8.1 – Theories of Acids and Bases

8.1.1 - Define acids and bases according to the Bronsted-Lowry and Lewis theories

There are two main theories that exist for classifying acids and bases: that of Bronsted and Lowry, and the Lewis theory. Both are used.

The **Bronsted-Lowry Theory** is that:

An **acid** is a substance that can donate a proton, or hydrogen ion

A **base** is a substance that can accept a proton, or hydrogen ion

$$\underset{acid}{\boldsymbol{HCl}_{(g)}} + \underset{base}{\boldsymbol{H_2O}_{(l)}} \leftrightarrow \underset{acid}{\boldsymbol{H_3O^+}_{(aq)}} + \underset{base}{\boldsymbol{Cl^-}_{(aq)}}$$

In the equation above, Cl^- is the **conjugate base** of HCl and H_3O^+ is the **conjugate acid** of H_2O. That is to say, it is what remains when the molecule has gained or lost a proton.

Interestingly, water (H_2O) is able to act as both an acid and a base in Bronsted-Lowry theory, called **amphiprotic**. Other examples include HCO_3^- and HCO_4^-. The substances are able to accept or donate a proton. Alternatively, a substance that can act as both an acid and a base is called **amphoteric**, such as Al_2O_3

The **Lewis Theory** is that:

An **acid** is an electron pair acceptor

A **base** is an electron pair donator

Therefore, all Lewis acids are deficient in an electron pair (such as H^+, BF_3 and SO_3), whilst a Lewis base must contain a non-bonding pair of electrons (such as OH^-, F^- and H_2O).

$$\boldsymbol{BF_3} \quad + \quad \boldsymbol{NH_3} \quad \rightarrow \quad \boldsymbol{BF_3NH_3}$$
$$acid + base \rightarrow Lewis\ acid - base\ complex$$

BF_3 is a Lewis acid because it does not have any non-bonding pairs of electrons and only three bonding pairs.

8.1.2 - Deduce whether or not a species could act as a Bronsted-Lowry and/or a Lewis acid or base

Many acids or bases that do not fit the Bronsted-Lowry definition fit the Lewis definition, along with their reactions. Hence, substances like BF_3, SO_3, H^+ and SbF_5 are not Bronsted-Lowry acids, but are Lewis acids. Also, H_2O, OH^- and F^- are not Bronsted-Lowry bases, but are Lewis bases. Many other substances **can be classified as both**.

The reaction below could be classified as both:

$$H^+ + NH_3 \rightarrow NH_4{}^+$$

From the perspective of a **Bronsted-Lowry** acid-base reaction, the H^+ ion is being donated to the NH_3 molecule to form the new complex. As for the **Lewis** theory, the NH_3 molecule has a non-bonding pair of electrons, which are able to bond with the H^+ ion.

When classifying a reaction, the Lewis theory is usually only used if the Bronsted-Lowry theory does not apply.

8.1.3 - Deduce the formula of the conjugate acid (or base) of any Bronsted-Lowry base (or acid)

Remember that a **conjugate acid** is the complex formed after a Bronsted-Lowry base has received a proton. On the other hand, a **conjugate base** is the complex formed after a Bronsted-Lowry acid has donated a proton. Therefore, an acid will always have one more proton than its conjugate base, and vice versa.

When you write the formula of the conjugate acid or base, you must always indicate where the proton is located. For example:

$$CH_3COOH \leftrightarrow CH_3COO^-$$