Basics of Acids and Bases

ACIDS

- Acids ionize (break apart into ions) in aqueous solutions to form Hydrogen ions H+ (aq)
- Monoprotic acids – yield one H+ per molecule of acid

$$HCl(g) \xrightarrow{H_2O} H^+(aq) + Cl^-(aq)$$

- Diprotric acids – yield two H+ per molecule of acid (ionization occurs in 2 steps)

$$H_2SO_4(aq) \longrightarrow H^+(aq) + HSO_4^-(aq)$$

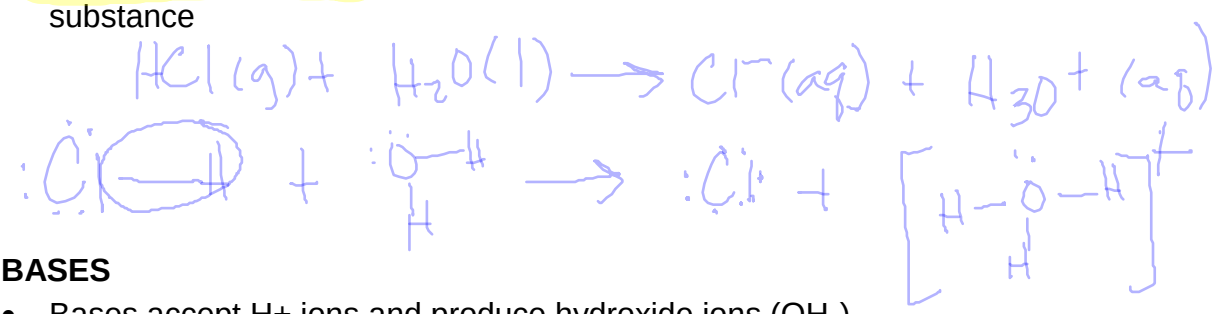
$$HSO_4^-(aq) \rightleftharpoons H^+(aq) + SO_4^{2-}(aq)$$

- Often called proton donors
- Memorize "Magnificent Seven" strong acids: HCl (Hydrochloric), HBr (Hydrobromic), HI (Hydroiodic), $HClO_3$ (Chloric), $HClO_4$ (Perchloric), HNO_3 (Nitric), and H_2SO_4 (Sulfuric)
- Arrhenius acids – a substance that when dissolved in water increases the concentration of H+ ions.

$$HCl(aq) \xrightarrow{H_2O} H^+(aq) + Cl^-(aq)$$

- BrØnstead-Lowry acid is a substance that donates a proton to another substance

$$HCl(g) + H_2O(l) \longrightarrow Cl^-(aq) + H_3O^+(aq)$$



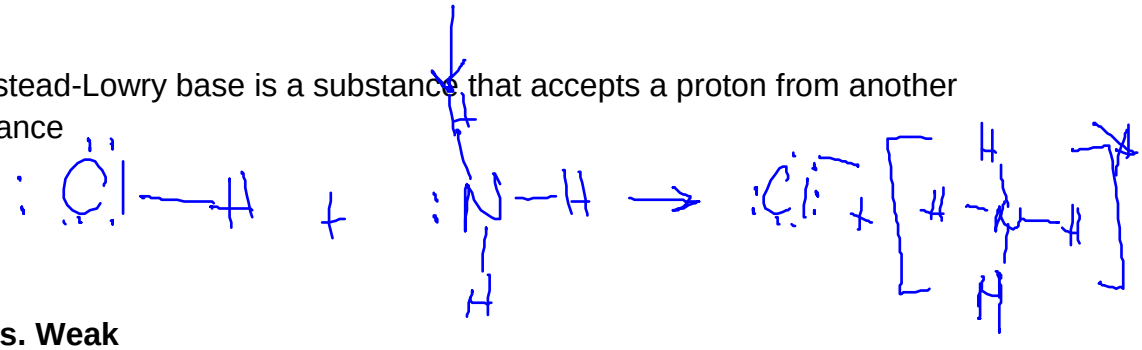
BASES

- Bases accept H+ ions and produce hydroxide ions (OH-)

$$NH_3(aq) + H_2O(l) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

- Memorize common 8: Group 1A metal hydroxides (LiOH, NaOH, KOH, RbOH, CsOH) and Group 2A heavy metal hydroxides ($Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$)
- Arrhenius bases – a substance that when dissolved in water, increases the concentration of OH- ions

- BrØnstead-Lowry base is a substance that accepts a proton from another substance



Strong vs. Weak

- Strong acids/bases completely ionize and are therefore strong electrolytes
- Weak acids/bases only partially ionize and are therefore weak electrolytes

Miscellaneous

- An acid and a base always work together to transfer a proton. So:
  - To be a BrØnstead-Lowry acid, a molecule or ion must have a hydrogen atom it can lose as an H+ ion.
  - To be a BrØnstead-Lowry base, a molecule or ion must have a non-bonding pair of electrons it can use to bind the H+ ion.
- Some substance can act as either an acid or a base: amphiprotic
  - When combined with something more strongly acidic than itself it acts as a base
  - When combined with something more strongly basic than itself it acts as an acid.

$H_2S(aq) + CH_3NH_2(aq) \rightleftharpoons HS^-(aq) + CH_3NH_3^+(aq)$

In any acid-base equilibrium, both the forward reactions (to the right) and the reverse reaction (to the left) involve a proton transfer.

$HX(aq) + H_2O(l) \rightleftharpoons X^-(aq) + H_3O^+(aq)$

Conjugate Acid-Base Pairs

- An acid and base (such as HX and X- that differ only in the presence or absence of a proton) are called a conjugate acid-base pair (the word conjugate means "joined together as a pair").
- Every acid has a conjugate base formed by removing a proton from the acid

OH^- conj base of H_2O

and X^- is the conj. base of HX

H_3O^+ is the conj acid of H_2O and HX is the conj acid of X^-

- Every base has a <u>conjugate acid</u> formed by adding a proton to the base.
- So in any acid-base (proton-transfer) reaction, we can identify two sets of conjugate acid-base pairs.

remove H^+

$$\underset{\text{acid}}{HNO_2(aq)} + \underset{\text{Base}}{H_2O(l)} \rightleftharpoons \underset{\text{conj. base}}{NO_2^-(aq)} + \underset{\text{conj acid}}{H_3O^+(aq)}$$

add H^+

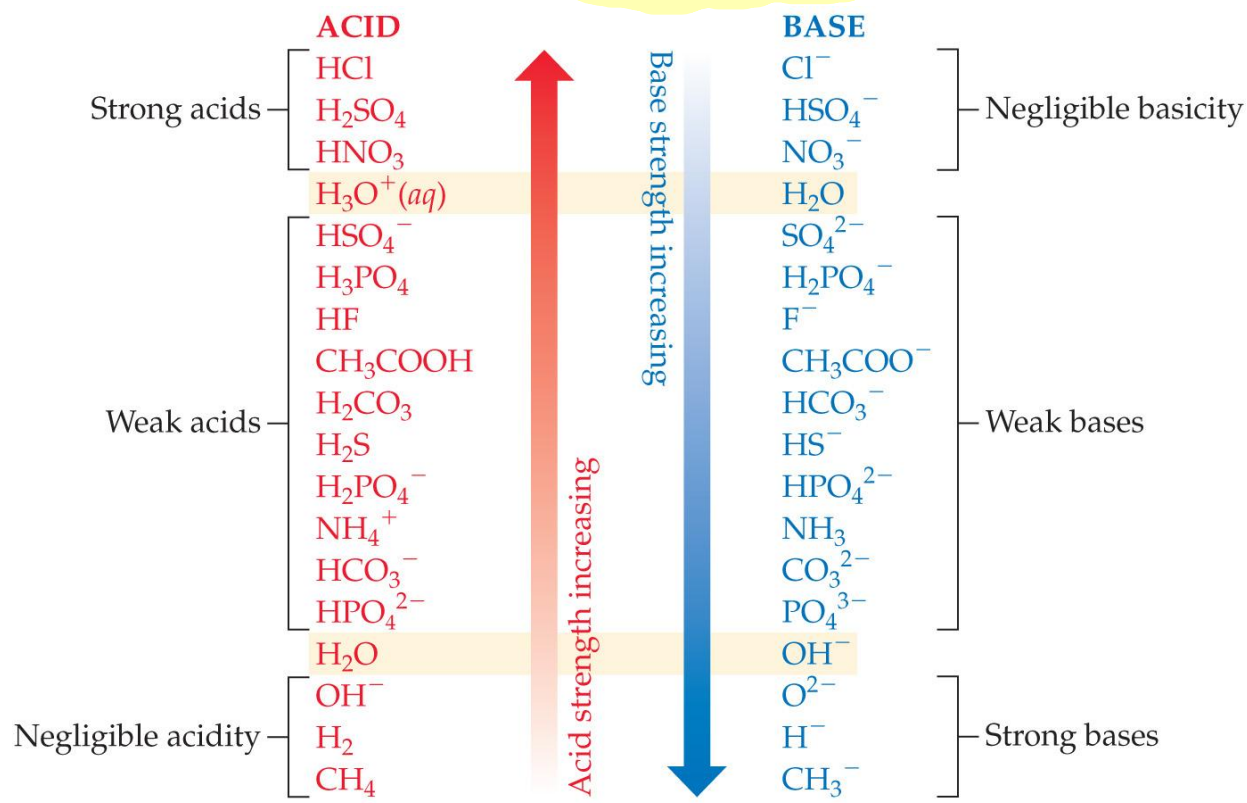
$$\underset{B}{NH_3(aq)} + \underset{A}{H_2O(l)} \rightleftharpoons \underset{CA}{NH_4^+(aq)} + \underset{CB}{OH^-(aq)}$$

Li_2O $\quad$ $\underline{O^{2-}}$

$$\underset{\text{base}}{O^{2-}(aq)} + \underset{\text{acid}}{H_2O(l)} \rightarrow \underset{\text{conj a}}{OH^-_{aq}} + \underset{\text{conj. b}}{OH^-_{aq}}$$

Relative Strengts of Acids and Bases

- A strong acid completely transfers its protons to water, leaving no undissociated molecules in solution. Its conjugate base has a negligible tendency to be protonated (to accept protons) in aqueous solution (so the conjugate base of a strong acid show negligible basicity).
- A weak acid only partially dissociates in aqueous solution so it exists in the solution as a mixture of the acid and its conjugate base. The conjugate base of a weak acid shows a slight ability to remove protons from water (so the conjugate base of a weak acid is a weak base).
- A substance with negligible acidity contains hydrogen but doesn't demonstrate any acidic behavior in water. Its conjugate base is a strong base, reacting completely with water, abstracting protons to form OH- ions (so the conjugate base of a substance with negligible acidity is a strong base).



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$$HX(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq) + X^-(aq)$$

base → cbase