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.
- **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

- **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 H₂ (g) + O₂ (g) → 2 H₂O (l)

H₂ & O₂ are reactants; H₂O is a product 2 moles of H₂ react with 1 mole of O₂ and produces 2 moles of H₂O

Types of Reactions

- **Composition**: More than one type of matter combine to form one type of matter.
- **Decomposition**: One type of matter decomposes into more than one type of matter.
- **Single Replacement**: A single element changes place with an ion in a compound.
- **Double Replacement**: Two ionic compounds switch ions.
- **Neutralization Reaction**: Double replacement reaction with an acid and a base as the reactants.
- **Redox Reaction**: Reduction-oxidation reaction.
- **Precipitation Reaction**: A precipitate is formed

Oxidation numbers are determined and used to decide which is being reduced and oxidized.

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:

H₂SO₄  H = +1; S = +6; O = -2
H₂SO₃  H = +1; S = +4; O = -2

Chemical Reactions

- **Precipitation and Solubility Rules**

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

<table>
<thead>
<tr>
<th>Anion</th>
<th>Forms insoluble compounds with</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO₃⁻</td>
<td>No common ions</td>
</tr>
<tr>
<td>CH₂COO⁻</td>
<td>Ag⁺</td>
</tr>
<tr>
<td>Cl⁻, Br⁻, I⁻</td>
<td>Ag⁺, Pb⁺⁺, Hg₂⁺⁺, Ti⁺⁺</td>
</tr>
<tr>
<td>SO₄²⁻</td>
<td>Ag⁺, Pb⁺⁺, Ba⁺⁺, Sr⁺⁺, Ca⁺⁺</td>
</tr>
<tr>
<td>CrO₄²⁻</td>
<td>Ag⁺, Pb⁺⁺, Ba⁺⁺, Sr⁺⁺</td>
</tr>
<tr>
<td>S²⁻</td>
<td>All anions except NH₄⁺, columns 1 &amp; 2</td>
</tr>
<tr>
<td>OH⁻</td>
<td>All anions except NH₄⁺, column 1, Ba⁺⁺ &amp; Sr⁺⁺</td>
</tr>
<tr>
<td>CO₃²⁻</td>
<td>All anions except NH₄⁺, column 1 (except Li⁺)</td>
</tr>
</tbody>
</table>

- NH₄⁺, Na⁺ and K⁺ are soluble with all common ions

Examples:

Na₂CO₃ → soluble
Ag₂SO₄ → insoluble

Net Ionic Reactions

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

Examples:

CaCl₂ (aq) + 2 AgNO₃ (aq) → 2 AgCl (s) + Ca(NO₃)₂ (aq)
Ca²⁺ + 2 Cl⁻ + 2 Ag⁺ + 2 NO₃⁻ → 2 AgCl (s) + Ca²⁺ + 2 NO₃⁻
2Cl⁻ + 2 Ag⁺ → Ag₂Cl (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 substrates.
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.