

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 $Mg_{(s)}$	H_2 gas releases	No reaction
Reaction with $NaHCO_3$	CO_2 releases	No reaction
Formation	$NM-O_x + H_2O \rightarrow$ acids	$M-O_x + H_2O \rightarrow$ 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:



Total Ionic Equation: $H^+_{(aq)} + Cl^-_{(aq)} + Na^+_{(aq)} + OH^-_{(aq)} \longrightarrow Na^+_{(aq)} + Cl^-_{(aq)} + H_2O_{(l)} \quad \Delta H = -56 \text{ kJ}$

Net Ionic Equation: $H^+_{(aq)} + OH^-_{(aq)} \longrightarrow H_2O_{(l)} \quad \Delta H = -56 \text{ kJ}$

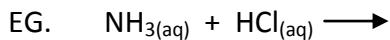
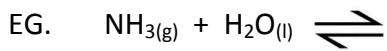
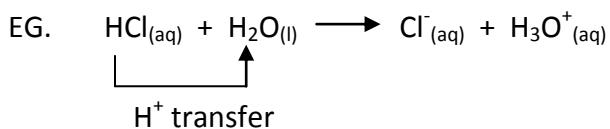
Limitations of Arrhenius Theory:

- $\text{H}^+_{(\text{aq})}$ (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")

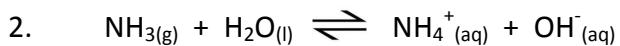
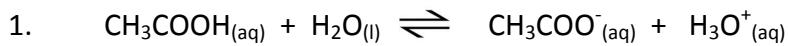
... Explains limitations of Arrhenius.



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

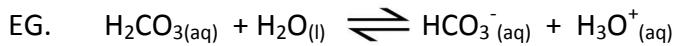
- BINARY -- $\text{HX}_{(\text{aq})}$ where $\text{X} = \text{Cl, Br, I}$
(all other binary acids are weak)
 - as one moves to the right along a period of the periodic table, the increasing strength of the EN of the non-metal draws electrons away from H, making it δ^+
 - the δ^- of H_2O then attracts 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.
- 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 \longrightarrow 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)



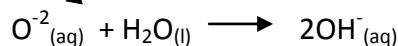
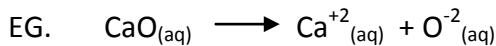
weaker

-- 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 Ca(OH)_2 and Ba(OH)_2
 - reason for Be -- small atom, so with O, it is hard to break strong bond.

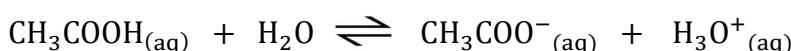
- all 1A OXIDES -- such as Na_2O and K_2O
- all 2A OXIDES, except Be -- such as CaO and BaO



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 Ba(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. *moles ER – moles LR = 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 $\text{Ca(OH)}_{2\text{(aq)}}$. Is the solution acidic or basic? What is the [] of the ion that causes this?