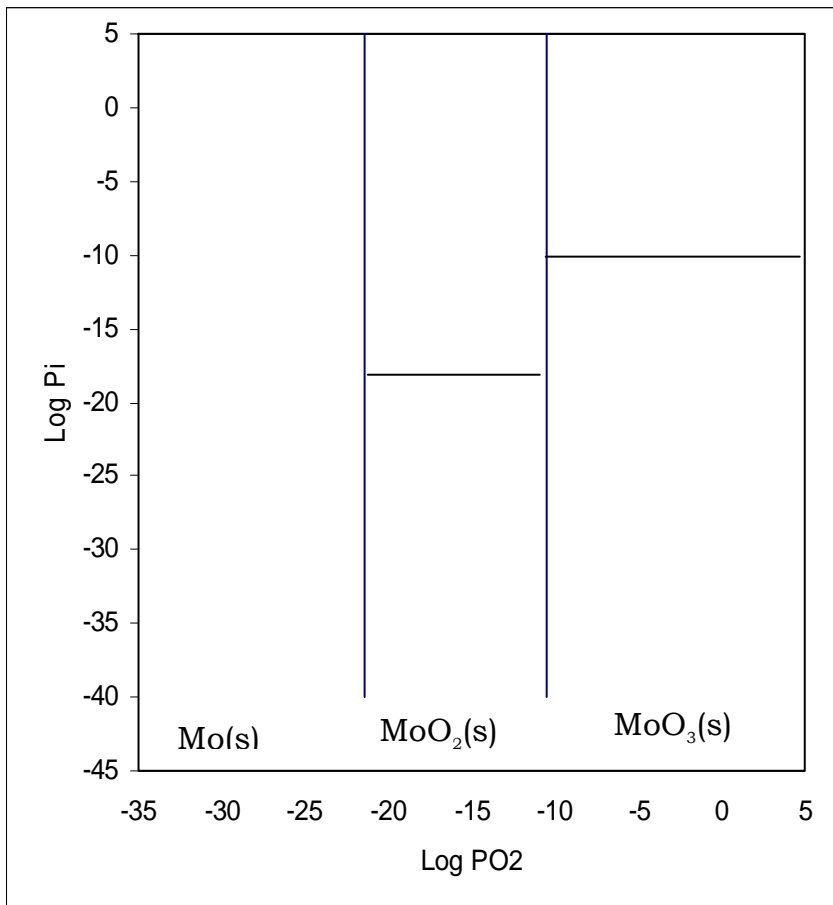
1. (20%) Molybdenum is a refractory metal with a melting point of 2892 K. One would think it would have an exceedingly low vapor pressure, which it does ( $10^{-61}$  atm at 1000 K). However, this does not mean that Mo does not have significant vapor pressures in the form of volatile oxide species.
  - o Known Mo-bearing gas species are Mo, MoO, MoO<sub>2</sub>, and MoO<sub>3</sub>.
  - o Condensed (solid) species in the system at 1000 K are Mo, MoO<sub>2</sub>, and MoO<sub>3</sub>.

The log of the equilibrium oxygen pressures between the condensed phase at 1000 K are -21.4 for Mo/MoO<sub>2</sub> and -10.5 for MoO<sub>2</sub>/MoO<sub>3</sub> as sketched below.

Sketch the position of the lines for the MoO<sub>2</sub> gas and MoO<sub>3</sub> gas across the full range of O<sub>2</sub> pressures.

The pressures of MoO<sub>2</sub> and MoO<sub>3</sub> in equilibrium with their respective solids are  $10^{-18.6}$  and  $10^{-10}$  atm at 1000 K as shown. Label the slope of your lines and show your work.

Work \_\_\_\_\_.



2. (20%) Find the refining ratio  $R^0$  for Cu in molten Fe at 1900 K using the data provided.

**Data:**

Vapor Pressures Selected  
Molten Metals at 1900 K

Metal	P (atm)
Fe	$1.13 \times 10^{-4}$
Cu	$1.69 \times 10^{-3}$
Zn	$1.08 \times 10^1$

Cu-Fe

TABLE 3

Partial Molar Quantities for Liquid Alloys at 1823°K

A. Cu Component  $Cu_{(l)} = Cu(\text{in alloy})_{(l)}$

$x_{Cu}$	$a_{Cu}$	$\gamma_{Cu}$	$\Delta\bar{G}_{Cu}$	$\Delta\bar{G}_{Cu}^{xs}$	$\Delta\bar{H}_{Cu}$	$\Delta\bar{S}_{Cu}$	$\Delta\bar{S}_{Cu}^{xs}$
1.0	1.000	1.000	0	0	0	0.000	0.000
0.9	0.929	1.032	-267	114	118	0.211	0.002
0.8	0.896	1.120	-397	411	409	0.442	-0.001
0.7	0.878	1.254	-471	821	830	0.713	0.005
0.6	0.857	1.428	-560	1290	1355	1.051	0.035
0.5	0.829	1.657	-681	1830	1982	1.461	0.084
	(±.01)	(±.02)	(±100)	(±100)	(±200)	(±.12)	(±.12)
0.4	0.804	2.010	-790	2529	2714	1.922	0.102
0.3	0.780	2.598	-902	3459	3702	2.525	0.133
0.2	0.728	3.641	-1149	4682	5312	3.544	0.346
0.1	0.557	5.575	-2117	6225	7897	5.493	0.917
0.0	0.000	9.512	-∞	8160	11370	∞	1.761

B. Fe Component  $Fe_{(l)} = Fe(\text{in alloy})_{(l)}$

$x_{Fe}$	$a_{Fe}$	$\gamma_{Fe}$	$\Delta\bar{G}_{Fe}$	$\Delta\bar{G}_{Fe}^{xs}$	$\Delta\bar{H}_{Fe}$	$\Delta\bar{S}_{Fe}$	$\Delta\bar{S}_{Fe}^{xs}$
0.0	0.000	10.570	-∞	8550	9300	∞	0.411
0.1	0.573	5.728	-2019	6323	6978	4.935	0.359
0.2	0.716	3.582	-1208	4622	5299	3.570	0.371
0.3	0.763	2.542	-981	3380	4028	2.748	0.355
0.4	0.798	1.996	-816	2503	3049	2.120	0.300
0.5	0.832	1.663	-668	1843	2282	1.618	0.241
	(±.01)	(±.02)	(±100)	(±100)	(±200)	(±.12)	(±.12)
0.6	0.853	1.421	-577	1274	1678	1.237	0.222
0.7	0.867	1.239	-517	775	1152	0.916	0.207
0.8	0.886	1.107	-438	370	624	0.583	0.139
0.9	0.925	1.028	-282	100	178	0.253	0.043
1.0	1.000	1.000	0	0	0	0.000	0.000

3. Lab

(15%) Calorimeter

- a) The heat of reaction for the complete oxidation of  $\text{Mg}_{(s)}$  to  $\text{MgO}_{(s)}$  is  $-143 \text{ Kcal/gmole MgO}$ . Show the computation needed to determine the expected temperature rise (in C degrees) in an oxygen bomb calorimeter using 1000 g of water with a bomb having a water equivalent of 500 g. The formula weight of Mg is 24.

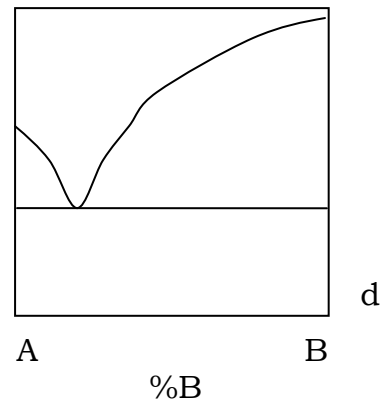
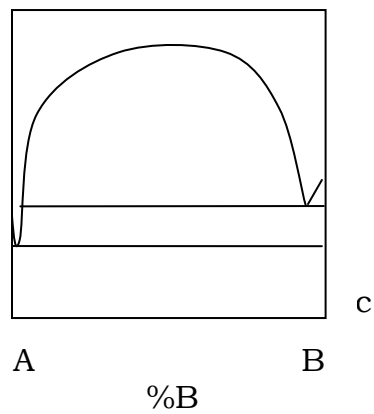
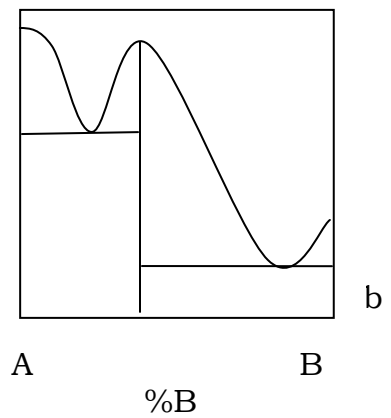
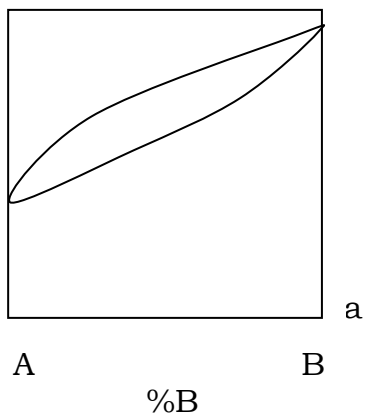
(15%) Slag

- b) How does PbO make  $\text{SiO}_2$  more fluid? Use the terms basic, acidic, covalent, ionic, network, and basicity. Include a sketch of the bonding change caused by PbO.

4. a) ( 5%) Which of the following phase diagrams would allow liquation refining? \_\_\_\_\_

b) (10%) Draw a heavy horizontal line along the base of each diagram indicating the composition range along which one could compute the activity of the component B using the method covered in lecture.

c) ( 5%) List the data needed to compute an activity from a phase diagram.



5. (10%) Writing Experience

Rate the importance of the following experiences to improving your writing skills:

5 (very important), 4, 3, 2, 1, 0 (unimportant)

Experience	Importance (5, 4, 3, 2, 1, 0)	Optional Comments (Course/Professor/etc)
Home		
Friends		
Grade School		
Middle School		
High School		
SDSM&T		
Engl but <b>NOT</b> Tech Comm		
Tech Comm		
Met Eng Courses		
Other Courses		
AMP		
Other SDSM&T		
Other (optional)		
Other (optional)		

*Optional comments:*