WS 11.15 Name:_____ p._____

$\Delta H_{rxn} = \Sigma\ \Delta H_{bonds\ broken} - \Sigma\ \Delta H_{bonds\ formed}$

The ΔH of a reaction can be estimated* using average bond enthalpies (aka "bond dissociation energies").

The bond enthalpy ("ΔH_{bond}") is the energy required to break a bond.
It is usually reported in kJ/mole (kJ energy required to break 1 mole of bonds).

* the calculation is only an estimation, since you are using average bond energies; not all C-C, H-O, C=O, etc. bonds require the same energy to break. Also, this method is less accurate when non-gases (solids and liquids) are reacting, since solids and liquids not only have bonds within molecules; they also have intermolecular attractive forces, which require energy to overcome.

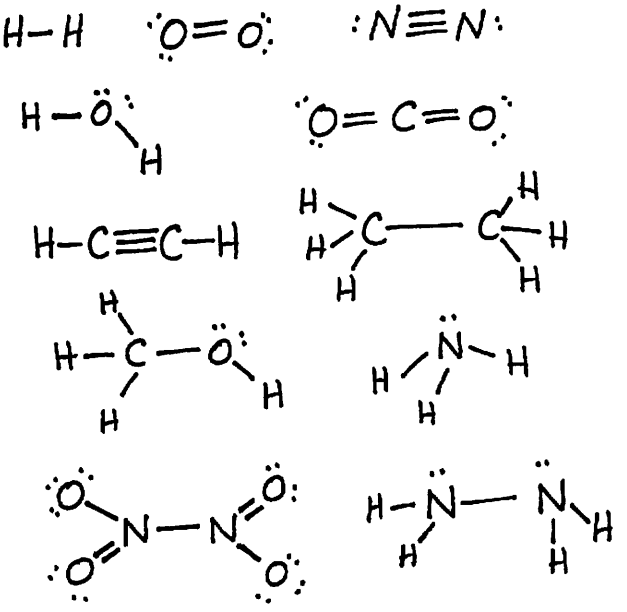
Average Bond Enthalpies/Bond Dissociation Energies (kJ/mole)

Single Bonds

C—H	413	N—H	391	O—H	463	F—F	155
C—C	348	N—N	163	O—O	146		
C—N	293	N—O	201	O—F	190	Cl—F	253
C—O	358	N—F	272	O—Cl	203	Cl—Cl	242
C—F	485	N—Cl	200	O—I	234		
C—Cl	328	N—Br	243			Br—F	237
C—Br	276			S—H	339	Br—Cl	218
C—I	240	H—H	436	S—F	327	Br—Br	193
C—S	259	H—F	567	S—Cl	253		
		H—Cl	431	S—Br	218	I—Cl	208
Si—H	323	H—Br	366	S—S	266	I—Br	175
Si—Si	226	H—I	299			I—I	151
Si—C	301						
Si—O	368						
Si—Cl	464						

Multiple Bonds

C=C	614	N=N	418	O_2	495
C≡C	839	N≡N	941		
C=N	615	N=O	607	S=O	523
C≡N	891			S=S	418
C=O	799				
C≡O	1072				



Use bond enthalpies to estimate the ΔH_{rxn} for each reaction:

1. Electrolysis of water $2\ H_2O_{(g)}$ -----> $2\ H_{2(g)} + O_{2(g)}$

2. Ethane burns: $2\ C_2H_{6(g)} + 7\ O_{2(g)}$ -----> $4\ CO_{2(g)} + 6\ H_2O_{(g)}$

3. Formation of ammonia: $N_{2(g)} + 3\ H_{2(g)} \text{ -----> } 2NH_{3(g)}$

4. Combustion of acetylene: $2\ C_2H_{2(g)} + 5\ O_{2(g)} \text{ -----> } 4\ CO_{2(g)} + 2\ H_2O_{(g)}$

5. Rocket Fuel Reaction! $2\ N_2H_{4(g)} + N_2O_{4(g)} \text{ -----> } 3\ N_{2(g)} + 4\ H_2O_{(g)}$

6. Combustion of methanol: $2\ CH_3OH_{(l)} + 3\ O_{2(g)} \text{ -----> } 2\ CO_{2(g)} + 4\ H_2O_{(g)}$

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