Name ______________________

Please put answers within
boxes provided.

Chemistry 342

October 23, 1998
Second Exam

1 J = 1 kg m^2 s^{-2} k_B = 1.38066×10^{-23} J K^{-1} $R = N_{Avogadro}k_B$

R = 8.31441 J mol^{-1} K^{-1} =1.98718 cal mol^{-1} K^{-1} = 0.082057 L atm mol^{-1} K^{-1}

$C_p - C_V = \{ p + (\partial U/\partial V)_T \}(\partial V/\partial T)_p$

$(\partial \mathbf{U}/\partial V)_T = T(\partial p/\partial T)_V - p$ $(\partial \mathbf{H}/\partial p)_T = - T(\partial V/\partial T)_p + V$

$\mu_{JT} = (\partial T/\partial p)_H$ $(\partial H/\partial p)_T = - C_p \mu_{JT}$

monatomic gas molar heat capacity: $C_V = (3/2)R$

1. Consider the following cycle using 1 mole of an ideal gas, initially at 25°C and 1 atm pressure.

Step (1) Isothermal expansion against zero pressure to double the volume (Joule expansion).

Step (2) Isothermal, reversible compression from 1/2 atm to 1 atm.

(a) Calculate the value of $\oint \eth q/T$.

(b) Calculate $\Delta \boldsymbol{S}$ for Step (2)

(c) Calculate $\Delta \boldsymbol{S}$ for Step (1)

2. Given the following data for benzene, C_6H_6:
At the normal boiling point, 80.1°C , $\Delta_{\text{vap}}\boldsymbol{H}$ is 7.353 kcal mol^{-1} , and
C_p for the liquid is 31 cal mol^{-1} K^{-1}
C_p for the vapor is $-0.409 + 77.621\times10^{-3}\,T - 264.29\times10^{-7}\,T^2$ cal mol^{-1} K^{-1}

Assume that benzene vapor behaves ideally. Calculate $\Delta\boldsymbol{S}$ for the process:
C_6H_6 (liq, 82.1°C, 1 atm) → C_6H_6 (g, 82.1°C, 0.5 atm)

continue **2.** here

3. (a) Derive $(\partial \boldsymbol{S}/\partial p)_T$ for an ideal gas by making use of the First and Second Law and the fact that $\mathrm{d}\boldsymbol{G}$ is an exact differential.

(b) One mole of liquid water (density = 1 g/mL) is allowed to expand into an evacuated flask of volume such that the final pressure is 0.3 atm. The bulb containing the liquid and the flask are thermostated so that a constant temperature of 100 °C is maintained. It is found that 11,000 cal of heat are absorbed when this process occurs. Calculate the values for $\Delta \boldsymbol{U}$, $\Delta \boldsymbol{H}$, $\Delta \boldsymbol{S}$, and $\Delta \boldsymbol{G}$. Assume vapor is ideal.

$\Delta \boldsymbol{U}$

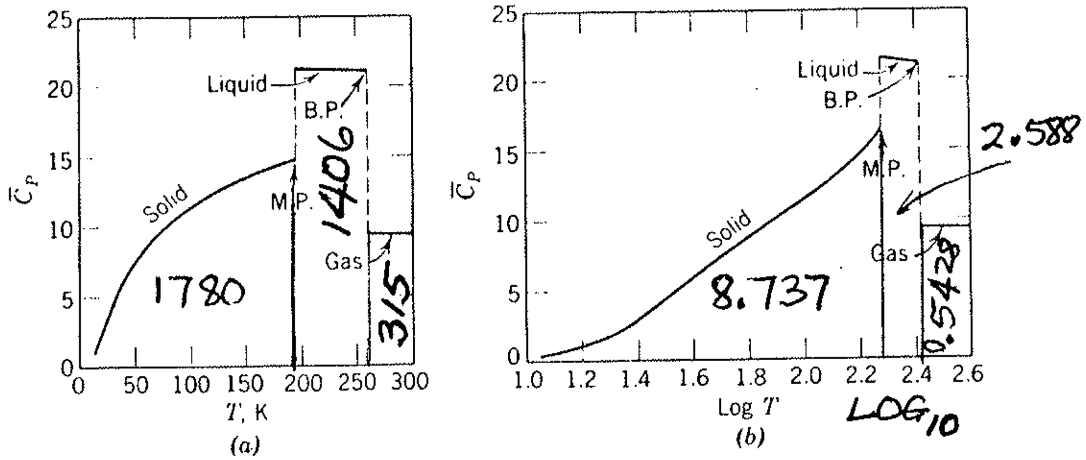
ΔH

ΔS

Δ***S*** continue here

Δ***G***

4. The heat capacity of sulfur dioxide at a constant pressure of 1 atm at different temperatures is shown below. At 15 K the heat capacity at constant pressure of $SO_2(s)$ is 0.90 cal mol^{-1} K^{-1}. Solid SO_2 melts at 197.64 K, $\Delta_{fus}H$ is 1769 cal mol^{-1}. At this pressure, liquid SO_2 vaporizes at 263.08 K and the $\Delta_{vap}H$ is 5960 cal mol^{-1}. The heat capacity of SO_2 gas between 300 K and 1500 K is $\{6.15 + 13.8\times10^{-3}\ T - 91.0\times10^{-7}\ T^2 + 2.06\times10^{-9}\ T^3\}$ cal $mol^{-1}K^{-1}$. Calculate the molar entropy value for SO_2 gas at 298.1 K.



Areas underneath the curves from 15 K to 298.1 K are given.

Heat capacity in cal K^{-1} mol^{-1} of sulfur dioxide at a constant pressure of 1 atm at different temperatures.

4. continue here

5. Two moles of a gas whose equation of state is $pV = RT + ap$ where $a = 0.020 \text{ L mol}^{-1}$ at 300 K, 0.025 L mol^{-1} at 400 K, 0.030 L mol^{-1} at 500 K, undergoes isothermal compression at 300 K from 1 atm to 11 atm. Calculate ΔU, ΔG, ΔS, ΔA, and ΔH for the gas. First, derive the expressions that are appropriate for this ***non-ideal*** equation of state.

In this space, derive the expressions that are appropriate for this ***non-ideal*** equation of state, that you will need in the calculations of the changes in thermodynamic quantities.

continue here derivations, as needed

$\Delta \boldsymbol{U}$

ΔG

ΔS

ΔA

ΔH