

Chapter 4
Aqueous Reactions and Solution Stoichiometry
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Solutions:

- Homogeneous mixtures of two or more pure substances.
- The solvent is present in greatest abundance.
- All other substances are solutes.

Dissociation

- When an ionic substance dissolves in water, the solvent pulls the individual ions from the crystal and solvates them.
- This process is called dissociation.

Electrolytes

- Substances that dissociate into ions when dissolved in water.
- A nonelectrolyte may dissolve in water, but it does not dissociate into ions when it does so.

Electrolytes and Nonelectrolytes

Soluble ionic compounds tend to be electrolytes.

Electrolytes and Nonelectrolytes

Molecular compounds tend to be nonelectrolytes, except for acids and bases.

Electrolytes

- A strong electrolyte dissociates completely when dissolved in water.
- A weak electrolyte only dissociates partially when dissolved in water.

Strong Electrolytes Are...

- Strong acids

Strong Electrolytes Are...

- Strong acids

- Strong bases

Strong Electrolytes Are...

- Strong acids

- Strong bases

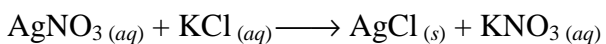
- Soluble ionic salts

Precipitation Reactions

When one mixes ions that form compounds that are insoluble (as could be predicted by the solubility guidelines), a precipitate is formed.

Metathesis (Exchange) Reactions

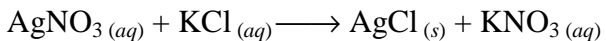
- Metathesis comes from a Greek word that means “to transpose”



Metathesis (Exchange) Reactions

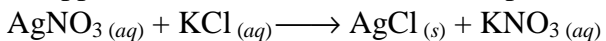
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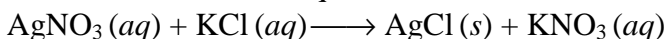


Solution Chemistry

- It is helpful to pay attention to *exactly* what species are present in a reaction mixture (i.e., solid, liquid, gas, aqueous solution).
- If we are to understand reactivity, we must be aware of just what is changing during the course of a reaction.

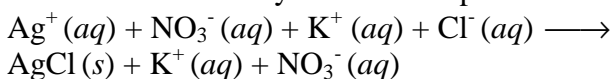
Molecular Equation

The molecular equation lists the reactants and products in their molecular form.



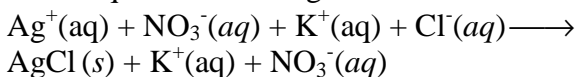
Ionic Equation

- In the ionic equation all strong electrolytes (strong acids, strong bases, and soluble ionic salts) are dissociated into their ions.
- This more accurately reflects the species that are found in the reaction mixture.



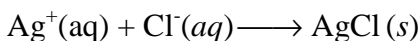
Net Ionic Equation

- To form the net ionic equation, cross out anything that does not change from the left side of the equation to the right.



Net Ionic Equation

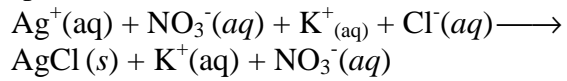
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Net Ionic Equation

- To form the net ionic equation, cross out anything that does not change from the left side of the equation to the right.
- The only things left in the equation are those things that change (i.e., react) during the course of the reaction.

- Those things that didn't change (and were deleted from the net ionic equation) are called spectator ions.



Writing Net Ionic Equations

- Write a balanced molecular equation.
- Dissociate all strong electrolytes.
- Cross out anything that remains unchanged from the left side to the right side of the equation.
- Write the net ionic equation with the species that remain.

Acids:

- Substances that increase the concentration of H^+ when dissolved in water (Arrhenius).

- Proton donors (Brønsted–Lowry).

Acids

There are only seven strong acids:

- Hydrochloric (HCl)
- Hydrobromic (HBr)
- Hydroiodic (HI)
- Nitric (HNO₃)
- Sulfuric (H₂SO₄)
- Chloric (HClO₃)
- Perchloric (HClO₄)

Bases:

- Substances that increase the concentration of OH⁻ when dissolved in water (Arrhenius).
- Proton acceptors (Brønsted–Lowry).

The strong bases are the soluble salts of hydroxide ion:

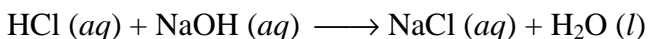
- Alkali metals
- Calcium
- Strontium
- Barium

Acid-Base Reactions

In an acid-base reaction, the acid donates a proton (H⁺) to the base.

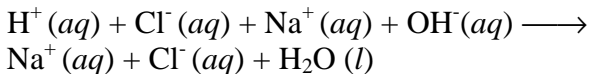
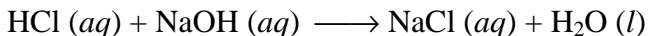
Neutralization Reactions

Generally, when solutions of an acid and a base are combined, the products are a salt and water.



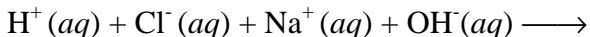
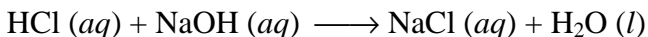
Neutralization Reactions

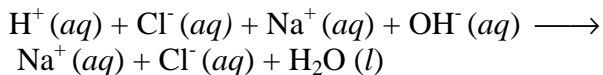
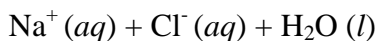
When a strong acid reacts with a strong base, the net ionic equation is...



Neutralization Reactions

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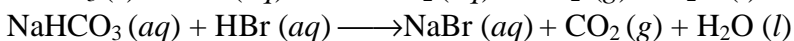
Neutralization Reactions

Observe the reaction between Milk of Magnesia, $\text{Mg}(\text{OH})_2$, and HCl .

Gas-Forming Reactions

•These metathesis reactions do not give the product expected.

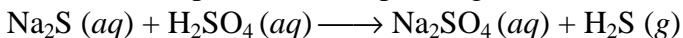
•The expected product decomposes to give a gaseous product (CO_2 or SO_2).



Gas-Forming Reactions

•This reaction gives the predicted product, but you had better carry it out in the hood, or you will be very unpopular!

•Just as in the previous examples, a gas is formed as a product of this reaction:



Oxidation-Reduction Reactions

•An oxidation occurs when an atom or ion *loses* electrons.

•A reduction occurs when an atom or ion *gains* electrons.

Oxidation-Reduction Reactions

One cannot occur without the other.

Oxidation Numbers

To determine if an oxidation-reduction reaction has occurred, we assign an oxidation number to each element in a neutral compound or charged entity.

Elements in their elemental form have an oxidation number of 0.

- The oxidation number of a monatomic ion is the same as its charge.

- Nonmetals tend to have negative oxidation numbers, although some are positive in certain compounds or ions.

- Oxygen has an oxidation number of -2 , except in the peroxide ion in which it has an oxidation number of -1 .

- Hydrogen is -1 when bonded to a metal, $+1$ when bonded to a nonmetal.

Oxidation Numbers

- Nonmetals tend to have negative oxidation numbers, although some are positive in certain compounds or ions.

- Fluorine always has an oxidation number of -1 .

The other halogens have an oxidation number of -1 when they are negative; they can have positive oxidation numbers, however, most notably in oxyanions.

- The sum of the oxidation numbers in a neutral compound is 0.

- The sum of the oxidation numbers in a polyatomic ion is the charge on the ion.

Oxidation Numbers

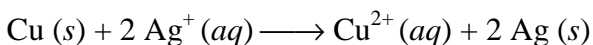
Displacement Reactions

- In displacement reactions, ions oxidize an element.

- The ions, then, are reduced.

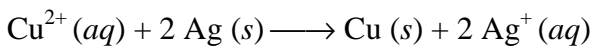
Displacement Reactions

In this reaction,
silver ions oxidize
copper metal.



Displacement Reactions

The reverse reaction,
however, does not
occur.



Activity Series

Molarity

- Two solutions can contain the same compounds but be quite different because the proportions of those compounds are different.

- Molarity is one way to measure the concentration of a solution.

Mixing a Solution

Dilution

Using Molarities in
Stoichiometric Calculations

Titration

The analytical technique in which one can calculate the concentration of a solute in a solution.

Titration