Acid-Base Introduction

proton p^+

H^+ hydrogen = H^+ ≡ Just a proton

$1p^+$

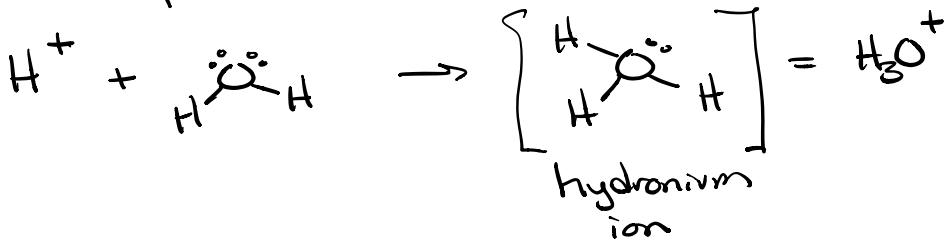
$\not{0}e^-$

proton = hydrogen ion = H^+

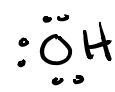
3 Definitions of Acid / Base

Arrhenius Definition

Acid = produced hydronium ion when placed in **water**



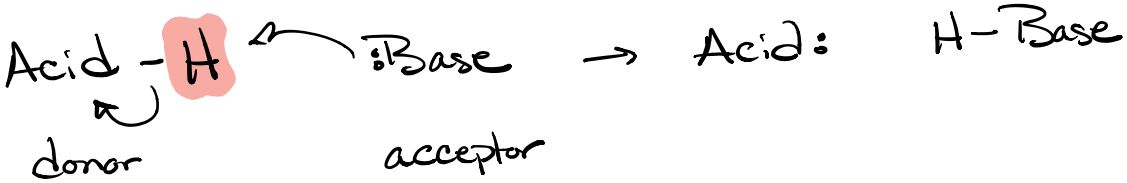
Base = produced hydroxide ion when placed in **water**

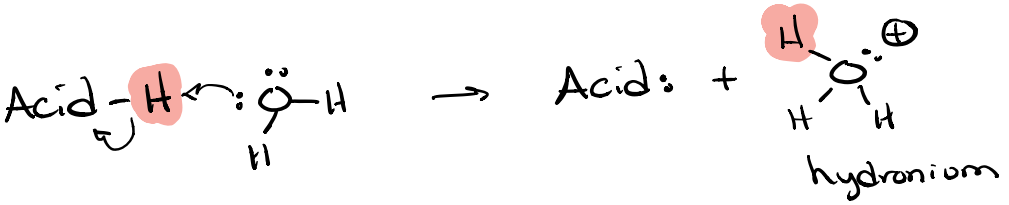


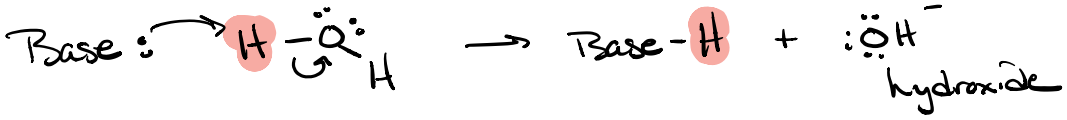
Brönsted - Lowry

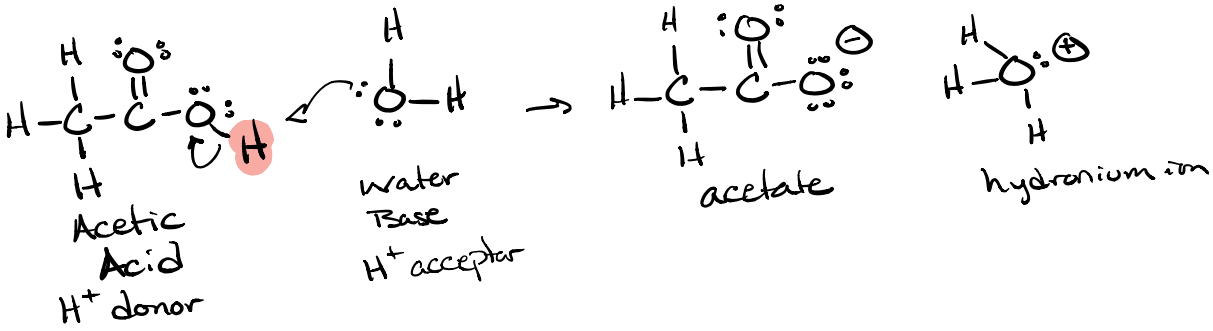
Acid - Acid is a hydrogen ion donor

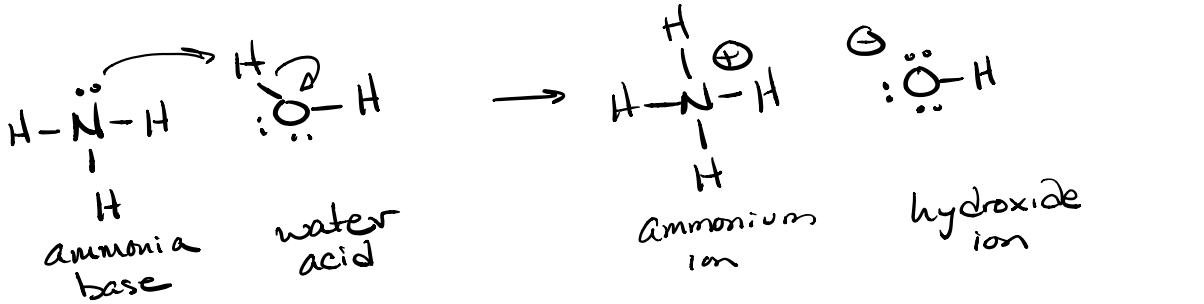
Base - Base is a hydrogen ion acceptor



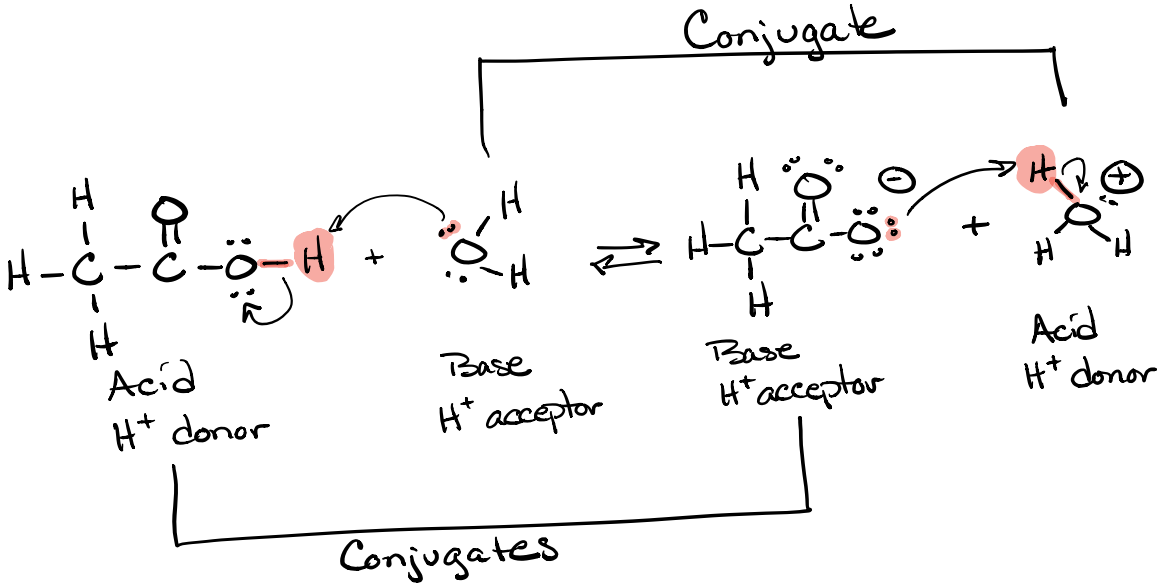




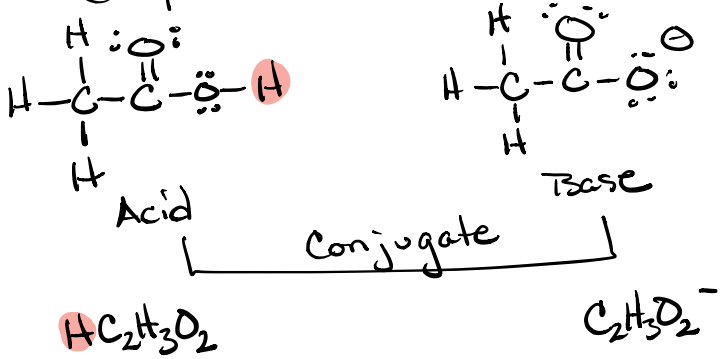




Amphoteric - a species that can act as an acid or a base depending on what it is reacting with.



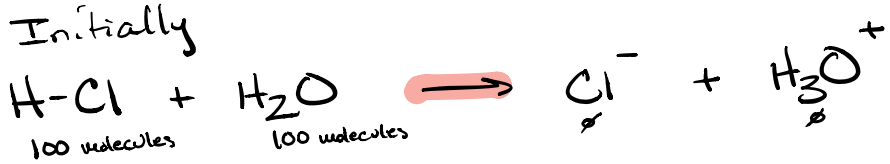
Conjugate → A relationship between two compounds that differ by 1 proton



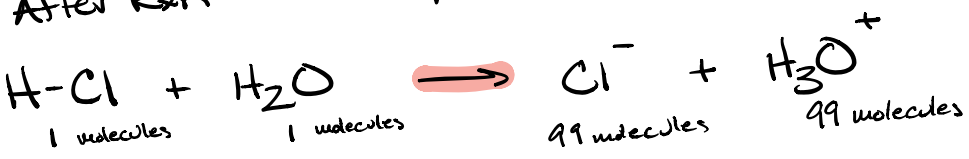
Strength of Acid

Strong acid – Dissociates Completely when placed in H_2O

Initially

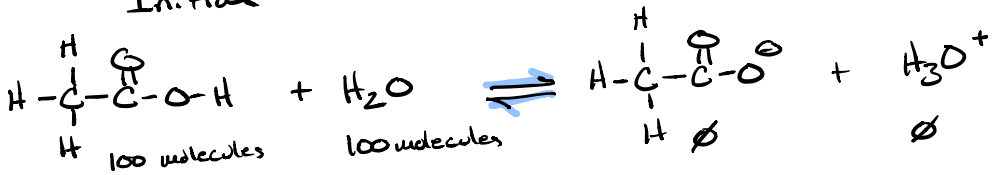


After Rxn

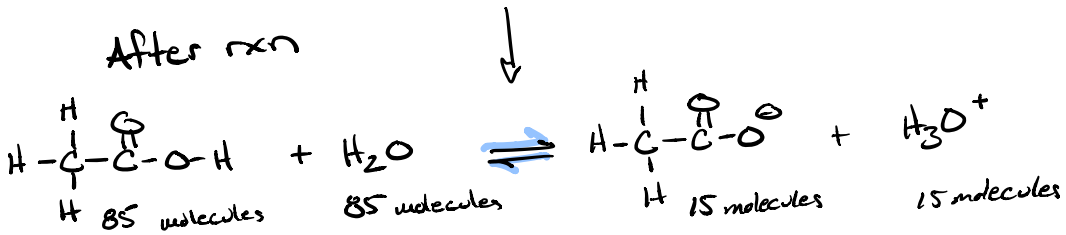


Weak acid – Dissociates only a little when placed into water

Initial



After rxn



Strong Acid

HCl	hydrochloric acid
HNO_3	nitric acid
H_2SO_4	sulfuric acid
HBr	hydrobromic acid
HI	hydroiodic acid

Weak Acid

many weak acids

ex

$HC_2H_3O_2$	acetic acid
$H_2C_2O_2$	oxalic acid

*Any acid not on the strong acid list

Strength of Base

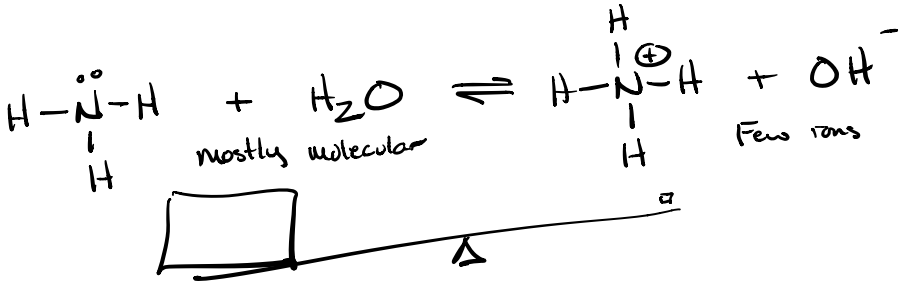
Strong base → Dissociates completely in H_2O

Generally Group 1A metal hydroxides

$$NaOH_{(s)} \xrightarrow{H_2O} NaOH_{(aq)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$$

"ionizes" → produces ions

Weak Base → Dissociates a little in water



"Confusing"

$NaOH_{(s)} + H_2O_{(l)} \rightarrow NaOH_{(aq)} + H_2O_{(l)}$

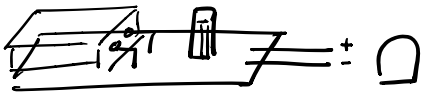
instead

$NaOH_{(s)} \xrightarrow{H_2O} NaOH_{(aq)}$

Lab Experiment

Color indicator Bromophthymol blue (BTB)

Base	neutral	Acid
Blue	Green	yellow



Bright LED → many ions in solution ⇒ Strong

Dim LED → Few ions in solution ⇒ weak

Test

$NaHSO_4$
Sodium Bisulfate

BTB ⇒ yellow ⇒ acid

Na_2HPO_4
Sodium hydrogen Phosphate

BTB ⇒ Blue ⇒ Base

HSO_4^-
Acid

HPO_4^{2-}
Base

Only by testing can we tell acid from base

H_3PO_4 Phosphoric acid

H_2SO_4 Sulfuric acid

NaOH
KOH
Base

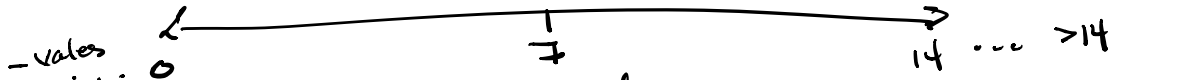
pH is a measurment of the amount of hydrogen ion in solution

$H^+ \equiv$ 

$$pH = -\log [H^+] = -\log [H_3O^+]$$

$[\ ]$ = Concentration measured in moles / L solution

pH Scale



$[H^+] = 10^{-0}$ moles/L $\quad [H^+] = 10^{-7}$ moles/L $\quad [H^+] = 10^{-14}$ moles/L

$$[H^+] = 10^{-pH} \text{ moles/L}$$

$\text{Log } x = 10^{y} = x$

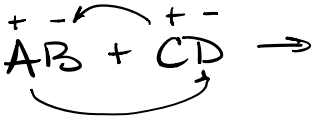
$\text{Log } 3 = 10^{y} = 3$

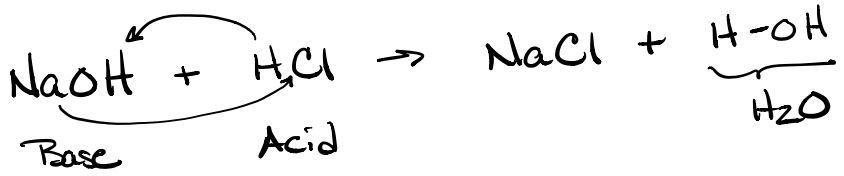
} Log base 10

ln natural log $\Rightarrow$ base e

$\ln 3 = e^{y} = 3$

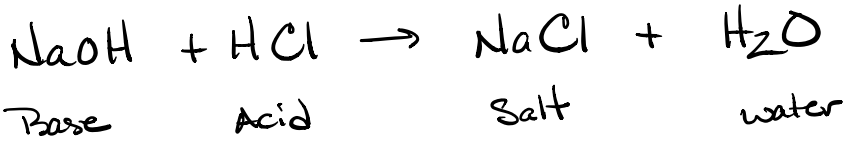
Acid-Base Reactions follow double displacement pattern.

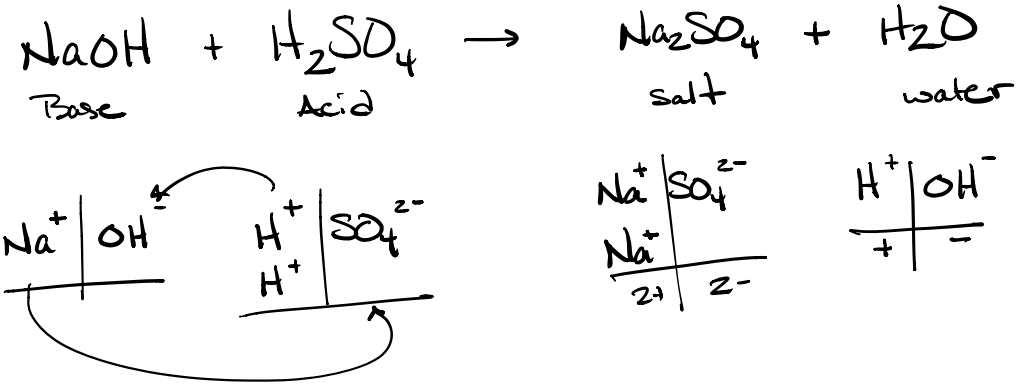




Neutralization Rxn - Rxn between acid and base to produce "a salt" and water.

an ionic compound





$2\,NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2\,H_2O$

~~Na^+~~	Na	✗ 2		Na 2	✓
~~OH^-~~	H	✗ 4		H ✗ 4	✓
~~H^+~~	O	✗ 6		O ✗ 6	✓
~~SO_4^{2-}~~	S	1		S 1	✓

$2\,NaOH + H_2SO_4 \rightarrow Na_2SO_4 + 2\,H_2O$

$3\,NaOH + H_3PO_4 \rightarrow Na_3PO_4 + 3\,H_2O$

$3 \times \{ OH^- + H^+ \rightarrow H_2O \}$

HCl	monoprotic	$NaOH$	monobasic
H_2SO_4	diprotic	$Ca(OH)_2$	dibasic
H_3PO_4	triprotic	$Fe(OH)_3$	tribasic

$$Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$$

dibasic — diprotic

Ca^{2+}	SO_4^{2-}
2+	2-

$$Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$$

Ca	1
H	4
O	6
S	1

Ca	1	✓
H	~~2~~ 4	✓
O	~~5~~ 6	✓
S	1	✓

Double Displacement Rxn

Chemical
Ionic
Net Ionic

Chemical

$$HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

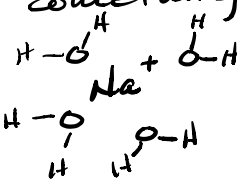
Ionic

$$H^+_{(aq)} + Cl^-_{(aq)} + Na^+_{(aq)} + OH^-_{(aq)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)} + H_2O_{(l)}$$

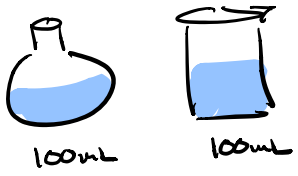
Net Ionic

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

aqueous = something dissolved in water



Liquid = Variable Shape, but fixed in volume



Mult materials
ethanol
water
Methanol
Toluene

Chemical

$$2NaOH_{(aq)} + H_2SO_{4(aq)} \rightarrow Na_2SO_{4(aq)} + 2H_2O_{(l)}$$

Ionic

$$2Na^+_{(aq)} + 2OH^-_{(aq)} + 2H^+_{(aq)} + SO_4^{2-}{}_{(aq)} \rightarrow 2Na^+_{(aq)} + SO_4^{2-}{}_{(aq)} + 2H_2O_{(l)}$$

net ionic

$$2OH^-_{(aq)} + 2H^+_{(aq)} \rightarrow 2H_2O_{(l)}$$

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

All neutralization Rxn's have same net ionic equation

$$H^+_{(aq)} + OH^-_{(aq)} \rightarrow H_2O_{(l)}$$

① Double Displacement (Precip Rxns)

Traded Cation & Anion

$\overset{+}{A}\overset{-}{B} + \overset{+}{C}\overset{-}{D} \rightarrow \overset{+}{A}\overset{-}{D} + \overset{+}{C}\overset{-}{B}$

② Acid-Base

Traded H^+ (proton)

$\text{Acid}^{\ominus}\text{-H} \curvearrowleft \text{Base} \rightarrow \text{Acid}^{\ominus}: + \overset{\oplus}{\text{H}}\text{-Base}$

③ RedOx = Oxidation - Reduction

Trade e^-

$2\,\overset{\circ}{Na} + \overset{\circ}{Cl_2} \rightarrow 2\,\overset{+}{Na}\overset{-}{Cl}$

$2\,\overset{\circ}{Na} \rightarrow 2\,\overset{+}{Na} + 2e^-$

$+ \quad \overset{\circ}{Cl_2} + 2e^- \rightarrow 2\,Cl^-$

$2\,Na + Cl_2 \rightarrow 2\,NaCl$

$2e^-$ have been traded