42.081 g/mol 53.064 g/mol

$$4\,C_3H_6 + 6\,NO \longrightarrow 4\,C_3H_3N + 6\,H_2O + N_2$$

propylene acrylonitrile

Calculate how many grams of acrylonitrile could be obtained from 651 kg of propylene, assuming there is excess NO present.

---

1 - Convert mass propylene to moles using formula weight.
2 - Convert moles propylene to moles acrylonitrile using chemical equation.
3 - Convert moles acrylonitrile to mass using formula weight.

$42.081\,g\,C_3H_6 = mol\,C_3H_6$ | $4\,mol\,C_3H_6 = 4\,mol\,C_3H_3N$

$53.064\,g\,C_3H_3N = mol\,C_3H_3N$ | $kg = 10^3\,g$

$$651\,kg\,C_3H_6 \times \frac{10^3\,g}{kg} \times \frac{mol\,C_3H_6}{42.081\,g\,C_3H_6} \times \frac{4\,mol\,C_3H_3N}{4\,mol\,C_3H_6} \times \frac{53.064\,g\,C_3H_3N}{mol\,C_3H_3N}$$

need mass in grams...

① ② ③

$$= \boxed{821000\,g\,C_3H_3N} \quad (821\,kg)$$

151.90 g/mol

$$10\,FeSO_4 + 2\,KMnO_4 + 8\,H_2SO_4 \rightarrow 5\,Fe_2(SO_4)_3 + 2\,MnSO_4 + K_2SO_4 + 8\,H_2O$$

How many mL of 0.250M potassium permangenate are needed to react with 3.36 g of iron(II) sulfate?

---

1 - Convert mass of iron(II) suflate to moles using formula weight.
2 - Convert moles iron(II) sulfate to moles potassium permangenate using chemical equation.
3 - Convert moles potassium permangenate to volume using concentration.

$151.90\ g\ FeSO_4 = mol\ FeSO_4$	$10\ mol\ FeSO_4 = 2\ mol\ KMnO_4$
$0.250\ mol\ KMnO_4 = L$	$mL = 10^{-3}\ L$

$$3.36\ g\ FeSO_4 \times \frac{mol\ FeSO_4}{151.90\ g\ FeSO_4} \times \frac{2\ mol\ KMnO_4}{10\ mol\ FeSO_4} \times \frac{L}{0.250\ mol\ KMnO_4} =$$

(1) (2) (3)

$$= 0.176956525\ L \times \frac{mL}{10^{-3}\ L} = 17.7\ mL\ of\ 0.250M\ KMnO_4$$

Electrolytes and Ionic Theory

- electrolytes: substances that dissolve in water to form charge-carrying solutions

* Electrolytes form ions in solution - (ions that are mobile are able to carry charge!). These IONS can undergo certain kinds of chemistry!

IONIC THEORY

- the idea that certain compounds DISSOCIATE in water to form free IONS

What kind of compounds?

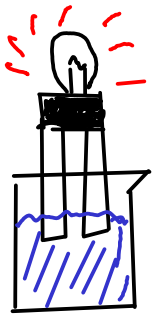
- Soluble ionic compounds
- Acids (strong AND weak)
- Bases (strong AND weak)

The ions formed may interact with each other to form NEW compounds!

Strong vs weak?

- If an electrolyte COMPLETELY IONIZES in water, it's said to be STRONG
- If an electrolyte only PARTIALLY IONIZES in water, it's said to be WEAK
- Both kinds of electrolyte undergo similar kinds of chemistry.

Ionic theory experiment



Simple conductivity tester: The stronger the electrolyte, the brighter the light.

SOME PURE COMPOUNDS (MOLECULAR AND IONIC)

DISTILLED WATER

No light. Pure water does not conduct an appreciable electric current.

SOLID SODIUM CHLORIDE

Nonconductor (no light). There are charged particles, but they're locked into the solid crystal structure of NaCl.

SOLID SUCROSE $C_{12}H_{22}O_{11}$

Like water, this molecular compound is a nonconductor - made of neutral molecules.

MOLECULAR AND IONIC SOLUTIONS

SODIUM CHLORIDE + WATER

Bright light. Sodium chloride - like other soluble ionic compounds - is a STRONG ELECTROLYTE; it breaks apart in water to form free ions.

SUCROSE + WATER

No light. The sugar water is a NONELECROLYTE. Sucrose molecules do not break apart in water to form ions.

ACIDS

PURE (GLACIAL) ACETIC ACID

No liight. Just like water, pure acetic acid is a nonconductor. It's a molecular substance - no ions available to carry a current, so even though it's liquid, it doesn't conduct.

ACETIC ACID + WATER

Light. (Not as bright as NaCl/water): Acetic acid is a weak electrolyte. Some molecules of acetic acid have ionized in water (others don't)

2M ACETIC ACID (AQUEOUS)

Dim light. WEAK ELECTROLYTE, since the same concentration of HCl is much brighter.

2M HYDROCHLORIC ACID (AQUEOUS)

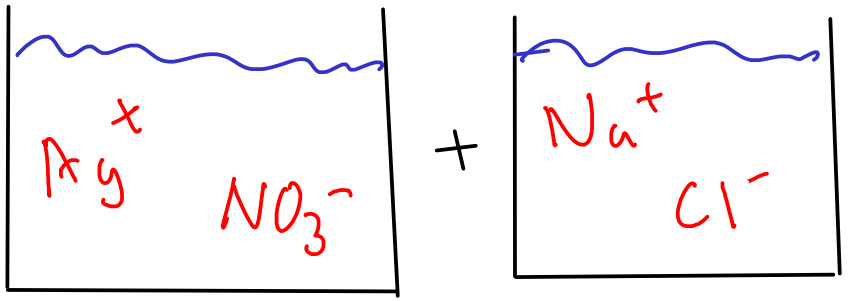
Bright light. HCl is a STRONG ELECTROLYTE (at least, stronger than acetic acid)

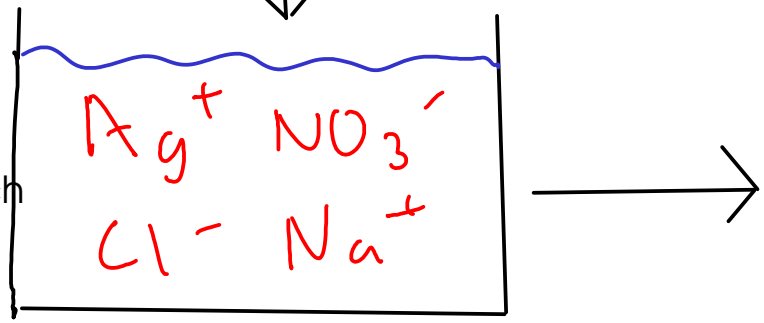
- What good is ionic theory?

- provides an easy-to-understand MECHANISM for certain kinds of chemical reactions.

- "Exchange" reactions. (a.k.a "double replacement" reactions)

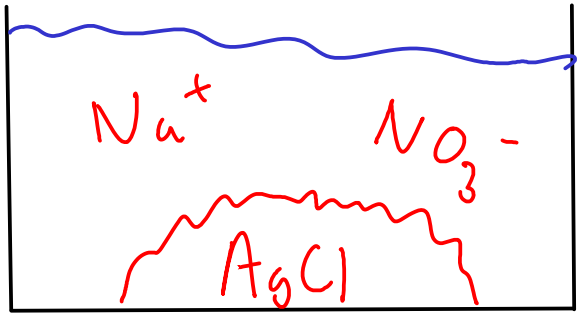
$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$





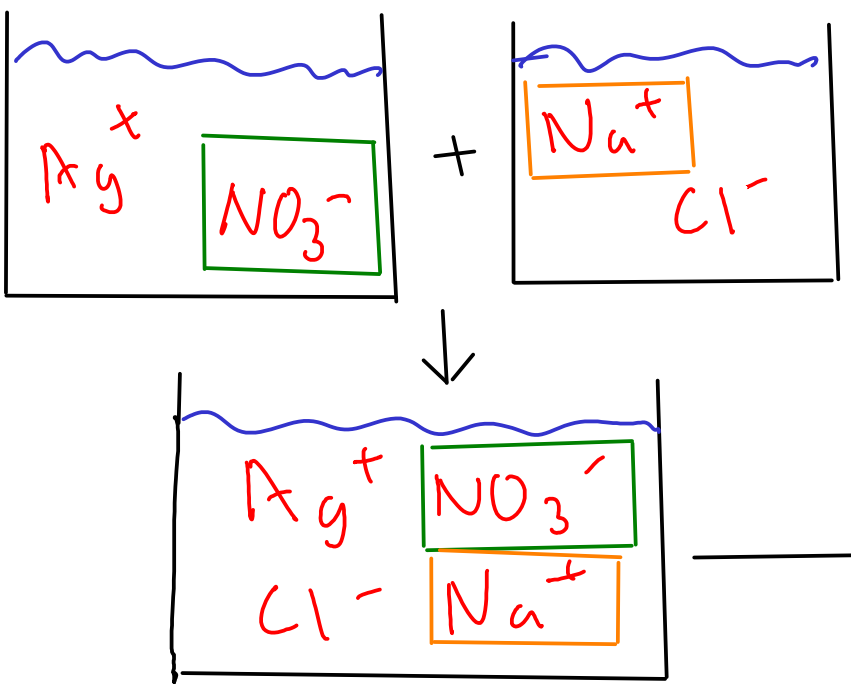
These free ions mix and can interact with each other!

"ion soup"!



Insoluble AgCl falls out of solution as it is formed - "precipitation"

Looking a bit more closely...



The nitrate and sodium ions do not really participate in this reaction. They start and end in exactly the same state. We call them "SPECTATOR IONS".

$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$ "Molecular equation"

$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ "Net ionic equation"

(The net ionic equation shows only ions and substances that change during the course of the reaction!)

- The net ionic equation tells us that any source of aqueous silver and chloride ions will exhibit this same chemistry, not just silver nitrate and sodium chloride!

A bit more about molecular, ionic, and net ionic equations

- molecular equations: Represent all substances (even ionic substances) as if they were molecules. Include spectator ions, and do not show charges on ions. Traditional chemical equations.

- ionic equations: Show all free ions - including spectators - in a chemical reaction. Molecules and WEAK electrolytes are shown as molecules. STRONG electrolytes (like HCl) are shown as ions. Ions that are part of undissolved ionic compounds are shown as molecules.

- NET ionic equation: An ionic equation that leaves out spectator ions. Intended to show only things that actually change in a reaction.

$$AgNO_3(aq) + NaCl(aq) \rightarrow AgCl(s) + NaNO_3(aq)$$

$$Ag^+(aq) + NO_3^-(aq) + Na^+(aq) + Cl^-(aq) \rightarrow AgCl(s) + Na^+(aq) + NO_3^-(aq) \quad *$$

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

* You can get from the complete ionic equation to the net ionic equation by crossing out the spectator ions on both sides.

"Undissolved ionic compounds":

How can I tell if an ionic compound dissolves in water?

- consult experimental data: "solubility rules"!

A few of the "rules"...

- Compounds that contain a Group IA cation (or ammonium) are soluble
- Nitrates and acetates are soluble
- Carbonates, phosphates, and hydroxides tend to be insoluble

See p 129 9th edition

... or see the web site for a solubility chart.

$Fe(OH)_3$

#8 - hydroxides generally insoiluble, except Group IA, ammonium, calcium strontium, barium

Conclusion: iron(III) hydroxide is insoluble.

$Ca(C_2H_3O_2)_2$

#2 - acetates are soluble, no common exceptions.

Conclusion: calcium acetate is soluble.

AgI

#3 - Iodides usually dissolve, exceptions are silver, mercury, lead

Conclusion: silver(I) iodide is INSOLUBLE

Exchange Chemistry

- Three kinds of exchange chemistry.

1. PRECIPITATION

2. ACID/BASE or NEUTRALIZATION

3. GAS FORMATION (formation of unstable molecules)
   - SOME (but not all) reactions that form gases are examples of exchange chemistry.

Just because you mix together two ionic compounds does NOT mean that a reaction will occur. You need a DRIVING FORCE for a reaction.