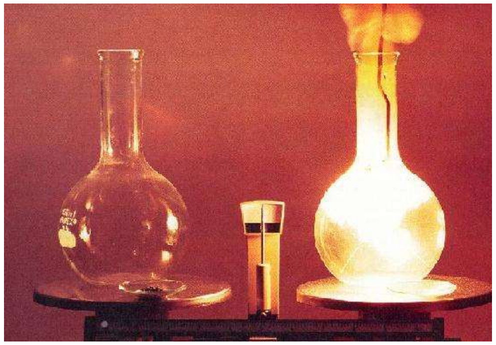


Combustion

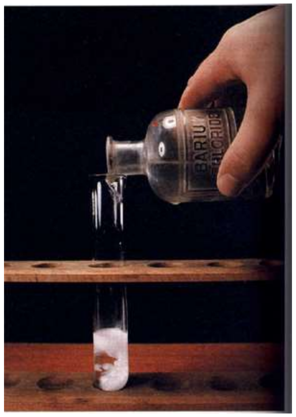
Oxidation Reduction

Acid-Base

Neutralization

Chapter 4

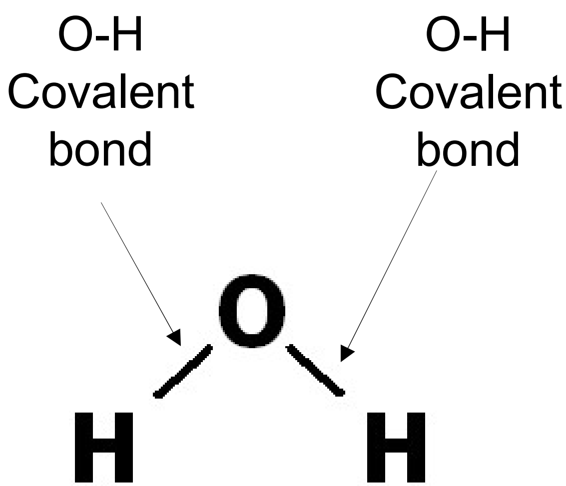
Major Classes of Chemical Reactions



Precipitation

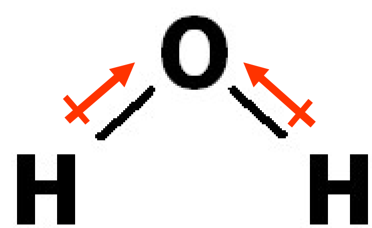
Oxidation-Reduction

Water Molecules



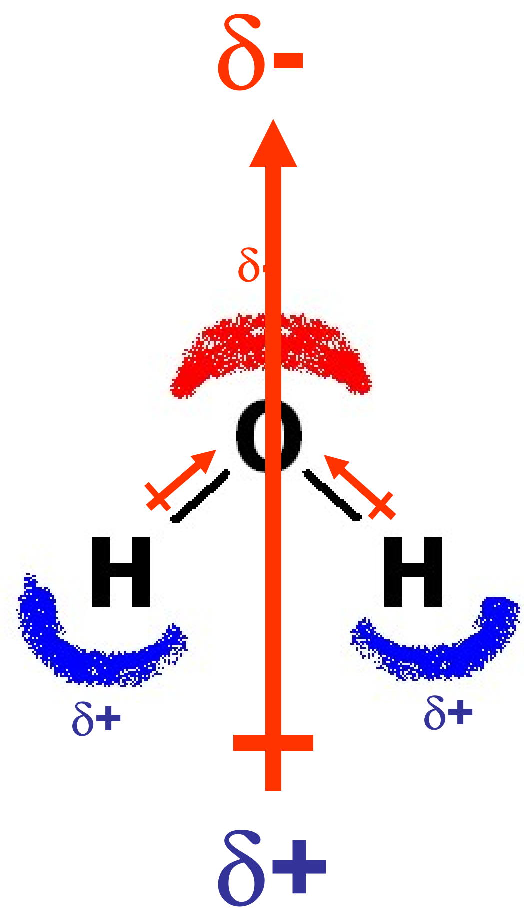
"V" shaped

a.k.a. Angular or bent



Polar Covalent Bonds

- Uneven sharing of electrons
- Oxygen has more "pull" for electrons
- Hydrogen looses electron density to oxygen

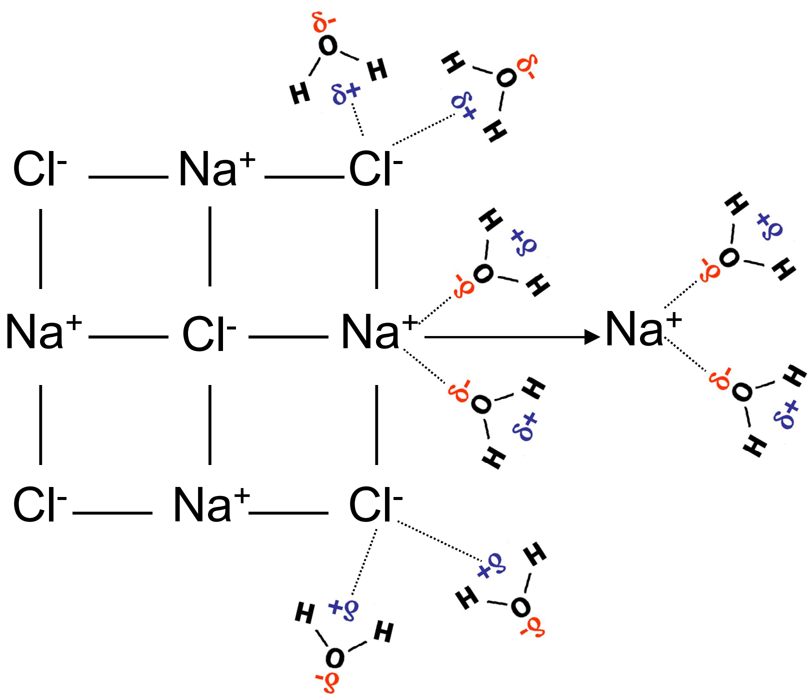


Water: Polar Molecule

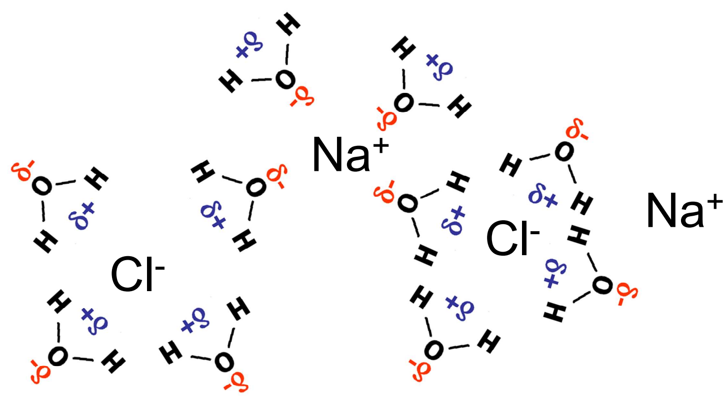
H's (+) Positive end

O (-) Negative end

Attack of the Water Molecules



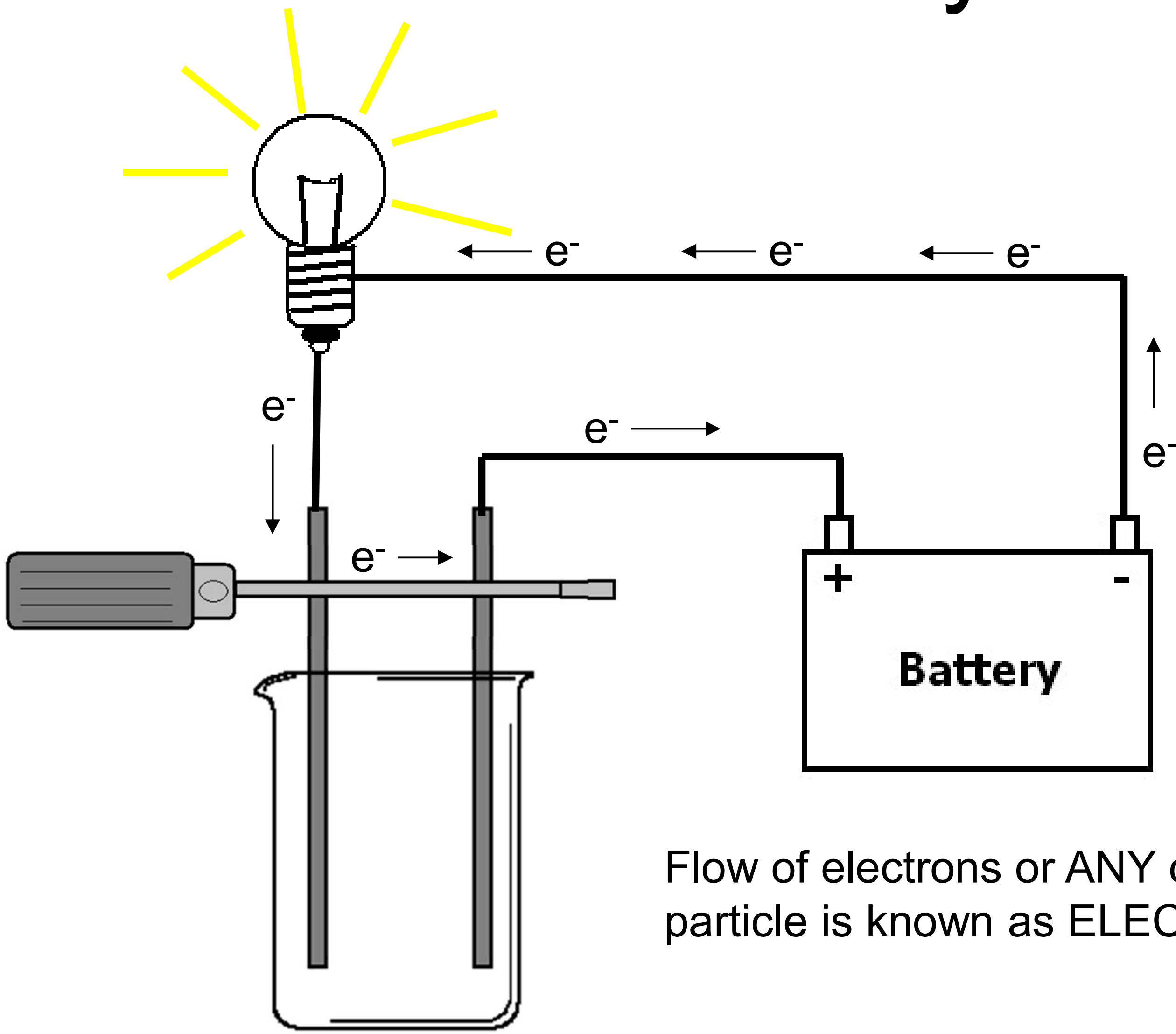
NaCl Crystal Lattice



Water molecules surround liberated salt ions

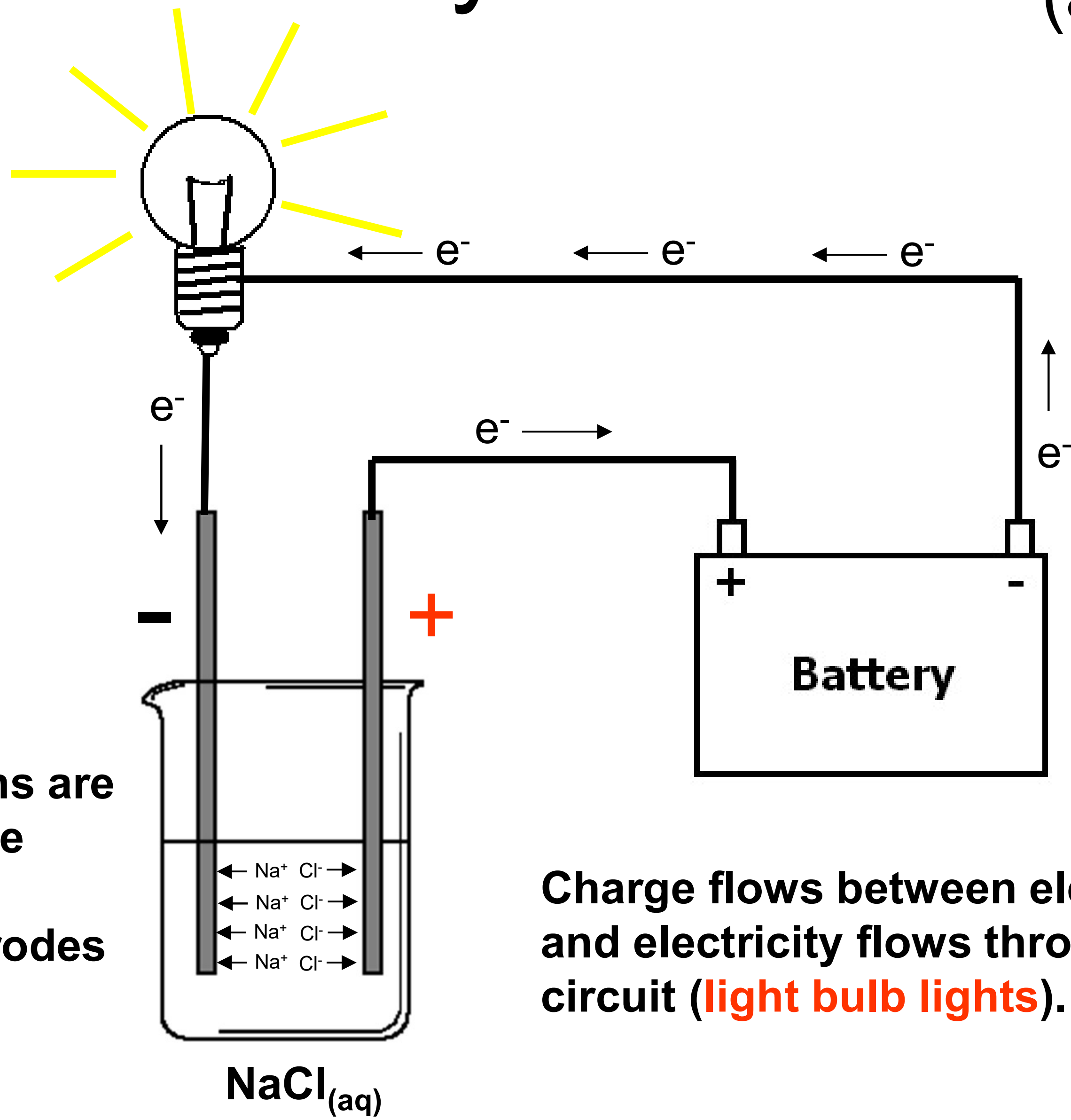
Ions now are free to move.

Solution Conductivity Tester



Flow of electrons or ANY charged particle is known as ELECTRICITY!

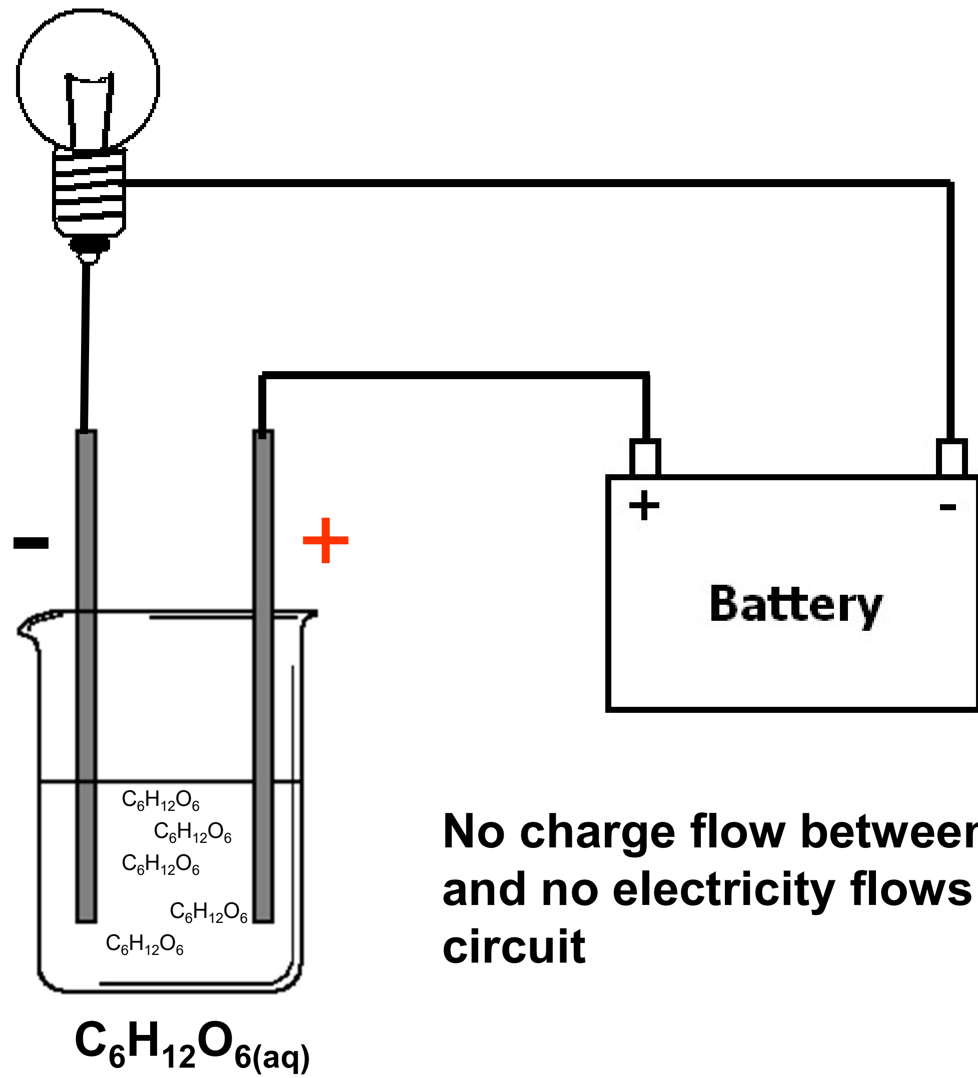
Conductivity Test: $NaCl_{(aq)}$



Na^+ and Cl^- ions are attracted to the negative and positive electrodes respectively.

Charge flows between electrodes and electricity flows through the circuit (light bulb lights).

Conductivity Test: $C_6H_{12}O_{6(aq)}$



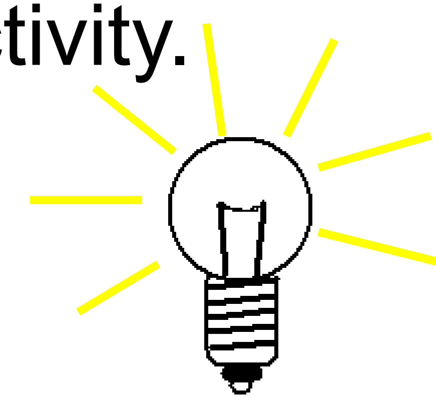
Sugar molecules are neutral and therefore not attracted to either the positive or negative electrode.

No charge flow between electrodes and no electricity flows through the circuit

Solutions:

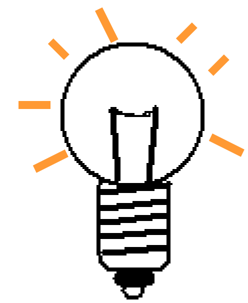
Qualitative (*Descriptive*) Conductivity.

- Electrolytes: Solutions that conduct electricity well.

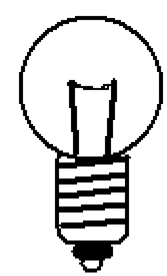


i.e. ions in solution are free to move

- Weak Electrolytes: Solutions that don't conduct electricity well.



- Non Electrolytes: Solutions that don't conduct electricity.



Why is water conductive?

There must be ions present!

- Impurities (Na^+, Ca^{2+}, Fe^{2+}, etc.)
- Water Dissociation:

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

Liquid Water	Liquid Water	Hydronium ion	Hydroxide ion

Ions formed.

∴ Water conducts

Why is pure, distilled water conductive?

$$H_2O_{(l)} + H_2O_{(l)} \xrightarrow{\text{Forward reaction}} H_3O^+_{(aq)} + OH^-_{(aq)}$$

$$H_2O_{(l)} + H_2O_{(l)} \xleftarrow{\text{Reverse reaction}} H_3O^+_{(aq)} + OH^-_{(aq)}$$

$$H_2O_{(l)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + OH^-_{(aq)}$$

Dynamic Equilibrium: Reactants → Products → Reactants

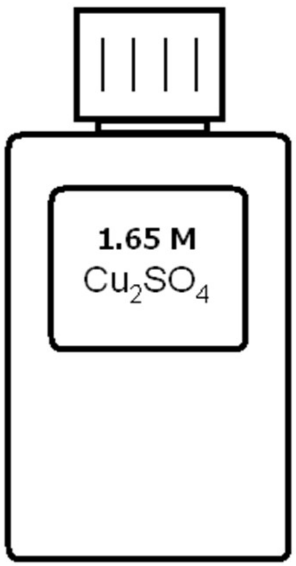
Concentrations of H_3O^+ and OH^- remain low (but significant) and constant.

Conductivity: Acetic Acid

- Glacial Acetic Acid $CH_3COOH_{(L)}$
  - Liquid
  - 100% CH_3COOH (acetic acid)
  - Non-electrolyte: no ions to conduct electricity
- Solutions of Acetic Acid $CH_3COOH_{(aq)}$
  - Solvent: Water   Solute: CH_3COOH
  - Much more conductive than pure water
  - Many ions are present

$$CH_3COOH_{(L)} + H_2O_{(l)} \rightleftarrows H_3O^+_{(aq)} + CH_3COO^-_{(aq)}$$

Ions and Concentration



What is the concentration of Copper and Sulfate ions in 1.65 M Copper (I) Sulfate?

$Cu_2SO_{4(aq)}$

Cu^+ Cu^+ SO_4^{2-}

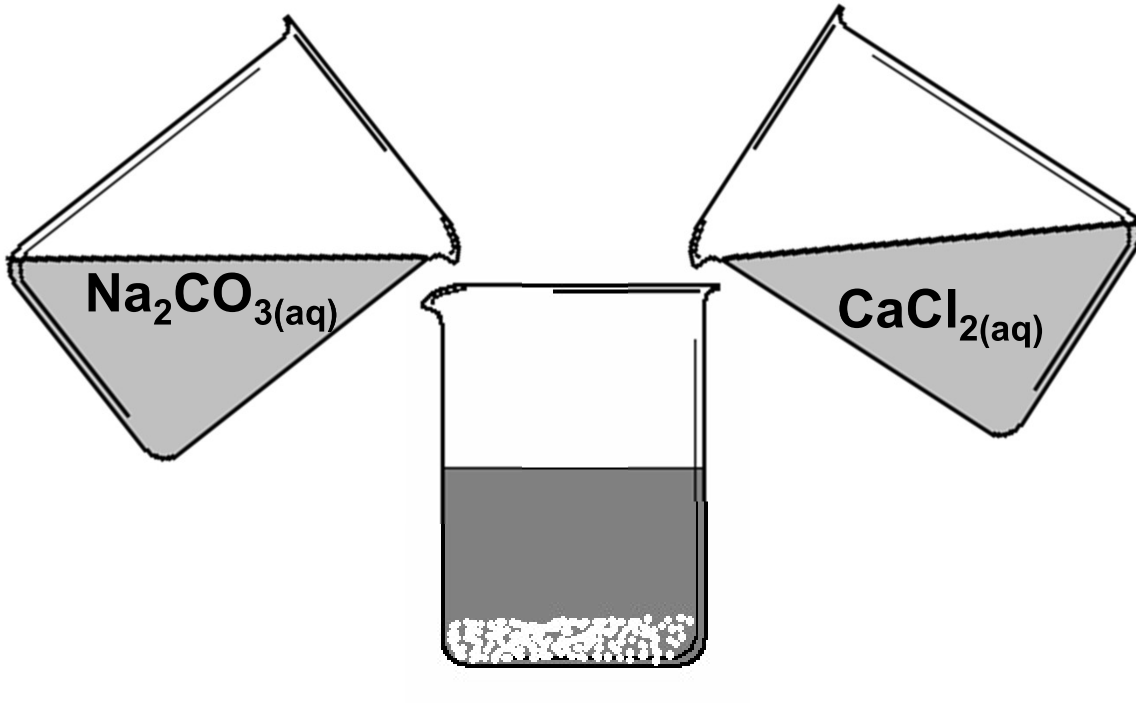
1 mole Cu_2SO_4 produces:
2 mole of Cu^+ and 1 mole SO_4^{2-}

Conversion Factor: 1 mole Cu_2SO_4 = 2 mole Cu^+ ions

$$\frac{1.65 \text{ mole } Cu_2SO_4}{1 \text{ liter solution}} \times \frac{2 \text{ mole } Cu^+ \text{ ions}}{1 \text{ mole } Cu_2SO_4} = 3.30 \text{ M } Cu^+ \text{ ions}$$

$$\frac{1.65 \text{ mole } Cu_2SO_4}{1 \text{ liter solution}} \times \frac{1 \text{ mole } SO_4^{2-} \text{ ions}}{1 \text{ mole } Cu_2SO_4} = 1.65 \text{ M } SO_4^{2-} \text{ ions}$$

Reactions: Precipitation Reactions

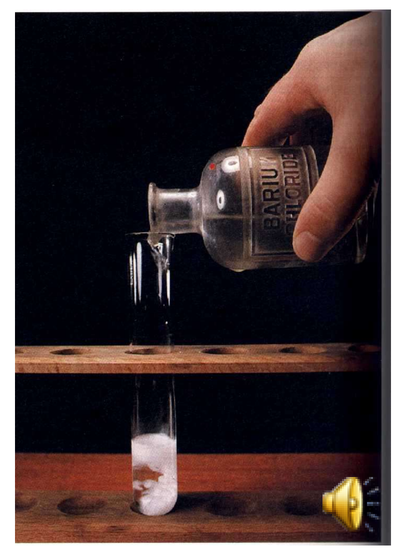


Solid Forms:

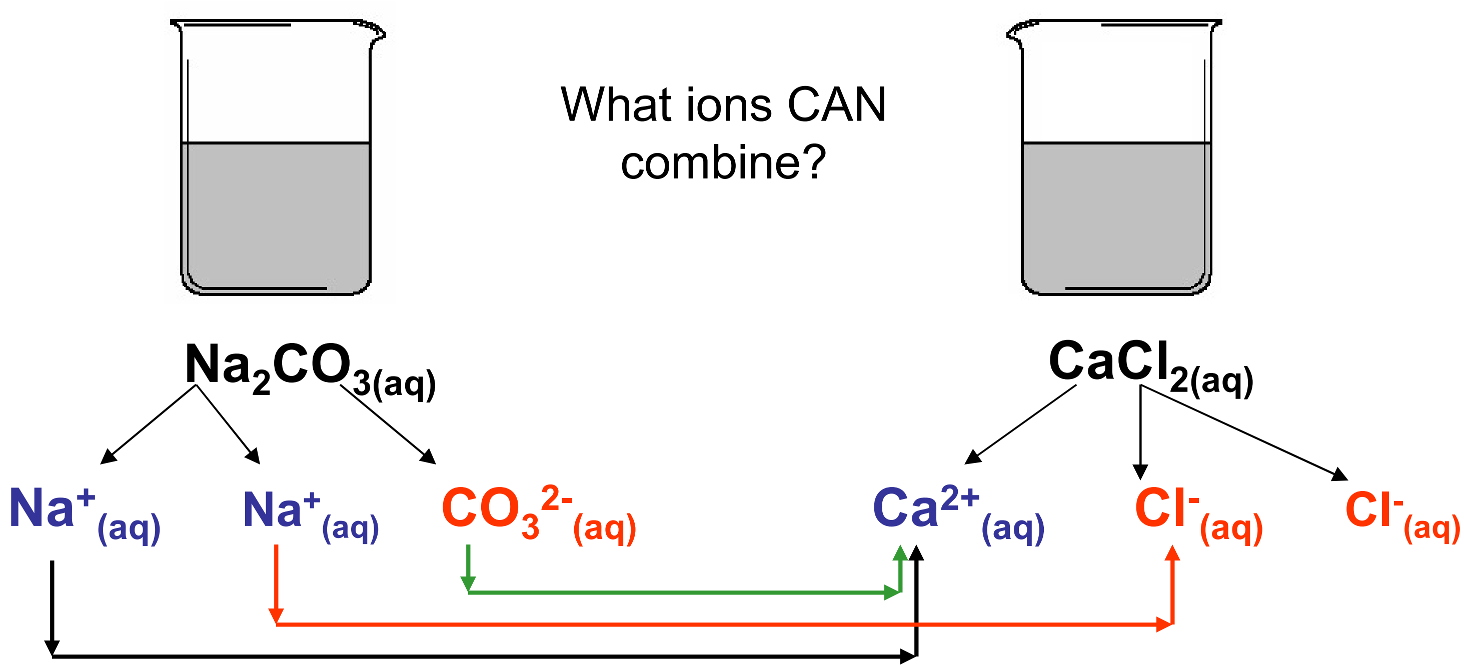
Finely divided (small particles)

Appearance: Cloudy

Solid eventually settles to bottom



Reactions: Precipitation Reactions



$Na^+_{(aq)}$ & $Ca^{2+}_{(aq)}$ No. Opposite Charges repel

$Na^+_{(aq)}$ & $Cl^-_{(aq)}$ No. NaCl dissolves in water (Soluble in water)

$Ca^{+2}_{(aq)}$ & $CO_3^{2-}{}_{(aq)}$ Yes. Opposite Charges. Only likely combination for solid's identity

Solubility: Dissolving Solids

Definitions:

Soluble: A solid (solute) that will dissolve in the solvent.

Insoluble: A solid that will NOT visibly dissolve in the solvent.

Note: *Everything* dissolves to some extent.

Solubility: The maximum amount of solute that will dissolve in a given amount of solvent.

Example: NaCl Solubility

$$\frac{6.14 \text{ mol}_{NaCl}}{1.00 \text{ L}_{H2O}}$$

Observed to dissolve in water.

Example: AgCl Solubility

$$\frac{0.0000135 \text{ mol}_{AgCl}}{1.00 \text{ L}_{H2O}}$$

Not observed to dissolve in water.

...even though a little does!

Solubility Rules:

How do we know what combinations DON'T form solid precipitates?

Soluble Combinations: Table 4.1 pg 143

- All common compounds of Group 1A(1) ions (Li^+, Na^+, K^+, etc) and ammonium ion (NH_4^+) are soluble. **That is, they will dissolve and won't form a precipitate.**
- All common nitrates (NO_3^-), acetates (CH_3COO^-) and most perchlorates (ClO_4^-) are soluble.
- All common chlorides (Cl^-), bromides (Br^-) and iodides (I^-) are soluble
  except those of Ag^+, Pb^{2+}, Cu^+, and Hg_2^{2+} . (Exceptions DO form solids)
- All common fluorides (F-) are soluble
  except those of Pb2+ and Group 2A(2)
- All common sulfates (SO_4^{2-}) are soluble
  except those of Ca^{2+}, Sr^{2+}, Ba^{2+}, Ag^+ and Pb^{2+}.

Solubility Rules:

How do we know what combinations DO form solid precipitates?

Insoluble Combinations: Table 4.1 pg 143

- All common metal hydroxides are insoluble,
  except those of Group 1A(1) and the larger members of Group 2A(2) beginning with Ca^{2+}.
  (Exceptions are soluble and DO dissolve)

- All common carbonates (CO_3^{2-}) and phosphates (PO_4^{3-}) are insoluble
  except those of Group 1A(1) and NH_4^+.

- All common sulfides (S^{2-}) are insoluble
  except those of Group 1A(1), Group 2A(2) and NH_4^+.

Solubility Rules Exam

Solubility Rules

Soluble	Exceptions
Group IA, NH_4^+	
NO_3^-, CH_3COO^-, most ClO_4^-	
Cl^-, Br^-, I^-	Ag^+, Pb^{2+}, Cu^+, Hg_2^{2+}
F^-	Pb^{2+}, Group 2A
SO_4^{2-}	Ca^{2+}, Sr^{2+}, Ba^{2+}, Ag^+, Pb^{2+}
Insoluble	**Exceptions**
OH^-	Group 1A, larger members of Group 2A
CO_3^{2-}, PO_4^{3-}	Group 1A and NH_4^+
S^{2-}	Group 1A, Group 2A and NH_4^+