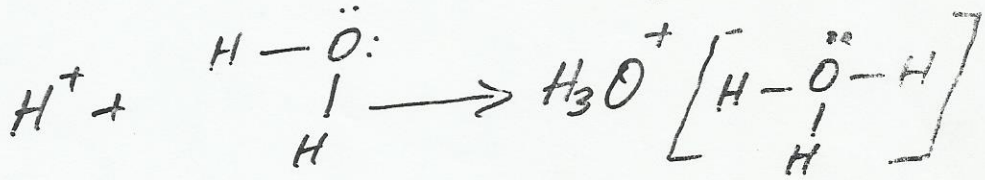
ACIDS & BASES

- Arrhenius Difinitions of Acids & Bases

- Acids in $H_2O \longrightarrow H^+$
- Bases : : $\longrightarrow OH^-$
- neutralization of acid & base $\rightarrow$ salt + H_2O

$$NaOH \xrightarrow{\text{in } H_2O} Na^+ + OH^-$$

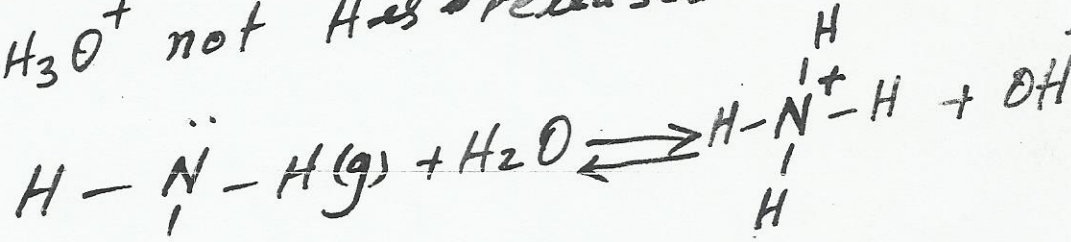
$$HCl \xrightarrow{\text{in } H_2O} Cl^- + \underbrace{H^+}_{\text{very reactive}}$$



Drawback

(1) H_3O^+ not H^+ is released

(2)



(3) reaction is necessary in aq.

e.g. $NH_{3(g)} + HCl_{(g)}$

Common Acids & Bases

Acids :- H_2SO_4, HCl, H_3PO_4 & HNO_3, CH_3COOH

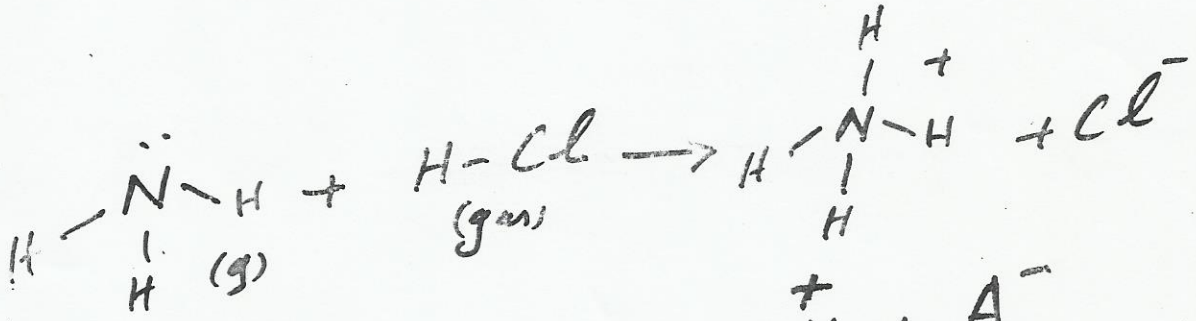
Bases :- Metal hydroxides :- $NaOH$, $Ca(OH)_2$, $Mg(OH)_2$, Ammonia (NH_3)

- Bronsted-Lowry Difinition of Acids & Bases

Acid : proton donor

Base : Proton acceptor

should have at least one non-bonding electron pair



$$B: + H-A \rightleftharpoons BH^+ + A^-$$

$$B^-: + H-A \rightleftharpoons BH + A^-$$

$$NH_3 + H-A \rightleftharpoons NH_4^+ + :A^-$$

$$H-\ddot{O}:^- + H-A \rightleftharpoons H_2O + A^-$$

$$\underset{\text{Base}}{B:} + \underset{\text{Acid}}{H-A} \rightleftharpoons \underset{\text{Base}}{:A^-} + \underset{\text{Acid}}{B^+-H}$$

conjugate acid-base pair

Conjugate acid-base pairs:

Conjugate acids:

$$CH_3\overset{O}{\overset{\|}{C}}-OH \rightleftharpoons H^+ + CH_3\overset{O}{\overset{\|}{C}}O^-$$

$$H_3O^+ \rightleftharpoons H^+ + H_2O$$

$$NH_4^+ \rightleftharpoons H^+ + NH_3$$

conjugate bases

Water as both an Acid and a Base:

$$\underset{\text{(base)}}{CH_3-\overset{O}{\overset{\|}{C}}-O} + \underset{\text{(acid)}}{H_2O} \rightleftharpoons \underset{\text{(acid)}}{CH_3-\overset{O}{\overset{\|}{C}}-OH} + \underset{\text{base}}{OH^-}$$

$$\underset{\text{(base)}}{H-\ddot{\underset{H}{O}}:} + \underset{\text{acid}}{HCl} \longrightarrow \underset{\text{acid}}{\underset{(H_3O^+)}{H-\underset{H}{O}-H}} + \underset{\text{(base)}}{Cl^-}$$

strong: $HClO_4$, H_2SO_4, HCl

weak: HNO_2, CH_3COOH

v. weak: H_2CO_3, $H_2PO_4^-$, NH_4^+, HCO_3^-

H_2O

ClO_4^-, HSO_4^-, Cl^- } v.v. weak or no reaction

NO_2^-, CH_3COO^- } v. weak bases

HCO_3^-, HPO_4^{2-}, NH_3, CO_3^{2-} } weak bases

OH^- } strong base

Table 10.1 Relative strengths of acids and conjugate bases

TABLE 10.1 Relative Strengths of Acids and Conjugate Bases

Increasing acid strength ↑

	ACID		CONJUGATE BASE		
Strong acids: 100% dissociated	Perchloric acid	$HClO_4$	ClO_4^-	Perchlorate ion	Little or no reaction as bases
	Sulfuric acid	H_2SO_4	HSO_4^-	Hydrogen sulfate ion	
	Hydriodic acid	HI	I^-	Iodide ion	
	Hydrobromic acid	HBr	Br^-	Bromide ion	
	Hydrochloric acid	HCl	Cl^-	Chloride ion	
	Nitric acid	HNO_3	NO_3^-	Nitrate ion	
	Hydronium ion	H_3O^+	H_2O	**Water**	
Weak acids	Hydrogen sulfate ion	HSO_4^-	SO_4^{2-}	Sulfate ion	Very weak bases
	Phosphoric acid	H_3PO_4	$H_2PO_4^-$	Dihydrogen phosphate ion	
	Nitrous acid	HNO_2	NO_2^-	Nitrite ion	
	Hydrofluoric acid	HF	F^-	Fluoride ion	
	Acetic acid	CH_3COOH	CH_3COO^-	Acetate ion	
Very weak acids	Carbonic acid	H_2CO_3	HCO_3^-	Bicarbonate ion	Weak bases
	Dihydrogen phosphate ion	$H_2PO_4^-$	HPO_4^{2-}	Hydrogen phosphate ion	
	Ammonium ion	NH_4^+	NH_3	Ammonia	
	Hydrocyanic acid	HCN	CN^-	Cyanide ion	
	Bicarbonate ion	HCO_3^-	CO_3^{2-}	Carbonate ion	
	Hydrogen phosphate ion	HPO_4^{2-}	PO_4^{3-}	Phosphate ion	
	Water	H_2O	OH^-	**Hydroxide ion**	Strong base

Increasing base strength ↓

$$\underset{\text{strong Acid}}{HA} + H_2O \rightleftharpoons H_3O^+ + \underset{\text{weak base}}{A^-}$$

$$\underset{\text{Weak acid}}{HA} + H_2O \rightleftharpoons H_3O^+ + \underset{\text{strong base}}{A^-}$$

$$\text{strong acid} + \text{strong base} \rightleftharpoons \text{Weak base} + \text{Weak acid}$$

$$\underset{\text{weaker acid}}{CH_3-\overset{O}{\overset{\|}{C}}-OH} + \underset{\text{weaker base}}{H_2O} \rightleftharpoons \underset{\text{stronger base}}{CH_3\overset{O}{\overset{\|}{C}}-O^-} + \underset{\text{stronger acid}}{H_3O^+}$$

$$\underset{\text{stronger acid}}{CH_3-\overset{O}{\overset{\|}{C}}OH} + \underset{\text{v. strong base}}{OH^-} \rightleftharpoons \underset{\text{weaker base}}{CH_3\overset{O}{\overset{\|}{C}}-O^-} + \underset{\text{weaker acid}}{H_2O}$$

Acid Dissociation Constant

$$HA_{(aq)} + H_2O \rightleftharpoons H_3O^+_{(aq)} + A^-_{(aq)}$$

$$\underset{(\text{eq. constt.})}{K} = \frac{[H_3O^+][A^-]}{[HA][H_2O]} \rightarrow 55.5\ M$$

Dissociation constt. $= K_a = K\,[H_2O]$

$$K_a = \frac{[H_3O^+][A^-]}{[HA]}$$

Strong acids have large K_a, much greater than 1

HNO_3, HCl, H_2SO_4

Weak acids have K_a much less than 1

NH_4^+, CH_3COOH, H_2CO_3 4.3×10^{-7}, HCO_3^- 5.6×10^{-11}

HCN 6×10^{-10}, HF 3.5×10^{-4}, HSO_4^- (1.3×10^{-2})

Table 10.2 Some acid dissociation constants, K_a, at 25 °C

TABLE 10.2 Some Acid Dissociation Constants, K_a, at 25 °C

ACID	K_a
Hydrofluoric acid (HF)	3.5×10^{-4}
Hydrocyanic acid (HCN)	4.9×10^{-10}
Ammonium ion (NH_4^+)	5.6×10^{-10}
Organic acids	
Formic acid (HCOOH)	1.8×10^{-4}
Acetic acid (CH_3COOH)	1.8×10^{-5}
Propanoic acid (CH_3CH_2COOH)	1.3×10^{-5}
Ascorbic acid (vitamin C)	7.9×10^{-5}

ACID	K_a
Polyprotic acids	
Sulfuric acid	
H_2SO_4	Large
HSO_4^-	1.2×10^{-2}
Phosphoric acid	
H_3PO_4	7.5×10^{-3}
$H_2PO_4^-$	6.2×10^{-8}
HPO_4^{2-}	2.2×10^{-13}
Carbonic acid	
H_2CO_3	4.3×10^{-7}
HCO_3^-	5.6×10^{-11}

$pKa = -\log Ka$

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