SNC2D CHEMISTRY

CHEMICAL REACTIONS

- Types of Chemical Reactions (P.222-236)

Types Of Chemical Reactions

Just as a chef knows how ingredients will work together in a recipe, so a chemist knows that elements and compounds undergo particular types of chemical reactions. Just as all members of a chemical family react in a similar way, compounds have definite patterns of chemical properties.

Types Of Chemical Reactions

Chemists use these patterns to classify groups of chemical changes. Most chemical reactions can be grouped into five categories:

1. *synthesis*
2. *decomposition*
3. *single displacement*
4. *double displacement*
5. *combustion*

Types Of Chemical Reactions

NOTE!

Knowledge of these types of reactions is useful for two reasons:

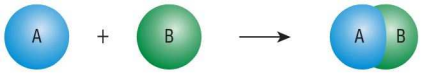
① *we can better understand experimental observations of the behaviour of substances in chemical changes.*

② *we can predict the products of unknown reactions.*

Synthesis Reactions

Synthesis reactions *involve the combination of smaller atoms and/or molecules into larger molecules. These reactions are sometimes also called* ***combination reactions****. Often the reactants are elements that combine chemically to form compounds. Synthesis reactions have the following general formula:*

A + B ➜ AB



Synthesis Reactions

NOTE!

If you see two elements as reactants, you know the reaction has to be a synthesis reaction. For example, when powdered zinc metal reacts with sulphur, the product formed is zinc sulphide powder.

zinc + sulphur ➜ zinc sulphide
Zn + S ➜ ZnS

Synthesis Reactions

Synthesis reactions can also involve combinations of small molecules. For example, when ammonia and hydrogen peroxide combine, they form a white smoke as solid particles of ammonium chloride are formed.

hydrogen chloride + ammonia ➜ ammonia chloride

HCl + NH_3 ➜ NH_4Cl

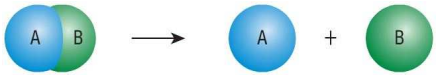
Types Of Chemical Reactions

TYPE OF REACTION	FORMAT
① Synthesis	A + B ➜ AB

Decomposition Reactions

Decomposition reactions *involve the splitting of a large molecule into elements or smaller molecules. Decomposition reactions have the following general formula:*

AB ➜ A + B



Decomposition Reactions

NOTE!

If you see a binary compound (made of only two elements) as the only reactant, you know that the reaction has to be a decomposition reaction that produces two elements as products. For example, the electrolysis of water uses electricity to split water molecules into their elements.

water ➜ hydrogen + oxygen

$H_2O \rightarrow H_2 + O_2$

Decomposition Reactions

Sometimes decomposition reactions can also involve the production of two small molecules from a large molecule. For example, when ammonium nitrate is heated to above 250°C, it decomposes explosively to form nitrous oxide and water molecules.

ammonium nitrate ➜ nitrous oxide + water

$NH_4NO_3 \rightarrow N_2O + H_2O$

Types Of Chemical Reactions

TYPE OF REACTION	FORMAT
① Synthesis	A + B ➜ AB
② Decomposition	AB ➜ A + B

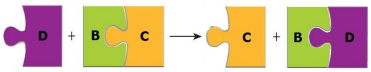
Single Displacement Reactions

Single displacement reactions *are chemical changes that involve an element and a compound as a reactant. One element displaces or replaces another element from a compound. Single displacement reactions have the following general formula(s):*

A + BC ➜ B + AC

or

D + BC ➜ C + BD



Single Displacement Reactions

NOTE!

In the first case, the metal A has taken the place of element B. In the second case, the non-metal D has taken the place of element C. In deciding which element is replaced, we use the general rule of metal replacing metal and non-metal replacing non-metal.

A + BC ➜ B + AC or D + BC ➜ C + BD

Single Displacement Reactions

For example, when magnesium ribbon is placed in a solution of silver nitrate, the magnesium replaces the silver ion so that silver and magnesium nitrate are produced (metal replaces metal).

magnesium + silver nitrate ➜ silver + magnesium nitrate

$Mg + AgNO_3 \rightarrow Ag + Mg(NO_3)_2$

Single Displacement Reactions

And when bromine is added to a solution of calcium iodide, the bromine replaces the iodide ion so that iodine and calcium bromide are produced (non-metal replaces non-metal).

bromine + calcium iodide ➜ iodine + calcium bromide

Br_2 + CaI_2 ➜ I_2 + $CaBr_2$

RECALL!

Bromine and iodine are diatomic molecules (i.e. they come in pairs).

Types Of Chemical Reactions

TYPE OF REACTION	FORMAT
① Synthesis	A + B ➜ AB
② Decomposition	AB ➜ A + B
③ Single Displacement	A + BC ➜ B + AC or D + BC ➜ C + BD

Double Displacement Reactions

Double displacement reactions *occur when elements in different compounds displace each other or exchange places. Double displacement reactions have the following general formula (where A and C are metals and B and D are non-metals):*

AB + CD ➜ AD + CB

Double Displacement Reactions

NOTE!

During a double displacement reaction, the metals (or non-metals if you prefer) exchange places. For example, when solutions of lead (II) nitrate and potassium iodide are combined, lead ions from the lead (II) nitrate solution and iodide ions from the potassium iodide solution combine to form a solid lead (II) iodide precipitate. The potassium and nitrate ions remain in solution and combine to form potassium nitrate.

lead (II) nitrate + potassium iodide ➜ lead (II) iodide + potassium nitrate

$Pb(NO_3)_2$ + KI ➜ PbI_2 + KNO_3

Types Of Chemical Reactions

TYPE OF REACTION	FORMAT
① Synthesis	A + B ➜ AB
② Decomposition	AB ➜ A + B
③ Single Displacement	A + BC ➜ B + AC or D + BC ➜ C + BD
④ Double Displacement	AB + CD ➜ AD + BC

GENERAL RULE FOR ③ & ④:
- ☞ metal replaces metal
- ☞ non-metal replaces non-metal

Combustion Reactions

*A **combustion reaction** is a chemical reaction in which a substance rapidly combines with oxygen gas to produce compounds called oxides. We often call this process burning. One way to represent combustion is using the following word equation:*

fuel + oxygen ➜ oxides + energy

where the energy produced is mainly in the form of heat and light and the fuel can be a variety of elements and compounds.

Combustion Reactions

NOTE!

*The most important fuels that we burn are hydrocarbons. Gasoline in our automobiles, natural gas in our home furnaces, kerosene in jet airplanes, and even the candles on a birthday cake are all made of hydrocarbons. The **complete** combustion of a hydrocarbon can be represented as:*

hydrocarbon + oxygen ➜ carbon dioxide + water vapour + energy

Combustion Reactions

*However, when there is not enough oxygen, hydrocarbons undergo **incomplete** combustion. In this case, the word equation becomes:*

hydrocarbon + oxygen ➜ carbon monoxide + carbon + energy

Combustion Reactions

An example of the combustion of hydrocarbons is the burning of butane in a lighter. Butane (C_4H_{10}) is a gas at room temperature, but it is a liquid under pressure. When butane is allowed to escape the lighter through a valve and a spark ignites it, the following reaction occurs:

butane + oxygen ➜ carbon dioxide + water + energy

$C_4H_{10} + O_2 \rightarrow CO_2 + H_2O$

Types Of Chemical Reactions

TYPE OF REACTION	FORMAT
① Synthesis	A + B ➜ AB
② Decomposition	AB ➜ A + B
③ Single Displacement	A + BC ➜ B + AC or D + BC ➜ C + BD
④ Double Displacement	AB + CD ➜ AD + BC
⑤ Combustion	hydrocarbons + oxygen ➜ carbon dioxide + water + energy

GENERAL RULE FOR ③ & ④:
- ☞ metal replaces metal
- ☞ non-metal replaces non-metal

✔ Check Your Learning

1. Consider the five types of reactions you have learned about. They all involve elements and compounds as reactants. Which type of reaction has the following as reactants:
   (a) two compounds? double displacement
   (b) one element and one compound? single displacement
   (c) hydrocarbons and oxygen? combustion
   (d) two elements? synthesis
   (e) one compound? decomposition

✔ Check Your Learning

2. Classify each of the following chemical reactions.
   (a) barium + sulphur ➜ barium sulphide
   (b) propane + oxygen ➜ carbon dioxide + water vapour
   (c) bromine + sodium iodide ➜ iodine + sodium bromide
   (d) barium nitrate + sodium sulphide ➜ barium sulphide + sodium nitrate
   (e) lithium carbonate ➜ carbon dioxide + lithium oxide

   (a) synthesis
   (b) combustion
   (c) single displacement
   (d) double displacement
   (e) decomposition

✔ Check Your Learning

3. Classify each of the following chemical reactions.

(a)	Cu	+	O_2	➜	CuO			Synthesis
(b)	Al	+	Fe_2O_3	➜	Al_2O_3	+	Fe	Single Displ...
(c)	Ag	+	S	➜	Ag_2S			Synthesis
(d)	H_2O	+	energy	➜	H_2	+	O_2	Decomposition
(e)	FeS	+	HCl	➜	$FeCl_2$	+	H_2S	Double Displ...
(f)			NaCl	➜	Na	+	Cl_2	Decomposition
(g)	C_4H_{10}	+	O_2	➜	CO_2	+	H_2O	Combustion
(h)	NaOH	+	HCl	➜	NaCl	+	H_2O	Double Displ...
(i)	Zn	+	HCl	➜	$ZnCl_2$	+	H_2	Single Displ...
(j)	C_2H_6	+	O_2	➜	CO_2	+	H_2O	Combustion

✔ Check Your Learning

TEXTBOOK

P.226 Q.1,2
P.227 Q.1,2
P.233 Q.1,2 ☞ *do not worry about showing "states"*
P.234 Q.1,2
P.235 Q.1,2 ☞ *do not worry about showing "states"*

WIKI (CHEMISTRY)

✎.... 2DCHEM - QUIZ#3 (Equations & Types of Reactions)

NOTE!

- Check your work often – see P.554 of your text.
- Be sure to check, correct, and total your quiz before handing it in.