

Worksheet 5

CHEM 401

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1. Standard molar entropy of $\text{Cl}_2(\text{g})$ at 298 K is 223.066 J/(mol K). Determine its value at 1500 K given that

a. $C_{P,m}^\theta = 33.91 \text{ J}/(\text{mol K})$

b. $C_{P,m}^\theta \left(\frac{\text{J}}{\text{mol K}} \right) = 31.284 + 10.144 \times 10^{-3}T - 40.38 \times 10^{-7}T^2$

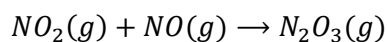
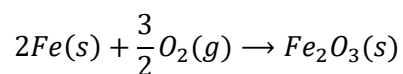
2. Determine Standard molar entropy of Cl_2 at 1500 K and 0.500 bar. Use the data from part b of problem 1. (Hint: Think of it as a composite process)

3. For an unknown substance (X_2) the following data is reported at 298 K.

$C_{P,m}^\theta(X_2, l)$ J/(mol K)	$S_m^\theta(X_2, l)$ J/(mol K)	$C_{P,m}^\theta(X_2, g)$ J/(mol K)	T_b K	$\Delta_{vap}H^\theta$ kJ/mol
75.488	152.231	36.190	332.503	29.563

Calculate standard molar entropy for $X_2(g)$ at 298 K.

4. For each of the following reactions use the data in tables 2.C4 and 2.C5 to calculate $\Delta_r S^\theta$, $\Delta_r H^\theta$ and $\Delta_r G^\theta$. Use both $\Delta_f G^\theta$ and $\Delta_r S^\theta$, $\Delta_r H^\theta$ to calculate $\Delta_r G^\theta$ and compare your results. (Hint: Please refer to similar problems done in class) Which reaction is spontaneous? Under what conditions (Low T, high T, always, never) these reactions will be spontaneous?



(for N_2O_3 $\Delta_f H^\theta = 83.72$ kJ/mol, $\Delta_f G^\theta = 139.41 \frac{kJ}{mol}$, $S_m^\theta = 312.17$ J/(mol K))

5. The molar heat capacity of 1-butane can be expressed as

$$\frac{C_{p,m}}{R} = 0.05641 + 0.04635 K^{-1}T - 2.395 \times 10^{-5} K^{-2}T^2 + 4.80 \times 10^{-9} K^{-3}T^3$$

Over the temperature range $300 \text{ K} < T < 1500 \text{ K}$. Calculate the change in entropy when one mole of 1-butane is heated from 300 K to 1000 K at constant pressure.

6. a. Think of the internal energy (U) as a function of T (temperature) and V (volume). Write dU in terms of dV and dT.

b. Think of the internal energy as a function of S (entropy) and V (volume). Write dU in terms of dV and dS.

c. Show that for one mole of a perfect gas,

$$dS_m = C_{v,m} \frac{dT}{T} + R \frac{dV_m}{V_m}$$

7. Enthalpy is defined as $H = U + PV$.

a. Use this equation to derive $dH = TdS + Vdp$

b. Show that for one mole of a perfect gas, $dS_m = C_{p,m} \frac{dT}{T} - \frac{R}{P} dP$

8. Suppose that 2.5 mmol of $N_2(g)$ occupies 42 cm^3 at 300 K and expands isothermally to 600 cm^3 . Calculate the ΔG for the process (assuming that N_2 is a perfect gas).

9. For a given constant pressure process, the Gibbs energy variation was found to be

$$\Delta G(J) = -85.40 + 36.5(T/K)$$

Calculate the value of ΔS for this process.

10. What is the change in the molar Gibbs energy as the pressure of 1.00 dm³ of a liquid increases from 1.0 atm to 100 atm? The density of the liquid is 0.703 g cm⁻³ and its molecular mass is 114.23 g mol⁻¹.

11. Calculate the change in molar Gibbs energy of a perfect gas as its pressure is increased isothermally from 1.0 atm to 100 atm at 298K.

12. Consider the two equations of states for two gases. Use Maxwell relations to calculate $\left(\frac{\partial S}{\partial V}\right)_T$

a. $p = \frac{RT}{V_m - b} - \frac{a}{V_m^2}$ (van der Waals, a and b are constant)

b. $p = \frac{RTe^{-a/(RTV_m)}}{V_m - b}$ (a and b are constant)

13. Use the equation $dH = TdS + Vdp$ to derive the Maxwell relation: $\left(\frac{\partial T}{\partial p}\right)_s = \left(\frac{\partial V}{\partial S}\right)_p$

(Practice at home: check table 3D.1 and derive the Maxwell relations from each of the exact differential listed)