

SCH 4U

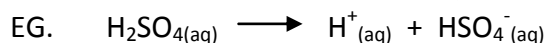
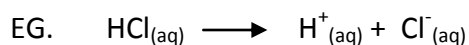
PROPERTIES OF ACIDS & BASES

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 $\text{Mg}_{(s)}$	H_2 gas releases	No reaction
Reaction with NaHCO_3	CO_2 releases	No reaction
Formation	$\text{NM-O}_x + \text{H}_2\text{O} \rightarrow \text{acids}$	$\text{M-O}_x + \text{H}_2\text{O} \rightarrow \text{bases}$
Neutralization	acid + base \rightarrow salt + water	base + acid \rightarrow salt + water

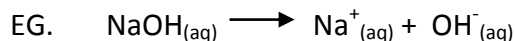
PART 1: ACID/BASE THEORIES

① ARRHENIUS THEORY (1887)

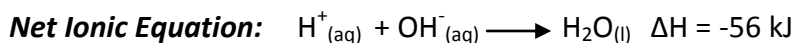
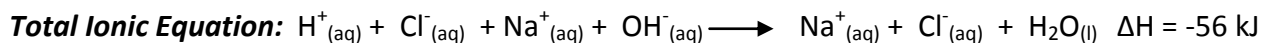
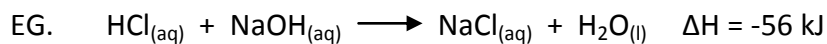
ACID -- substance that dissociates in water to form H^+ ions.



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



... Explains neutralization:



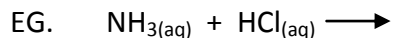
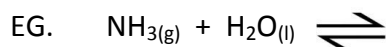
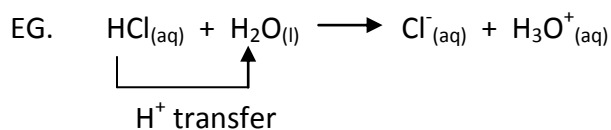
Limitations of Arrhenius Theory:

- $\text{H}^+_{(\text{aq})}$ (bare proton) does not exist-- instead $\text{H}^+_{(\text{aq})} + \text{H}_2\text{O}_{(\text{l})} \longrightarrow \text{H}_3\text{O}^+_{(\text{aq})}$ hydronium ion
- NH_3 is a base, but does not dissolve to form OH^- .
- NH_3 neutralizes acids
- many salt solutions are basic
- some neutralizations required no water -- $\text{NH}_{3(\text{g})} + \text{HCl}_{(\text{g})} \longrightarrow \text{NH}_4\text{Cl}_{(\text{s})}$

② BRONSTED-LOWRY THEORY (1923)

- acid/base reaction is actually chemical equilibrium with \rightleftharpoons
- involves transfer of a proton
- acid -- substance from which proton can be removed ("proton donor")
- base -- substance that can accept a proton ("proton receiver")

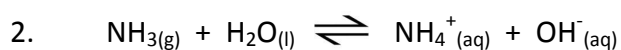
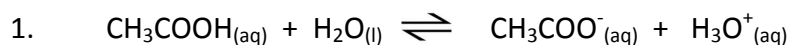
... Explains limitations of Arrhenius.



CONJUGATE ACID-BASE PAIRS

- differ by one proton (H^+)
- involves weak acids or bases dissociating -- equilibrium reactions

EG. Identify the conjugate acid/base pairs.



EG. What is the conjugate acid of the base HCO_3^- ?

EG. What is the conjugate base of the acid $H_2PO_4^-$?

EG. Complete and identify the conj. acid-base pairs if only one proton is transferred

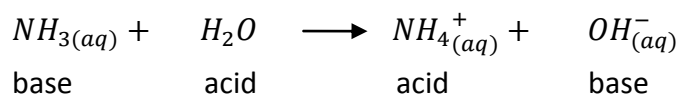
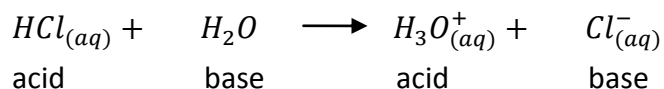
i) phosphoric acid and ammonia

ii) carbonate ion and sulfuric 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:




PART 2: STRENGTHS OF ACIDS & BASES

STRONG ACIDS

- **BINARY** -- $\text{HX}_{(\text{aq})}$ where $\text{X} = \text{Cl, Br, I}$
(all other binary acids are weak)

electronegativity \uparrow
acid strength \uparrow


 - as one moves to the right along a period of the periodic table, the increasing strength of the EN of the non-metal draws electrons away from H, making it δ^+
 - the δ^- of H_2O then attracts and pulls away H^+
 - as one moves down a group of the periodic table, the attraction between H and non-metal decreases due to larger radius, therefore it is easier to pull H^+ away.


acid strength \uparrow
as bond strength \downarrow
- **OXOACIDS** -- $(\# \text{Oxygens}) - (\# \text{dissociable H}) \geq 2$


EG. H_2SO_4 $4 - 2 = 2$ -- strong acid

EG. H_2SO_3 $3 - 2 = 1$ -- weak acid

EG. CH_3COOH $2 - 1 = 1$ -- weak acid

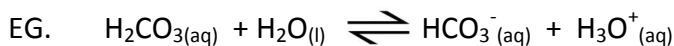
 - only H's attached to O's dissociate
 - oxygen more EN than hydrogen
 - as # of O's increase, electron density around hydrogen decreases (greater polarity of H – O bond), therefore H^+ is more easily pulled away by water.

EG. HClO HClO_2 HClO_3 HClO_4

weakest acid  strongest acid

POLYPROTIC ACIDS

- more than 1 H^+ can be removed.
- $\text{HNO}_{3(\text{aq})}$ is monoprotic (only 1 H^+ removed)
- $\text{H}_2\text{CO}_{3(\text{aq})}$ is diprotic (2 H^+ can be removed)



weaker

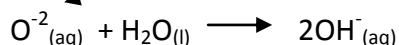
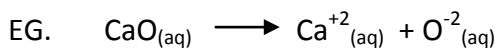
-- harder to remove H^+ from already negative ion

STRONG BASES

- all 1A **HYDROXIDES** -- such as NaOH and KOH
- all 2A **HYDROXIDES**, except Be -- such as $\text{Ca}(\text{OH})_2$ and $\text{Ba}(\text{OH})_2$

-- reason for Be -- small atom, so with O, it is hard to break strong bond.

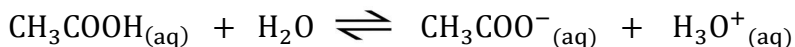
- all 1A **OXIDES** -- such as Na_2O and K_2O
- all 2A **OXIDES**, except Be -- such as CaO and BaO



In general,

- Equilibrium systems involving Bronsted acids & bases favour the weaker species.
- Stronger acids and bases tend to react with each other to produce weaker conjugates.
- The stronger the acid, the weaker its conjugate base.
- The weaker the acid, the stronger its conjugate base.

EG. Describe the following equilibrium system:



PART 3: CALCULATIONS WITH STRONG ACIDS & BASES

1. What is the $[\text{H}_3\text{O}^+]$ of 0.035 mol/L $\text{HNO}_{3(\text{aq})}$?

2. What is the $[\text{OH}^-]$ of 0.45 mol/L $\text{Ba}(\text{OH})_2$?

DILUTING SOLUTIONS: $c_1v_1 = c_2v_2$

3. What is the $[\text{OH}^-]$ of 15.0 mL of 2.50 mol/L NaOH diluted to 75.0 mL?

MIXING ACIDS & BASES UNEVENLY

1. Balance chemical equation.

2. moles of each acid and base (H^+ and OH^-)

3. determine the LR.

4. $\text{moles ER} - \text{moles LR} = \text{amount of ER leftover}$.

5.
$$[\text{ER}] = \frac{n \text{ ER leftover}}{v_1 + v_2}$$

EG. 40.0 mL of 3.25 mol/L $\text{HCl}_{(\text{aq})}$ is mixed with 30.0 mL of 2.50 mol/L $\text{Ca}(\text{OH})_{2(\text{aq})}$. Is the solution acidic or basic? What is the [] of the ion that causes this?