# STRONG AND WEAK ACIDS

The pH of a 0.1 mol $l^{-1}$ solution of hydrochloric acid is 1. Hydrochloric acid is a strong acid and is fully dissociated into ions in aqueous solution.

$$HCl_{(g)} \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}$$

1 mole 1 mole

So if the HCl concentration is 0.1 mol $l^{-1}$ then $[H^+]$ is also 0.1 mol $l^{-1}$

ie $[H^+]$ 0.1 = $10^{-1}$ mol $l^{-1}$
So the pH = 1

When the pH of 0.1 mol $l^{-1}$ ethanoic acid is measured it is found to be 3. This indicates a lower hydrogen ion concentration. Ethanoic acid is a weak acid because it is not fully dissociated into ions in aqueous solution.

$$CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H^+_{(aq)}$$

**Comparison of Strong and Weak Acids**
Equimolar (0.1 mol $l^{-1}$) solution of hydrochloric and ethanoic acids were compared in a number of experiments. The results were:

| | Hydrochloric acid | Ethanoic acid |
|---|---|---|
| pH | 1 | 3 |
| Conductivity | High | Low |
| Reaction with Mg | Fast | Slow |
| Reaction with $CaCO_3$ | Fast | Slow |

The higher concentration of $H^+_{(aq)}$ ions in hydrochloric acid accounts for the lower pH, the high conductivity and the faster reaction rates.

The experiments above can be used to distinguish strong and weak acids.

**Amount of Alkali Neutralised by Strong and Weak Acids**
Neutralisation is the joining of $H^+$ and $OH^-$ ions to form water.

$$H^+_{(aq)} + OH^-_{(aq)} \longrightarrow H_2O_{(l)}$$

We might expect that weak acids with their lower concentration of $H^+_{(aq)}$ ions would neutralise a smaller amount of alkali than a strong acid. However 0.1 mol $l^{-1}$ ethanoic acid neutralises exactly the same volume of sodium hydroxide solution as 0.1 mol $l^{-1}$ hydrochloric acid.

$$CH_3COOH_{(aq)} \rightleftharpoons CH_3COO^-_{(aq)} + H^+_{(aq)}$$

$H^+_{(aq)}$ ↓ removed by $OH^-_{(aq)}$ to form water

Ethanoic acid is a weak acid so at any one time there is a small concentration of $H^+_{(aq)}$ ions. As these are removed from the equilibrium mixture by joining with $OH^-_{(aq)}$ ions to form water, the equilibrium shifts to the right. More $CH_3COOH$ molecules dissociate to produce more $H^+_{(aq)}$ ions which are in turn neutralised by $OH^-_{(aq)}$ ions. This continues until all the weak acid molecules have dissociated and so the same amount of alkali is neutralised by a weak acid as a strong acid.

This all means that the amount of alkali neutralised cannot be used to distinguish strong and weak acids.

**Examples of Strong Acids**

Hydrochloric acid $HCl \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}$

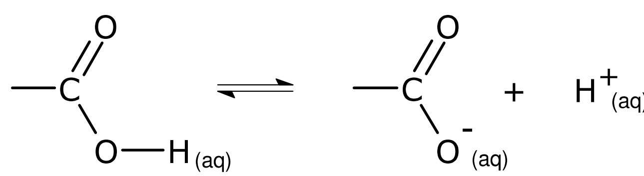
Nitric Acid $HNO_3 \longrightarrow H^+_{(aq)} + NO_3^-{}_{(aq)}$

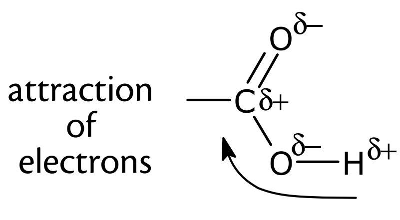
Sulphuric Acid $H_2SO_4 \longrightarrow 2H^+_{(aq)} + SO_4^{2-}{}_{(aq)}$

**Examples of Weak Acids**

*Carboxylic acids*

We have used ethanoic acid as an example of a weak acid, but the carboxylic acids in general are weak acids.






Note that the hydrogen atoms bonded to carbon have no tendency to ionise. The hydrogen atom bonded to the oxygen has a limited tendency to ionise.

The polarisation of the covalent bonds makes the hydrogen δ+ and assists in its removal as an $H^+$ ion.

*Carbonic Acid*

Carbon dioxide is slightly soluble in water giving the weak acid, carbonic acid, $H_2CO_3$

$$CO_{2(g)} + H_2O_{(l)} \longrightarrow H_2CO_{3(aq)} \rightleftharpoons 2H^+_{(aq)} + CO_3^{2-}{}_{(aq)}$$

*Sulphurous acid*

Sulphur dioxide is very soluble in water forming the weak acid, sulphurous acid, $H_2SO_3$

$$SO_{2(g)} + H_2O_{(l)} \longrightarrow H_2SO_{3(aq)} \rightleftharpoons 2H^+_{(aq)} + SO_3^{2-}{}_{(aq)}$$

Sulphur dioxide is released into the atmosphere by the combustion of fossil fuels. It dissolves in atmospheric moisture to give sulphurous acid, one of the main constituents of acid rain.