

Chemistry 456A
Final Exam
March 20, 2002

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Constants and conversion factors that you *may* need

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

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

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

$$1 \text{ atm} = 760 \text{ Torr} = 101.325 \times 10^3 \text{ Pa}$$

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

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

NOTE: You must show your work to receive credit!

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1) Consider the reaction $\text{N}_2(\text{g}) + 3\text{H}_2(\text{g}) \rightarrow 2\text{NH}_3(\text{g})$. At 1000 K, $\Delta H^\circ = -123.77 \text{ kJ mol}^{-1}$. Given the heat capacity data below, calculate ΔH_f° for $\text{NH}_3(\text{g})$ at 300K.

Substance	N_2	H_2	NH_3
$C_{p,m}/R$	3.502	3.466	4.217

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2) A sample of 4.0 mol of an ideal gas is originally confined to a volume of 20L at 270 K. It undergoes an adiabatic expansion against a constant pressure of 600 Torr until the volume has tripled. $C_{v,m} = 5/2 R$. Calculate q , w , ΔT , ΔU , ΔH , ΔS , ΔS_{surr} , and ΔS_{total} .

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3) The density of diamond is 3.52 g/cm^3 and that of graphite is 2.25 g/cm^3 . At 25° C , the Gibbs energy of formation of diamond from graphite is 2.900 kJ/mol . What pressure must be applied to bring diamond and graphite into equilibrium at 25° C ?

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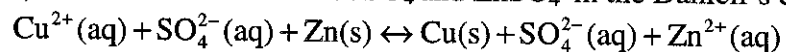
4) At 25° C, $\Delta G^0 = 161.67$ kJ/mol for the reaction $\text{Br}_2(\text{g}) \leftrightarrow 2\text{Br}(\text{g})$.

a) Calculate K_p at 25° C.

b) Assume that initially, 1.00 mol of $\text{Br}_2(\text{g})$ is introduced into the reaction vessel and no $\text{Br}(\text{g})$ is present. Obtain an expression for ξ , the extent of reaction, in terms of the total pressure P , and K_p .

c) Using your result to part b), calculate ξ at 25° C and a total pressure of 10 atm.

5) The reaction between CuSO_4 and ZnSO_4 in the Daniell's cell is



$\Delta_r G^\circ = -212.7 \text{ kJ}$ for this reaction at 25° C. The concentrations are given by $b(\text{CuSO}_4) = 1.0 \times 10^{-3} \text{ molal}$ and $b(\text{ZnSO}_4) = 3.0 \times 10^{-3} \text{ molal}$. Note that the sulfate ion concentration in the two half-cells differs.

a) Calculate the ionic strength in each of the half-cell solutions.

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b) Calculate the mean activity coefficient in each of the half-cell solutions using the Debye-Huckel limiting law.

c) Calculate the reaction quotient

d) Calculate the standard cell potential

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e) Calculate the cell potential for the molalities given above

6) Give brief responses to the following questions or statements.

a) Explain why $C_{p,m} - C_{v,m}$ is much larger for a gas than for a liquid.