**Take-home Exam III**

**Chemistry 6854**

**Physical Chemistry**

**Spring 2014**

**Alfred State College**

**Due by 4 PM Monday 12 May**

**Use the answer sheet provided and append any other work. Partial credit is awarded if substantial work is shown but answers are incorrect**

You must also schedule a time during finals week for a brief, 10-15 minute oral interview worth 25 pts wherein your base understanding of the broad, qualitative lessons of the course are evaluated**.**

**Take home Thermodynamics Exam Chem 6854 Spring 2014 (45 points)**

1. Two blocks of copper metal, A and B (Cv=specific heat = 0.385 J/K g) are initially isolated in an adiabatically sealed device. Block **A** weighs 10 grams. Block **B** weighs 5 grams. The two blocks have been prepared at two different temperatures:

TA(initial)= 500 K

TB(initial)= 1000 K

1. **Compute the final temperature, T, the two blocks will reach when they are allowed to touch assuming no other heat exchange with surroundings is allowed. (1 pt)**
2. **Compute Q, W, and ΔU for both A and B (2 pts)**
3. **Compute the total ΔS that occurs. (3 pts)**
4. Consider the set of steps carried out on a mole of monatomic ideal gas in a piston initially at a temperature = T1 =300 K (P4,V1)

Step 1: reversible expansion at constant P1 from V1🡪V2 P step 4

Step 2: reversible adiabatic compression from V2 to V3 < V1. (P2,V3)

Step 3: reversible isothermal expansion from V3 back to V2 step 3

 Step 4: reversible adiabatic compression back to (V1) step 2 (P3,V2)

Given P1 = 5 bar and V1 = 1 dm3, V2 = 10 dm3, V3 = ½ dm3 , R=8.314 J/K mol, Cv = 3R/2, Cp = 5R/2, 1 bar dm3 = 100 J:

**Compute numerical values for Qrev, Wrev, ΔUsystem for all four steps. ( 8 pts)**

 step 1

(P1,V1) (P1,V2)

 V

 **3**. An adiabatic compression of one mole of ideal monatomic gas is carried out starting from state 1:

 T1= 300 K and V1 =10 L to state 2: V2 = 5 L at T2 = 600 K. R=8.314 J /K mol T2 = 600 K

 P f

1. **Prove through calculations that the compression described**

**is irreversible. (4 pts)**

1. **Compute the total entropy change from state 1 to state 2 along path (*a+ b*) in J/K and its component ΔSa and ΔSb (5 pts)**

-path a is a reversible constant pressure compression from 10🡪 5 L

-path b is a reversible constant V heat transfer to reach T2

1. **Compute the total entropy change from state 1 to state 2 along path (c + d +e +f ) in J/K and its component ΔSc , ΔSd, ΔSe and ΔSf**

**(8 pts)**

-path c is a reversible isothermal compression from 10🡪 7.5 L at 300 K

-path d is a reversible, constant volume heat transfer from 300 to 350K at 7.5 L

-path e is a reversible, constant pressure compression from 7.5 L to 5 L starting

 from the end of path d ( causing attendant temperature loss)
-path f is a constant volume heating from the final temperature at the end of

 step e to the final temperature of 600 K.

 e

 d

 *b* c

 T1=300 K

 ***a***

 **| | | 5 7.5 10 V(L)**

**d)** Your two entropy calculations should yield finite, positive and identical values for the two pathways *(a+b*) and (c+d+e+f). **Does it make sense that:**

**1) you should have gotten identical answers for these two wildly different pathways ? (2 pts)**

**2) that the entropy of the system is positive despite being an adiabatic one ? (2 pts)**

1. The average American drinks ~ 2 cans of 12 oz soft drinks (which contain~50 g of sucrose=C12H22O11 /12 oz can) per day . **Use table 19.2, page 795 and the conversion factor 1 calorie = 4.184 J to compute the fraction of the estimated required caloric intake of 2000 kcals/day Americans get by drinking this amount of soda each day.** Assume the product of combustion is liquid water and gas phase CO2.

 (**5 pts)**

1. An inventor files application for a US patent claiming development of a heat engine which can convert 1 kg of gasoline (octane=C8H18 ) to heat stored in 400 kilograms of water initially at 25oC held in a well-insulated reservoir. The energy reservoir is used to operate an engine between the hot water temperature and room temperature (298K) . The inventor claims a maximum efficiency of 25% given these design parameters. Assume the water’s heat capacity = 4.184 J/K g and that the heat from octane comes from the combustion reaction: 2C8H18(l) + 25 O2(g)🡪16CO2(g) + 18H2O(l)

**Assuming you might have to defend your decision (as presiding patent clerk) to deny or approve the patent application, provide detailed quantitative arguments for what you decide. (6 pts)**