Principles of Inorganic Solids and Material Chemistry

Introduction

- Chemistry is the study of change, and "reactivity" describes how readily a substance undergoes that change.
- Some elements, like Gold, are chemically boring (inert) and stay shiny for centuries. Others, like Sodium, explode effectively the moment they touch water.
- Understanding reactivity allows us to predict whether mixing two chemicals will result in a harmless solution, a useful new product, or a dangerous explosion.
- This module applies the concepts of periodic trends and electron configurations to predict specific chemical reactions.

Learning Objectives

By the end of this module, you will be able to:

- Apply key concepts (like ionization energy and electronegativity) to explain why certain elements are more reactive than others.
- Predict the products of common inorganic reactions, including single replacement and double displacement reactions.
- Use the **Activity Series** to determine if a redox reaction will occur.
- Classify reactions into major types: Synthesis, Decomposition, Single/Double Displacement, and Combustion.

Key Concepts and Definitions

Term	Definition
Chemical Reactivity	The impulse for which a chemical substance yields a chemical reaction, either by itself or with other materials, generally with an overall release of energy.
Activity Series	A list of elements in decreasing order of their reactivity. Elements at the top can replace elements below them in a reaction.
Oxidation-Reduction (Redox)	A type of reaction that involves a transfer of electrons between two species. • **Oxidation:** Loss of electrons (Oil Rig: Oxidation Is Loss). • **Reduction:** Gain of electrons (Oil Rig: Reduction Is Gain).
Precipitate	An insoluble solid that emerges from a liquid solution during a reaction.
Metathesis Reaction	(Double Displacement) A reaction where two compounds exchange ions to form two new compounds.

Detailed Discussion

Periodic Trends in Reactivity

Reactivity is not random; it follows the map of the Periodic Table.

1. Metals (Losers)

- Metals react by **losing** electrons to form positive ions (cations).
- **Trend:** Reactivity **increases** as you go **down** a group and to the **left**.
    - *Why?* Larger atoms hold their valence electrons loosely (low Ionization Energy), making them easier to give away.
    - *Most Reactive Metal:* Francium (Fr).

2. Nonmetals (Gainers)

- Nonmetals react by **gaining** or sharing electrons to form negative ions (anions).
- **Trend:** Reactivity **increases** as you go **up** a group and to the **right** (ignoring Noble Gases).
    - *Why?* Smaller atoms have a stronger pull on electrons (high Electronegativity).
    - *Most Reactive Nonmetal:* Fluorine (F).

The Activity Series and Single Replacement

One of the most common questions in inorganic chemistry is: *"Will this metal react with this acid or salt?"* To answer this, we use the Activity Series.

The Rule: A single element can only replace another element in a compound if it is **more active** (higher on the list).

- **Activity List (Simplified):**
    - Lithium > Potassium > Calcium > Sodium > Magnesium > Aluminum > Zinc > Iron > Hydrogen > Copper > Silver > Gold
- **Reaction General Formula:** A + BC -> AC + B
    - If A is higher than B: Reaction happens.
    - If A is lower than B: No reaction.

Radioactive nuclide	Nuclide notation	Half-life
Lithium-8	$^{8}_{3}Li$	0.838 s
Krypton-89	$^{89}_{36}Kr$	3.16 minutes
Sodium-24	$^{24}_{11}Na$	15 hours
Iodine-131	$^{131}_{53}I$	8 days
Cobalt-60	$^{60}_{27}Co$	5.27 years
Radium-226	$^{226}_{88}Ra$	1600 years
Uranium-235	$^{235}_{92}U$	703 million years

Types of Inorganic Reactions

1. Synthesis (Combination) Two or more substances combine to form one new substance.

- *Example:* 2Na + Cl2 -> 2NaCl

2. Decomposition One substance breaks down into two or more simpler substances. Usually requires heat.

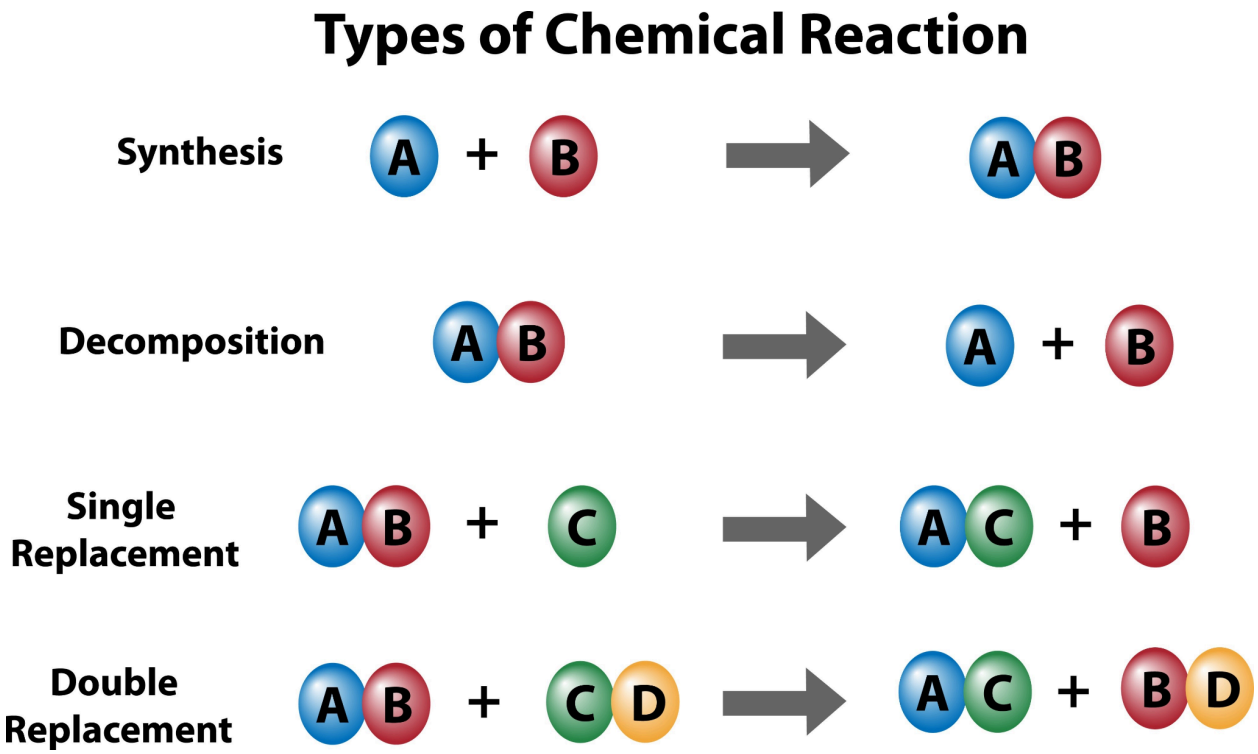
- *Example:* CaCO3 -> CaO + CO2

3. Single Replacement (Displacement) An active element kicks out a less active element from a compound (Redox).

- *Example:* Zn + 2HCl -> ZnCl2 + H2

4. Double Replacement (Metathesis) The positive ions of two ionic compounds trade places. This usually happens only if a **precipitate** (solid), water, or gas is formed.

- *Example:* AgNO3 + NaCl -> NaNO3 + AgCl (Solid Precipitate)



References

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