Unit 5 Practice Problems (with answers at end)

> I use not only the brains I have, but all I can borrow.
> --Woodrow Wilson

Bonding

1. Define a chemical bond in general terms.

2. When a bond is formed between two atoms, what generally happens to the electron configurations of the atoms?

3. Show the electron dot diagrams for the following covalent compounds or ions:
a. PH_3 b. H_2S c. $SiCl_4$ d. HBr e. SF_2 f. ClO^-

Bond Energies

4. Use bond energy values found in your text book to estimate ΔH for each of the following reactions in the gas phase:

a. $H_2 + Cl_2 \rightarrow 2\ HCl$
b. $N_2 + 3\ H_2 \rightarrow 2\ NH_3$ (N_2 is N≡N)
c. $H_2 + S \rightarrow H_2S$
d. $CH_3OH + HBr \rightarrow H_2O + CH_3Br$ (C-Br is 276 kJ)

Hess' Law

5. Given the following reactions:

$S(s) + O_2(g) \rightarrow SO_2(g)$ ΔH = -297 kJ/mol

$SO_2(g) + \frac{1}{2}\ O_2(g) \rightarrow SO_3(g)$ ΔH = -141 kJ/mol

calculate the ΔH for the reaction:

$S(s) + {}^3/_2 O_2(g) \rightarrow SO_3(g)$

6. "Water gas" is an industrial fuel composed of a mixture of carbon monoxide and hydrogen gases. When this fuel is burned, carbon dioxide and water result. From the information given below, write a balanced equation and determine the enthalpy of this reaction:

$CO(g) + \frac{1}{2}\ O_2(g) \rightarrow CO_2(g) + 282.8\ kJ$

$H_2(g) + \frac{1}{2}\ O_2(g) \rightarrow H_2O(g) + 241.8\ kJ$

7. To produce the original "water gas" mixture, carbon (in a combustible form known as *coke*) is reacted with steam:

$131.4\ kJ + H_2O(g) + C(s) \rightarrow CO(g) + H_2(g)$

From this information and the equations in the previous problem, calculate the enthalpy for the combustion of carbon to form carbon dioxide.

Calorimetry

8. Sodium hydroxide and hydrochloric acid react in a 1:1 ratio. If 20.0 g of solid NaOH are added to 1000 mL of a solution containing 0.500 moles of HCl, the temperature of the solution rises 6.9°C. Assuming that the total solution mass is 1000 g and the specific heat of the solution is 4.184 J/g°C, calculate the heat released by this reaction. Then calculate ΔH_{rxn} (i.e., the heat released *per mole* of NaOH).

9. When 15.3 g of sodium nitrate, $NaNO_3$,was dissolved in water in a calorimeter, the temperature fell from 25.00°C to 21.56°C. If the heat capacity of the solution plus the calorimeter is 1071 J/°C, what is the enthalpy change when one mole of $NaNO_3$ dissolves?

Calculating ΔH_{rxn} and stoichiometry

10. Calculate the enthalpy change for the reaction given below, using thermodynamic tables in your book (Appendix 3):

$C_2H_4(g) + O_2(g) \rightarrow H_2O(g) + CO_2(g)$
(not balanced)

11. When 1.14 g of S is burned to give SO_2, 10.3 kJ is released. From this information write the balanced equation, inserting the ΔH value (per mole) on the proper side of the equation.

12. ΔH^o_f for CO_2 is -393.5 kJ/mol. Calculate the heat released by the burning of 0.327 g of carbon to form carbon dioxide.

I'm opposed to millionaires, but it would be dangerous to offer me the position.
--Mark Twain

Entropy and spontaneity

13. Give the signs you would expect for ΔG, ΔH, and ΔS for each of the following:
 a. electrolysis of water to give gaseous hydrogen and oxygen
 b. dissolving a small amount of sodium nitrate in water (the solution becomes cold)
 c. melting ice on a highway by adding salt

The Gibbs-Helmholz equation

14. Calculate ΔG^o for the reaction: $CH_4(g) + O_2(g) \rightarrow CO_2(g) + H_2O(\ell)$,(not balanced) using Appendix 2 . Is this reaction spontaneous at room temperature?

15. Calculate ΔS^o for the reaction above. What does this value suggest? Why is the sign what it is?

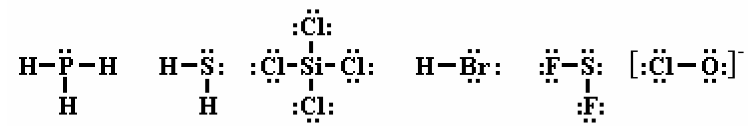
16. Assuming the temperature is 25°C, calculate ΔH^o for the reaction above, using the results in the previous problems. Since the entropy decreases for the system, how can you account for the fact that the reaction is spontaneous at this temperature?

Calculate the equilibrium temperature for this same reaction.

Under what temperature conditions will this reaction occur?

<u>Answers:</u>

1. a bond results from the simultaneous attraction of the electrons of one atom for two nuclei
2. they become noble gas configurations



3.
4. -185 kJ, -107.4 kJ, -300 kJ, -19 kJ
5. -438 kJ
6. $CO + H_2 + O_2 \rightarrow CO_2 + H_2O$; ΔH = -524.6 kJ
7. ΔH = -393.2 kJ
8. 29 kJ, -58 kJ/mol
9. +20.5 kJ/mol
10. ΔH_{rxn} = -1322.9 kJ
11. $S + O_2 \rightarrow SO_2$ + 290 kJ
12. -10.7 kJ or simply 10.7 kJ
13. in the order requested: (a) +,+,+ (b) -,+,+ (c) -,+,+
14. -818 kJ, yes
15. -242.8 J/K, it suggests that ΔH must be very large to offset the large decrease in entropy; the sign is negative mostly because 3 moles of gas are replaced by 1 mole of gas and 2 moles of liquid
16. -890 kJ; the large decrease in enthalpy releases significant heat to the surroundings so that the net entropy change in the universe is positive--the requirement for spontaneity
3670 K, less than 3670 K