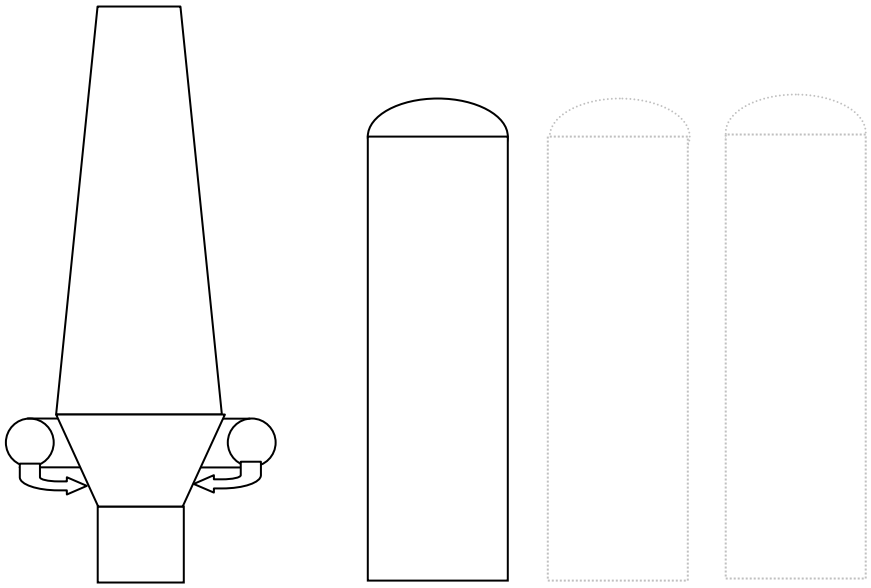
South Dakota School of Mines and Technology
Department of Materials and Metallurgical Engineering

Met 321 **HQ 1** **4/6/2009**

1. a) Label any five items on the below sketch of an Iron Blast Furnace.



b) Describe the Kroll process for Ti using approximately 40 words, sketches and reactions.

c) What is ENDO gas and how is it formed?

2. Using the JANAF Thermochemical Tables for CO and Al_2O_3 data provide at the end of this exam, find the cell potential required to produce pure liquid aluminum from cryolite saturated with pure, solid Al_2O_3 at 1100 K. State all assumptions. State all assumed or known activity values. Setup the theoretical computation first. Then make all needed data values from JANAF known.

3. Answer the following questions based on the Professional Engineers Code of Ethics:
   a) What it the first ethical responsibility of a professional engineering?

   b) Place the letter "Y" on the line for each item that ***is*** a fundamental canon of ethical practice and an "N" on the line for each item that is ***not*** of ethical practice for professional engineers.

   Engineers, in the fulfillment of their professional duties, shall:

   ____ Follow their employer's guidance at all times.

   ____ Perform services only in areas of their competence.

   ____ Issue public statements only in an objective and truthful manner

   ____ Approve judiciously any delays in regulatory obligations to preserve employee's positions.

   ____ Avoid expressing political opinions in public.

   ____ Act for each employer or client as faithful agents or trustees.

   ____ Avoid deceptive acts.

   ____ Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

   True-False

   c) ___ Engineers shall not accept compensation, financial or otherwise, from more than one party for services on the same project, or for services pertaining to the same project, unless the circumstances are fully disclosed and agreed to by all interested parties.

   d) ___ Engineers may reveal facts, data, or information without the consent of the client or employer at their discretion.

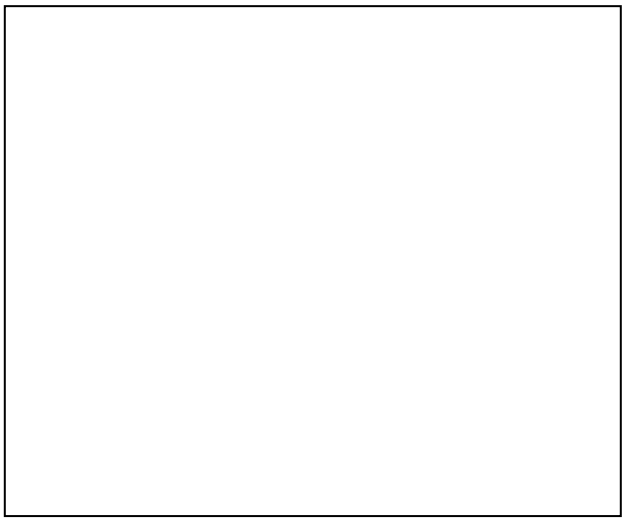
   e) ___ Engineers shall not accept commissions or allowances, directly or indirectly, from contractors or other parties dealing with clients or employers of the engineer in connection with work for which the engineer is responsible unless a pledge is made to remain unaffected by such transactions.

   f) ___ Engineers in salaried positions shall accept part-time engineering work only to the extent consistent with policies of the employer and in accordance with ethical considerations.

4. Consider a stability diagram for the Co-O-S system. The condensed components present are CoS_2, Co_3O_4, Co, Co_9S_8, $CoSO_4$, and CoO. The **vertical** coordinate is Log P_{SO2} and the **horizontal** (axis) is Log P_{O2}.

   a) Sketch the diagram showing the relative position of each compound.

Log P_{SO_2}



Log P_{O_2}

   b) Assuming the Co_9S_8 and the $CoSO_4$ phases are in equilibrium, what is the slope of the line between them?

   c) What would be the slope of a line of constant SO_2?

5. Questions on copper
   a) How has the smelting of Cu evolved from the days when copper oxide was plentiful, SO_2 emissions were uncontrolled (before 1070's), and energy was very cheap (before mid 1980's)?

   b) Use the Ellingham Diagram to explain the Cu-Fe-S matte smelting process at 1200 °C.

   c) What is the order of oxidation and the reason for the order.

   d) Find the approximate sulfur ($S_{2\,(Liq)}$) activity in matte smelting at 1200 °C when Cu just begins to oxidize to form pure Cu_2O.

DATA SHEET

JANAF

Al_2O_3

Aluminum Oxide, Gamma (γ - Al_2O_3)

(Crystal) Mol. Wt. - 101.9612

T, °K.	C_p° (cal. mole^{-1}deg.$^{-1}$)	S°	$-(F^\circ-H^\circ_{298})/T$	$H^\circ-H^\circ_{298}$ (kcal. mole^{-1})	ΔH_f°	ΔF_f°	Log K_f
0							
100							
200							
298	19.833	12.550	12.550	.000	- 396.000	- 373.790	273.982
300	19.928	12.673	12.550	.037	- 396.005	- 373.652	272.193
400	24.135	19.023	13.388	2.254	- 396.052	- 366.184	200.004
500	26.612	24.691	15.093	4.799	- 395.866	- 358.736	156.796
600	28.233	29.694	17.118	7.545	- 395.570	- 351.337	127.968
700	29.367	34.135	19.238	10.428	- 395.224	- 343.991	107.394
800	30.196	38.112	21.353	13.407	- 394.876	- 336.697	91.977
900	30.804	41.705	23.418	16.458	- 394.570	- 329.443	79.996
1000	31.305	44.977	25.413	19.565	- 390.370	- 321.853	70.338
1100	31.623	47.976	27.330	22.711	- 398.000	- 314.122	62.407
1200	31.987	50.743	29.167	25.891	- 398.610	- 306.423	55.805
1300	32.447	53.321	30.927	29.113	- 398.190	- 298.756	50.223
1400	32.855	55.741	32.614	32.378	- 397.738	- 291.123	45.444
1500	33.193	58.020	34.232	35.681	- 397.260	- 283.527	41.308
1600	33.516	60.172	35.787	39.016	- 396.758	- 275.960	37.693

ALUMINUM OXIDE, GAMMA (γ - Al_2O_3) (CRYSTAL)

$S^\circ_{298.15}$ = [12.55] cal. deg.$^{-1}$ mole^{-1}

T_m = 2523°K.

CO

Carbon Monoxide (CO)

(Ideal Gas) Mol. Wt. = 28.01055

T, °K.	C_p° (cal. mole^{-1}deg.$^{-1}$)	S°	$-(F^\circ-H^\circ_{298})/T$	$H^\circ-H^\circ_{298}$ (kcal. mole^{-1})	ΔH_f°	ΔF_f°	Log K_p
0	.000	.000	INFINITE	- 2.072	- 27.200	- 27.200	INFINITE
100	6.956	39.613	53.401	- 1.379	- 26.876	- 28.741	62.809
200	6.957	44.435	47.951	- .683	- 26.600	- 30.718	33.566
298	6.965	47.214	47.214	.000	- 26.417	- 32.783	24.029
300	6.965	47.257	47.214	.013	- 26.414	- 32.823	23.910
400	7.013	49.265	47.488	.711	- 26.318	- 34.975	19.109
500	7.121	50.841	48.006	1.417	- 26.296	- 37.144	16.235
600	7.270	52.152	48.591	2.137	- 26.332	- 39.311	14.318
700	7.450	53.287	49.182	2.873	- 26.409	- 41.468	12.946
800	7.624	54.293	49.759	3.627	- 26.514	- 43.612	11.914
900	7.786	55.200	50.314	4.397	- 26.637	- 45.744	11.108
1000	7.931	56.028	50.845	5.183	- 26.771	- 47.859	10.459
1100	8.057	56.790	51.351	5.983	- 26.914	- 49.962	9.926
1200	8.168	57.496	51.834	6.794	- 27.062	- 52.049	9.479
1300	8.263	58.154	52.295	7.616	- 27.218	- 54.126	9.099
1400	8.346	58.769	52.736	8.446	- 27.376	- 56.189	8.771
1500	8.417	59.348	53.158	9.285	- 27.537	- 58.241	8.485

CARBON MONOXIDE (CO) (IDEAL GAS)

Ground State Configuration $^1\Sigma^+$

$S^\circ_{298.15}$ = 47.21 ± 0.01 cal. deg.$^{-1}$ mole^{-1}

ω_e = 2169.52 cm.$^{-1}$ $\omega_e x_e$ = 13.453 cm.$^{-1}$

B_e = 1.9302 cm.$^{-1}$ α_e = 0.01746 cm.$^{-1}$

Heat of Formation.

The enthalpy change ($\Delta H^\circ_{f\ 298.15}$) for the reaction: CO(g) + 0.029 kcal. mole^{-1}, based on molecular weight of CO_2 = 44.010, by 22, 407 (1939). It was recalculated to be -67.638 ± 0.03 kcal.

<u>Other Information</u>

F = 23,061 cal/(volt*equiv)

R = 1.987 cal/gmole-K = 0.08205 L*atm/K*gmole