42.081 g/mol $\qquad\qquad\qquad\qquad$ 53.064 g/mol

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

propylene $\qquad\qquad\qquad\qquad$ 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 (but watch units...)
2 - Convert moles propylene to moles acrylonitrile using CHEMICAL EQUATION.
3 - Convert moles acrylonitrile to mass using FORMULA WEIGHT.

$42.081\,g\ C_3H_6 = mol\ C_3H_6$	$53.064\,g\ C_3H_3N = mol\ C_3H_3N$
$4\ mol\ C_3H_6 = 4\ mol\ C_3H_3N$	$kg = 10^3\,g$

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

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

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 iron(II) sulfate 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 molar concentration (0.250 mol/L)

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

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

$= 0.0177\,L$ ... but we wanted mL, so do a quick unit conversion.

$$0.0177\,L \times \frac{mL}{10^{-3}\,L} = \boxed{17.7\,mL \text{ of } 0.250M\,KMnO_4}$$

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?

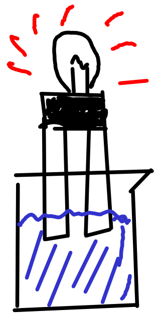
- Soluble ionic compounds
- Acids (strong AND weak)
- Bases (strong AND weak)

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 is NONCONDUCTOR. Itr doesn't carry an appreciable electric current.

SOLID SODIUM CHLORIDE

No light. Solid sodium chloride is also a NONCONDUCTOR. We have ions, but they're locked in place in the solid structure.

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

Like water, sucrose is a NONCONDUCTOR. This is typical behavior for molecules.

MOLECULAR AND IONIC SOLUTIONS

SODIUM CHLORIDE + WATER

Bright light. Sodium chloride (like all other soluble ionic compounds) is a STRONG ELECTROLYTE that breaks apart in water to form free ions.

SUCROSE + WATER

NJo light. Sucrose is a NONELECTROLYTE - its solutions do not carry a current. When sucrose dissolves, it remains as sucrose molecules. (This is typical of molecular substances.)

ACIDS

PURE (GLACIAL) ACETIC ACID

No light. Like water, this MOLECULAR substance is a nonconductor. Since there are no ions in the pure material, we don't expect it to be a good conductor of electricity.

ACETIC ACID + WATER

Light (dimmer than NaCl test) - Acetic acid is a WEAK ELECTROLYTE - meaning that at least some of the acid ionizes in solution.

2M ACETIC ACID (AQUEOUS)

Dim light. Confirms that acetic acid is a WEAK ELECTROLYTE, since it lights up less brightly than the same amount and concentration of HCl solution.

2M HYDROCHLORIC ACID (AQUEOUS)

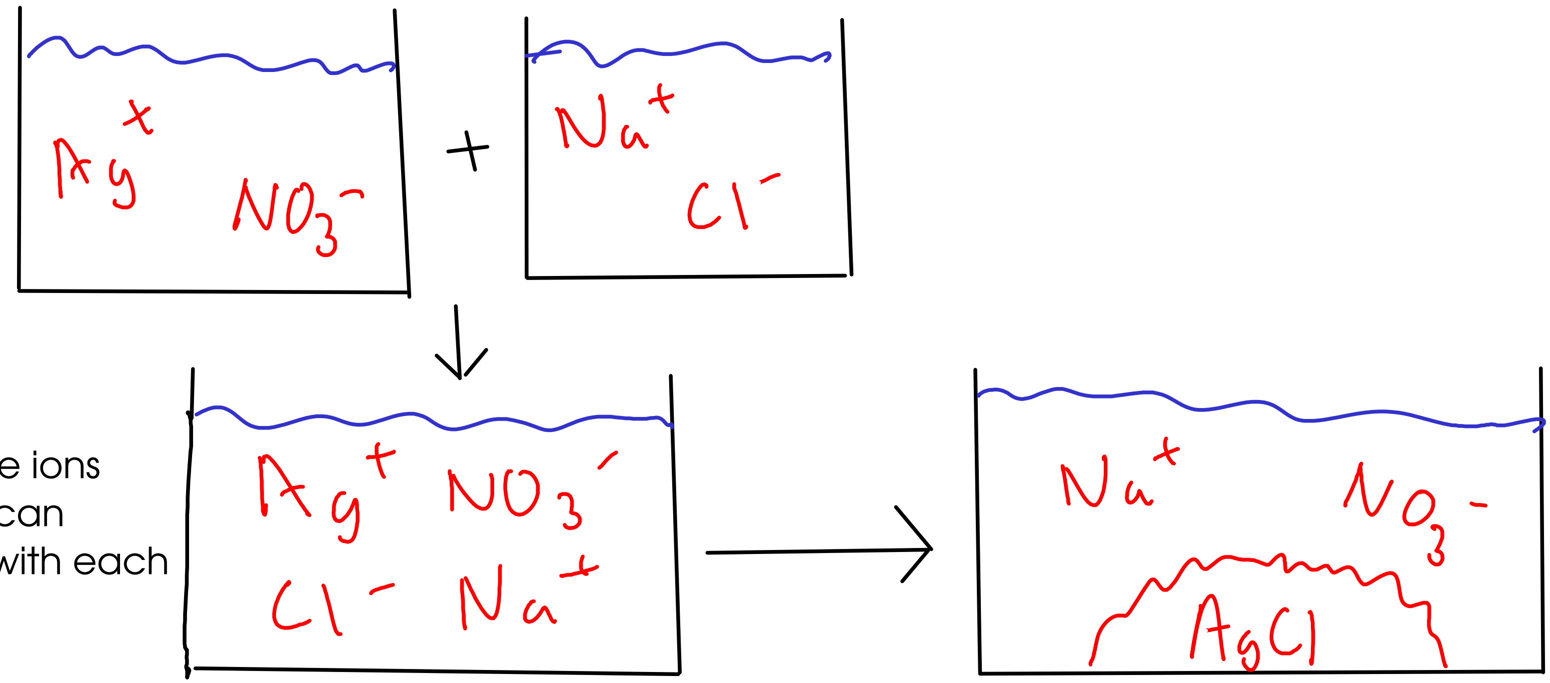
Bright light. Hydrochloric acid is a STRONG ELECTROLYTE (or at least, a stronger electrolyte than acetic acid!)

- 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)

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

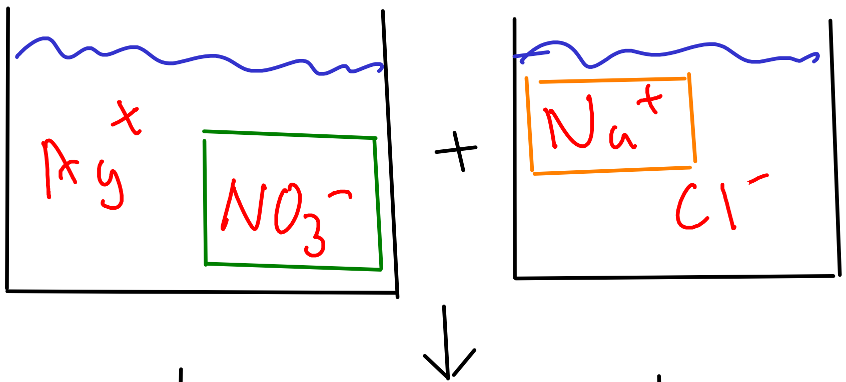
These free ions mix and can interact with each other!



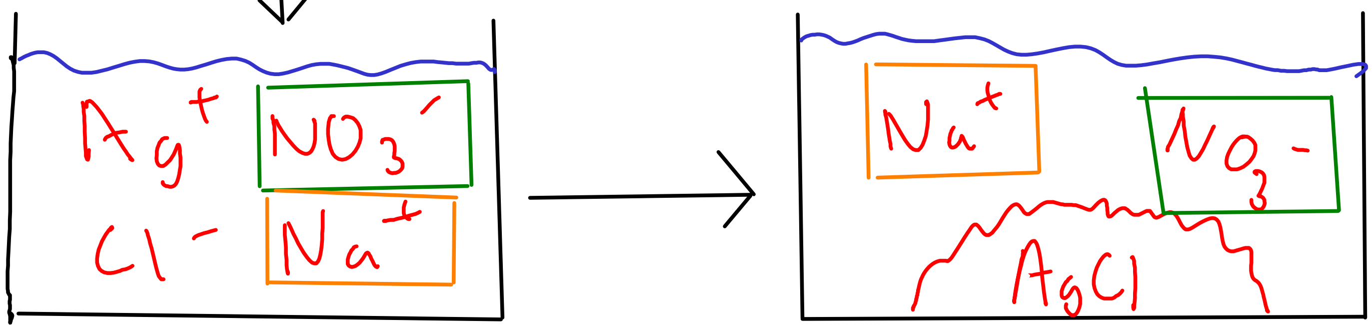
"ion soup"!

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.

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

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

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

* 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 p129 9th edition (10th ed: p131)

... 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

$BaCO_3$

#5 - Most carbonates are insoluble

Conclusion - baroum carbonate 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.

PRECIPITATION REACTIONS

- driving force is the formation of an insoluble ionic compound.

$$3MgCl_2(aq) + 2Na_3PO_4(aq) \rightarrow 6NaCl(aq) + Mg_3(PO_4)_2(s)$$

ions: Mg^{2+} Cl^- Na^+ PO_4^{3-}

Potential products: $NaCl$

$Mg_3(PO_4)_2$

Mg^{2+} PO_4^{3-}

Formation of solid (insoluble) magnesium phosphate drives this reaction!

When you're trying to complete a precipitation reaction:

1. Write the IONS that form when the reactants are dissolved.
2. Make NEW compounds by pairing up cations with anions. Don't forget that the positive and negative charges must balance each other out!
3. Use the solubility rules to determine the PHASE of each new compound - solid or aqueous.
4. Balance the overall equation.

$MgCl_2(aq) + NaC_2H_3O_2(aq) \rightarrow$ NO REACTION!*

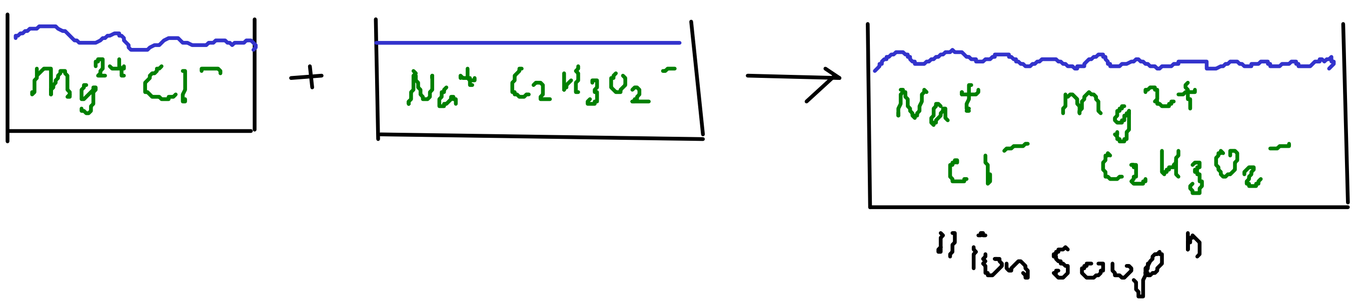
ions: Mg^{2+} Cl^- Na^+ $C_2H_3O_2^-$

"exchange"

$Mg(C_2H_3O_2)_2$ ... dissolves in water

$NaCl$ ... dissolves in water

So, no solid forms here. All possible combinations of these four ions result in compounds that dissolve readily in water.



NO CHANGE, therefore NO DRIVING FORCE, and NO REACTION

*We will learn about other driving forces than the formation of solid, but these driving forces do not apply to this reaction

ACID/BASE REACTIONS (also called NEUTRALIZATION REACTIONS)

- There are several stable molecules that may be formed in double replacement reactions, but the most common is WATER!

- Double replacement reactions that form water are also called "neutralizations"

$$HA + BOH \rightarrow H_2O + BA$$

acid   base   salt

ionic compound

$H^+ A^-$ $B^+ OH^-$ "HOH"

* To make water (H_2O), you need a source of hydrogen ion (H^+) and hydroxide ion (OH^-)

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$$

This is the NET IONIC EQUATION for many neutralizations

... assumes you're reacting STRONG acid with STRONG base!

ACIDS

- compounds that release hydrogen ion (H^+), when dissolved in water.

Properties of acids:

- Corrosive: React with most metals to give off hydrogen gas
- Cause chemical burns on contact
- Taste sour (like citrus - citric acid!)
- Changes litmus indicator to RED

BASES

- Substances that release hydroxide ion (OH^-) when dissolved in water

Properties of bases:

- Caustic: Attack and dissolve organic matter (think lye, which is NaOH)
- Cause skin/eye damage on contact
- Taste bitter
- changes litmus indicator to BLUE

Due to the dissolving action of base on your skin, bases will feel "slippery". The base ITSELF is not particularly slippery, but what's left of your skin IS!