In a **double replacement**, two elements in the reactants exchange places.

The positive ions of two ionic compounds change places to form two new ionic compounds as products.

**Double replacement**

\[
\begin{align*}
\text{Two elements} & \quad \text{replace} \quad \text{each other} \\
\text{A}\text{B} & \quad \text{+} \quad \text{C}\text{D} & \quad \rightarrow & \quad \text{A}\text{D} & \quad \text{+} \quad \text{C}\text{B}
\end{align*}
\]

\[
\text{AgNO}_3(aq) \quad + \quad \text{NaCl}(aq) \quad \rightarrow \quad \text{AgCl}(s) \quad + \quad \text{NaNO}_3(aq)
\]

\[
\text{ZnS}(s) \quad + \quad 2\text{HCl}(aq) \quad \rightarrow \quad \text{ZnCl}_2(aq) \quad + \quad \text{H}_2\text{S}(g)
\]


Double Replacement Reaction: \( \text{BaSO}_4 \)

- Usually occur between ionic compounds in aqueous solution, meaning they are solids that have been dissolved in water.
- In many cases, when 2 aqueous solutions are mixed, a precipitate is one of the products.

**Example:**

*When Sodium sulfate and barium chloride are mixed these 2 clear solutions produce a white powdery looking precipitate suspended in a sodium chloride solution.*
2 Types of Double Replacement:

There are 2 main types of double replacement reactions:

1. **Precipitation Reactions** - where a solid is produced from 2+ aqueous solutions

2. **Neutralization Reactions** - when an acid and a base react to produce water and an ionic salt
Precipitation Reactions: Stop @ 7min mark….too “chem 11”
https://www.youtube.com/watch?v=Ilu16dy3ThI&vl=en
1. Precipitation Reactions

- Reactions in which a **solid forms** from two aqueous solutions *(appear as liquids)* are called **precipitation reactions**.

- When a solid doesn’t dissolve it is called **insoluble**.

  - Eg. *The scale that builds up in taps, kettles, and pipes is solid calcium carbonate *(CaCO₃)* that has precipitated out of the tap water.*
Precipitation Reactions

For example:
When potassium iodide and lead (II)nitrate solutions are mixed, the $K^+$ and $Pb^{2+}$ ions switch places and the $PbI_2(s)$ bright yellow precipitate is formed.

$$2KI(aq) + Pb(NO_3)_2(aq) \rightarrow PbI_2(s) + 2KNO_3(aq)$$
Beautiful Chemical Reactions:
https://www.youtube.com/watch?v=BGUfC3UUBkI
**Uses of precipitation reactions**

✓ **Most precipitation reactions are very fast reactions that occur between ions.**

This makes them very useful for identifying specific ions based on the type of precipitate formed.

Precipitation reactions have a number of other uses:

- production of coloured pigments for paints and dyes
- removal of toxic chemicals from water
- separation of reaction products.
Precipitation reactions

When two aqueous solutions are mixed, they may react to form a product that is insoluble in water. The solid is called a precipitate and the reaction is called a precipitation reaction.

To predict whether a precipitation reaction will occur, information on the solubility of the products is needed. This will be given to you in a word equation, or my using state symbols in a chemical formula.

What are the symbols for these physical states?

- solid \((s)\)
- liquid \((l)\)
- gas \((g)\)
- aqueous \((aq)\) (dissolved in water)
Practice Problems

1. Complete and balance the following double replacement reactions. You do not need to decide which product(s) form a precipitate or to show states in the balanced equation.
   (a) CaS + NaOH →
   (b) K_2PO_4 + MgI_2 →
   (c) SrCl_2 + Pb(NO_3)_2 →
   (d) AlCl_3 + CuNO_3 →
   (e) AgNO_3 + Na_2CrO_4 →

2. Classify each reaction as synthesis, decomposition, single replacement, or double replacement.
   (a) 2FeBr_3 + 3Zn → 3ZnBr_2 + 2Fe
   (b) FeBr_3 + ZnSO_4 → ZnBr_2 + FeSO_4
   (c) 2Al + Fe_2O_3 → 2Fe + Al_2O_3
   (d) 2Fe + O_2 → 2FeO
   (e) 2FeBr_3 → 2Fe + 3Br_2

Answers provided on page 592
2. Neutralization Reactions

- A neutralization reaction is a chemical reactions between and acid and a base that produces water and a salt.

- A salt is a type of ionic compound, it refers to the fact that a metal has bonded with a non-metal in a crystalline lattice structure.

\[
\text{Acid} + \text{Base} \rightarrow \text{H}_2\text{O} + \text{Salt}
\]

Figure 6.7A This equipment allows precise amounts of an acid to be added to a base.
2. Neutralization Reactions

- Notice that this reaction is actually a **type of double replacement**.
- The **ions of the reactants switch places** to form two new compounds.
- The water forms as the **H⁺ from the acid** and the **OH⁻ from the base** combine.
- The salt is made up of whatever cation and anion remain…in this case **Na⁺ and Cl⁻**
Example: Neutralization Reaction

- Phosphoric acid (H₃PO₄) is a main ingredient in rust remover solutions.
- Rust is a mixture of iron compounds, one of which is iron(II) hydroxide (Fe(OH)₂).
- Iron(II) hydroxide dissolves when it reacts with phosphoric acid.

*Predict the products of the following neutralization reaction:*

\[
2\text{H}_3\text{PO}_4 + 3\text{Fe(OH)}_2 \rightarrow 6\text{H}_2\text{O} + \text{Fe}_3(\text{PO}_4)_2
\]

Water + Salt (ionic compound)
Acids react with **metals** and **carbonates**.

**Metal** + Acid $\rightarrow$ Salt + Hydrogen

Zinc + hydrochloric acid $\rightarrow$ zinc chloride + hydrogen

Zn\(_{(s)}\) + HCl\(_{(aq)}\) $\rightarrow$ ZnCl\(_2(aq)\) + H\(_2(g)\)

**Acid** + **Carbonate** $\rightarrow$ **Salt** + **Water** + Carbon dioxide

sulphuric acid + copper carbonate $\rightarrow$ copper sulphate + water + carbon dioxide

*The two reactants have rearranged into a larger number of smaller products, this rxn can be described as a decomposition reaction as well*
Assignment #5:
Questions #1-2 in your textbook pg 263 & Metal and Acid Reactions Worksheet

Practice Problems

1. Complete and balance the following neutralization (acid-base) reactions.
   (a) HBr + NaOH →
   (b) H₃PO₄ + Mg(OH)₂ →
   (c) HCl + Pb(OH)₂ →
   (d) Al(OH)₃ + HClO₄ →

2. Classify each reaction as synthesis, decomposition, single replacement, double replacement, or neutralization.
   (a) 2HCl + Zn → ZnCl₂ + H₂
   (b) 2HCl → H₂ + Cl₂
   (c) 2HCl + Sr(OH)₂ → SrCl₂ + 2H₂O
   (d) 2HCl + Pb(NO₃)₂ → 2HNO₃ + PbCl₂

Answers provided on page 503.
Metal and Acid Reactions

General Rules

| Metal酸 | Acid酸 | Salt酸 | Hydrogen
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Zinc酸</td>
<td>Hydrochloric Acid</td>
<td>Chloride酸</td>
<td>Hydrogen酸</td>
</tr>
<tr>
<td>Zinc酸</td>
<td>Sulfuric Acid</td>
<td>Sulfate酸</td>
<td>Hydrogen酸</td>
</tr>
<tr>
<td>Zinc酸</td>
<td>Nitric Acid</td>
<td>Nitrate酸</td>
<td>Hydrogen酸</td>
</tr>
</tbody>
</table>

Task 1
In your exercise book, write word equations for the reactions between the following pairs of reactants. If you have been taught how to, then write a balanced symbol equation under each word equation. Remember that when writing word equations, the reactants should all be to the left of the arrow, and the products to the right.

<table>
<thead>
<tr>
<th>Reactants</th>
<th>Products (If first if helpful)</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Sodium and hydrochloric acid</td>
<td></td>
</tr>
<tr>
<td>b. Calcium sulfite acid</td>
<td></td>
</tr>
<tr>
<td>c. Lithium and nitric acid</td>
<td></td>
</tr>
<tr>
<td>d. Magnesium and hydrochloric acid</td>
<td></td>
</tr>
<tr>
<td>e. Aluminum and sulfuric acid</td>
<td></td>
</tr>
<tr>
<td>f. Potassium and nitric acid</td>
<td></td>
</tr>
<tr>
<td>g. Beryllium and sulfuric acid</td>
<td></td>
</tr>
<tr>
<td>h. Iron and hydrochloric acid (forming an Iron (III) salt)</td>
<td></td>
</tr>
<tr>
<td>i. Lead and nitric acid (forming a Lead (II) salt)</td>
<td></td>
</tr>
<tr>
<td>j. Copper and sulfuric acid (forming a Copper (I) salt)</td>
<td></td>
</tr>
<tr>
<td>k. Silver and hydrochloric acid</td>
<td></td>
</tr>
<tr>
<td>l. Aluminum and nitric acid</td>
<td></td>
</tr>
<tr>
<td>m. Iron and sulfuric acid (forming an Iron (III) salt)</td>
<td></td>
</tr>
<tr>
<td>n. Lead and hydrochloric acid (forming a Lead (II) salt)</td>
<td></td>
</tr>
<tr>
<td>o. Copper and nitric acid (forming a Copper (II) salt)</td>
<td></td>
</tr>
<tr>
<td>Element</td>
<td>Acid/salt Reagent</td>
</tr>
<tr>
<td>---------------</td>
<td>-------------------</td>
</tr>
<tr>
<td>a. Sodium</td>
<td>HCl</td>
</tr>
<tr>
<td>b. Calcium</td>
<td>HCl</td>
</tr>
<tr>
<td>c. Lithium</td>
<td>HNO₃</td>
</tr>
<tr>
<td>d. Magnesium</td>
<td>HCl</td>
</tr>
<tr>
<td>e. Aluminium</td>
<td>HCl</td>
</tr>
<tr>
<td>f. Potassium</td>
<td>HNO₃, H₂SO₄</td>
</tr>
<tr>
<td>g. Beryllium</td>
<td>HCl, H₂SO₄</td>
</tr>
<tr>
<td>h. Iron</td>
<td>HCl</td>
</tr>
<tr>
<td>i. Lead</td>
<td>HCl</td>
</tr>
<tr>
<td>j. Copper</td>
<td>HCl, H₂SO₄</td>
</tr>
<tr>
<td>k. Silver</td>
<td>HCl, H₂SO₄</td>
</tr>
<tr>
<td>l. Aluminium</td>
<td>HNO₃, H₂SO₄</td>
</tr>
<tr>
<td>m. Iron</td>
<td>H₂SO₄</td>
</tr>
<tr>
<td>n. Lead</td>
<td>H₂SO₄</td>
</tr>
<tr>
<td>o. Copper</td>
<td>HNO₃</td>
</tr>
</tbody>
</table>
Combustion Reaction \textit{(a type of Oxidation)}

\textbf{Combustion} is the scientific word for \textbf{burning} and is a type of chemical reaction.

Combustion is the reaction when a compound or element burns and \textbf{reacts with oxygen} to produce heat and light energy.
Using combustion

Burning has been an important source of energy since primitive man and is still a hugely important process today.

Burning fuel, like coal, petrol and natural gas, provides > 90% of the energy needed for transport, factories and in the home.

How different would life be without combustion?
What is needed for combustion to take place?

- Heat
- Fuel
- Oxygen
Equations for combustion

- When a compound or element burns and react with oxygen the new substances formed are called “oxides”.
- The oxides contain oxygen and the elements that make up the reactant compound.

What are the word equations for these combustion reactions?

1. **Coal** (made from carbon) burns and forms carbon dioxide:
   
   \[
   \text{carbon} + \text{oxygen} \rightarrow \text{carbon dioxide}
   \]

2. **Hydrogen** burns and forms dihydrogen oxide (i.e water!):
   
   \[
   \text{hydrogen} + \text{oxygen} \rightarrow \text{water}
   \]

3. **Methane** burns and forms carbon dioxide and water:
   
   \[
   \text{methane} + \text{oxygen} \rightarrow \text{carbon dioxide} + \text{water}
   \]
Combustion of methane

The natural gas, **methane**, is often burnt for cooking. Methane is made up of carbon and hydrogen.

- What gas does methane react with when it burns?
- What substance will the carbon in methane change into when it burns in oxygen?
- What substance will the hydrogen in methane change into when it burns in oxygen?
- What is the word equation for the combustion of methane?

```
methane + oxygen → carbon dioxide + water
```

*In this reaction we say that “methane is oxidised”*
Combustion of Sulfur

The combustion of Sulfur (or sulfur containing compounds) will react with oxygen to produce sulfur dioxide, $\text{SO}_2(\text{g})$

$$S_8(\text{s}) + 8\text{O}_2(\text{g}) \rightarrow 8\text{SO}_2(\text{g})$$

- Sulfur-containing compounds are said to be "dirty" because their combustion releases $\text{SO}_2(\text{g})$ which is one of the major chemical species that produces air pollution contributing to ACID RAIN.

- This is, of course, harmful to the environment and damages manmade structures, too.
Not all Combustion is bad...

Many combustion reactions produce heat and light.

The burning of fuels such as natural gas and gasoline involves the combustion of compounds called hydrocarbons.

Hydrocarbons are compounds made up of just 2 elements: hydrogen and carbon.

The general equation is:

\[ C_x H_y + O_2 \rightarrow CO_2 + H_2O \]

(where \( x \) and \( y \) are any number of carbons and hydrogen atoms)

For Example, the burning of Methane gas:

\[ CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O \]

methane oxygen carbon dioxide water
Incomplete Combustion

The burning of methane is what supplies school Bunsen burners.

*Air hole open* = complete combustion

*Air hole closed* = incomplete combustion

- When the supply of oxygen is too low, **incomplete combustion** occurs.

- Carbon dioxide and water are still products, but there are additional products such as **carbon (soot)** and **carbon monoxide**

**Caution** Carbon monoxide is a poisonous gas. This is one of the reasons why BBQs are not used indoors, cars should not be run inside a garage and gas fireplaces are properly vented.
Practice Problems

1. Complete and balance the following combustion reactions.
   (a) \( \text{C}_3\text{H}_8 + \text{O}_2 \rightarrow \) 
   (b) \( \text{C}_4\text{H}_{10} + \text{O}_2 \rightarrow \) 
   (c) \( \text{C}_2\text{H}_4 + \text{O}_2 \rightarrow \) 
   (d) \( \text{C}_6\text{H}_{12}\text{O}_6 + \text{O}_2 \rightarrow \) 
   (e) \( \text{C}_{12}\text{H}_{22}\text{O}_{11} + \text{O}_2 \rightarrow \)

2. Classify each reaction as synthesis, decomposition, single replacement, double replacement, neutralization, or combustion.
   (a) \( 3\text{Ca(NO}_3\text{)}_2 + 2\text{Na}_3\text{PO}_4 \rightarrow 6\text{NaNO}_3 + \text{Ca}_3(\text{PO}_4)_2 \)
   (b) \( \text{Ca(OH)}_2 + \text{H}_2\text{SO}_4 \rightarrow 2\text{H}_2\text{O} + \text{CaSO}_4 \)
   (c) \( 2\text{C}_6\text{H}_6 + 15\text{O}_2 \rightarrow 12\text{CO}_2 + 6\text{H}_2\text{O} \)
   (d) \( 6\text{Mg} + \text{P}_4 \rightarrow 2\text{Mg}_3\text{P}_2 \)
   (e) \( \text{C}_2\text{H}_6\text{O} + 3\text{O}_2 \rightarrow 2\text{CO}_2 + 3\text{H}_2\text{O} \)

Answers provided on page 592
# Summary of Reaction Types

<table>
<thead>
<tr>
<th>Reaction Type</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Combination</strong></td>
<td></td>
</tr>
<tr>
<td>A + B $\rightarrow$ AB</td>
<td>Ca(s) + Cl$_2$(g) $\rightarrow$ CaCl$_2$(s)</td>
</tr>
<tr>
<td><strong>Decomposition</strong></td>
<td></td>
</tr>
<tr>
<td>AB $\rightarrow$ A + B</td>
<td>Fe$_2$S$_3$(s) $\rightarrow$ 2Fe(s) + 3S(s)</td>
</tr>
<tr>
<td><strong>Single Replacement</strong></td>
<td></td>
</tr>
<tr>
<td>A + BC $\rightarrow$ AC + B</td>
<td>Cu(s) + 2AgNO$_3$(aq) $\rightarrow$ Cu(NO$_3$)$_2$(aq) + 2Ag(s)</td>
</tr>
<tr>
<td><strong>Double Replacement</strong></td>
<td></td>
</tr>
<tr>
<td>AB + CD $\rightarrow$ AD + CB</td>
<td>BaCl$_2$(aq) + K$_2$SO$_4$(aq) $\rightarrow$ BaSO$_4$(s) + 2KCl(aq)</td>
</tr>
<tr>
<td><strong>Combustion</strong></td>
<td></td>
</tr>
<tr>
<td>C$_x$H$_y$ + ZO$_2$(g) $\rightarrow$ CO$_2$(g) + Y/2 H$_2$O(g) + energy</td>
<td>CH$_4$(g) + 2O$_2$(g) $\rightarrow$ CO$_2$(g) + 2H$_2$O(g) + energy</td>
</tr>
</tbody>
</table>
Assignment #7:
Questions #1-2 in your textbook pg 265 & Mixed Practice Worksheets ALL!

Practice Problems
For each of the following reactions, classify the reaction type and then predict what the products will be. Then write the balanced equation and balance it. After you have answered all the questions, turn the page to review the solutions and the steps for solving each equation.

1. Fe₂O₃ →
2. Al + NiBr₃ →
3. Cl₂ + NiBr₃ →
4. HCl + Mg(OH)₂ →
5. C₂H₆O + O₂ →
6. Li + N₂ →
7. AgNO₃ + Na₂CO₃ →

Worked solutions to these on pg 266

Types of Reactions Worksheet
Given the reactions below, identify each as synthesis (S), decomposition (D), single replacement (SR), double replacement (DR), or combustion (C). Afterwards, balance the reaction.

1) ___ K + ___ Cl₂ → ___ KCl
   Type of Reaction: ________

2) __NH₃ → ___ N₂ + ___ H₂
   Type of Reaction: ________

3) ___ NaCl + ___ Br₂ → ___ NaBr + ___ ___ F₂
   Type of Reaction: ________

4) ___ CaO + ___ H₂O → ___ Ca(OH)₂
   Type of Reaction: ________

5) ___P₂S₅ → ___ P₂O₅ + ___ ___ O₂
   Type of Reaction: ________

6) ___Al + ___ P₂O₅ → ___ ___ Fe + ___ Al₂O₃
   Type of Reaction: ________

7) ___ Fe₂O₃ → ___ ___ F₂
   Type of Reaction: ________

8) ___ CaCO₃ + ___ ___ O₂ → ___ ___ CO₂ + ___ ___ H₂O
   Type of Reaction: ________

9) ___ KClO₃ → ___ ___ KCl + ___ O₂
   Type of Reaction: ________

10) ___ Pb(NO₃)₂ + ___ ___ NaCl + ___ ___ NaNO₃ + ___ ___ PbCl₂
    Type of Reaction: ________

11) What type of reaction is shown in the last?