Acid - Base Theories

Revised Arrhenius Theory of Acids and Bases

- acids are hydrogen-containing compounds that ionize in aqueous solutions to give H^+ $HCl\ (H^+ Cl^-)$ $CH_3COOH\ (CH_3COO^- H^+)$
- bases ionize to give OH^- ions $NaOH\ (Na^+ OH^-)$ $CH_3OH\ (CH_3^+ OH^-)$

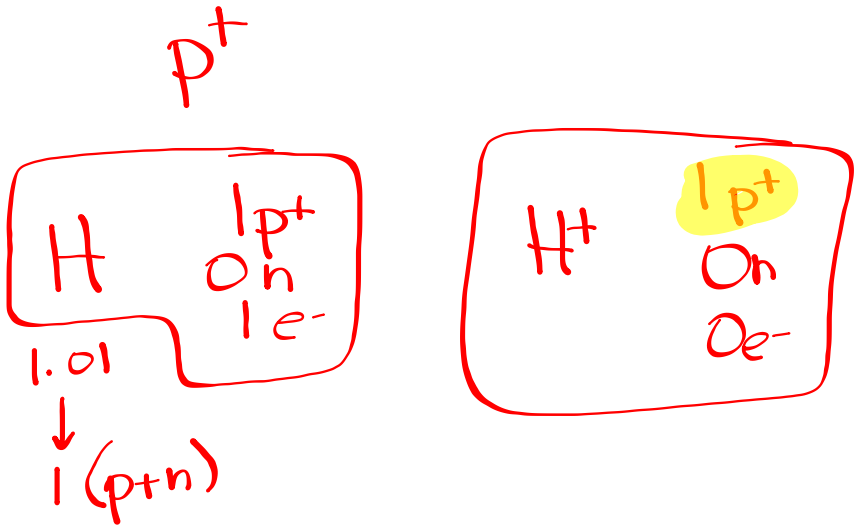
Monoprotic Acid - one hydrogen will ionize Ex. HNO_3 $H^+ NO_3^-$

Diprotic Acid - two hydrogens will ionize Ex. H_2SO_4 $2H^+ SO_4^{2-}$

Triprotic Acid - three hydrogens will ionize Ex. H_3PO_4 $3H^+ PO_4^{3-}$

Advantage: it explained neutralization as H^+ and OH^- combining to give H_2O

Disadvantage: not all hydrogen containing substances have acid properties (i.e., CH_4) and not all bases have OH^- (NH_3).


p+
H
1 p+
0 n
1 e-
1.01
1 (p+n)
H+
1 p+
0n
0e-

Arrhenius H^+, OH^-

Revised Arrhenius H^+, OH^- *

Bronsted-Lowry

Lewis

BRONSTED - LOWRY THEORY OF ACIDS & BASES

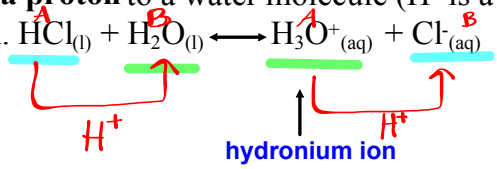
Bronsted-Lowry Acids and Bases

A new theory was needed because:
(i) not all acid/base reactions involve water.
(ii) not all bases contain hydroxide ions (Na_2CO_3, NH_3).

Bronsted - Lowry Acid - a proton (hydrogen-ion) donor
Bronsted - Lowry Base - a proton (hydrogen-ion) acceptor

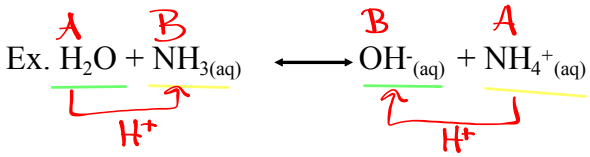
- **acids lose a proton** to a water molecule (H^+ is a proton!)

Ex. $HCl_{(l)} + H_2O_{(l)} \longleftrightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$



hydronium ion
(water molecule gains a proton)

- **bases gain a proton** from a water molecule



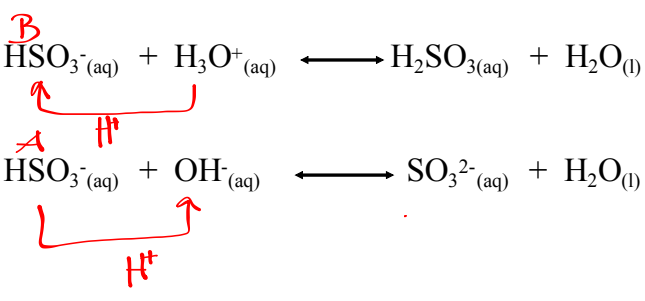
(H_2O acts as an acid, NH_3 acts as a base)

However water does not have to be present in order to have a proton exchange.

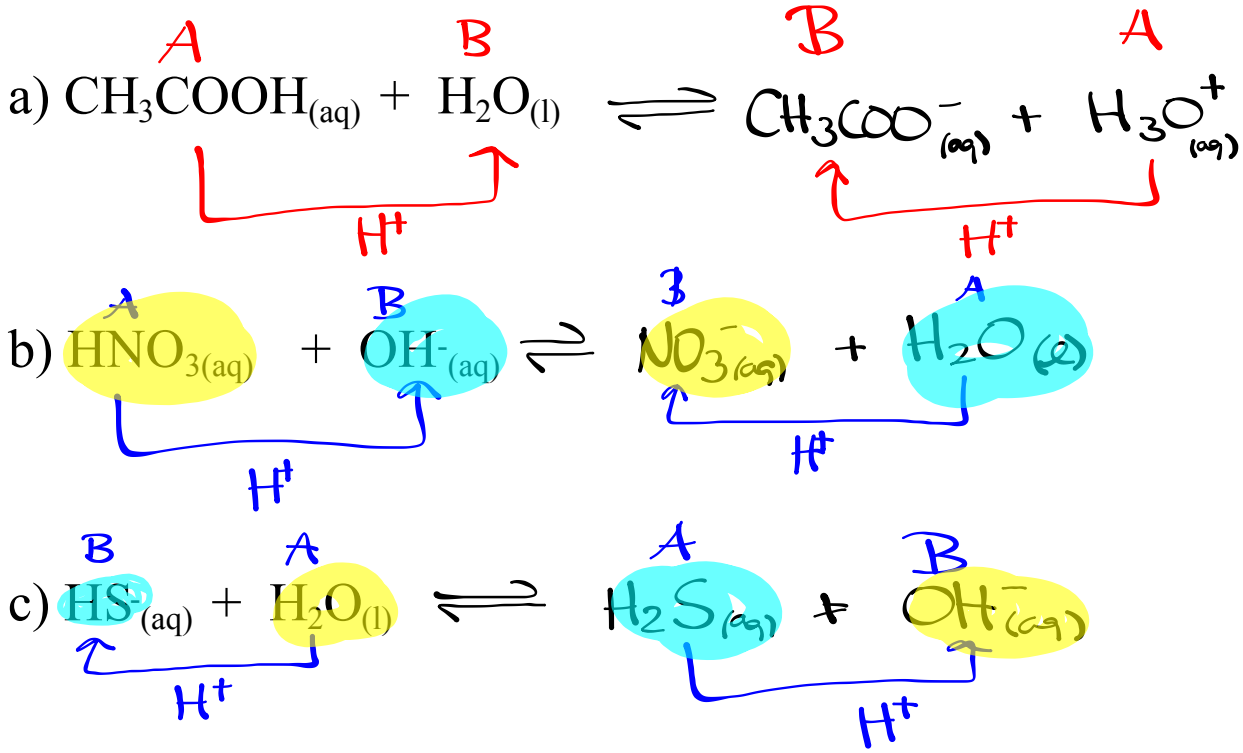
Ex. $HCl_{(g)} + NH_{3(g)} \longleftrightarrow NH_4^+{}_{(aq)} + Cl^-_{(aq)}$

HCl donates a proton (acid)
NH_3 accepts a proton (base)

amphoteric (amphiprotic) -substance that can act as a Bronsted-Lowry acid in some reactions and a Bronsted-Lowry base in other reactions.



Predict the products for the following reaction, and identify each substance as an acid or a base.



Conjugate Acid-Base Pairs

$$CH_3COOH_{(aq)} + H_2O_{(l)} \qquad CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$$

Acid-Base reactions are at equilibrium !

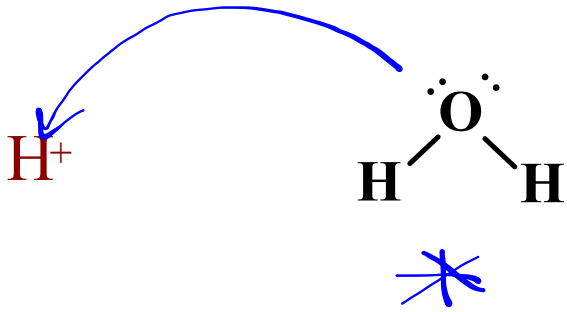
(Look at forward reaction and reverse reaction)

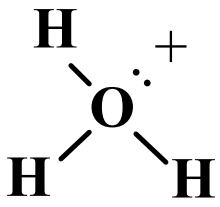
- Every acid-base reaction at equilibrium has two acids and two bases.
- Acid on 'product' side is formed by addition of proton to base on 'reactant' side
- Base on 'product' side is formed by removal of a proton from acid on 'reactant' side

Conjugate acid-base pair

A pair of substances that differ by only a proton

Ex.





H_3O^+