SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY
DEPARTMENT OF METALLURGICAL ENGINEERING

MET 320 FINAL Dec. 21, 1998

Constants:
R = 1.987 cal/K•gmole = 8.31 J/K•gmole
$\mathcal{F}$ = 23,060 cal/volt•gram equivalent = 96,259 cal/volt•gram equivalent

1. Two moles of an ideal gas at 1 atm and 300 K are adiabatically compressed to 30 atm.
   a) What is the final temperature?
   b) How much heat was required?
   c) How much work was required?

2. Your neighbor comes over to say that he has welded shut the pressure relief valve of his wife's pressure cooker so it will cook potatoes faster. If the pressure cooker will rupture at 12 atm, how hot will his cooker be as it leaves for orbit? The heat of vaporization of water is 40,680 J/gmole.

3. What is the maximum amount of work that could be obtained from 1000 Joules of heat from a solar heat collector at 1200 K if the coldest heat sink available is at 300 K?

4. A natural gas well accidentally ignited on a drilling platform and there is concern about the maximum temperature some salvaged equipment was exposed to. Draw the calculation schematic, needed to calculate the maximum flame temperature expected from the fire. Also, show the required equations for determining the flame temperature of CH_4 with air (21 % O_2 and 79 % N_2). Assume the beginning temperature of the air and the CH_4 is 298 K.

5. Would a gas with the following composition react with liquid Sn to form liquid $SnCl_2$ at 800 K? Show your work.

   H_2 = 0.5 atm; HCl = 0.05 atm; balance N_2; P_T= 1 atm

6. Use the data given below for the liquid Cu-Sb system at 1190 K to determine the enthalpy change when (assume all components start in the liquid state at 1190 K)
   a) 2 moles of Cu are dissolved in 1,000,000 moles of Cu-Sb alloy having a mole fraction of Cu of 0.7.
   b) 3 moles of Sb and 7 moles of Cu are mixed at 1190 K

Data for the Liquid Cu-Sb System at 1190 K

X_{cu}	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
H^M (cal/mole)	-983	-1474	-2399	-2458	-2487	-2017	-1586	-978	98
H^M_{Sb} (cal/mole)	81	266	465	698	1093	1053	-66	-2929	-6800

7. a) Calculate the cell potential for the electrolysis of pure, liquid NaCl at 1000 K to form Cl_2 at 1 atm and pure, liquid Na.

   b) How would the cell potential change if the Na were in a solution having an activity of Na of 0.01 relative to pure, liquid Na?

$$Na_{(l)} + 0.5\ Cl_{2(g)} = NaCl_{(l)} \qquad \Delta G° = -76{,}200 \text{ cal/gmole}$$

SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY
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Met 320 FINAL 3-5 PM; Dec. 17,1997

1. Ten moles of ideal gas at 500 K and 10 atm are isothermally compressed to 50 and then adiabatically expanded reversibly back to 10 atm. What is the entropy change for the gas?

2. a) Write the Maxwell relation that comes from dU=TdS-PdV
   b) Derive the fundamental equation dH= ?
   c) Write the Gibbs-Duhem equation for partial molar volumes: $0=x_1 d...$?
   d) Write the "other" thermodynamic relations that arise from: dU=TdS-PdV. T=? P=?

3. To what pressure would water have to be pressurized to raise its boiling temperature to 200 C?

4. Show on the attached Ellingham Diagram the pressure of O_2 in equilibrium with Ti and TiO_2 at 1000°C?

5. Which direction will the following reaction proceed at 800 K when the activity of Mg relative to pure, liquid Mg is 1.0; the activity of $MgCl_2$ is 0.4 relative to pure, liquid $MgCl_2$; and the pressure of Cl_2 is 0.25 atm?

   $MgCl_{2(l)} = Cl_{2(g)} + Mg_{(l)}$ $\Delta G° = 605{,}000 - 125.4T$ J/gmole

6. Use the data given below for the liquid Cu-Pb system at 1473 K to determine the enthalpy change when

   a) 2 moles of liquid Pb and 8 moles of liquid Cu both at 1473 K are mixed

   b) 3 moles of liquid Pb at 1473 K are dissolved in 10,000 moles of liquid Cu-Pb alloy at 1473 K with a mole fraction of Cu of 0.15.

   Data for the Liquid Cu-Pb System at 1473 K

X_{Cu}	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
H^M (Cal/mole)	584	1026	1338	1534	1607	1567	1422	1154	707

Data: Data sheet provided
$\Delta H_{vap,\ water}$ = 10,800 J/gmole
R=8.31 Joules/(gmole*K) = 1.987 cal/(gmole*K) = 0.08205 (L*atm)/(gmole*K)
Ellingham Diagram attached
$\mathcal{F}$ = 23,060 cal/volt-gmole-equiv = 96,529 J/volt-gmole-equiv

Graph paper

SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY
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MET 320 QUIZ 4b Dec. 11, 1998

1. Pure, liquid Cu_2O at 1423 K is to undergo electrolysis to form O_2 gas at a pressure of 1 ATM and pure liquid Cu. What cell potential is needed? (15)

2. Calculate the cell potential if the O_2 pressure is 1.2 ATM, the oxide is dissolved in a more stable second oxide in which the activity of Cu_2O (relative to pure, liquid oxide) is 0.4, and the produced liquid Cu is collected in a liquid Ag-Cu alloy in which the mole fraction of Cu is 0.2. Activity data for liquid Ag-Cu alloys at 1423 K are given below. (10)

DATA:

$2\ Cu_{(l)} + 0.5\ O_{2(g)} = Cu_2O_{(s)}$ $\quad \Delta G^\circ = -195{,}000 - 7.12 T \ln T + 143 T$ Joules/gmole

$Cu_2O_{(s)} = Cu_2O_{(l)}$ $\quad \Delta G^\circ = 13{,}580 - 9.0\ T$ Joules/gmole

Activity data for liquid $\quad \mathcal{F} = 96{,}525$ Joule/(volt*Equivalent)

Ag-Cu Alloys at 1423 K

X_{Cu}	a_{Cu}
0.0	0.000
0.1	0.260
0.2	0.422
0.3	0.535
0.4	0.616
0.5	0.679
0.6	0.731
0.7	0.782
0.8	0.841
0.9	0.912
1.0	1.000