AP Chemistry

Exercise 8.8

Bond Energy & Enthalpy

Name: _____

Date: _____ Per: _____

Bond energy is defined as the amount of energy required to break a bond. These values are positive, indicating that bond breaking is endothermic. Bond energies are reported in kilojoules per mole (kJ/mol). The energy for breaking a hydrogen-hydrogen bond is 432 kJ/mol so when a hydrogen-hydrogen bond is formed the process releases 432 kJ/mol.

In a chemical reaction several bonds are broken and formed. For example, in the reaction below a hydrogen-hydrogen bond is broken and a fluorine-fluorine bond is broken. Two hydrogen-fluorine bonds are formed. The overall energy change for this process is calculated below.

$$H_2(g) + F_2(g) \rightarrow 2HF(g)$$

$$\Delta H_{rxn} = [\text{energy used to break bonds}] - [\text{energy released when bonds form}]$$

$$\Delta H_{rxn} = [432 \text{ kJ/mol} + 154 \text{ kJ/mol}] - [2(565 \text{ kJ/mol})] = -544 \text{ kJ/mol}$$

DIRECTIONS: Answer the following in the space provided:

1. Use bond energy values from the table to estimate ΔH for each of the following reactions in the gas phase.
   a. $H_2 + Cl_2 \rightarrow 2HCl$

   b. $N{\equiv}N + 3H_2 \rightarrow 2NH_3$

2. Use bond energies to predict ΔH for the isomerization of methyl iocyanide to acetonitrile:

   $$CH_3N{\equiv}C(g) \rightarrow CH_3C{\equiv}N$$

Average Bond Energies (kJ/mol)

Single Bonds						Multiple Bonds	
H—H	432	N—H	391	I—I	149	C═C	614
H—F	565	N—N	160	I—Cl	208	C≡C	839
H—Cl	427	N—F	272	I—Br	175	O═O	495
H—Br	363	N—Cl	200			C═O*	745
H—I	295	N—Br	243	S—H	347	C≡O	1072
		N—O	201	S—F	327	N═O	607
C—H	413	O—H	467	S—Cl	253	N═N	418
C—C	347	O—O	146	S—Br	218	N≡N	941
C—N	305	O—F	190	S—S	266	C≡N	891
C—O	358	O—Cl	203			C═N	615
C—F	485	O—I	234	Si—Si	340		
C—Cl	339			Si—H	393		
C—Br	276	F—F	154	Si—C	360		
C—I	240	F—Cl	253	Si—O	452		
C—S	259	F—Br	237				
		Cl—Cl	239				
		Cl—Br	218				
		Br—Br	193				

*C═O(CO_2) = 799

3. Use bond energies to predict ΔH for the following reaction:

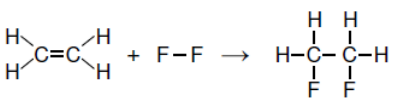
   $$H_2S(g) + 3F_2(g) \rightarrow SF_4(g) + 2HF(g)$$

4. Use bond energies to estimate ΔH for the combustion of one mole of acetylene:

   $$C_2H_2(g) + {}^5/_2O_2(g) \rightarrow 2CO_2(g) + H_2O(g)$$

5. Estimate the enthalpy change (ΔH_{rxn}) of the following reactions using the bond energies above.

   a. $H{-}H + Cl{-}Cl \rightarrow H{-}Cl + H{-}Cl$

   b. 

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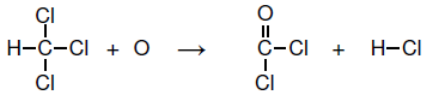
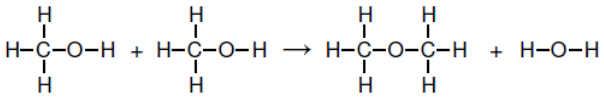
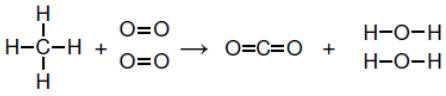
c. 

d. 

e. 

6. The standard enthalpies of formation for S(g), F(g), SF_4(g), and SF_6(g) are +278.8, +79.0, -775, and -1209 kJ/mole respectively.
   a. Use these data to estimate the energy of an S-F bond.

   b. Compare your calculated value to the value given in the table. What conclusions can you draw?

   c. Why are the $\Delta H°_f$ values for S(g) and F(g) not equal to zero since sulfur and fluorine are elements?

7. Estimate the enthalpy change (ΔH_{rxn}) for the reactions using bond energies.
   a. $CO\ (g) + 2H_2\ (g) \rightarrow CH_3OH\ (g)$

   b. $N_2\ (g) + 3H_2\ (g) \rightarrow 2NH_3\ (g)$

   c. $2C_2H_6\ (g) + 7O_2\ (g) \rightarrow 4CO_2\ (g) + 6H_2O\ (g)$

   d. $HCN\ (g) + 2H_2\ (g) \rightarrow CH_3NH_2\ (g)$