Chem 1515.001 - 006	Name
Problem Set #1	TA's Name
Spring 2002	

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ALL work must be shown to receive full credit. **Due in lecture, at 8:30 a.m. on Friday, January 25, 2002.**

- PS1.1. Using the table of thermodynamic values found in Appendix B in your textbook, calculate the ΔH°_{rxn} (standard enthalpy change) for each of the following reactions: a) $3NO(g) \rightarrow N_2O(g) + NO_2(g)$
 - b) $C_6H_{12}O_6(s) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(l)$
 - c) $HCN(aq) + NaOH(aq) \rightarrow NaCN(aq) + H_2O(l)$ NOTE: HCN does not completely dissociate, it is a weak acid.
- PS1.2. For each of the following pairs, indicate which substance you would expect to possess the larger standard entropy. In each case provide a short explanation.a) 1 mol CH₃OH(g) at 373 K and 1 atm or 1 mol CH₃OH(l) at 373 K and 1 atm.
 - b) 1 mol Na₂SO₄(aq) at 23 °C or 1 mol Na₂SO₄(s) at 23 °C.
 - c) $1 \mod N_2(g)$ at 10 °C and 1 atm or 1 mol $N_2(g)$ at 10 °C and 10 atm.
 - d) 1 mol He(g) at 25 °C and 1 atm or 1 mol C₂Cl₆(g) at 25 °C and 1 atm

- PS1.3. Predict whether the entropy change in the system is positive or negative for each of the following processes: (Note: do not do any calculations.)
 a) 8H₂S(g) + 4O₂(g) → S₈(s) + 8H₂O(g)
 - b) $2\mathbf{K}(s) + \mathbf{F}_2(g) \rightarrow 2\mathbf{K}\mathbf{F}(s)$
 - c) $CaCO_3(s) + 2HCl(aq) \rightarrow 2CaCl_2(aq) + CO_2(g) + H_2O(l)$
 - d) $N_2(g) + O_2(g) \rightarrow 2NO(g)$
- PS1.4. For each reaction below, use the table of thermodynamic values from Appendix B in your textbook to determine the values of ΔH° and ΔS° . a) $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$

b)
$$6CO_2(g) + 6H_2O(l) \rightarrow C_6H_{12}O_6(s) + 6O_2(g)$$

c) $\operatorname{Br}_2(g) \to \operatorname{Br}_2(l)$

d) $2H_2O_2(l) \rightarrow 2H_2O(l) + O_2(g)$

e) $HCl(g) + NH_3(g) \rightarrow NH_4Cl(s)$

PS1.5. a) Calculate ΔG° for each of the reactions in problem PS1.4.

- b) Which of the reactions in PS1.4 are spontaneous at 298 K?
- c) For each of the reactions listed in b), find the temperature above or below which the reaction becomes nonspontaneous.

- d) Which of the reactions in PS1.4 are nonspontaneous at 298 K?
- e) For each of the reactions listed in d), find the temperature above or below which the reaction becomes spontaneous.

PS1.6. Ethanol could be synthesized using either of the following reactions; $C_2H_4(g) + H_2O(g) \rightarrow CH_3CH_2OH(l)$ $C_2H_6(g) + H_2O(g) \rightarrow CH_3CH_2OH(l) + H_2(g)$

Using thermodynamics arguments which reaction is more feasible under standard conditions? Explain.

PS1.7. When liquid water is introduced into an evacuated vessel at 25 °C, some of the water vaporizes. Predict how the enthalpy, entropy, and free energy change in the system during this process. Explain the reasoning behind your predictions.

PS1.8. Consider the reaction represented below, which is spontaneous at 298 K.

$$\operatorname{CO}_2(g) + 2\operatorname{NH}_3(g) \rightarrow \operatorname{CO}(\operatorname{NH}_2)_2(s) + \operatorname{H}_2\operatorname{O}(l) \qquad \Delta \operatorname{H}^\circ = -134 \text{ kJ}$$

a) For the reaction, indicate whether the standard entropy change, ΔS°_{rxn} is positive, negative or zero. Justify your answer. (NOTE: do not use a calculation to justify your answer.)

b) Which factor, the change in enthalpy, ΔH° , or the change in entropy, ΔS° , provides the principal driving force for the reaction at 298 K? Explain.

c) For the reaction, how is the value of the standard free energy change, ΔG° , affected by an increase in temperature? Explain.

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$\Delta H^{\circ} f\left(\frac{kJ}{mol}\right)$	$S^{\circ}\left(\frac{J}{\text{mol}\cdot K}\right)$	
0	5.69	
-393.5	213.6	
0	130.6	
-285.8	69.96	
0	205	
?	120.1	
	$\Delta H^{\circ} f\left(\frac{kJ}{mol}\right)$ 0 -393.5 0 -285.8 0 $?$	$\Delta H^{\circ}_{f} \left(\frac{kJ}{mol} \right) \qquad S^{\circ} \left(\frac{J}{mol \cdot K} \right) \\ \begin{array}{c} 0 & 5.69 \\ -393.5 & 213.6 \\ 0 & 130.6 \\ -285.8 & 69.96 \\ 0 & 205 \\ ? & 120.1 \end{array}$

PS1.9. The enthalpy of combustion, ΔH°_{comb} , for oxalic acid, $C_2H_2O_4(s)$, is -246.05 kJ·mol⁻¹ and

a) Write the balanced chemical equation that describes the combustion of one mole of oxalic acid.

b) Write the balanced chemical equation that describes the standard formation of oxalic acid.

c) Using the information given above and the equations in a) and b), calculate ΔH°_{f} for oxalic acid.

d) Calculate ΔS_{f}° for oxalic acid and ΔS_{rxn}° for the combustion of one mole of oxalic acid.

e) Calculate ΔG°_{f} for oxalic acid and ΔG°_{rxn} for the combustion of one mole of oxalic acid.

f) Is the formation of oxalic acid from its elements spontaneous? Is the combustion of oxalic acid at 25 $^\circ C$ spontaneous?