Bond Energies

1. Read pages 586 – 587 in your textbook.
2. Which process releases energy: breaking a bond or forming a bond?
3. Which process requires energy: breaking a bond or forming a bond?
4. Define bond energy.
5. If the energy used to break bonds is greater than the energy released in the formation of new bonds, is the reaction endothermic or exothermic?
6. If the energy used to break bonds is less than the energy released in the formation of new bonds, is the reaction endothermic or exothermic?
7. Look at the table of selected bond energies to the right.
   a. Which is the strongest single bond on this table?
   b. Which is the weakest single bond on this table?

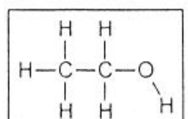
Bond type	Energy kJ/mol
Br–Br	193
C–Br	288
C–C	348
C=C	614
C≡C	839
C–Cl	330
C–F	488
C–H	413
C–I	216
C–N	308
C–O	360
C=O	799
C–S	272
Cl–Cl	243
F–F	158
H–Br	366
H–Cl	432
H–F	568
H–H	436
H–I	298
H–N	391
H–O	459
I–I	151
N–N	170
N≡N	945
O–O	145
O=O	498

8. (Note: <u>This is not a question</u>. It is an explanation of how to calculate the total energy from a reaction, based on bond energies. There are supposed to be empty spaces in the table.)
   Let's examine the electrolysis of water (fig 4 on page 587). The general reaction is
   $$2H_2O \rightarrow 2H_2 + O_2 \quad \text{or} \quad \text{H–O–H H–O–H} \rightarrow \text{H–H H–H + O=O}$$
   The overall heat of reaction can be calculated as follows:

Bond	Bond energy (kJ/mol)	Number of bonds broken	Energy required (kJ)	Number of bonds formed	Energy Released (kJ)
H–O	459	4	1836		
H–H	436			2	872
O=O	498			1	498
		Sum	1836		1370
		Result	466		

   Thus, this is an endothermic reaction (energy required) that absorbs 466 kJ.
   The thermochemical equation is $2H_2O + 466\text{ kJ} \rightarrow 2H_2 + O_2$
9. Calculate the heat of reaction for $H_2 + Cl_2 \rightarrow 2HCl$ (fig. 5 on page 587) by completing a table similar to the one above. Write the thermochemical equation for this reaction.
10. In yesterday's lab we found the molar heat of reaction for burning paraffin in oxygen. You will now calculate the theoretical value and compare it to the experimental value.
    a. Draw Lewis structures for O_2, H_2O, and CO_2.
    b. Write the balanced equation for the combustion of $C_{25}H_{52}$.
    c. Fill in this table to calculate the theoretical molar heat of combustion for $C_{25}H_{52}$.

Bond	Bond energy (kJ/mol)	Number of bonds broken	Energy required (kJ)	Number of bonds formed	Energy Released (kJ)
C–C					
C–H					
C=O					
H–O					
O=O					
		Sum			
		Result			



C_2H_5OH

    d. How does your theoretical value (calculated above) compare to your experimental value (measured in yesterday's lab)? What can account for the discrepancy between these values?
11. Calculate the molar heat of combustion & the specific heat of combustion for C_2H_5OH (shown above).

9 • Bonding & Molecular Structure

Table 9.9 • Some Average Single- and Multiple-Bond Energies (kJ/mol)

	H	C	N	O	F	Si	P	S	Cl	Br	I
H	436	413	391	463	565	318	322	347	432	366	299
C		346	305	358	485			272	339	285	213
N			163	201	283				192		
O				146		452	335		218	201	201
F					155	565	490	284	253	249	278
Si						222		293	381	310	234
P							201		326		184
S								226	255		
Cl									242	216	208
Br										193	175
I											151

Multiple Bonds

N=N	418	C=C	602
N≡N	945	C≡C	835
C=N	615	C=O	732
C≡N	887	C≡O	1072
O=O (in O_2)	498		

Table 6.2 • Standard Enthalpies of Formation (kJ/mol)

$C_2H_6(g)$	ethane	-84.7
$H_2O(g)$	water vapor	-241.8
$CO_2(g)$	carbon dioxide	-393.5

1. Write the balanced chemical equation for the complete combustion of ethane, $C_2H_6(g)$.

2. Draw structural formulas (shortcut Lewis structures) for each of the species.

3. Calculate the energy needed to break the bonds in the reactants. __________
   Calculate the energy released as the bonds in the products are formed. __________

What is the $\Delta H_{combustion}$ based on bond energies? ______________