$$\underset{6.00g}{\overset{\underline{\underline{L.R.}}}{2H_{2(g)}}} + \underset{76.00g}{\overset{\underline{\underline{xs.}}}{O_{2(g)}}} \rightleftharpoons 2H_2O_{(g)}$$

17.0g

$$6.00g\ H_2 \times \frac{1\,mol\ H_2}{2.02g\ H_2} \times \frac{1\,mol\ O_2}{2\,mol\ H_2} \times \frac{32.00g\ O_2}{1\,mol\ O_2} = \underset{\underline{\underline{used}}}{47.52g}$$

Acid - Base Theories

Arrhenius Theory of Acids and Bases

- acids are hydrogen-containing compounds that ionize in aqueous solutions to give H^+
- bases ionize to give OH^- ions ~~CH_3OH~~

Monoprotic Acid - one hydrogen will ionize Ex. HNO_3

$$HNO_3 \rightarrow H^+ + NO_3^-$$

Diprotic Acid - two hydrogens will ionize Ex. H_2SO_4

$$H_2SO_4 \rightarrow 2H^+ + SO_4^{2-}$$

Triprotic Acid - three hydrogens will ionize Ex. H_3PO_4

$$H_3PO_4 \rightarrow 3H^+ + PO_4^{3-}$$

poly-protic

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).

H^+ = proton

$H^+ \rightarrow 1p^+$

1.01

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).

H^+

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

lose H^+ accepts H^+

hydronium ion
(water molecule gains a proton)

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

Ex. $H_2O + NH_{3(aq)} \longleftrightarrow OH^-_{(aq)} + NH_4^+{}_{(aq)}$

lose H^+

(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.

$HSO_3^-{}_{(aq)} + H_3O^+_{(aq)} \longleftrightarrow H_2SO_{3(aq)} + H_2O_{(l)}$

$HSO_3^-{}_{(aq)} + OH^-_{(aq)} \longleftrightarrow SO_3^{2-}{}_{(aq)} + H_2O_{(l)}$

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

a) $\overbrace{\underset{A}{CH_3COOH_{(aq)}} + \underset{B}{H_2O_{(l)}}}^{H^+} \rightleftharpoons \overbrace{\underset{B}{CH_3COO^-_{(aq)}} + \underset{A}{H_3O^+_{(aq)}}}^{H^+}$

b) $\overbrace{\underset{A}{HNO_{3(aq)}} + \underset{B}{OH^-_{(aq)}}}^{H^+} \rightleftharpoons \overbrace{\underset{B}{NO^-_{3(aq)}} + \underset{A}{H_2O_{(l)}}}^{H^+}$

c) $HS^-_{(aq)} + H_2O_{(l)}$

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)

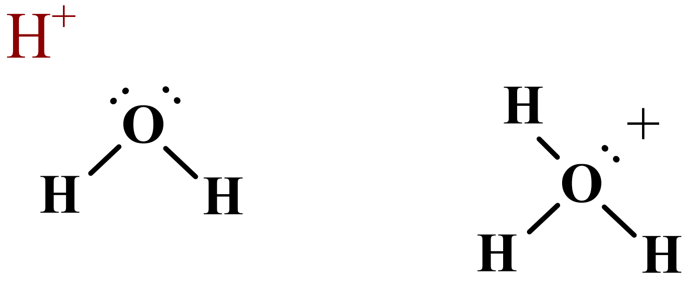
- Every acid-base reaction at equilibrium has two acids and two bases.
- Acid on 'product' side is formed by addition of proton to base on 'reactant' side
- Base on 'product' side is formed by removal of a proton from acid on 'reactant' side

Conjugate acid-base pair

A pair of substances that differ by only a proton

Ex.

See Appendix F, p. 611


H+
O
H
H
H
+
O
H
H