Basic Ways to Classify Reactions

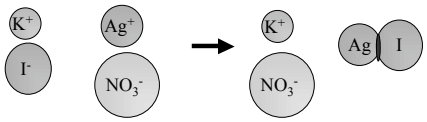
Double Replacement Reactions

- Two ionic compounds exchange ions
- $X^{\oplus}Y^{-}(aq) + A^{\oplus}B^{-}(aq) \rightarrow XB + AY$
- $BaCl_{2(aq)} + Na_2SO_{4(aq)} \rightarrow \mathbf{BaSO_4(s)} + \mathbf{NaCl(aq)}$
- Reaction will not occur unless one of the products either (1) precipitates, or (2) is water

Precipitation Reactions

- In all precipitation reactions, the ions of one substance are exchanged with the ions of another substance when their aqueous solutions are mixed.
- At least one of the products formed is insoluble in water.

$KI(aq) + AgNO_3(aq) \rightarrow KNO_3(aq) + AgI(s)$



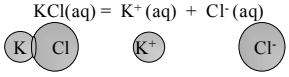
Dissociation

- Ionic compounds
  - Metal + nonmetal (Type I & II)
  - Metal + polyatomic anion
  - Polyatomic cation + anion
- **Dissociation:** when ionic compounds dissolve in water the anions and cations are separated from each other
- We know that ionic compounds dissociate when they dissolve in water because the solution conducts electricity.

Dissociation (cont.)

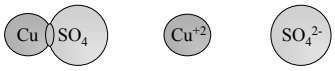
- Potassium chloride dissociates in water into potassium cations and chloride anions.

$KCl(aq) = K^{+}(aq) + Cl^{-}(aq)$



- Copper(II) sulfate dissociates in water into copper(II) cations and sulfate anions.

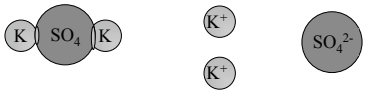
$CuSO_4(aq) = Cu^{+2}(aq) + SO_4^{2-}(aq)$



Dissociation (cont.)

- Potassium sulfate dissociates in water into potassium cations and sulfate anions.

$K_2SO_4(aq) = 2\,K^{+}(aq) + SO_4^{2-}(aq)$



Process for Predicting the Products of a Precipitation Reaction

- Determine what ions each aqueous reactant has
- Exchange ions
  - (+) ion from one reactant with (-) ion from other
- Balance charges of combined ions to get formula of each product
- Balance the equation
  - Count atoms
- Determine solubility of each product in water
  - Solubility rules
  - If product is insoluble or slightly soluble, it will precipitate.

Solubility Rules
(see p. 170)

- Most compounds that contain NO_3^- ions are soluble.
- Most compounds that contain Na^+, K^+, or NH_4^+ ions are soluble
- Most compounds that contain Cl^- ions are soluble, except AgCl, $PbCl_2$, and Hg_2Cl_2
- Most compounds that contain SO_4^{2-} ions are soluble, except $BaSO_4$, $PbSO_4$, $CaSO_4$

Solubility Rules (cont.)

- Most compounds that contain OH^- ions are slightly soluble (will precipitate), except NaOH and KOH, which are soluble, and $Ba(OH)_2$, $Ca(OH)_2$, which are moderately soluble.
- Most compounds that contain S^{2-}, CO_3^{2-}, or PO_4^{3-} ions are slightly soluble (will precipitate).

Electrolytes

- **Electrolytes**: substances whose aqueous solutions conducts electricity
- All electrolytes have ions dissolved in water
- There are strong electrolytes, weak electrolytes, and nonelectrolytes.

Reactions that Form Water: Acids + Bases

- Acids all contain H^+ cations and an anion.
- Bases all contain OH^- anions and a cation, except for weak bases such as NH_3
- When acids dissociate in water they release H^+ ions and their anions.
- When bases dissociate in water they release or form OH^- ions and their cations.

Acid-Base Reactions

- In the reaction of an acid with a base, the H^+ from the acid combines with the OH^- from the base to make water
- The cation from the base combines with the anion from the acid to make the salt

acid + base → salt + water

$H_2SO_4(aq) + Ca(OH)_2(aq) \rightarrow CaSO_4(aq) + 2\ H_2O(l)$

- The net ionic equation for a strong acid-strong base reaction is always

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

Reactions of Metals with Nonmetals (Oxidation-Reduction)

- The metal loses electrons and becomes a cation (**oxidation)**
- The nonmetal gains electrons and becomes an anion (**reduction)**
- In the reaction, electrons are transferred from the metal to the nonmetal.

Oxidation-Reduction Reactions

- **Oxidation-reduction reactions:** reactions that involve a transfer of one or more electrons
- The substance that loses electrons in the reaction is **oxidized**. The substance that gains electrons in the reaction is **reduced.**

Predicting Products of Metal + Nonmetal Reactions

- Metal + nonmetal → ionic compound
  - Ionic compounds always solids unless dissolved in water
- In the ionic compound the metal is now a cation.
- In the ionic compound the nonmetal is now an anion.

Predicting Products of Metal + Nonmetal Reactions (cont.)

- To predict direct synthesis of metal + nonmetal:
  - Determine the charges on the cation and anion from their position on the periodic table.
  - Determine numbers of cations and anions needed to have charges cancel.
  - Balance the equation.

Another Kind of Oxidation-Reduction Reaction

- Some reactions between two non-metals are also oxidation-reduction reaction.
- Any reaction in which O_2 is a reactant or a product will be an oxidation-reduction reaction.

$$CH_4(g) + 2\ O_2(g) \rightarrow CO_2(g) + 2\ H_2O(g)$$

$$2\ SO_3(g) \rightarrow 2\ SO_2(g) + O_2(g)$$

Ways to Classify Reactions

- **Precipitation reactions:** reactions that involve solid formation
- **Acid-base reactions:** reactions that involve water formation
- **Double displacement reactions:** ion exchange reactions
- Both precipitation reactions and acid-base reactions involve compounds exchanging ions.

Ways to Classify Reactions (cont.)

- **Oxidation-reduction reactions:** reactions that involve electron transfer
  - Metals + Nonmetal
  - O_2 as a reactant or product
- **Gas forming reactions:** reactions that occur in aqueous solution because one of the products is a gas

$NaHCO_3(aq) + HCl(aq) \rightarrow NaCl(aq) + CO_2(g) + H_2O(l)$