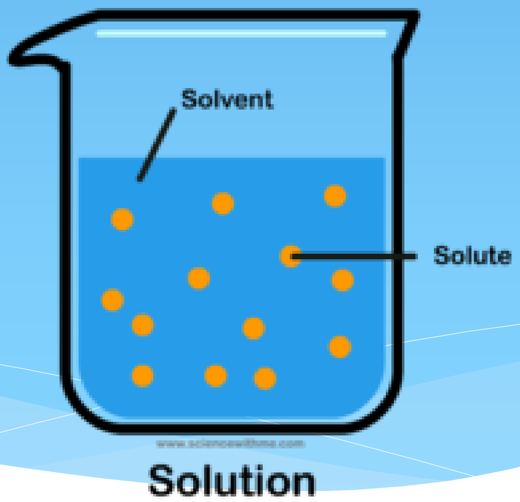
CHEMISTRY 20 UNIT 2: Solution Chemistry

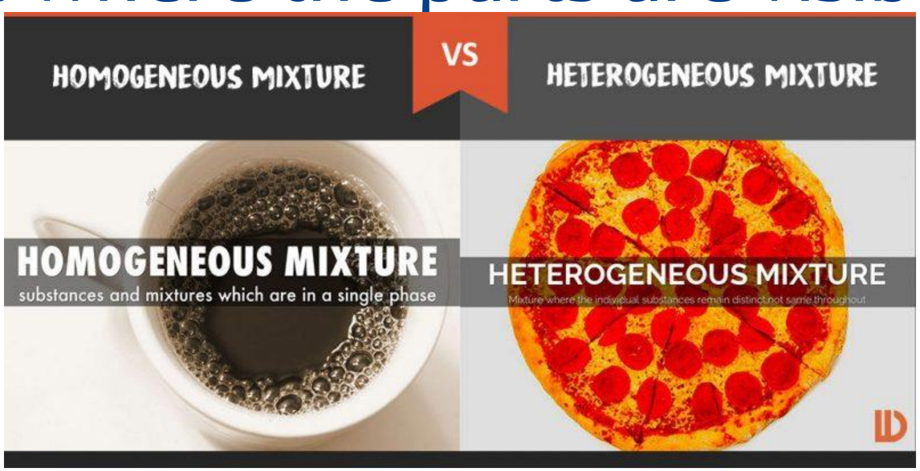


Lesson 1

DEFINITIONS & PROPERTIES OF SOLUTIONS

A. Definitions

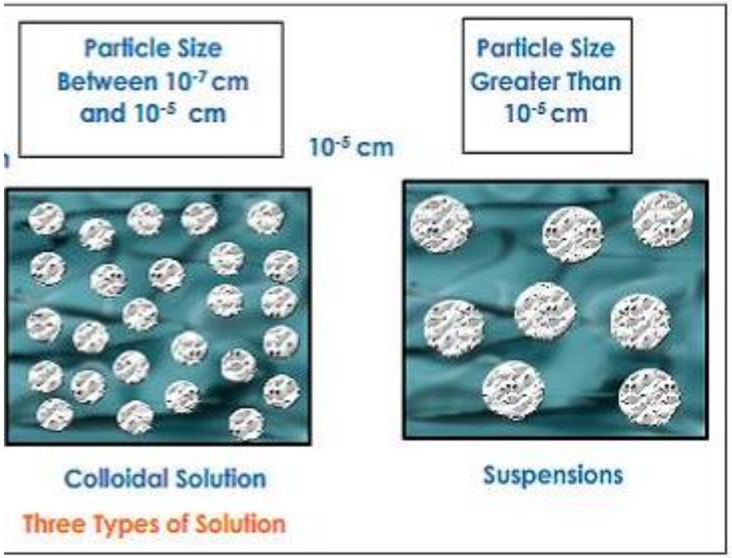
- Mixture: a combination of 2 or more substances
  - Solution/Homogenous: uniform mixture where the parts are not visible
    - Solvent (large part - water) + Solute (small part) → Solution
    - Alloy: a solution of two metals like bronze
  - Mechanical/Heterogeneous: non-uniform mixture where the parts are visible.

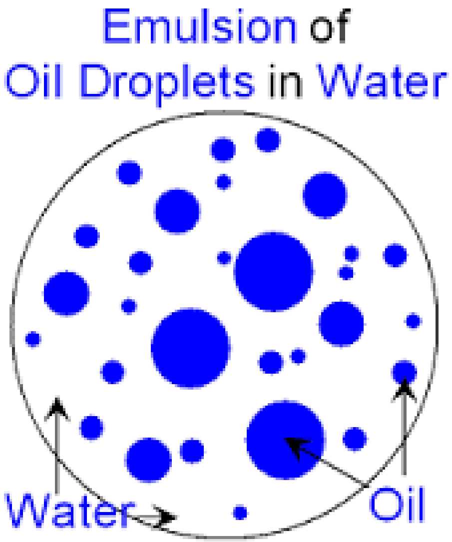


Ie) Coffee ie) Pizza

A. Definitions

* Suspension: a heterogeneous mixture containing large particles that settle
* Colloid: a heterogeneous mixture containing small particles that do not settle.
* Emulsion: a heterogeneous mixture made of two liquids





A. Definitions Continued

* Miscible: liquids that dissolve in each other. (ethanol & water)
* Immiscible: liquids that are insoluble in each other - do not dissolve. (oil & water)
* Electrolyte: a aqueous or molten compound that conducts electricity. Only aqueous ionic compounds are electrolytes

Immiscible
Oil & water

Miscible
alcohol & water

B. Solubility

Definition: Maximum amount of solute that dissolves in a given quantity of solvent at a given temperature ie)NaCl

31.6g/100mL at 0C

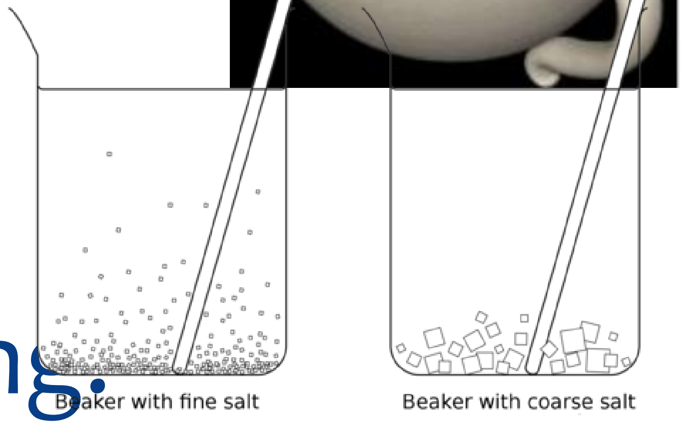
36.2g/100mL at 25C

39.2g/100ml at 100C

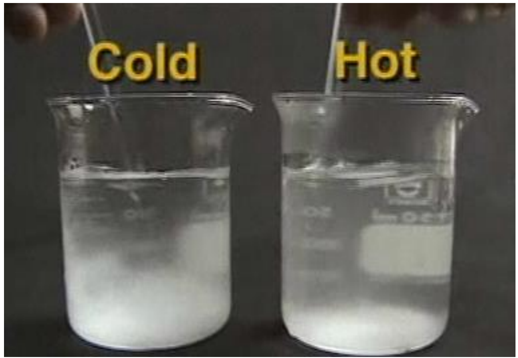
B. Solubility Rate depends on:

1. Agitation: shaking brings solvent into contact with solute & results in faster dissolving. (Does not affect the amount)

2. Particle size: larger surface area (powder) results in faster dissolving.



3. Temperature: higher temperature results in faster dissolving.



B. Solubility Amount depends on

1. Temperature: the higher the temp. the greater the amount **Exception**: Gases
2. Pressure: the greater the pressure the greater the amount.

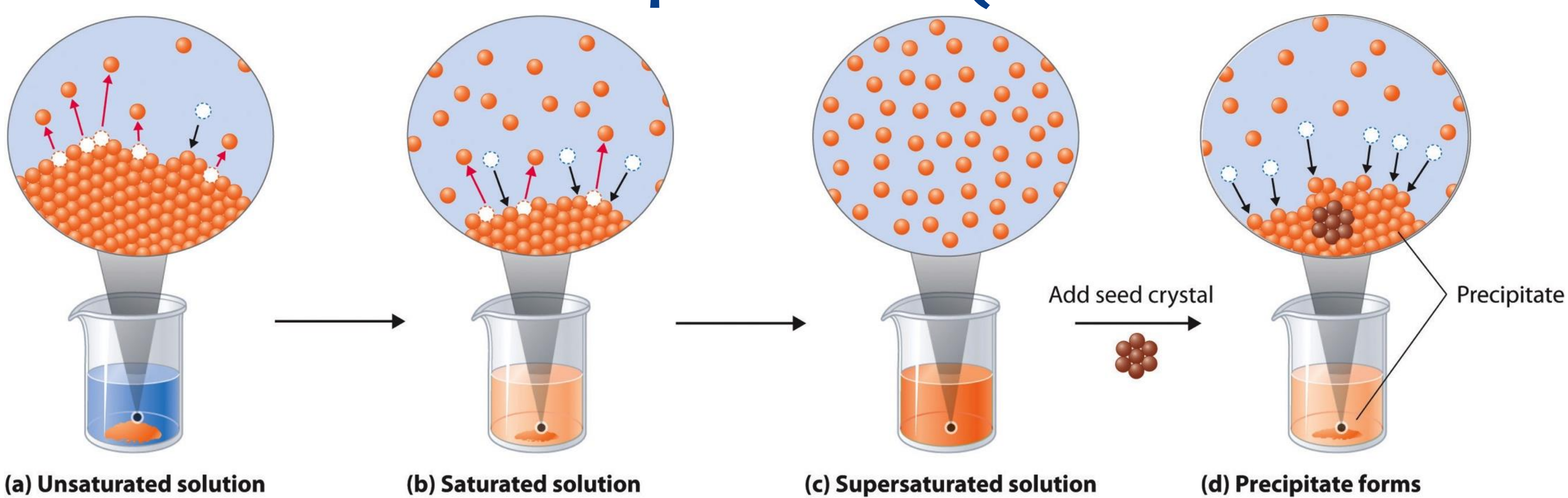
   Ie)chromatography: separates compounds depending on their:

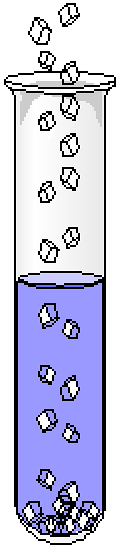
   a) size (smaller particles on top)

   b) solubility (most soluble parts on top)

C. Saturation

* Saturated: maximum amount of solute at given conditions.
* Unsaturated: maximum amount of solute not reached
* Supersaturated: higher amount of solute than expected (heat & then





D. Dissolving: Solute + Solvent

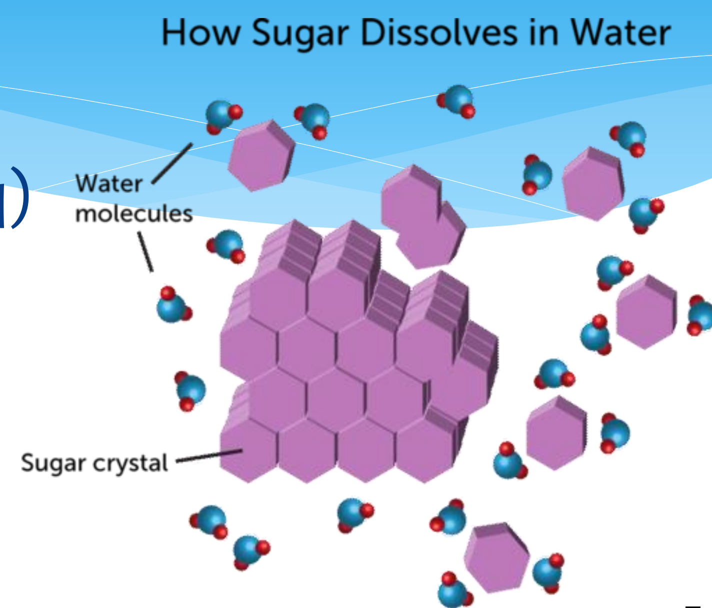
Polar dissolves polar (not a chemical reaction)

1. Molecular compound

$C_6H_{12}O_{6(s)} \rightarrow^{H2O} \rightarrow C_6H_{12}O_{6(aq)}$

+ve hydrogen from water

surrounds the oxygens



2. Ionic compound

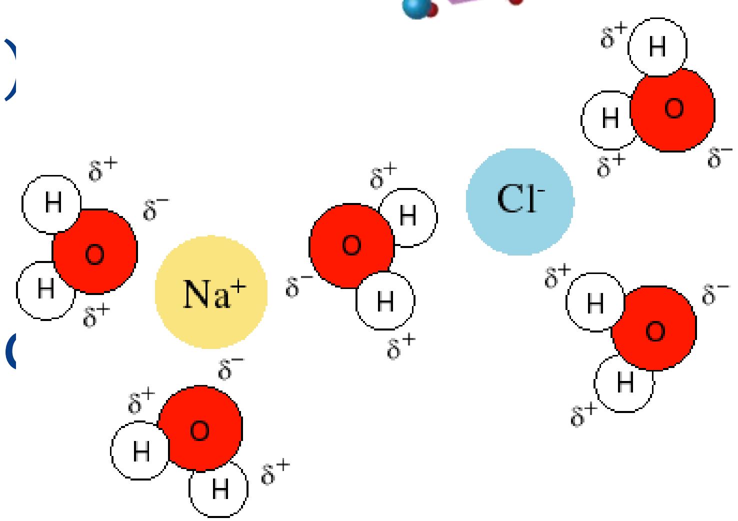
$NaCl_{(s)} \rightarrow^{H2O} \rightarrow Na^{+}_{(aq)} + Cl^{-}_{(aq)}$

-ve oxygen from water surrounds

the positive sodium ion.

+ve hydrogen from water surroun

The negative chloride ion.



Lesson 2

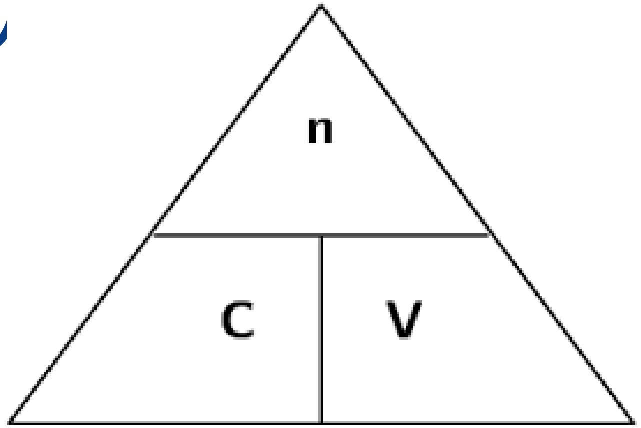
MOLAR CONCENTRATION

A. Definitions

The moles of solute in a given volume of solution (liters)

- Symbol is C or [ ]
- Unit is mol/L or M
- Formula: C=n/V (n=CV)

C= concentration (mol/L)
n= moles of solute (mol)
V= volume of solvent (L)



B. Examples

1. Calculating concentration from moles and volume.

* What is the concentration of 0.100 mol of 1.00 L solution

C= n/V

C= 0.100 mol/1.00L

C= 0.100 mol/L

B. Examples

2. Calculating concentration from mass and volume.

* What is the concentration of 40.0g of NaOH in 1000 mL of water

Step 1) n=m/M   n=40.0g/40.00g/mol

n=1.00 mol

Step 2) C= n/V   C=1.00mol/1.00L

C= 1.00 mol/L

B. Other forms of concentration

a) ppm = $\frac{\text{mass solute}}{\text{mass solvent}} \times 10^6$

ie) 2.00E-3g of Pb in 1.0kg of water=2ppm

NOTE: 1.0 mL of water = 1.0 g

b)% mass=$\frac{\text{mass solute}}{\text{(mass solute+solvent)}} \times 100$

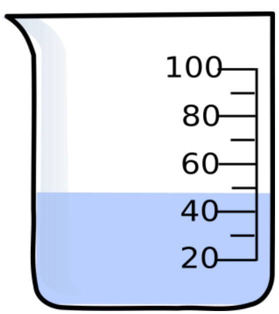
ie) 0.84g of tin in a 7.0g loonie = 12% tin

c)% volume=$\frac{\text{volume solute}}{\text{volume solution}} \times 100$

ie) 1000mL of 2% milk has 20 mL of fat

B. Steps to prepare a solution

1) Calculate the moles of solute needed. Use n=CV
2) Calculate & measure (with a scale) the mass of solute needed. Use m=nM



3) In a beaker, mix solute in about half of the solvent.

B. Steps to prepare a solution

4) Pour into a volumetric flask with the desired volume. Add more solvent (water). Use an eye dropper to add solvent to the calibration line.

5) Cap the flask, invert and mix

B. Example

Prepare 100 mL of 0.400 M magnesium sulfate

1) Calculate moles. n=CV

n = 0.100 L x 0.400 mol/L

n= 0.0400 mol

2) Calculate mass. Use scale m=nM

m=0.0400mol x 120.38 g/mol

m=4.82 g (3 sig digs)

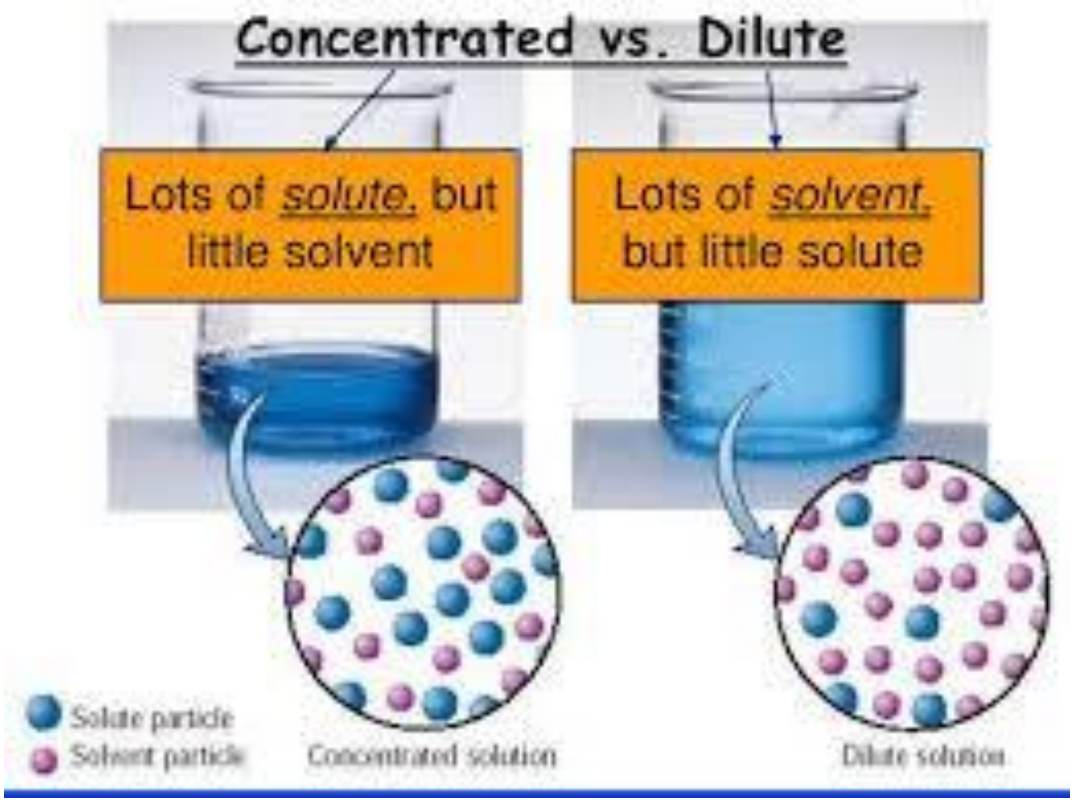
Weight in with a scale

B. Example

3) In 100mL beaker, mix 4.82 g in about 50 mL of water.
4) Pour into a 100 mL volumetric flask and fill to the calibration line. Use eye dropper near the end.
5) Cap the flask, invert and mix

Lesson 3
DILUTIONS

* Dilution: process of decreasing the concentration of a solution by adding more solvent.
  * Concentrated: a solution containing a large amount of solute when compared to another solution
  * Dilute: a solution containing a small amount of solute when compared to another solution.



B. Mathematical expression

$n_1 = n_2$;   ($n=CV$)

$C_1V_1=C_2V_2$

HINTS: $V_2=V_1+V_{water}$

1 refers to concentrated, original or pure solutions

2 refers to diluted or prepared solutions

C_1 is larger than C_2

V_1 is smaller than V_2

C. Examples

Steps to a dilution

1) Find volume $V_1 = C_2 V_2 / C_1$
2) Remove volume with a volumetric or graduated pipet
3) Place in a ___ mL volumetric flask and fill with water
4) Cap, Invert & Mix

C. Example 1)

How do you prepare 100mL 0.40 M magnesium sulphate from 100mL of 2.0M solution

1) $V_1=C_2V_2/C_1$

V=100mL x 0.40M/2.0M

V=0.020L or 20 mL

2) Remove 20 mL with pipet

3) Fill volumetric flask with 80 mL of water

4) Cap, Invert & Mix

C. Example 2)

If a student begins with 1000 ml of 1.00 M solution and dilutes it to 0.100 M, what volume of water was added?

1) $V_2=C_1V_1/C_2$

V=1.0M x 1.000L/0.10 = 10.0L

Vwater = V2-V1

= 10.0 - 1.000 = 9.0 L

C. Example 3)

If 100 mL of 1.0 M solution is added to 900 mL of 0.10 M solution what is the new C

C = ntotal/Vtotal

$$= \frac{(0.1L \times 1.0M)+(0.9L \times 0.1M)}{(0.100 + 0.900)}$$

= 0.19 M

NOTE: Cannot add concentrations

C. Example 4)

If 100 mL (Vw) of water was added to 1.0 M solution and the resulting solution was 0.250 M. What is the initial volume? 1.00 L solution was made

$V_1 = C_2V_2/C_1$

$V_1 = 0.250 \times 1.00L / 1.0M$

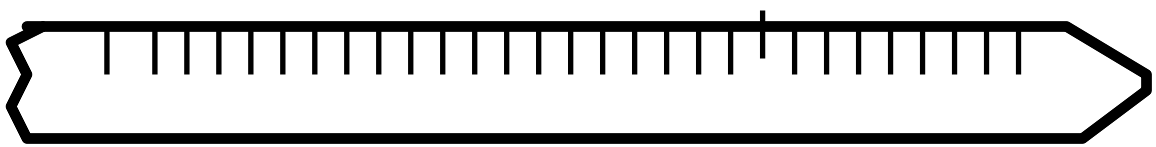
Lesson 4
Pipetting

A. Definitions

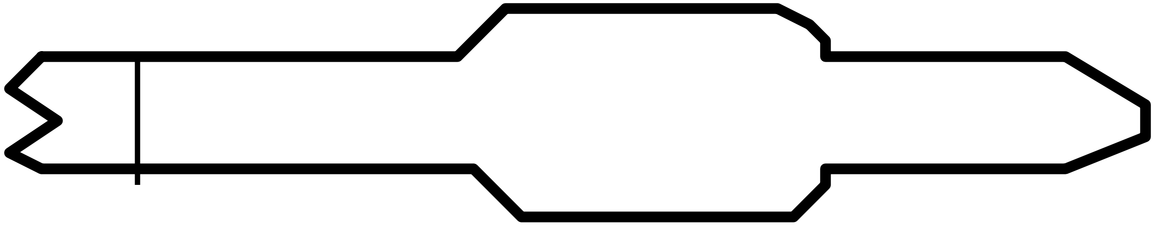
Pipetting: Technique used to measure out a small accurate volume of liquid (25 mL or less) to high precision (0.1 mL to 0.01 mL)

B. Types of pipets

* *graduated:* Measures a range of volumes from 0.1 to 10 mL



* *volumetric:* delivers one specific volume accurate to within 0.04 mL



C. Technique

Step 1: Rinse with distilled water to remove any residue or liquid

Step 2:Rinse with sample

WHY? Distilled water lowers the concentration

C. Technique

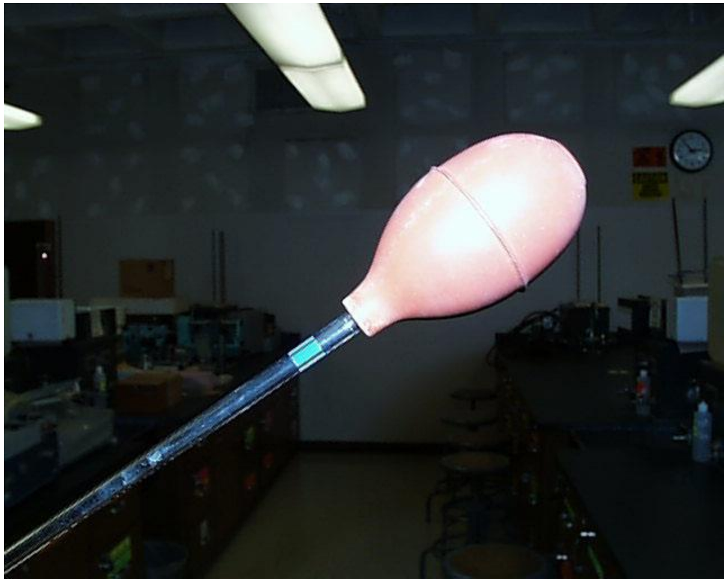
Step 3: Hold the pipet near the top with one (left) hand leave your index finger free

WHY? more accurate, easier to read

C. Technique

Step 4: Place the pipet into the sample, resting the tip on the bottom of the container

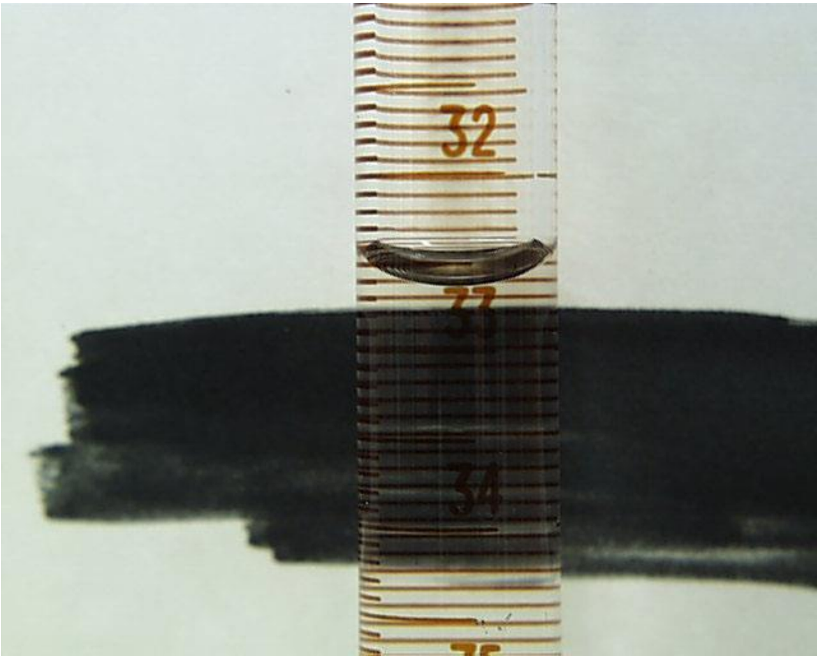
Step 5: Squeeze the bulb with your right hand and place the bulb/dispenser firmly and squarely on the end of the pipet



C. Technique

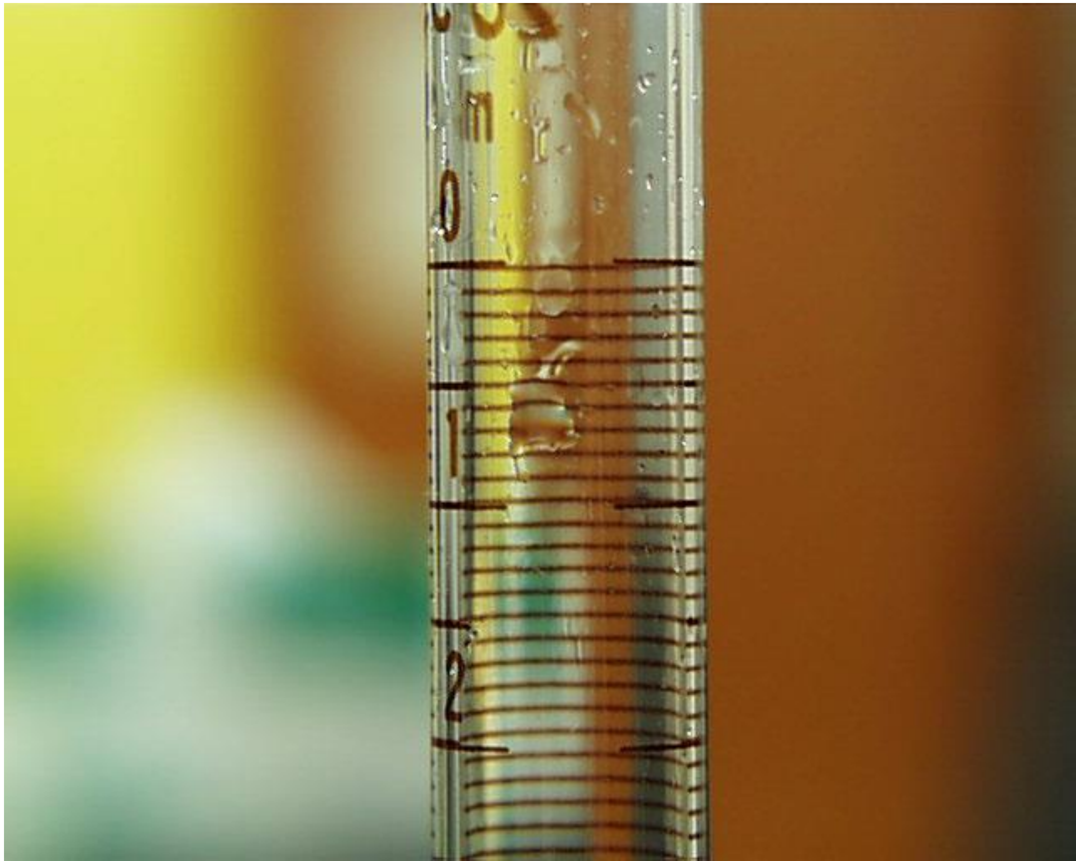
Step 6: Release the bulb until the liquid has risen above the desired calibration line

Step 7: Remove the bulb and quickly put your index finger of your left hand over the top



C. Technique

Step 8: remove from the solution and wipe excess solution. ***WHY?***Changes Volume

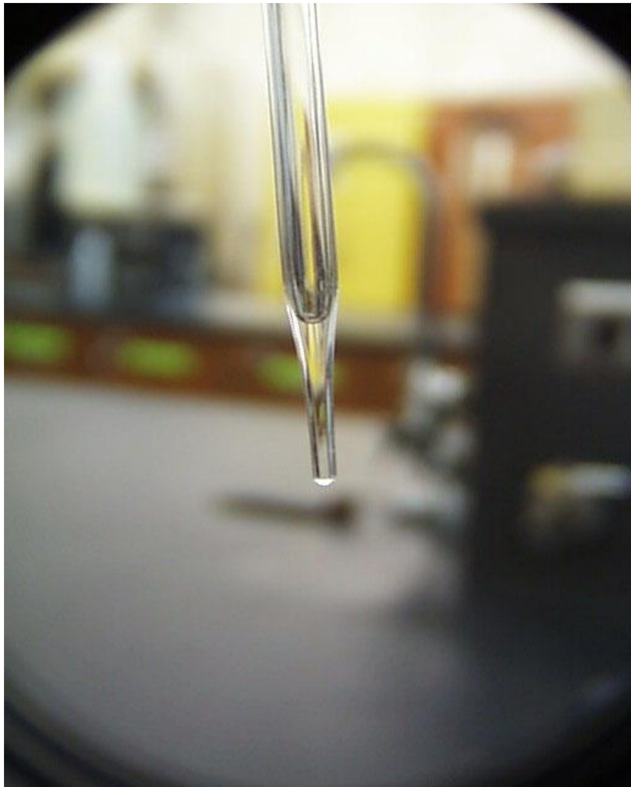


C. Technique

Step 9: while touching the tip of the pipet to the inside of the waste beaker, gently roll your index finger off to allow the liquid layer to drop. Stop when meniscus reaches the calibration line. (at eye level)

C. Technique

Step 10) Touch the tip of the pipet to the inside wall of the receiving container and remove finger to allow liquid to flow freely. A small volume is expected to stay in the tip.



Lesson 5
Dissociation

A. Solubility Table

* Look for the ions in row 1 of your solubility table.

A) if the other ion is in row 2 it is soluble and is aqueous (aq) in the presence of water

B) If the other ion is in row 3 or is not on the table it will form a precipitate(non-soluble) (s)

A. Other terminology

- Hydronium ion: $H_3O^+_{(aq)}$ formed when water gains a $H^+_{(aq)}$ (acidic)

$H_2O_{(l)} + H^+_{(aq)} \Rightarrow H_3O^+_{(aq)}$

- Solvation: A process that occurs when an ionic solute dissolves; in solution, the ions are surrounded by solvent molecules
- Hydration: addition of water

B. Dissociation & Ionization

Definition: Separation of an compound into individual ***ions*** when placed in a solvent

- ie) $NaOH_{(s)}$ ***dissociates*** into $Na^{+}_{(aq)}$ + $OH^{-}_{(aq)}$

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

- NOTE: NaOH ***decomposes*** into Na, O_2 and H_2 elements

$2\ NaOH_{(s)} \rightarrow 2Na_{(s)} + O_{2(g)} + H_{2(g)}$

B. Dissociation & Ionization

* **Electrolyte:** a compound that conducts electricity (separates into ions) ionic compounds and acids
* **Non- electrolyte:** compounds that do not conduct electricity

B. Dissociation & Ionization

- **Dissociation equations:** breaking of ionic compounds into ions
- **Ionization equations:** breaking of molecular gases and acids into ions when water is added

B. Dissociation & Ionization

CAUTIONS:

- Write a balanced equation.
- Remember all ions are (aq).
- Show correct ionic charges.

B. Dissociation & Ionization

EXAMPLES

* a)Ionic compounds

$KCl_{(S)} \rightarrow K^+_{(aq)} + Cl^-_{(aq)}$

$Cu(NO_3)_{2(s)} \rightarrow Cu^{2+}{}_{(aq)} + 2NO_3^-{}_{(aq)}$

$Al_2(SO_4)_{3(S)} \rightarrow 2Al^{3+}_{(aq)} + 3SO_4^{2-}{}_{(aq)}$

Atoms must be conserved. The net charge must be zero.

B. Dissociation & Ionization

b) Molecular Gases

$$HI_{(g)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + I^-_{(aq)}$$

c) Bases - the only one

$$NH_{3(g)} + H_2O_{(l)} \rightarrow NH_4^+_{(aq)} + OH^-_{(aq)}$$

3. Dissociation & Ionization

d) Acids

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

Only the six following acids completely dissociate: HCl, HBr, HI, HNO_3, H_2SO_4, $HClO_4$

Strong Acid - completely dissociates

$H_2SO_{4(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + HSO_4^-{}_{(aq)}$

Weak Acid - do not completely dissociate

$CH_3COOH_{(aq)} + H_2O_{(l)} \Leftrightarrow H_3O^+_{(aq)} + CH3COO^-_{(aq)}$

C. Equilibrium

* Definition: a state of a closed system in which all measurable properties are constant.
* There is a dynamic equilibrium that exists in saturated solution since the rate of crystallization is equal to the rate of dissolving. You observe no change
* Ie) $NaCl_{(s)} \Leftrightarrow NaCl_{(aq)}$
* rate or salt crystals forming=rate of salt dissolving

Lesson 6
Net Ionic Equations

A. Definitions

Non Ionic equation - an equation without any ions

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

A. Definitions

Total Ionic equation - an equation where only the aqueous solutions are broken into their ions.

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

NOTE: liquids, solids and gases do not break into ions

A. Definitions

- Net Ionic equation - a summary where **spectator** ions that appear on both sides of the equation are removed.

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

NET IONIC: $\mathbf{H^+_{(aq)} + OH^-_{(aq)} \Rightarrow HOH_{(l)}}$

A. Example

Lead(II)nitrate & sodium hydroxide react.

* $Pb(NO_3)_{2(aq)} + 2NaOH_{(aq)} \rightarrow 2NaNO_{3(aq)} + Pb(OH)_{2(s)}$
* $Pb^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} + 2Na^+_{(aq)} + 2OH^- \rightarrow 2Na^+_{(aq)} + 2NO_3^-{}_{(aq)} + Pb(OH)_{2(s)}$
* $Pb^{2+}_{(aq)} + 2OH^-_{(aq)} \Rightarrow Pb(OH)_{2(s)}$

B. Purpose of ionic equations

- A net ionic equation is a summary of what occurs. Most reactions donot occur unless their are in water.
- A net ionic equation is used when you want to know the amount (concentration) of an ion.

B. Steps to write ionic equations

1. Write the non ionic equation
2. Write the total ionic equation. Do not change solids, gases or liquids.
3. Write the net ionic equation - cross out ions that repeat & reduce

Lesson 7
Solution Stoichiometry

STEPS

1. Write a balanced equation-non ionic, dissociation or net ionic
2. Find the moles of known using one of the 4 formulas (if 2 reactants; x 2)
3. Multiply by mole ratio (R/G)
4. Change to desired unit using one of the 4 formulas
5. Calculate %yield &/or %error

Example #1

If 200 mL of NaOH reacts with 100mL of 0.150 M HCl what is the concentration of the NaOH?

- NaOH+HCl => NaCl + HOH
- ? n=CV=0.100L x 0.150 M

  n=0.0150 mol
- 0.0150x1mol/1mol= 0.0150mol
- C=n/V = 0.0150mol/0.200L = **0.0750 mol/L**

Example #2

In the previous question, what is the concentration of the solution produced?

* NaOH+HCl => NaCl + HOH
* n=CV ?

  n=0.0150 mol
* 0.0150 x 1mol/1mol= 0.0150mol
* C=n/V = 0.0150mol/0.300L = **0.0500 mol/L**

  (total volume)

Example #3

What is the concentration of ammonium ions if there is 100 g of ammonium sulphate solid placed in 100 mL of water?

1. $(NH_4)_2SO_{4\,(s)} \Rightarrow 2NH_4^+{}_{(aq)} + SO_4^{2-}{}_{(aq)}$
2. n=m/M ?
   n=100/132.16 = 0.756658…mol
3. 0.756mol x2mol/1mol=1.513mol
4. C=n/V=1.513mol/0.100L=**15.1 M**

Example #4

Lead (II) nitrate solution reacts with sodium hydroxide. Using net ionic equation, how many grams of solid form if 6.02 x 10^{23} particles of OH ion are present?

- $Pb(NO_3)_{2(aq)} + 2NaOH_{(aq)} \rightarrow 2NaNO_{3(aq)} + Pb(OH)_{2(s)}$
- $Pb^{2+}_{(aq)} + 2NO_3^-{}_{(aq)} + 2Na^+_{(aq)} + 2OH^- \rightarrow 2Na^+_{(aq)} + 2NO_3^-{}_{(aq)} + Pb(OH)_{2(s)}$
- $Pb^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Pb(OH)_{2(s)}$

Example #4 con't

- $Pb^{2+}_{(aq)} + 2OH^-_{(aq)} \rightarrow Pb(OH)_{2(s)}$
- n=p/P ? g

n=1.00mol

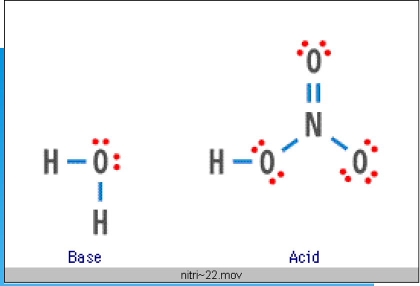
- 1.00mol x 1mol/2mol = 0.500 mol
- m=nM=0.500molx241.21g/mol

m= 121 g

Chemistry 20: Acid and Bases

I) Definitions

Definitions - Acid

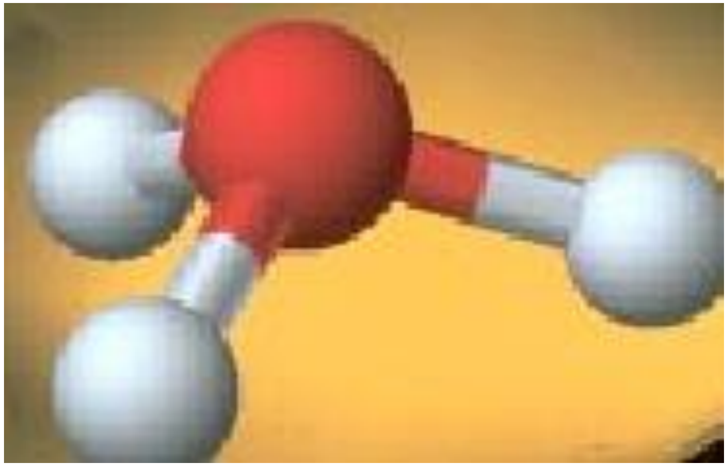


#1) Arrhenius def: substance that ionizes to form hydrogen ions

MODIFIED-forms hydronium ions (H_3O^+)

Bronstead Lowry:

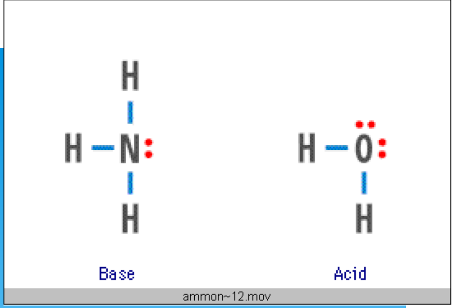
Donates hydrogen (proton)



Definitions - Acid Con't

#2) Operational def: turns blue litmus paper red & has a pH below 7

Bromothymol blue turns yellow



Definitions - Base

#1) Arrhenius def: substance that dissociates to form hydroxide ions

Bronstead Lowry: accepts hydrogen ions (protons)

#2) Operational def: turns red litmus paper blue & has a pH above 7

Bromothymol blue turns green

Definitions - neutral

#1) Arrhenius def: substance that forms equal amounts of hydroxide and hydronium ions; Bronstead Lowry def: does not donate or accept protons

#2) Operational def: red litmus & blue litmus do not change; pH = 7 (distilled water);

bromothymol blue turns green

Definitions - solutions

Acid Solutions: A solution where the hydronium concentration is greater than the hydroxide concentration.

Basis Solutions: A solution where the hydroxide concentration is greater than the hydronium concentration

Definitions - indicators

- Indicator: a chemical (weak acids) substance that changes color when added to an acid or base. (pg. 10 of databook)
- PURPOSE: determine the approximate pH range of a solution
- Common indicators:
  - Bromothymol blue: HBb(aq)/Bb-(aq)
  - Phenophthalein: HPh/Ph-(aq)

Use of the Indicator table

- Bromothymol blue is an ideal indicator in its pH range, 6.0-7.6 where it is yellow + blue or green.
- Below 6.0 HBb is yellow
- Above 7.6 HBb is blue.
- Indicators can be combined to narrow the pH.
- Don't worry about Ka until Chemistry 30

Acid–Base Indicators at 298.15 K

Indicator	Suggested Abbreviations	pH Range	Colour Change as pH Increases	K_a
methyl violet	$HMv(aq) / Mv^-(aq)$	0.0 – 1.6	yellow to blue	-2×10^{-1}
cresol red	$H_2Cr(aq) / HCr^-(aq)$ $HCr^-(aq) / Cr^{2-}(aq)$	0.0 – 1.0 7.0 – 8.8	red to yellow yellow to red	-3×10^{-1} 3.5×10^{-9}
thymol blue	$H_2Tb(aq) / HTb^-(aq)$ $HTb^-(aq) / Tb^{2-}(aq)$	1.2 – 2.8 8.0 – 9.6	red to yellow yellow to blue	2.2×10^{-2} 6.3×10^{-10}
orange IV	$HOr(aq) / Or^-(aq)$	1.4 – 2.8	red to yellow	-1×10^{-2}
methyl orange	$HMo(aq) / Mo^-(aq)$	3.2 – 4.4	red to yellow	3.5×10^{-4}
bromocresol green	$HBg(aq) / Bg^-(aq)$	3.8 – 5.4	yellow to blue	1.3×10^{-5}
methyl red	$HMr(aq) / Mr^-(aq)$	4.8 – 6.0	red to yellow	1.0×10^{-5}
chlorophenol red	$HCh(aq) / Ch^-(aq)$	5.2 – 6.8	yellow to red	5.6×10^{-7}
bromothymol blue	yellow $HBb(aq) / Bb^-(aq)$	green 6.0 – 7.6	blue yellow to blue	5.0×10^{-8}
phenol red	$HPr(aq) / Pr^-(aq)$	6.6 – 8.0	yellow to red	1.0×10^{-8}
phenolphthalein	$HPh(aq) / Ph^-(aq)$	8.2 – 10.0	colourless to pink	3.2×10^{-10}
thymolphthalein	$HTh(aq) / Th^-(aq)$	9.4 – 10.6	colourless to blue	1.0×10^{-10}
alizarin yellow R	$HAy(aq) / Ay^-(aq)$	10.1 – 12.0	yellow to red	6.9×10^{-12}
indigo carmine	$HIc(aq) / Ic^-(aq)$	11.4 – 13.0	blue to yellow	-6×10^{-12}
1,3,5–trinitrobenzene	$HNb(aq) / Nb^-(aq)$	12.0 – 14.0	colourless to orange	-1×10^{-13}

Definitions - pH & pOH

pH: Power/parts of Hydrogen (hydronium ion/proton) measured as a negative log of the hydronium concentration. $[H_3 0^+]$; no units

pOH: Parts of Hydroxide ion

Measured as a negative log of the hydroxide concentration.[OH-]; no units

Definitions - pH meter

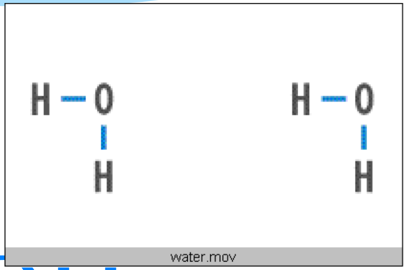
pH meter: instrument used to measure the pH

dynamic equilibrium: a balance between the forward and reverse processes to achieve a steady state

Ie) self-ionization of water (next slide)

Definitions: self-ionization of water

self-ionization: when two water molecules react & break up into ions



Old) $H_20 \Leftrightarrow H^+_{(aq)} + OH^-_{(aq)}$

Mod) $H_20 + H_20 \Leftrightarrow H_30^+_{(aq)} + OH^-_{(aq)}$

NOTE: fewer than 2 in one billion ionize

7 acids completely ionize(p. 8)

- perchloric acid($HClO_4$) – Strongest Acid
  - monoprotic: gives away one H
- hyrdroiodic acid (HI)
- hydrobromic acid (HBr)
- hydrochloric acid(HCl)
- *sulphuric acid ($SO_3(g) + H_2O \rightarrow H_2SO_4$) polyprotic: gives more than one H
  - $H_2SO_{4(aq)} + 2H_2O_{(l)} \rightarrow 2H_3O^+_{(aq)} + SO_4^{2-}{}_{(aq)}$
- *nitric acid ($NO_{2(g)} + H_2O \rightarrow HNO_3$)
- hydronium ion (H_3O^+) SA

Relative Strengths of Acids and Bases at 298.15 K

SA

Common Name IUPAC / Systematic Name	Acid Formula	Conjugate Base Formula
perchloric acid aqueous hydrogen perchlorate	$HClO_4(aq)$	$ClO_4^-(aq)$
hydroiodic acid aqueous hydrogen iodide	$HI(aq)$	$I^-(aq)$
hydrobromic acid aqueous hydrogen bromide	$HBr(aq)$	$Br^-(aq)$
hydrochloric acid aqueous hydrogen chloride	$HCl(aq)$	$Cl^-(aq)$
sulfuric acid aqueous hydrogen sulfate	$H_2SO_4(aq)$	$HSO_4^-(aq)$
nitric acid aqueous hydrogen nitrate	$HNO_3(aq)$	$NO_3^-(aq)$
hydronium ion	$H_3O^+(aq)$	$H_2O(l)$
oxalic acid	$HOOCCOOH(aq)$	$HOOCCOO^-(aq)$
sulfurous acid aqueous hydrogen sulfite	$H_2SO_3(aq)$	$HSO_3^-(aq)$
hydrogen sulfate ion	$HSO_4^-(aq)$	$SO_4^{2-}(aq)$
phosphoric acid aqueous hydrogen phosphate	$H_3PO_4(aq)$	$H_2PO_4^-(aq)$
citric acid 2-hydroxy-1,2,3-propanetricarboxylic acid	$C_3H_5O(COOH)_3(aq)$	$C_3H_5O(COOH)_2COO^-$
hydrofluoric acid aqueous hydrogen fluoride	$HF(aq)$	$F^-(aq)$
nitrous acid aqueous hydrogen nitrite	$HNO_2(aq)$	$NO_2^-(aq)$
formic acid methanoic acid	$HCOOH(aq)$	$HCOO^-(aq)$
hydrogen oxalate ion	$HOOCCOO^-(aq)$	$OOCCOO^{2-}(aq)$
lactic acid 2-hydroxypropanoic acid	$C_2H_5OCOOH(aq)$	$C_2H_5OCOO^-(aq)$
ascorbic acid 2(1,2-dihydroxyethyl)-4,5-dihydroxy-furan-3-one	$H_2C_6H_6O_6(aq)$	$HC_6H_6O_6^-(aq)$
benzoic acid benzenecarboxylic acid	$C_6H_5COOH(aq)$	$C_6H_5COO^-(aq)$
acetic acid ethanoic acid	$CH_3COOH(aq)$	$CH_3COO^-(aq)$
dihydrogen citrate ion	$C_3H_5O(COOH)_2COO^-(aq)$	$C_3H_5OCOOH(COO)_2^{2-}(aq)$
butanoic acid	$C_3H_7COOH(aq)$	$C_3H_7COO^-(aq)$
propanoic acid	$C_2H_5COOH(aq)$	$C_2H_5COO^-(aq)$
carbonic acid ($CO_2 + H_2O$) aqueous hydrogen carbonate	$H_2CO_3(aq)$	$HCO_3^-(aq)$
hydrogen citrate ion	$C_3H_5OCOOH(COO)_2^{2-}(aq)$	$C_3H_5O(COO)_3^{3-}(aq)$
hydrosulfuric acid aqueous hydrogen sulfide	$H_2S(aq)$	$HS^-(aq)$
hydrogen sulfite ion	$HSO_3^-(aq)$	$SO_3^{2-}(aq)$
dihydrogen phosphate ion	$H_2PO_4^-(aq)$	$HPO_4^{2-}(aq)$
hypochlorous acid aqueous hydrogen hypochlorite	$HOCl(aq)$	$OCl^-(aq)$
hydrocyanic acid aqueous hydrogen cyanide	$HCN(aq)$	$CN^-(aq)$
ammonium ion	$NH_4^+(aq)$	$NH_3(aq)$
hydrogen carbonate ion	$HCO_3^-(aq)$	$CO_3^{2-}(aq)$
hydrogen ascorbate ion	$HC_6H_6O_6^-(aq)$	$C_6H_6O_6^{2-}(aq)$
hydrogen phosphate ion	$HPO_4^{2-}(aq)$	$PO_4^{3-}(aq)$
water	$H_2O(l)$	$OH^-(aq)$

salts

Acid Rain

WB

vinegar

WA

SB

One type of base completely dissociates

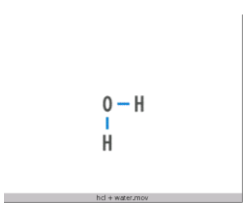
* Any Base with **OH-** completely dissociates and is considered a **strong base** (see the right side of pg 8 & 9 of your data book)
  * NaOH (mono hydroxide); NaOH(s) → $Na^{+}_{(aq)}$ + $OH^{-}_{(aq)}$
  * Ba(OH)2 (di hydroxide); $Ba(OH)_2$ → $Ba^{2+}_{(aq)}$ + 2 $OH^{-}_{(aq)}$
  * Al(OH)3 (poly hydroxide); $Al(OH)_3$ → $Al^{3+}_{(aq)}$ + 3 $OH^{-}_{(aq)}$
* The acids above the OH get weaker as you move up the table until **water**, which is the **weakest base**. The substances above water are called **salts.**
* NOTE: often the bases have a spectator ion like Na

Neutralization

- S Acid + S Base => Salt + Water

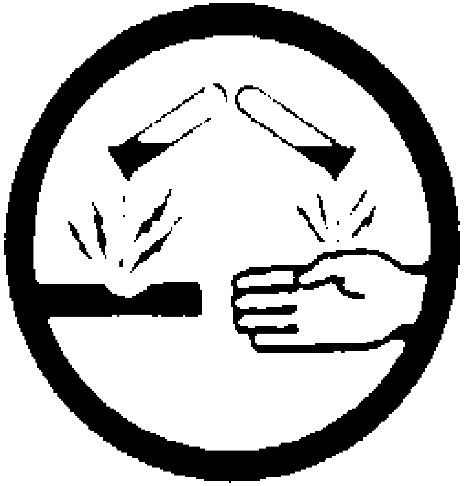
$HCl_{(aq)} + NaOH_{(aq)} \Rightarrow NaCl_{(aq)} + H_2 0_{(l)}$

- If you spill an acid neutralize it with baking soda (harmless)
- If you spill a base neutralize it with acetic acid (harmless vinegar)



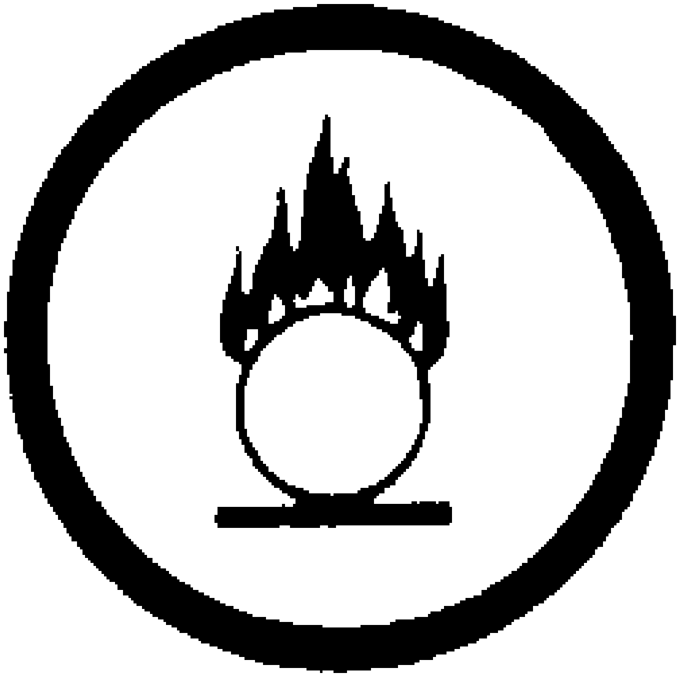
Safety - so no one gets hurt.

WHMIS (**Workplace Hazardous Materials Information System)** symbols often used for acids and bases. **a) corrosive materials**



b) **Materials causing immediate and serious toxic effects**

c) <u>Oxidizing materials</u>



Safety practics

* Report all accidents to a supervisor
* Wash off all acids and bases with cold water
* SAFELY Neutralize an acid with baking soda (sodium hydrogen carbonate)
* SARFELY Neutralize a base with vinegar (ethanoic acid)
* Always add acid to water (A to W)

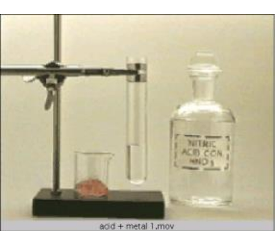
II) Properties

Properties of Acids & Bases

	Acid	Base
Feel:	like water	slippery
Taste	sour	bitter
Electrolyte:	Y	Y
State	s/aq	s/aq
Neutralize	bases	acids
$[H_3O^+_{(aq)}]$	high	low
$[OH^-_{(aq)}]$	low	high

Properties of Acids & Bases

	Acid	Base
* Common	HCl	NaOH
* Reacts with _ to produce _	metals H_2 gas	fat soap
* Bromothymol	Yellow	Blue
* Phenophthalein	Colorless	Pink
* Litmus	Red	Blue



III) Formulas

1) Ion-product constant

Definition: The product of the concentrations of hydroxide(OH^-) ions and the hydronium(H_3O^+) ions is the ion constant for water

Symbol: $K_w = 1.000 \times 10^{-14} (mol/L)^2$

Formula: $K_w = [H_3O^+] \times [OH^-]$

Ie) $1.0 \times 10^{-14} = 1.0 \times 10^{-7} \times 1.0 \times 10^{-7}$

Kw example #1

What is the concentration of the hydroxide ions in a 0.15 mol/L solution of hydrochloric acid?

Step 1: $HCl_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$

Step 2: C=0.15 mol/L (given)

Step 3: Multiply by mole ratio

$[H_3O^+_{(aq)}]$=0.15 mol/L x 1mol/1mol=0.15mol/L

Step 4: Use the ion product to Solve:

$[OH] = K_w/[H_3O^+_{(aq)}]$

$= 1.000 \times 10^{-14}\ M^2/\ 0.15M$

$= 6.7 \times 10^{-14}$ mol/L of OH-(aq)

Kw example #2

Calculate the hydronium concentration in a 0.25 mol/L solution of barium hydroxide

Step 1: $Ba(OH)_{2(s)} \Rightarrow Ba^{2+}_{(aq)} + 2OH^-_{(aq)}$

Step 2: C=0.25 mol/L of barium hydroxide

Step 3: Multiply by mole ratio

$[OH^-_{(aq)}] = 0.25\ M \times 2/1 = 0.50\ M$

Step 4: $[H_3O^+_{(aq)}] = K_w/[OH^-_{(aq)}]$

$= 1.000 \times 10^{-14}\ M^2/\ 0.50M$

$= 2.0 \times 10^{-14}$ mol/L of H_3O^+

Kw example #3

Calculate the $[H_3O^+_{(aq)}]$ and [OH] in 500 mL of water that has 2.6g of sodium hydroxide.

Step 1: $NaOH_{(s)} \Rightarrow Na^+_{(aq)} + OH^-_{aq)}$

2.6 g 0.500L; C=?

Step 2: n=m/M n= 2.6g/40.00g/mol = 0.065mol

Step 3: $[OH^-_{(aq)}]$=0.065 mol x 1/1=0.0.65mol

Step 4: C=n/V C= 0.065mol/0.500L =0.13mol/L

Use the ion product formula

$[H_3O^+_{(aq)}] = K_w/[OH^-_{(aq)}]$

$= 1.000 \times 10^{-14}\ M^2/\ 0.13\ M$

$= 7.7 \times 10^{-14}$ mol/L

2) Calculating pH/pOH

pH calculations are the negative log of concentrations.

Formulas: $pH = -\log [H_3O^+_{(aq)}]$

$pOH = -\log[OH^-_{(aq)}]$

2) Calculating pH/pOH

Significant digits: FOR pH & pOH values only - the digit before the decimal is NOT significant. This number represents the exponent.

pH example #1

pH of 4.7×10^{-11} mol/L of $[H_3O^+_{(aq)}]$

pH = - log [$\underline{4.7} \times 10^{-11}$]

NOTE: For programmable calculators punch in the exact order. For other calculators punch the number in first, then log, then +/-

pH = 10.$\underline{33}$ (2 significant digits)

pH example #2

What is the pOH of 0.0030 mol/L of hydroxide ions?

pOH = - log [0.0030]

pOH = 2.52 (2 significant digits)

3) Calculating $[H_3O^+_{(aq)}]$

Formulas: $[H_3O^+_{(aq)}] = 10^x(-pH)$

$= 10^{-pH}$

$[OH^-_{(aq)}] = 10^x(-pOH)$

$= 10^{-pOH}$

10^x may be called antilog, inverse log or 2nd log.

$[H_3O^+]$ example #1

What is the hydronium concentration of a pH of 10.<u>33</u>.

NOTE: 2 sig digs

$[H_3O^+]$ = 2nd log (-pH)

= 2nd log (-10.33)

= <u>4.7</u> x 10^{-11} mol/L

$[H_3O^+]$ example #2

Calculate the hydroxide ion concentration if the pOH is 2.31

NOTE: 2 sig digs

$[OH^-]$ = 2nd log (-pOH)

= 2nd log (-2.31)

= 4.91×10^{-3} mol/L

= 4.9×10^{-3} mol/L

4) pH & pOH relationship

Formula: 14.00 = pH + pOH

Example:

What is the pOH in example 1?

pOH = 14.00 - 10.33 = 3.67

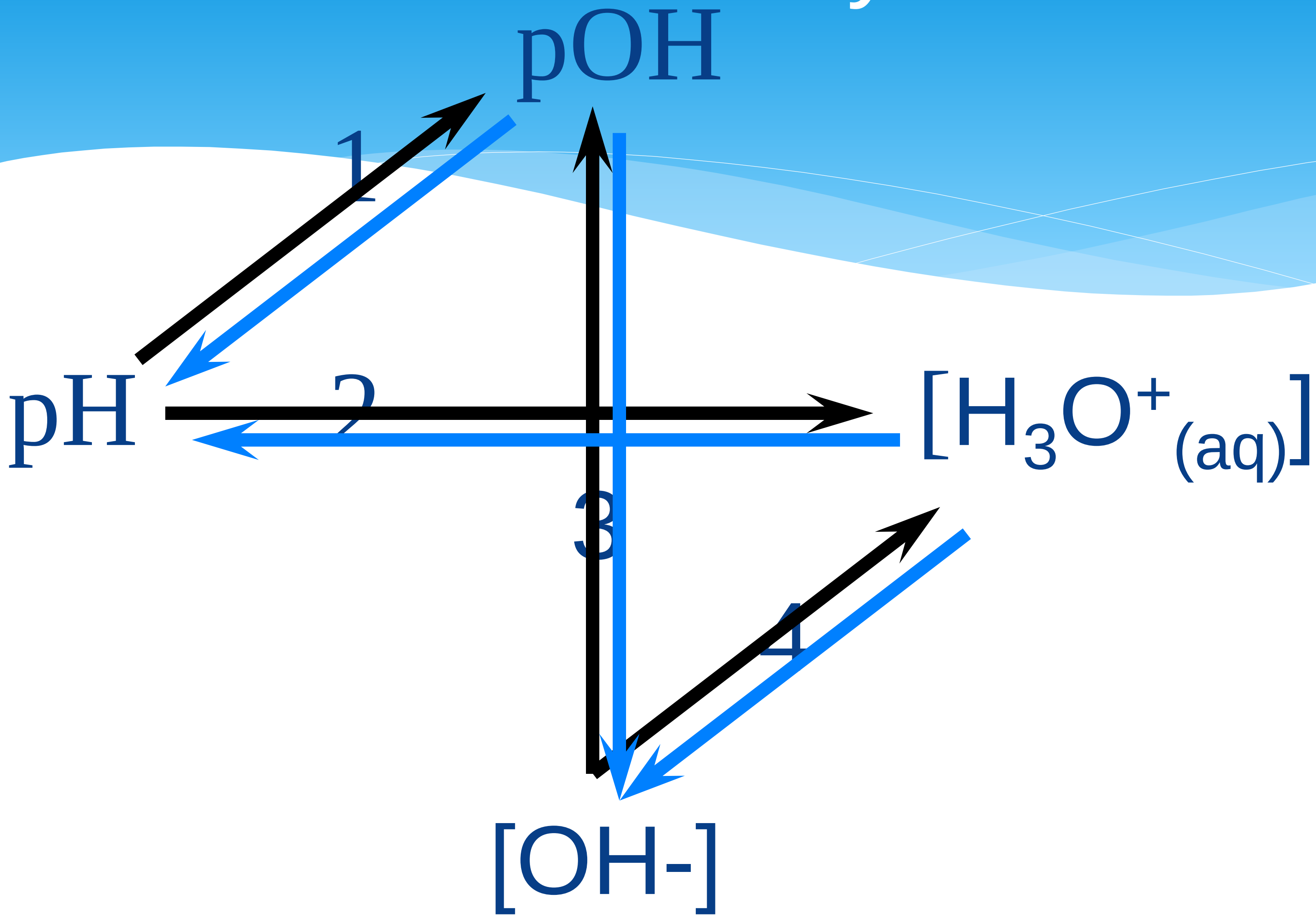
What is the pH in example 2?

pH = 14.00 - 2.52 = 11.48

Summary

- Defined acids, bases, indicators, pH, pOH
- Reviewed dissociation, self-ionization, neutralization
- Learned WHMIS & safety
- Properties of acids & bases

Summary



Summary

1) $pH = 14.00 - pOH$

$pOH = 14.00 - pH$

2) $pH = -\log [H_3O^+]$

$[H_3O^+] = 2nd \log (-pH)$

3) $[OH] = 2nd \log (-pOH)$

$pOH = -\log [OH]$

4) $[OH^-_{(aq)}] = K_w / [H_3O^+_{(aq)}]$

$[H_3O^+_{(aq)}] = K_w / [OH^-_{(aq)}]$

Acid – Base Stoichiometry

1. Balanced reaction or equation containing a Strong Acid or Strong Base
2. Change the given (limiting) to moles: Often you will need to find the concentration using one of the four acid-base formulas and then find moles using n=CV.
3. Multiply by the mole ratio (R/G)
4. Convert into desired units.

Example

200 mL solution of HCl with a pH of 1.45 neutralizes 300 mL of $Ba(OH)_2$. Determine the concentration of salt formed.

A 200 mL solution of $HCl_{(aq)}$ with a pH of 1.45 neutralizes 300 mL of $Ba(OH)_{2(aq)}$. Determine the concentration of salt formed.

- Step 1: Reaction
- Step 2: Find moles; First find concentration of HCl using pH formula
- Step 3: mole ratio
- Step convert to units

1) $2HCl + Ba(OH)_2 \rightarrow 2HOH + 1\ BaCl_2$

G R (salt)

2) $[A] = 10^{-1.45} = 3.548\ldots E\text{-}2$ mol/L

n=CV; n = 7.096…. E^{-3} mol

3) 7.096… E^{-1} x ½ =3.548…E^{-3}mol

4) C=n/Vtotal; C=3.548E-3/0.500L

C=7.096E-3 mol/L

More Information

- Chapter 18 in your text book.
- Notes & Worksheets
- Tutorials after class