Review Problems for Exam 1

This review sheet contains problems to help you prepare for the first hour exam, which will be given on Friday, February 16. In writing the exam, we assume you have done these problems and understand the solutions. However, this review sheet is not comprehensive. You should also review the lecture notes, assigned textbook reading, and assigned homework problems.

In all of these questions, thermodynamic variables without subscripts (H, S, G, etc.) refer to the system. Subscripts (S_{surr}, S_{univ}) will be used to indicate values for the surroundings and universe.

The first 9 problems involve calculations. The remainder are concept questions.

1) Determine ΔH_f^o of ethanol (C_2H_5OH) from its standard enthalpy of combustion (-1367.4 kJ/ mol to produce $CO_2(g)$ and $H_2O(l)$). [ΔH_f^o ($CO_2(g)$) = -393.51kJ/mol, ΔH_f^o ($H_2O(l)$) = -285.83kJ/mol]

2) When a 4.50g sample of NH_4NO_3 is dissolved in 80.0g of water, the temperature drops from 22.0°C to 17.7°C. Calculate ΔH (in kJ/mole) for the solution process,
$NH_4NO_3(s)$ ---> NH_4^+ (aq) + NO_3^- (aq)
Assume that the solution does not exchange heat with its surroundings, and that the heat capacity of the solution is the same as that of pure water [1.00 cal/ (g °C)]. Mol Wt (NH_4NO_3) = 80.0 g/mol

3) Consider dissolving solid Lithium Iodide (LiI) in water:

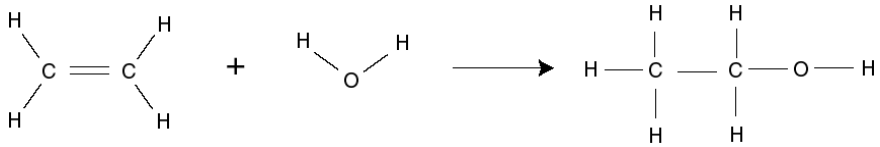
$$LiI_{(s)} \rightarrow Li^+_{(aq)} + I^-_{(aq)}$$

a) What is ΔH^o for this reaction? (Please use the chemical data in Appendix D)
b) 5.00 g of LiI is dissolved in 50ml of water. Before mixing, both the salt and the water are at 25°C. What is the temperature of the water after the LiI dissolves? (Assume that there is no heat exchanged with the surroundings.)

4) Before the invention of polymer fillings, dentists used amalgams of mercury and silver to fill cavities. You would like the amalgam to have a temperature of 37°C, so it doesn't hurt the patient when you put it in the cavity. You start with 1.20g of silver at 100.0°C. The mercury is initially at 25°C. How many grams of mercury must you mix with the silver to get a final temperature for the amalgam of 37°C? (The heat capacity of silver is 0.139J/(g K), and that of mercury is 0.235 J/(g K).)

5) Using the table of enthalpies of atomization and bond enthalpies in the textbook, please estimate ΔH for the following reaction:

$C_2H_{4\,(g)}$ + $H_2O\,(g)$ → $CH_3CH_2OH_{\,(g)}$



6) Consider vaporizing 60.0g of liquid nitrogen at its boiling point of -196°C. What is the entropy for this process (in kJ/mole K)?

7) Consider the following reaction:

$$H_2\,(g) + \tfrac{1}{2}\,O_2\,(g) \rightarrow H_2O\,(g)$$

a) Use Table 7.3 (average bond enthalpies) to estimate ΔH for this reaction.
b) Use Appendix D to calculate ΔH and ΔS for this reaction.
c) Is this reaction spontaneous at 25°C?
d) Does this reaction become more or less spontaneous when the temperature is increased?
e) Is this reaction enthalpy driven, entropy driven, driven by both enthalpy and entropy, or driven by neither?
f) For what range of temperatures (if any) is this reaction non-spontaneous?
g) A 1.00 liter vessel contains 0.0100 atm of H_2 (g) and 0.00500 atm of O_2 (g) and 10.0atm of Argon. The container is sealed such that its volume is fixed at 1.00 liter and insulated such that that the gas does not exchange heat with the walls of the vessel or with the surroundings. The initial temperature is 25.0°C. The reaction shown above then occurs and goes to completion. What is the final temperature? (You can assume the heat capacity of the gas is that appropriate for a monatomic ideal gas.)

8) Consider the following reaction occurring in water,

$$A_{(aq)} + 2\,B_{(aq)} \leftrightarrow C_{(aq)}$$

a) At 25°C, a system is allowed to equilibrate and the concentrations of the species are measured to be [A] = 0.10 M, [B] = 0.30 M, [C]=0.20 M. What is ΔG for the reaction written above?
b) You prepare a solution at 25°C and measure the concentrations [A] = 0.15 M, [B] = 0.27 M, [C]=0.18 M. Is this solution at equilibrium? If not, to reach equilibrium will the above reaction proceed to the left or to the right?
c)

9) Hemoglobin binds oxygen in the blood and carries it to the tissues. However, Hemoglobin can also bind carbon monoxide (CO) and it binds CO more tightly than oxygen. If you get too much CO in your blood, you can die. In this problem, you will calculate the relative amount of CO that must be present for half of your Hemoglobin to be bound to CO instead of O_2. Given the following equilibrium constants:

$$Hb_{(aq)} + O_{2\,(aq)} \leftrightarrow Hb(O_2)_{(aq)} \qquad K_{O2} = 100$$

$$Hb_{(aq)} + CO_{(aq)} \leftrightarrow Hb(CO)_{(aq)} \qquad K_{CO} = 500$$

At what ratio of $[O_2]/[CO]$ will the concentrations of $[Hb(O_2)]$ and $[Hb(CO)]$ be equal?

10) Consider a monatomic ideal gas stored in an insulated container (such that it can not exchange heat with the surroundings). Initially, the temperature is 25°C and the volume is 1 liter. If the gas is then compressed to 0.5 liter, what happens to the temperature of the gas?
a) It increases b) It decreases c) It remains the same

11) In class, we demonstrated the following reaction.

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

When the NH_3(g) and HCl (g) were mixed together, NH_4Cl (s) powder was formed and the container got hot.
What is the sign of ΔH for this reaction?
What is the sign of the ΔS for this reaction?

12) Many homes in Pittsburgh are heated by burning natural gas (methane = CH_4) , to give $CO_{2(g)}$ and $H_2O_{(l)}$. Without using Appendix D, what are the signs of ΔH and ΔS for this combustion reaction? Suppose that instead of producing $H_2O_{(l)}$, the reaction produced $H_2O_{(g)}$. What would happen to the magnitude of ΔH for the combustion reaction? What would happen to the sign of ΔS?

13) For which of the the following two reactions:

A) H_2 (g) + 1/2 O_2 (g) ---> H_2O (l)

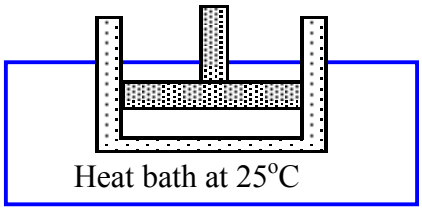
B) H_2 (g) + 1/2 O_2 (g) ---> H_2O (g)

Do you expect there to be a bigger difference between ΔE and ΔH?

14) The gas in the cylinder at the right is expanding, and absorbing heat from the surrounding heat bath. If the process is done irreversibly, is the heat absorbed from the bath

a) more than b) less than c) equal to

the heat absorbed for the corresponding reversible process.



15) The heat involved in a constant pressure process is equal to:

a) ΔH b) ΔT c) ΔE d) ΔS e) C_p

16) Sulfur dioxide (SO_2) is used as a preservative, a bleaching agent, and in the paper industry. Consider the following reactions and their corresponding ΔG's ,

$SO_2(g) + 1/2\ O_2(g) \rightarrow SO_3(g)$ ΔG_1 K_1

$2SO_3(g) \rightarrow 2SO_2(g) + O_2(g)$ ΔG_2 K_2

What is the relationship between ΔG_1 and ΔG_2.

What is the relationship between K_1 and K_2.

17) For which of the following substances does ΔH^o_f=0 (circle all that apply) ?

a) $Br_2(g)$ b) N(g) c) C(g) d) CO(g) e) Ne(g)

18) A traveler goes from Pittsburgh, PA to Aspen, CO. Which of the following is a state function of the trip:

a) distrance travelled b) elapsed time c) altitute change

d) work done to move the vehicle e) none of the items listed