12.2 – Bond Energy and Reactions

Electrical forces hold atoms together. If atoms or ions are bonded together, energy (in the form of heat, light, or electricity) is required to separate them.

In other words, bond breaking requires energy.

bonded particles + **energy** → separated particles

In contrast, bond making releases energy.

separated particles → bonded particles + **energy**

The stronger the bond holding the particles together, the greater the quantity of energy required to separate them.

Bond energy is the **energy required to break a chemical bond**. It is also the **energy released when a bond is formed.**

Even the simplest of chemical reactions involves the breaking and forming of several individual bonds.

Endothermic Reactions:

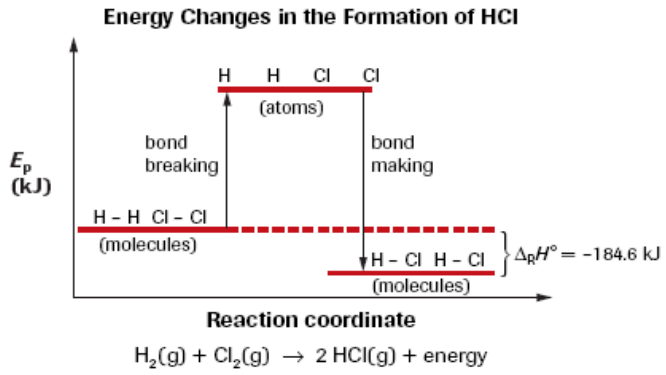
Consider the decomposition of water: $2\ H_2O_{(l)} \rightarrow 2\ H_{2(g)} + O_{2(g)}$ $\blacktriangle_r H° = +571.6$ kJ

- Hydrogen–oxygen bonds in the water molecules must be broken, and the hydrogen–hydrogen and oxygen–oxygen bonds must be formed.
- Since the overall change is endothermic, the energy required to break the O—H bonds must be greater than the energy released when the H—H and O=O bonds form.
- **In any endothermic reaction, more energy is needed to break bonds in the reactants than is released by bonds formed in the products.**

Exothermic Reactions:

- **For exothermic reactions more energy is released by bonds formed in the products than is needed to break bonds in the reactants.**

The reaction between hydrogen and chlorine (see diagram below) illustrates the energy of bond breaking and bond making.



Analysis of Formation of HCl Reaction

- Energy is required to break the bonds in hydrogen molecules (H_2) to create hydrogen atoms (H), each having higher chemical potential energy than a hydrogen molecule.
- The chlorine atoms have higher potential energy than the chlorine molecules. When the hydrogen and chlorine atoms make bonds to create hydrogen chloride molecules, energy is released.
- This reaction is **exothermic**, more energy is released by bond making than is required for bond breaking.

Bond energies are the fourth method that you have encountered for predicting or explaining a change in enthalpy for a chemical reaction.

The methods that you have studied for predicting and/or explaining a change in enthalpy are the following:

1. **calorimetry**: the change in enthalpy equals the change in thermal energy
2. **Hess' law**: the change in enthalpy equals the sum of component enthalpy changes
3. **molar enthalpies of formation**: the change in enthalpy equals the enthalpies of formation of the products minus the enthalpies of formation of the reactants.
4. **bond energies**: the change in enthalpy equals the energy released from bond