

# Chemical Reactions

## Chapter 4

## Interpreting a Chemical Equation:

- A chemical equation describes a chemical reaction much like a sentence describes some action.
  - Element Symbols - Letters
  - Formulas - Words
  - Equations - Sentences
- *Consider the following chemical reaction:*



*Sentence form:*

*Sodium metal reacts with water to form aqueous sodium hydroxide and hydrogen gas.*

# Symbols in Chemical Reactions

(s) = Solid

(l) = Liquid

(g) = Gas

(aq) = Aqueous (dissolved in water)

+ = "and"

→ = "reacts to form" or "yields"

$\Delta$   
→ = Heat added

Pt  
→ = Catalyst (in this example, platinum)

# Balancing Chemical Equations

- Balancing chemical equations is an application of both the **Modern Atomic Theory** and the **Law of Conservation of Matter**.
- The number of one kind of atom on the reactants side must be equal to the number of the same kind of atom on the product side.

## Types of Reactions

### Reactions of Ionic compounds: ***Double Replacement Reactions***

- A double replacement reaction is a reaction in which two ***ionic*** compounds react to form two new compounds by simply trading cations.
- Also known as a ***metathesis*** reaction.
- In order for a double replacement reaction to actually occur, one of the products must **NOT** be aqueous – a driving force.

## Double Replacement Reactions: Precipitation

- Usually, one of the products of a metathesis reaction is a precipitate (solid that falls out of solution).
- A precipitate will form if the ions in solution can combine to make a compound that is not soluble in water.
- Use the solubility chart to determine if one of the possible products is not soluble in water.

# Double Replacement Reactions: Precipitation

# Solubility Chart

<i>Anions</i>	<i>Soluble (aq)</i>	<i>Precipitate (s)</i>
nitrate	Most cations	No common cations
acetate	Most cations	Ag <sup>+</sup>
fluoride chloride bromide iodide	Most cations	Ag <sup>+</sup> , Pb <sup>2+,4+</sup> , Hg <sub>2</sub> <sup>2+</sup> , Tl <sup>+</sup>
sulfate	Most cations	Ba <sup>2+</sup> , Sr <sup>2+</sup> , Pb <sup>2+,4+</sup> , Ag <sup>+</sup> , Ca <sup>2+</sup>
chromate	Most cations	Ba <sup>2+</sup> , Sr <sup>2+</sup> , Pb <sup>2+,4+</sup> , Ag <sup>+</sup>
sulfide hydroxide oxide	NH <sub>4</sub> <sup>+</sup> & Cations of columns 1 and 2	Most other cations
carbonate phosphate	NH <sub>4</sub> <sup>+</sup> & Cations of column 1 except Li <sup>+</sup>	Most other cations



## A closer look at a precipitation reaction:

*Consider the DR reaction of calcium chloride and silver nitrate.*

- When dissolved in water, aqueous ionic compounds are generally dissociated and solvated by the water molecules.
- Calcium chloride dissolved in water:



- Silver nitrate dissolved in water:



## Ways of writing the reaction as an equation:

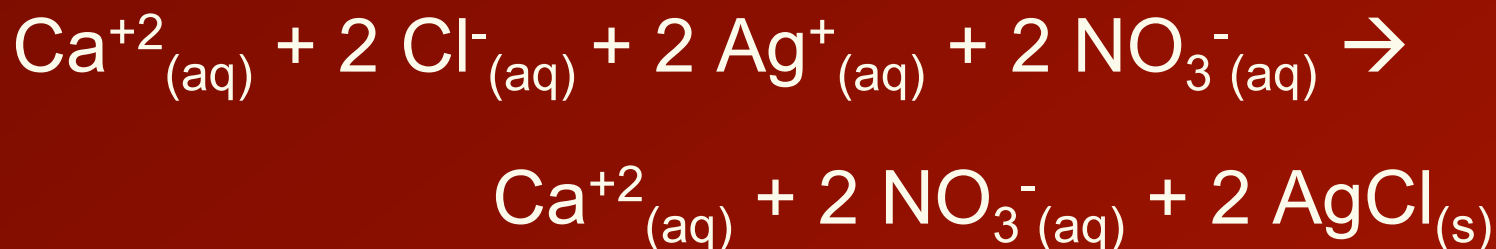
- **Molecular Equation:** A chemical equation that includes the complete, molecular formulas for all compounds in a chemical reaction.
- **Ionic Equation:** A chemical equation in which aqueous, ionic compounds are written as free ions in solution.
- **Net Ionic Equation:** A chemical equation in which only the species (ions, atoms, molecules) involved in the reaction are written. *Spectator ions* are cancelled.

## Reaction of $\text{CaCl}_2$ with $\text{AgNO}_3$ :

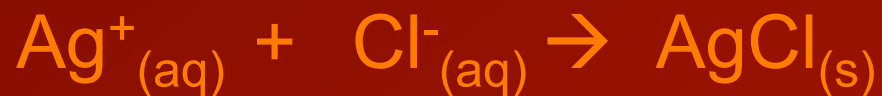
### ■ Molecular:



### ■ Ionic:



### ■ Net Ionic:



# Writing Net Ionic Equations

- The net ionic equations shows only the species involved in a chemical change.
- $\text{Ca}^{2+}$  and  $\text{NO}_3^-$  are **spectator ions**. They do not participate in the reaction.
- When both of the possible ionic products of a double replacement reaction are soluble in water, no reaction occurs, because all of the ions stay in solution.
- *Consider the mixing of a solution of sodium chloride and potassium bromide.*

## Double Replacement Reactions: Acid – Base Neutralization

- An acid and a base will react to form a salt and water.

## Double Replacement Reactions: Formation of a gas

- In some cases the double replacement reaction is followed by a decomposition reaction that forms a gas.

# Oxidation – Reduction Reactions (REDOX)

- *Oxidation-reduction reactions* involve a transfer of electrons from one element to another.
- *Oxidation numbers (oxidation states)* are a way of keeping track of the electrons in a redox reaction.
- In a monatomic ion, the oxidation number is equal to the charge on the atom.
- In compounds and polyatomic ions, oxidation numbers assign electrons that are being shared in a bond to the more *electronegative* atom – the one that has a greater pull on the electron.

## Oxidation – Reduction Reactions (cont.)

- *Oxidation* is the loss of electrons.
- *Reduction* is the gain of electrons.
- The *oxidizing agent* is the *species* (element or compound or ion) that is doing the oxidizing. In a redox reaction, the oxidizing agent is the species that is reduced.
- The *reducing agent* is the species that is doing the reducing. In a redox reaction, the reducing agent is the species that is oxidized.



## Oxidation – Reduction Reactions (cont.)

- Many oxidation reactions are very easy to analyze and can be balanced by inspection.
- The simple oxidation reactions often fit conveniently into the following common categories:
  - 1) Synthesis
  - 2) Decomposition
  - 3) Single replacement
  - 4) Combustion
- Other redox reactions are more complex, do not fit these categories, and require more complex analysis to balance.