

## PREDICTING ENTHALPY CHANGES USING BOND ENERGIES

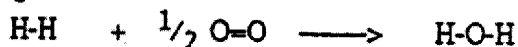
Since energy is always released when bonds are formed and always absorbed when bonds are broken, let us look at some bond energies. Since the exact bond energy depends upon the specific molecule in which the bond occurs, the values below are average bond energies in order to give a workable value.

<u>BOND</u>	<u>ENERGY (kJ/mol)</u>	<u>BOND</u>	<u>ENERGY (kJ/mol)</u>
H-H	435	C-H	414
C-C	347	C-O	360
C=C	610	C=O	740
C≡C	836	N=N	940
O-O	146	N-N	163
O=O	497	N-H	389
O-H	464	H-I	297

As bonds form between atoms, the stability of the atoms involved increases, since the potential energy decreases and heat is released. The increasing stability that results from bond formation is probably because there are more proton-electron attractions in the bonded situation than there were in the unbonded situation. As bonds are broken, the stability decreases.

Consider the following reaction 
$$\text{H}_2(\text{g}) + \frac{1}{2} \text{O}_2(\text{g}) \longrightarrow \text{H}_2\text{O}(\text{g})$$

A stick diagram would show the bonding to be as follows

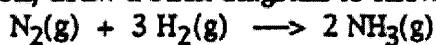


Therefore, in this reaction, one mole of H-H bonds are broken and half a mole of O=O bonds are broken for every two moles of O-H bonds that are formed. Let's make a tally of the bond breaking and bond making energies.

BOND BREAKING (energy absorbed)	BOND MAKING (energy released)
1 mole H-H                      435 kJ	2 moles O-H    2 x (464 kJ)
$\frac{1}{2}$ mole O=O $\frac{1}{2}$ x (497 kJ)	
Total absorbed is 683.5 kJ	Total released is 928 kJ

Since only 683.5 kJ of energy was absorbed while 928 kJ was released, overall 244.5 kJ would be released by the bond making and bond breaking process per mole of water formed.

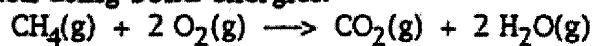
1. For the following reaction, draw a stick diagram to show the bonding in each molecule in the reaction



Find the resulting heat released or absorbed in the bond making and bond breaking processes of the above reaction.

(Answer 89.0 kJ/mol  $\text{N}_2$ )

2. For the following reaction, draw a stick diagram for each molecule and then estimate the heat of reaction using bond energies.



(Answer -686 kJ/mol  $\text{CH}_4$ )

3. Using bond energies, estimate the energy released when one mole of propane burns in oxygen gas.

(Answer -1661 kJ/mol  $\text{C}_3\text{H}_8$ )