

Arrhenius Theory

Svante Arrhenius (Swedish)

1880s

Acid - a substance that produces $\text{H}^+(\text{aq})$ in solution

Base - a substance that produces $\text{OH}^-(\text{aq})$ in solution

Brønsted-Lowry Theory

Johannes Brønsted (Danish)

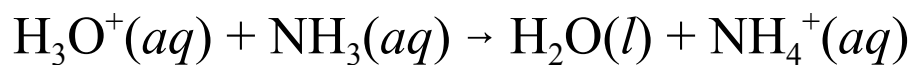
Thomas Lowry (English)

1923

Acid - a substance that donates protons (H^+)

Base - a substance that accepts protons (H^+)

Proton Transfer Reaction

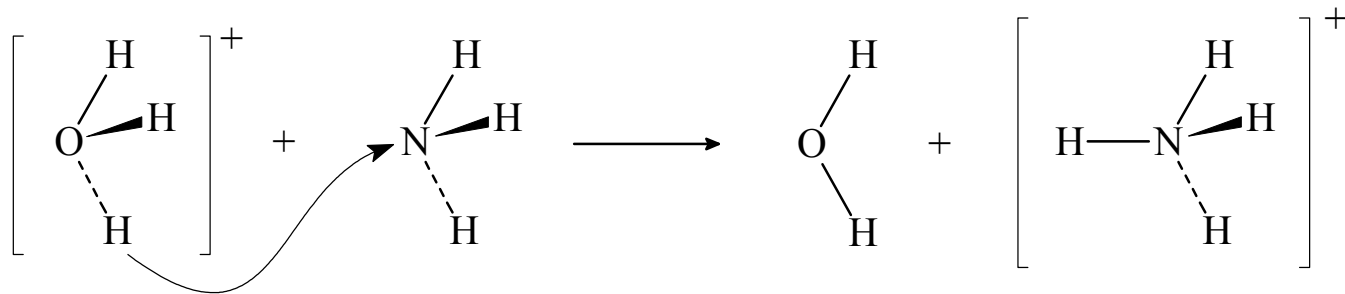


hydronium ion

ammonia

water

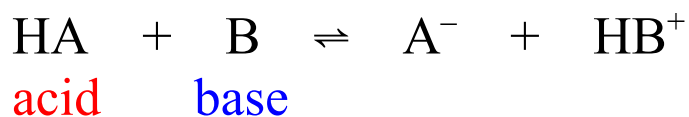
ammonium ion



proton donor
= acid

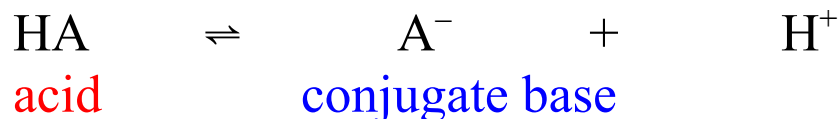
proton acceptor
= base

☞ In general terms, all acid-base reactions fit the general pattern

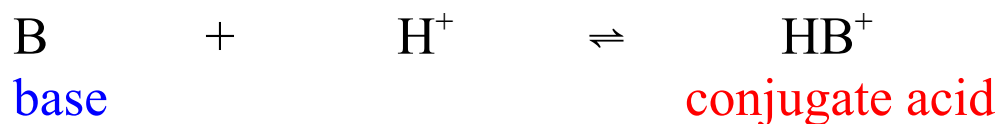


Conjugate Acid-Base Pairs

- ☞ When an acid, HA, loses a proton it becomes its **conjugate base**, A^- , a species capable of accepting a proton in the reverse reaction.

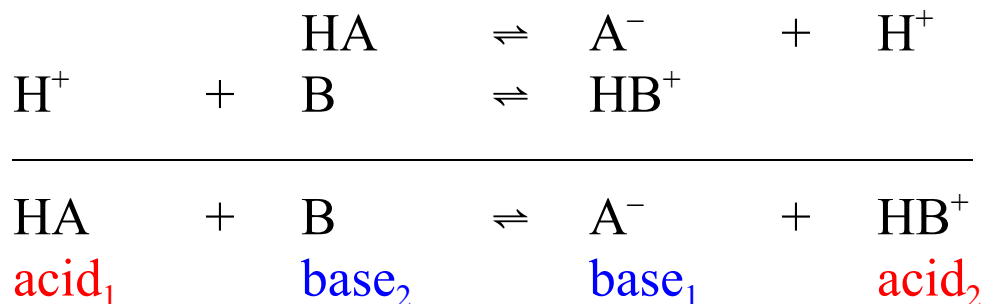


- ☞ When a base, B, gains a proton, it becomes its **conjugate acid**, BH^+ , a species capable of donating a proton in the reverse reaction.



Acid-Base Reactions

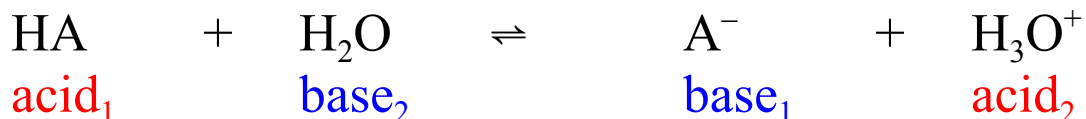
- ☞ We can analyze Brønsted-Lowry type proton transfer reactions in terms of conjugate acid-base pairs. The generic reaction between HA and B can be viewed as



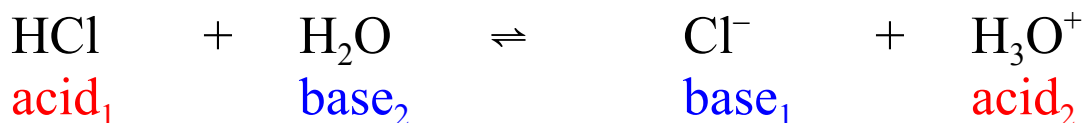
- Species with the same subscripts are conjugate acid-base pairs.

Acid Hydrolysis and the Role of Solvent Water

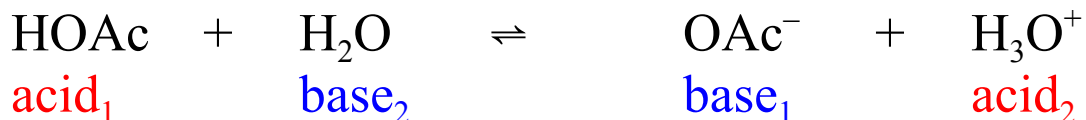
☞ When any Brønsted-Lowry acid HA is placed in water it undergoes *hydrolysis* to produce hydronium ion, H_3O^+ , and the conjugate base, A^- , according to the equilibrium:



- The acid HA transfers a proton to H_2O , acting as a base, thereby forming the conjugates A^- and H_3O^+ , respectively.
- The position of this equilibrium indicates the strength of the acid.



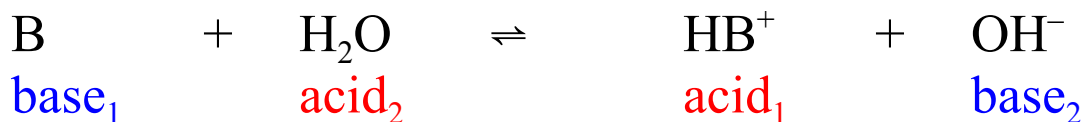
Equilibrium lies right. \Rightarrow HCl is a strong acid.



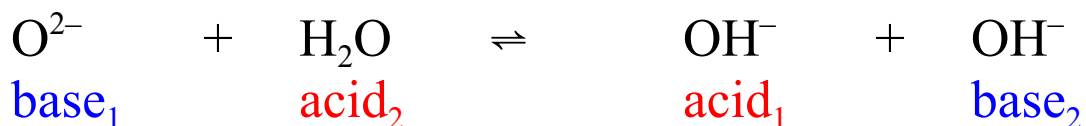
Equilibrium lies left. \Rightarrow HOAc is a weak acid.

Base Hydrolysis and the Role of Solvent Water

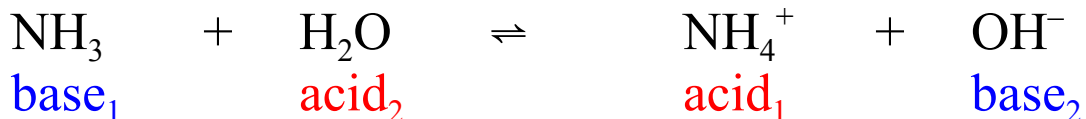
- ☞ Hydrolysis of a base also involves water as an active participant, functioning as an acid.



- H_2O acts as the acid, transferring a proton to B, thereby forming the conjugates OH^- and HB^+ , respectively.
- The position of this equilibrium indicates the strength of the base.



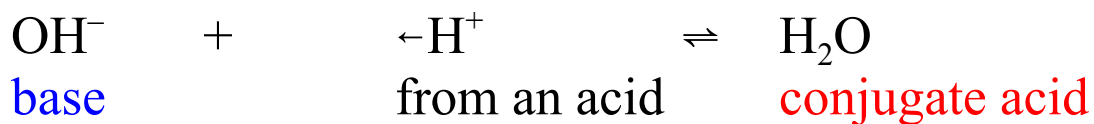
Equilibrium lies right. $\Rightarrow \text{O}^{2-}$ is a strong base.



Equilibrium lies left. $\Rightarrow \text{NH}_3$ is a weak base.

Water - An Amphiprotic Solvent

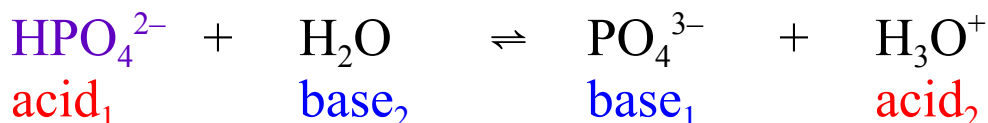
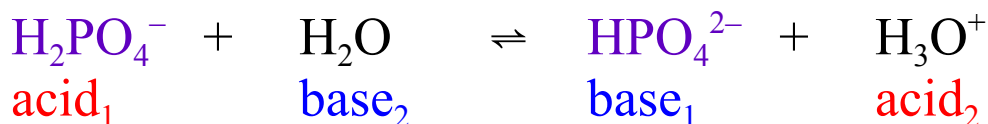
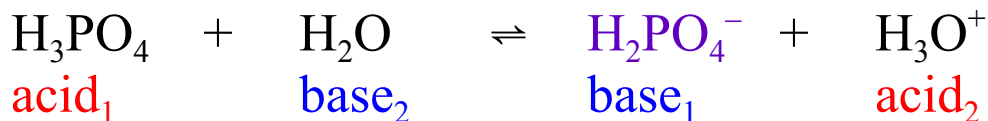
- Water can act as either a base or an acid, because it is the conjugate base of H_3O^+ and the conjugate acid of OH^- .



- ☞ Substances such as H_2O that can act as acids or bases through proton donation or acceptance are called **amphiprotic**.

Polyprotic Acids

- ☞ With polyprotic acids, each acid anion is the conjugate base of the acid from which it is formed, and it is also the acid by which the next conjugate base in the sequence is formed.



- ✓ Acid anions are indicated in purple.
- ✓ For virtually all polyprotic acids, the species formed from successive proton losses are progressively weaker acids.
- ✓ Acid anions are inherently amphiprotic species.