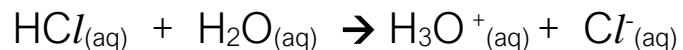


Conjugate Acids and Bases

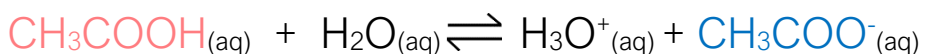
According to the Lowry- Brønsted theory of acids and bases, for a molecule to behave as an acid, it must be in the presence of a **base** that it can **donate** a proton to.

When we dissolve a **strong acid** in water, the acid fully protonates the water molecules which are behaving as a base.



Strictly speaking, this is an equilibrium that lies so far to the right-hand side that we say that the reaction goes to completion. Once the dissolved HCl molecule has donated its proton, it would seem sensible to assume that the Cl⁻ has no 'desire' to take it back.

Now compare this to the situation with a typical **weak acid** such as **ethanoic acid**.



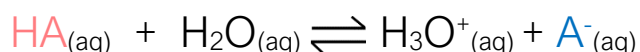
In this case, the ethanoic acid is far more reluctant to donate its proton. Furthermore, water isn't that great at accepting a proton from the acid. So, it seems reasonable to think that ethanoic acid molecules that have lost their proton (the **ethanoate ions**) may be reasonably 'keen' to get them back again from the water molecules that are holding onto them (H₃O⁺) and become **ethanoic acid** molecules again.

That means that on the right-hand side of this equilibrium, we have another acid (H₃O⁺) and another base (CH₃COO⁻). This second pair of acid and a base are called the conjugate acid and conjugate base of the acid and base on the left.

H₃O⁺ is the **conjugate acid** of H₂O (a conjugate pair)

CH₃COO⁻ is the **conjugate base** of CH₃COOH (a conjugate pair)

In general, we can write the following for all acids in water:



The **stronger the acid HA**, the **weaker its conjugate base** (also often called **salt**).

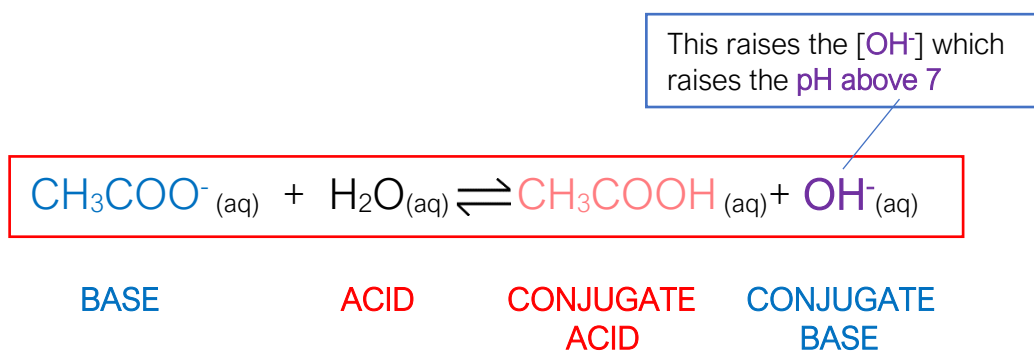
A moderately weak acid, such as **ethanoic acid** will have a **conjugate base** (or salt) that has some base strength! In fact, a 0.100 mol dm⁻³ solution of the salt **sodium ethanoate** has a pH of about 9.4. It's an alkaline salt! Many salts are **NOT NEUTRAL!**

Strong acids (assumed to be 100% dissociated) have conjugate bases that have no measurable base strength. However, it is wrong to assume that a typical **weak acid** will have a **strong conjugate base**. Only if the acid is extremely weak (**very high pKa**) would its conjugate base be considered strong.

Ethanol is never normally considered to be an acid. But it is an extremely weak acid! It has a pKa of 16.0. Its conjugate base is the **ethoxide ion** (CH₃CH₂O⁻). This is considered to be a strong base and produces highly alkaline solutions when the salt (**sodium ethoxide**, for example) is added to water.

Showing How Conjugate Bases (Salts) Produce Alkaline Solutions

If we take **sodium ethanoate salt** and put some into water, it reacts with the water to form an equilibrium. The Na^+ ions have been left out as they are only spectator ions!

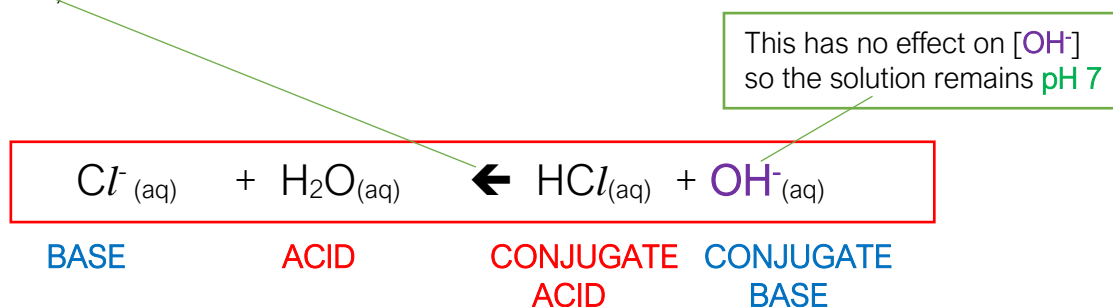


For HCl , the equilibrium position lies so far to the right that we don't consider it to be an equilibrium (which it strictly is).

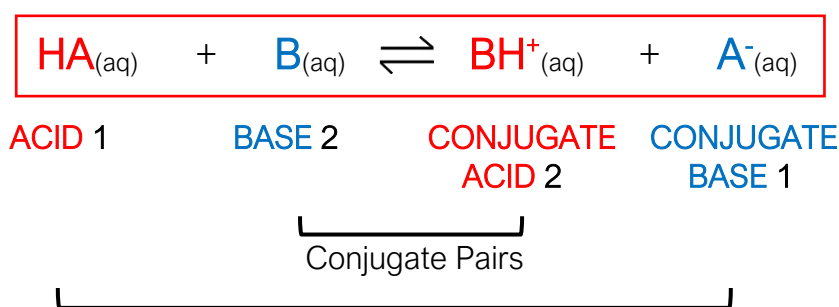
The conjugate base of HCl is the Cl^- ion and we don't think of this to be basic in any way. That's why a $0.100 \text{ mol dm}^{-3}$ solution of NaCl has a pH of 7.

Another way of expressing this is to say that the equilibrium when NaCl is dissolved in water lies **completely to the left**.

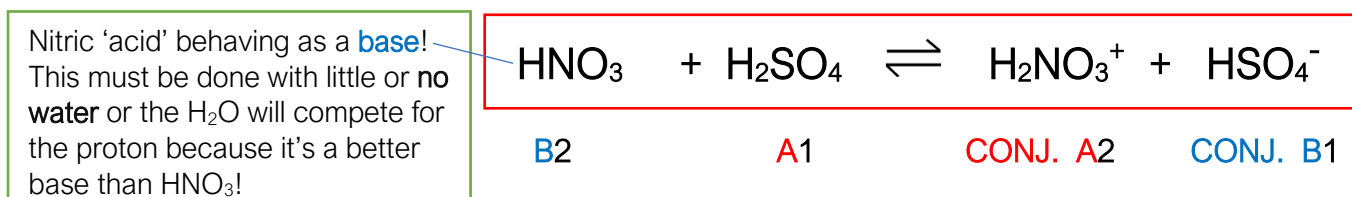
Cl^- ion **accepts no protons** from water and so no extra OH^- ions are produced and the salty solution remains neutral at pH 7 (@25°C)



We can write a general equation to represent the ACID-BASE conjugate pairs idea.



Here's an interesting example from organic chemistry:



The H_2NO_3^+ then decomposes to give the nitronium cation NO_2^+