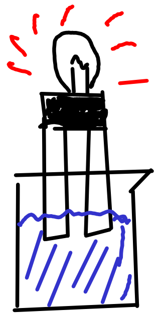
Ionic theory experiment



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

SOME PURE COMPOUNDS (MOLECULAR AND IONIC)

DISTILLED WATER

No light. Pure water is a NONCONDUCTOR - it doesn't conduct an appreciable electric current.

SOLID SODIUM CHLORIDE

While NaCl has charge carriers (ions), these ions are locked into the solid structure and can't move. NaCl(s) is a nonconductor.

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

No light. Just like water, sucrose is made of neutral molecules - and is also a nonconductor.

MOLECULAR AND IONIC SOLUTIONS

SODIUM CHLORIDE + WATER

Bright light. NaCl is an ELECTROLYTE. Like other soluble ionic compounds, it is pulled apart into its component ions in water, and these dissolved ions are also free to move in solution.

SUCROSE + WATER

No light. Sucrose is a NONELECTROLYTE. Sucrose molecules do not break apart of react with water to form ions. Typical molecular behavior, but there are other molecules that do react withwater.

ACIDS

PURE (GLACIAL) ACETIC ACID

No light, Like water, pure liquid acetic acid is a nonconductor. This means that it's a MOLECULAR substance!

ACETIC ACID + WATER

Dim light (not as bright as NaCl/water), Acetic acid is an ELECTROLYTE, though. It reacts with water to release ions, which can carry a charge in solution.

2M ACETIC ACID (AQUEOUS)

Dim light. Not as bright as 2M HCl. This means that acetic acid is a WEAK ELECTROLYTE - it does NOT completely ionize in water.

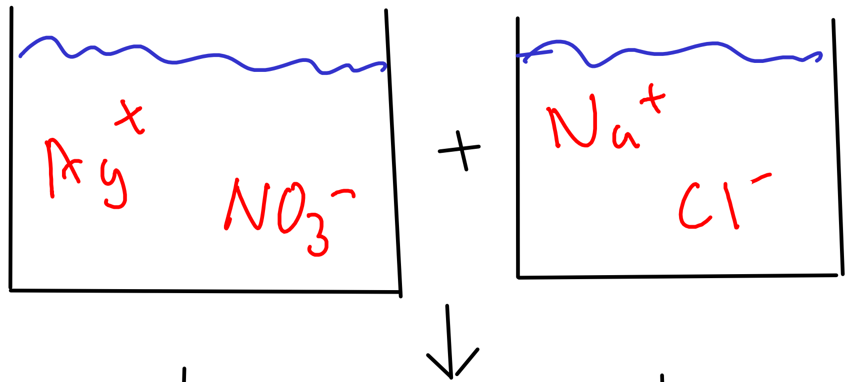
2M HYDROCHLORIC ACID (AQUEOUS)

Bright light. HCl is a STRONGER ELECTROLYTE than acetic acid is, (We can't prove it in this experiment, but HCl is actually a STRONG ELECTROLYTE - it completely ionizes)

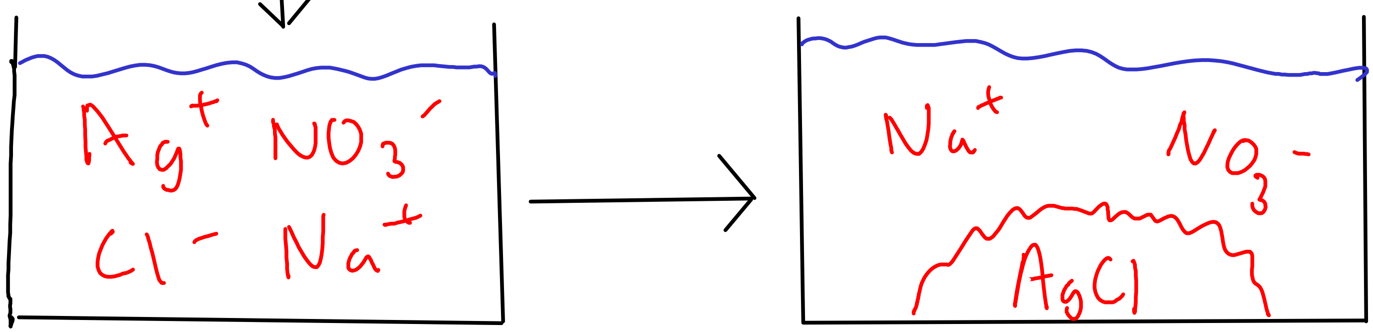
- What good is ionic theory?

- provides an easy-to-understand MECHANISM for certain kinds of chemical reactions.
  - "Exchange" reactions. (a.k.a "double replacement" reactions)

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



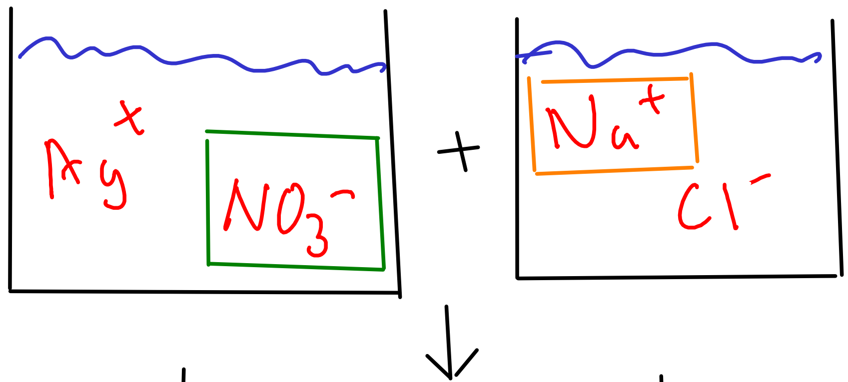
These free ions mix and can interact with each other!



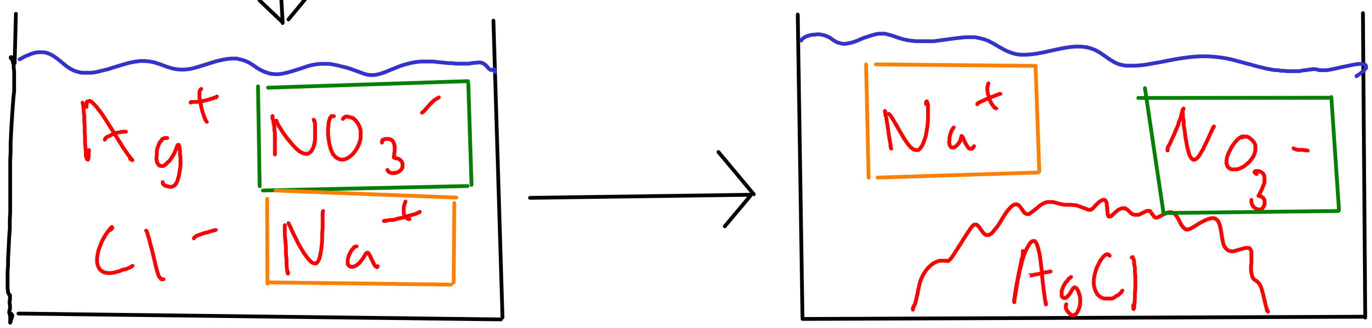
"ion soup"!

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.

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

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

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

* 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 p 129 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 - barium 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.