

Precipitation Reactions

Concepts: Dissolution of ionic compounds
Electrolytes (weak and strong)
Soluble ionic compounds are strong electrolytes.

Precipitation reactions occur when certain pairs of oppositely charged ions attract each other so strongly that they form an insoluble ionic solid.

The logic: Solubility guidelines (table 4.1)

The **solubility** of a substance is the amount of that substance that can be dissolved in a given quantity of solvent (insoluble < 0.01 mol/L < soluble).

The rules of solubility are empirically determined (experimental observations).

Solubility Rules for Ionic Compounds

Compounds containing the following ions are generally soluble in water:

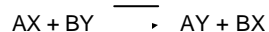
1. Li^+ , Na^+ , K^+ , NH_4^+
2. Acetate ion, $\text{C}_2\text{H}_3\text{O}_2^-$
3. Nitrate ion NO_3^-
4. Cl^- , Br^- , I^- (AgX , Hg_2X_2 , and PbX_2 are insoluble exceptions)
5. SO_4^{2-} (SrSO_4 , BaSO_4 and PbSO_4 are insoluble exceptions)

Compounds containing the following ions are generally insoluble in water:

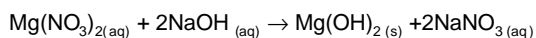
6. CO_3^{2-} (Rule #1 exceptions are soluble)
7. CrO_4^{2-} (Rule #1 exceptions are soluble)
8. PO_4^{3-} (Rule #1 exceptions are soluble)
9. S^{2-} (Rule #1 exceptions are soluble)
10. OH^- (Rule #1 exceptions are soluble)

Exchange (Metathesis) Reactions

Reactions in which positive ions and negative ions appear to exchange partners conform to the following general equation.



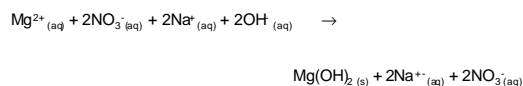
Ex:



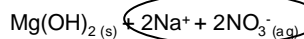
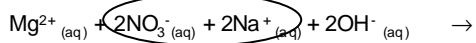
An equation written in this fashion, showing the complete chemical formulas of the reactants and products, is called a **molecular equation** (the ionic character is not indicated).

Often one can write a chemical equation indicating explicitly whether the dissolved substances are present predominantly as ions or as molecules.

Ex:



An equation written in this form, with all soluble strong electrolytes shown as ion, is known as a **complete ionic equation**.



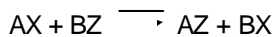
Notice that Na^{+} and NO_3^{-} appear on both sides of the equation. Ions that appear in identical forms as both reactants and products are called **spectator ions**.

When spectator ions are omitted from the equation we are left with the **net ionic equation**:



Double-Replacement reactions depend on the following three conditions:

- 1 An insoluble product is formed.
- 2 A gas is formed as product
3. A weakly ionized species is produced as a product (H_2O)



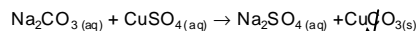
Mixing which of the following will cause nothing to happen?

- A) Sodium carbonate
- b) Copper (II) Sulfate
- c) Silver Nitrate
- d) ammonium chloride
- e) sodium phosphate
- f) sodium chloride

Mixing which of the following will cause a precipitate to form?

- A) Sodium carbonate
- b) Copper (II) Sulfate
- c) Silver Nitrate
- d) ammonium chloride
- e) sodium phosphate
- f) sodium chloride

What happens when 3.0 mL of .125M of sodium carbonate is mixed with 2.0 mL of 0.250M copper(II)sulfate?



A precipitate forms

How much precipitate?

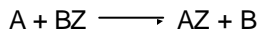
$$0.003\text{L} \cdot 0.125\text{M} = 3.75 \times 10^{-4} \text{ mol Na}_2\text{CO}_3$$

$$0.002\text{L} \cdot 0.250\text{M} = 5.00 \times 10^{-4} \text{ mol CuSO}_4$$

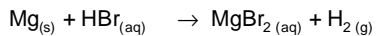
$$\begin{array}{ccccccc} 0.003\text{L} \cdot 0.125\text{M} & \text{Na}_2\text{CO}_3 & | & \text{mol CuCO}_3 & | & 23.56\text{g CuCO}_3 & = 0.046335 \text{ g} \\ & & & 1 \text{ mol Na}_2\text{CO}_3 & & 1 \text{ mol CuCO}_3 & \\ & & & & & & \text{or } 46 \text{ mg CuCO}_3 \end{array}$$

Oxidation of Metals by Acids and Salts

The reaction of a metal with either an acid or a metal salt takes the general pattern:



Ex:



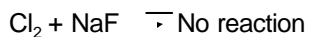
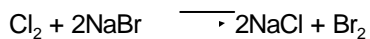
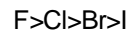
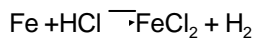
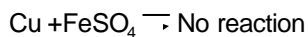
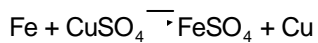
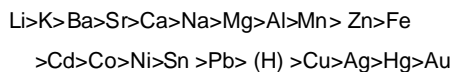
These reactions are called **displacement reactions** because the ion in solution is displaced by oxidation/reduction of an element.

Displacement reactions



In order for this reaction to take place "A" must have "more energy" than "B".

An **activity** series (electromotive series) is a sequence of metals arranged according to their ability to undergo reaction.



When a copper wire is placed in a solution of HCl which of the following occurs?

- Copper is reduced
- Copper is oxidized
- Hydrogen ion is oxidized
- Hydrogen ion is reduced
- No reaction occurs

When magnesium metal is placed in a solution of HCl which of the following occurs?

- magnesium is reduced
- magnesium is oxidized
- hydrogen ion is oxidized
- hydrogen ion is reduced
- no reaction occurs
- Fizzing occurs