SOUTH DAKOTA SCHOOL OF MINES AND TECHNOLOGY
DEPARTMENT OF MATERIALS & METALLURGICAL ENGINEERING

MET 320 Final Exam Dec. 16, 2008

Constants:
R = 1.987 cal/K•gmole = 8.31 J/K•gmole
F = 23,059 cal/volt•gram equivalent = 96,525 Joule/volt•gram equivalent

1. Five moles of an ideal gas at 2 atm and 500 K are adiabatically compressed to 20 atm.
   a) What is the final temperature?

   b) How much heat was required?

   c) How much work was required?

2. What is the theoretical amount of work that would be required to pump 100 Joules of heat from the outside air at -10 ^{o}F (-23 ^{o}C) into an office at 300 K?

3. An Airgas® HP-40 gas cylinder containing oxygen has a volume of 490 liters. If the pressure in the tank is 2190 psi (149 atm) at 307 K, how many moles of O_2 does it contain?

4. Consider molten cryolite (Na_3AlF_6) ***saturated*** with alumina (Al_2O_3). [Note that the activity of the oxide is then, of course, unity relative to pure, solid Al_2O_3 since it is in equilibrium with the pure solid.]

   $Al_2O_{3\,(S)} = 2Al_{(L)} + 1.5O_{2\,(G)}$

   a) What is ΔG for the reaction to form O_2 gas at a pressure of 0.21 atm and pure, liquid Al?

   b) What voltage is required to electrolyze the alumina to form O_2 gas at a pressure of 0.21 atm and pure, liquid Al?

5. How many degrees of freedom are there for a system consisting of $FeO_{(s)}$, $Fe_{(s)}$, $C_{(s)}$, $CO_{2(g)}$, $CO_{(g)}$, and $N_{2(g)}$? Complete two independent reactions below.

   $FeO + C = Fe +$ _____ $CO_2 + C =$ _____

6. Show how to find the adiabatic flame temperature for the combustion of C_2H_2 with air (21% O2 and 79% N_2). The air and the C_2H_2 start at 500 K. Use the data provided below only.

$$C_2H_2\,(g) + 2.5O_2(g) = 2CO_2\,(g) + H_2O(g)$$

Species	Heats of Formation (calories/g mole at 298°K)	C_p (cal/ gmole °K)
$C_2H_2(g)$	+ 54,190	19.0
$H_2O(g)$	- 57,800	10.5
$CO_2(g)$	- 94,000	13.6
$O_2(g)$		8.6
$N_2(g)$		7.0

7. Show and label on the attached Ellingham Diagram
   a) The pressure of O_2 in equilibrium with Ti and TiO_2 at 1000°C.
      Ans:

   b) The CO/CO_2 ratio in equilibrium with Si and SiO_2 at 1000 °C.
      Ans:

   c) The oxygen potential that C fixes at temperatures
      i) below 500 ^oC and
      ii) above 1000 ^oC.

8. For the composition marked with an ♦, find
   a) The 1st crystal to form upon cooling from the all liquid state.
      Ans:

   b) The temperature that the 1st crystal appears
      Ans:

   c) The final three crystals
      Ans:

   d) The approx percent liquid (label diagram and use algebraic notation) at 1300 ^oC.
      Ans:

Scratch Paper