Chem 1515 Section 9 - 15
Problem Set #1
Spring 2015

Name_____

TA's Name _____

Sec _____

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 $CH_3OH(g)$ at 373 K and 1 atm or 1 mol $CH_3OH(l)$ at 373 K and 1 atm.

b) 1 mol $Na_2SO_4(aq)$ at 23 ˚C or 1 mol $Na_2SO_4(s)$ at 23 ˚C.

c) 1 mol $N_2(g)$ 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 $C_2Cl_6(g)$ 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) $8H_2S(g) + 4O_2(g) \rightarrow S_8(s) + 8H_2O(g)$

b) $2K(s) + F_2(g) \rightarrow 2KF(s)$

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) $Br_{2(g)} \rightarrow Br_{2(l)}$

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.

$$CO_{2(g)} + 2NH_{3(g)} \rightarrow CO(NH_2)_{2(s)} + H_2O_{(l)} \qquad \Delta H^\circ = -134 \text{ kJ mol}^{-1}$$

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.

PS1.9. The enthalpy of combustion, ΔH°_{comb}, for oxalic acid, $C_2H_2O_{4(s)}$, is -246.05 kJ·mol^{-1} and

Substance	$\Delta H^\circ_f\left(\frac{kJ}{mol}\right)$	$S^\circ\left(\frac{J}{mol \cdot K}\right)$
$C_{(s)}$	0	5.69
$CO_{2(g)}$	-393.5	213.6
$H_{2(g)}$	0	130.6
$H_2O_{(l)}$	-285.8	69.96
$O_{2(g)}$	0	205
$C_2H_2O_{4(s)}$	?	120.1

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

b) Write the balanced chemical equation which 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 thermodynamically favored? Is the combustion of oxalic acid at 25 °C thermodynamically favored?