

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

MET 320

Final Exam

Dec. 16, 2008

Constants:

$$R = 1.987 \text{ cal/K}\cdot\text{gmole} = 8.31 \text{ J/K}\cdot\text{gmole}$$

$$F = 23,059 \text{ cal/volt}\cdot\text{gram equivalent} = 96,525 \text{ Joule/volt}\cdot\text{gram equivalent}$$

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?

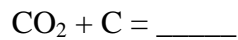
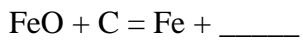
2. What is the theoretical amount of work that would be required to pump 100 Joules of heat from the outside air at -10°F (-23°C) into an office at 300 K?

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 O₂ does it contain?

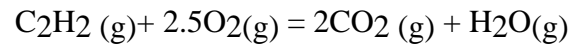
4. Consider molten cryolite (Na₃AlF₆) *saturated* with alumina (Al₂O₃). [Note that the activity of the oxide is then, of course, unity relative to pure, solid Al₂O₃ since it is in equilibrium with the pure solid.]



- a) What is ΔG for the reaction to form O₂ gas at a pressure of 0.21 atm and pure, liquid Al?
- b) What voltage is required to electrolyze the alumina to form O₂ 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.



6. Show how to find the adiabatic flame temperature for the combustion of C₂H₂ with air (21% O₂ and 79% N₂). The air and the C₂H₂ start at 500 K. Use the data provided below only.



Species	Heats of Formation (calories/g mole at 298°K)	C _p (cal/ gmole °K)
C ₂ H ₂ (g)	+ 54,190	19.0
H ₂ O(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 $1000^\circ C$.
Ans:

 - b) The CO/CO_2 ratio in equilibrium with Si and SiO_2 at $1000^\circ C$.
Ans:

 - c) The oxygen potential that C fixes at temperatures
 - i) below $500^\circ C$ and
 - ii) above $1000^\circ C$.
8. For the composition marked with an \blacklozenge , 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 $1300^\circ C$.
Ans:

Scratch Paper