Chemistry 456
First Exam
February 4, 2002

Constants and conversion factors that you *may* need

$R = 8.314\ J\ K^{-1}\ mol^{-1}$

$R = 8.21 \times 10^{-2}\ L\ atm\ K^{-1}\ mol^{-1}$

$R = 62.364\ L\ Torr\ K^{-1}\ mol^{-1}$

$1\ atm = 101.325 \times 10^{3}\ Pa$

$k = 1.381 \times 10^{-23}\ J\ K^{-1}$

$1\ L = 10^{-3}\ m^{3}$

NOTE: You must show your work to receive credit!

1) 1.00 mol of an ideal gas with $C_{v,m}=3/2R$ is compressed adiabatically with a constant external pressure of 1.00×10^6 Pa. Initially, the gas is at 27°C and 0.10×10^6 Pa. The final pressure is 1.00×10^6 Pa.

a) Calculate the final temperature of the gas

b) Calculate Q.

c) Calculate W.

d) Calculate ΔU.

e) Calculate ΔH.

2) You are given the following data at 25°C:

Substance	Fe(s)	$FeS_2(s)$	$Fe_2O_3(s)$	S(s)	$SO_2(g)$
ΔH_f° /(kJ/mol)	0	?	-824.2	0	-296.81
$C_{p,m}/R$	3.02	7.48		2.72	

You are also given that ΔH° is –1655 kJ/mol at 25°C for the reaction $2FeS_2(s) + 11/2\ O_2(g) \rightarrow Fe_2O_3(s) + 4SO_2(g)$. From this information, calculate ΔH_f^0 of $FeS_2(s)$ at 300°C.

3) The standard enthalpy of fusion of NH_3 at a standard pressure of 1.00 bar is $\Delta_{fus}H^0$ and the temperature of this transition at a standard pressure of 1.00 bar is T_{fus}. The molar heat capacities of the solid and liquid are $C_{p,s}$ and $C_{p,l}$. You wish to determine ΔS, ΔS_{surr}, and ΔS_{total}, for the process

$$NH_3(s) \rightarrow NH_3(l)$$

At a temperature $T_2 < T_{fus}$.

a) Because this process is not reversible, you need to come up with a reversible pathway involving the transition at T_{fus} in order to calculate ΔS. This pathway must originate at $NH_3(s, T_2)$ and end at $NH_3(l, T_2)$. Indicate such a pathway below.

b) Set up an expression for ΔS for each segment of the pathway of part a) in terms of $\Delta_{fus}H^0$, $C_{p,s}$, $C_{p,l}$, T_2, and T_{fus}. Obtain an expression for ΔS using your results.

c) Set up an expression for ΔS_{surr} for the transformation being considered in terms of $\Delta_{fus}H^0$, $C_{p,s}$, $C_{p,l}$, T_2, and T_{fus}.

d) Do you expect that ΔS_{total} will be positive or negative? Why?

4) Give brief responses to the four statements below, indicating whether the statement is correct or not and why, or answer the question asked.

a) Because both ΔU and ΔS are state functions, $\Delta U_{total} = \Delta U_{system} + \Delta U_{surroundings}$ and $\Delta S_{total} = \Delta S_{system} + \Delta S_{surroundings}$ are zero in any change occurring in the system.

b) What quantitities $\left(\frac{\partial U}{\partial x}\right)_y$ and $\left(\frac{\partial H}{\partial x}\right)_y$ are zero for an ideal gas, resulting in the fact that $dH = C_p dT$ and $dU = C_v dT$ are functions of temperature only? You are asked to identify x and y in each expression.

c) For an adiabatic change, ΔS_{system} and $\Delta S_{surroundings}$ are both zero.

d) ΔU and ΔH are never identical for a chemical reaction involving only gaseous species.