SCH 3U
ACID & BASE THEORY

PROPERTY	ACIDS	BASES
Taste	Sour	Bitter
Feel	No characteristic feel	Slippery
Phenolphthalein	Colourless	Pink
Litmus paper	Turns blue litmus red	Turns red litmus blue
Reaction with $Mg_{(s)}$ and other active metals	H_2 gas releases	No reaction
Reaction with $NaHCO_3$	CO_2 releases	No reaction
Formation	$NM\text{-}O_x + H_2O \rightarrow$ acids	$M\text{-}O_x + H_2O \rightarrow$ bases
Neutralization	acid + base → salt + water	base + acid → salt + water

ARRHENIUS DEFINITION (1887)

ACID -- substance that dissociates in water to form H^+ (hydrogen ions).

EG. $HCl_{(aq)} \longrightarrow H^+_{(aq)} + Cl^-_{(aq)}$

EG. $H_2SO_{4(aq)} \longrightarrow H^+_{(aq)} + HSO_4^-{}_{(aq)}$

BASE -- substance that dissociates in water to form OH^- (hydroxide ions).

EG. $NaOH_{(aq)} \longrightarrow Na^+_{(aq)} + OH^-_{(aq)}$

EG. $Mg(OH)_{2(aq)} \longrightarrow Mg^{+2}_{(aq)} + 2\ OH^-_{(aq)}$

... Explains ***neutralization***:

EG. $HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$

Total Ionic Equation: $H^+_{(aq)} + Cl^-_{(aq)} + Na^+_{(aq)} + OH^-_{(aq)} \longrightarrow Na^+_{(aq)} + Cl^-_{(aq)} + H_2O_{(l)}$

Net Ionic Equation: $H^+_{(aq)} + OH^-_{(aq)} \longrightarrow H_2O_{(l)}$

***PROBLEMS with Arrhenius Theory*:**

- $H^+_{(aq)}$ (bare proton) **does not exist**-- instead the hydrogen ion attaches to polar H_2O
  $H^+_{(aq)} + H_2O_{(l)} \longrightarrow H_3O^+_{(aq)}$
  hydronium ion

- ammonia (NH_3) is a base, but does not contain OH^- ions.
  $NH_{3(g)} + H_2O_{(l)} \longrightarrow NH_4^+{}_{(aq)} + OH^-_{(aq)}$

- many salt solutions are basic -- ones that contain carbonate ion.
- some neutralizations do not produce water -- $NH_{3(g)} + HCl_{(g)} \longrightarrow NH_4Cl_{(s)}$
- only accounts for water as a solvent.

BRONSTED-LOWRY THEORY OF ACIDS & BASES

ACIDS -- proton (H^+) donor

BASES -- proton (H^+) acceptor

- All Arrhenius acids are **Bronsted acids** -- both contain H^+ ion
- Any **negative ion** can be a **Bronsted base**
- Can use solvents other than H_2O.
- When H_2O is the solvent, chemists use Bronsted definitions.
- Acid-base reactions involve proton H^+ transfer.

CONJUGATE ACID-BASE PAIRS:

- 2 substances that differ from each other by only ***one*** proton are referred to as a conjugate acid-base pair.

conjugate pair (HCl ↔ Cl^-)

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

acid — base — acid — base

conjugate pair (H_2O ↔ H_3O^+)

conjugate acid = particle formed when the base receives H^+

conjugate base = particle left when H^+ is removed from acid

AMPHOTERIC SUBSTANCES:

- Substances that be either acids or bases depending on the other substance present.

EG. H_2O is a common example of an amphoteric substance, as shown in the following:

$HCl_{(aq)}$ +	H_2O	$\longrightarrow$	$H_3O^+_{(aq)}$ +	$Cl^-_{(aq)}$
acid	base		acid	base

$NH_{3(aq)}$ +	H_2O	$\longrightarrow$	$NH_4{}^+_{(aq)}$ +	$OH^-_{(aq)}$
base	acid		acid	base

EG. Illustrate the amphoteric behaviour of HCO_3^- with an acid and with a base.

$HCO_3{}^-{}_{(aq)} + H_3O^+{}_{(aq)} \longrightarrow$

$HCO_3{}^-{}_{(aq)} + OH^-_{(aq)} \longrightarrow$

EXERCISE:

1. If each of the following is an acid, name it conjugate base:

A)	H_2SO_4	B)	HCO_3^-	C)	$N_2H_5^+$	D)	CH_3COOH
E)	H_2O	F)	HPO_4^{2-}	G)	HNO_2	H)	NH_4^+

2. If each of the following is a base, name its conjugate acid:

A)	NO_3^-	B)	OH^-	C)	HCO_3^-	D)	NH_3
E)	SO_4^{2-}	F)	NH_2^-	G)	HO_2^-	H)	$H_2PO_3^-$

3. Identify the conjugate acid-base pairs in the following reactions:

A) $HS^-_{(aq)} + H_2O \rightarrow H_2S_{(aq)} + OH^-_{(aq)}$

B) $O^{2-}_{(aq)} + H_2O \rightarrow 2\ OH^-_{(aq)}$

C) $H_2S_{(l)} + NH_{3(aq)} \rightarrow NH^+_{4(aq)} + HS^-_{(aq)}$

D) $H_2SO_{4(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + HSO^-_{4(aq)}$

E) $CN^-_{(aq)} + H_3O^+_{(aq)} \rightarrow HCN_{(aq)} + H_2O$

F) $HCO_3^-{}_{(aq)} + H_2PO_4^-{}_{(aq)} \rightarrow H_2CO_{3(aq)} + HPO_4^{2-}{}_{(aq)}$

4. Identify substances in #3 above which are amphiprotic (aka amphoteric). Then illustrate their amphiprotic behaviour.