10: Chemical Reactions

Key Chemistry Terms

- **Chemical Reaction:** Bonds and atoms are rearranged to form new compounds.
- **Chemical Equation:** Symbolizes the chemical reaction with chemical formulas.
- **Reduction:** Gain of electrons, charge is "reduced".
- **Oxidation:** Lose of electrons.
- **Precipitation:** Insoluble compound formed in a double replacement reaction from two soluble ionic compounds.
- **Oxidation Number:** charge on an atom if electrons in a bond are assigned to the most electronegative atom.
- **Electronegativity:** Attraction an atom has for electrons it shares in a bond with another atom.
- **Ionic Reaction:** All soluble ionic compounds are dissociated (broken apart).
- **Spectator Ion:** Ion that remains unchanged on both sides of an ionic reaction
- **Net ionic Reaction:** Ionic reaction with all spectator ions removed.

Chemical Equations

- Reactants → Products.
- States of matter are shown (s = solid, l = liquid, g = gas, aq = aqueous).
- Coefficients give mole ratio.
- A double arrow (⇆) indicates a reversible, an equilibrium reaction.

Example:

$2\ H_2\ (g) + O_2\ (g) \rightarrow 2\ H_2O\ (l)$

H_2 & O_2 are reactants; H_2O is a product

2 moles of H_2 react with 1 mole of O_2 and produces 2 moles of H_2O

Types of Reactions

- **Composition:** More than one type of matter combine to form one type of matter.
  $2\ H_2 + O_2 \rightarrow 2\ H_2O$
- **Decomposition:** One type of matter decomposes into more than one type of matter.
  $H_2CO_3 \rightarrow H_2O + CO_2$
- **Single Replacement:** A single element changes place with an ion in a compound.
  $2\ HCl + Zn \rightarrow ZnCl_2 + H_2$
- **Double Replacement:** Two ionic compounds switch ions.
  $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$
- **Neutralization Reaction:** Double replacement reaction with an acid and a base as the reactants.
  $HCl + NaOH \rightarrow NaCl + HOH$
- **Redox Reaction:** Reduction-oxidation reaction.
  $CH_4 + O_2 \rightarrow CO_2 + H_2O$
- **Precipitation Reaction:** A precipitate is formed
  $AgNO_3\ (aq) + NaCl\ (aq) \rightarrow AgCl\ (s) + NaNO_3\ (aq)$

Redox Reactions

- Reduction and oxidation always happen together (electrons gained in the reduction were lost in the oxidation).
- Oxidation numbers are determined and used to decide which is being reduced and oxidized.

Oxidation Numbers

Oxidation number rules:

1. The sum of all oxidation numbers must equal the overall charge of the species (0 for elements or compounds, the charge for a polyatomic ion).
2. Hydrogen is +1 when with nonmetals, -1 with metals.
3. Oxygen is usually -2.
4. Halogens (column 7) are usually -1.
5. The oxidation number of an ion in an ionic compound is the charge.

Examples:

H_2SO_4 H = +1; S = +6; O = -2

H_2SO_3 H = +1; S = +5; O = -2

- Half reactions are used to balance complex redox reactions.

Precipitation and Solubility Rules

- Solubility rules can be used to determine if a compound is insoluble.
- An insoluble compound formed in a double replacement reaction is a precipitate.

Anion	Forms insoluble compounds with
NO_3^-	No common ions
CH_3COO^-	Ag^+
Cl^-, Br^-, I^-	Ag^+, Pb^{2+}, Hg_2^{2+}, Ti^+
SO_4^{2-}	Ag^+, Pb^{2+}, Ba^{2+}, Sr^{2+}, Ca^{2+}
CrO_4^{2-}	Ag^+, Pb^{2+}, Ba^{2+}, Sr^{2+}
S^{2-}	All anions except NH4+, columns 1 & 2
OH^-	All anions except NH_4^+, column 1, Ba^{2+} & Sr^{2+}
CO_3^{2-}, PO_4^{3-}	All anions except NH_4^+, column 1 (except Li^+)

- NH_4^+, Na^+ and K^+ are soluble with all common ions

Examples:

Na_2CO_3 → soluble

Ag_2SO_4 → insoluble

Net Ionic Reactions

1. Separate all aqueous, soluble, ionic compounds into ions. Only subscripts within polyatomic ions remain—all other subscripts are changed to coefficients.
2. Cross out all spectator ions.
3. Re-write the equation with remaining ions.

Examples:

$CaCl_2\ (aq) + 2\ AgNO_3\ (aq) \rightarrow 2\ AgCl\ (s) + Ca(NO_3)_2\ (aq)$

$Ca^{2+} + 2\ Cl^- + 2\ Ag^+ + 2\ NO_3^- \rightarrow 2\ AgCl\ (s) + Ca^{2+} + 2\ NO_3^-$

$2Cl^- + 2\ Ag^+ \rightarrow AgCl\ (s)$

Predicting Products in Double Replacement

1. Double replacement: two ionic compounds.
2. Combine cation of 1st compound with anion of 2nd.
3. Combine cation of 2nd compound with anion of 1st.
4. Remember that cations are always written first and charges are balanced with subscripts.
5. Determine if there is a precipitate using solubility rules.

If there is no precipitate, there is no chemical reaction

How to Use This Cheat Sheet: These are the keys related this topic. Try to read through it carefully twice then write it out from memory on a blank sheet of paper. Review it again before the exams.