UNIT 6

# CHEMICAL REACTIONS

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## 1.PHYSICAL AND CHEMICAL CHANGES.

Substances can undergo physical or chemical changes.

Physical changes:

The identity of the substance doesn´t change, the formula doesn´t change.

They are reversible

Examples of physical changes are:

Changing state

Separating mixtures

Dissolving

Chemical changes:

The identity of the substance changes, this means that in the beginning we have certain substances and after the change we have different substances with different formulae.

They aren´t reversible.

They are always accompanied by one or more of these things:

- see huge flames ... or tiny sparks
- notice a sweet smell ... or a foul stink
- feel the chemicals getting hotter ... or colder
- hear a loud bang ... or gentle fizzing.


By the end of the reaction, what you see probably looks very different to what you started with.

## 2.CHEMICAL REACTIONS

Chemical changes are also called chemical reactions.

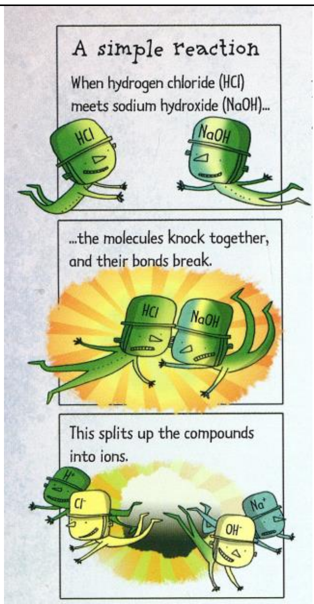
Chemical reactions are represented by chemical equations

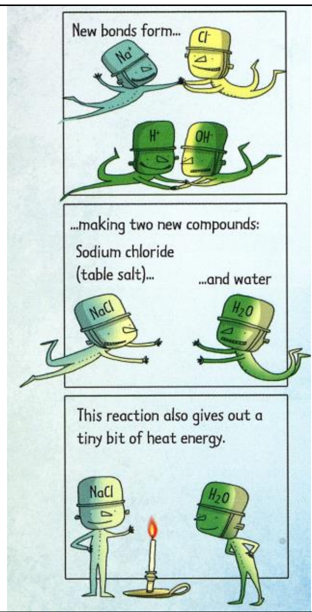
The chemical equation shows the reactants and products of a chemical reaction.

| Reactants | | Products |
|---|---|---|
| $MgO + C$ | ⟶ | $CO + Mg$ |

In a chemical reaction the bonds in the reactants are broken and new bonds are formed so the atoms combine differently.

$NaOH + HCl \longrightarrow NaCl + H_2O$




## 3.RATE OF A CHEMICAL REACTION

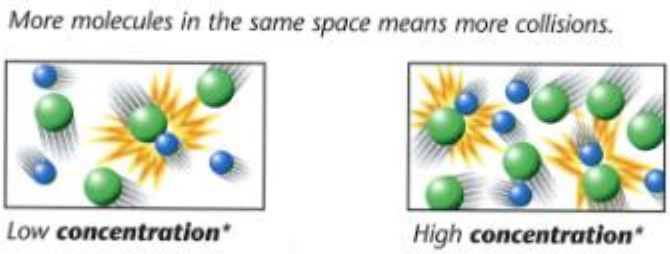
The rate of a chemical reaction is the speed with which the products are formed form the reactants.

The rate depends on four factors:

-The concentration of the reactants:

The rate of reaction depends on how often the particles of the reactants collide, more mollecules in the same space means more collisions.

As the concentration of the reactants increases the rate of reaction increases.
OR:
The bigger the concentration of the reactants the bigger the rate of reaction.

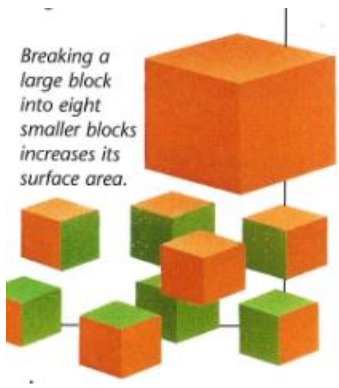



-The size of the particles of the solid reactants.

The rate of reaction depends on how often the particles of the reactants collide.

As the surface area of the particles increases the rate of the reaction increases.
OR:
The greater the surface area of the particles, the more particles there are available to react.

If we cut the particles in smaller pieces, the surface area and the number of particles increase.

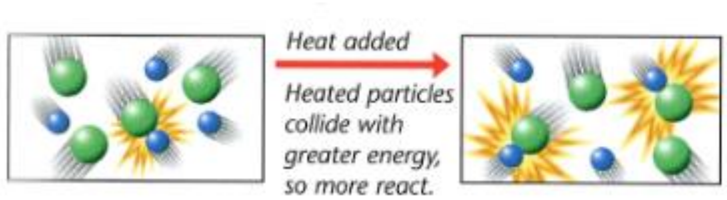



-The temperature.

In order to react, particles must collide with a minimum amount of energy.

As the temperature increases the rate of reactions increases.
OR
The higher the temperature the higher the rate of reaction

As the temperature gets higher, more and more particles have this minimum amount of energy to react when they collide, because they move faster.



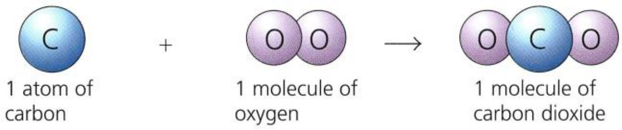

-The presence of a catalyst.

A catalyst is a substance that speeds up a chemical reaction. The catalyst is not used up in the reaction, it remains chemically the same as it was at the start of the reaction.

## Equations for two sample reactions

**1 The reaction between carbon and oxygen** When carbon is heated in oxygen, they react together to form carbon dioxide. Carbon and oxygen are the **reactants**. Carbon dioxide is the **product**.

You could show the reaction using a diagram, like this:



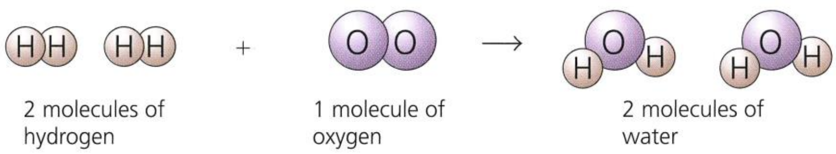

or by a word equation, like this:

carbon + oxygen ⟶ carbon dioxide

or by a **symbol equation**, which gives symbols and formulae:

$C + O_2 \longrightarrow CO_2$

**2 The reaction between hydrogen and oxygen** Hydrogen and oxygen react together to give water. The diagram is:




and you can use it to write the symbol equation:

$2H_2 + O_2 \longrightarrow 2H_2O$

Equations must be balanced

This means that the number of each type of atoms is the same on both sides of the arrow.

To balance an equation is to place stoichiometric coefficients in front of every substance in order to have the same number of each type of atom in both the reactants and the products.

## Symbol equations must be balanced

Now look at the number of atoms on each side of this equation:

$2H_2 + O_2 \longrightarrow 2H_2O$

| On the left: | | On the right: |
|---|---|---|
| 4 hydrogen atoms | $\longrightarrow$ | 4 hydrogen atoms |
| 2 oxygen atoms | | 2 oxygen atoms |

The number of each type of atoms is the same on both sides of the arrow. This is because atoms do not *disappear* during a reaction – they are just *rearranged*, as shown in the diagram of the molecules, in **2** above.

When the number of each type of atom is the same on both sides, the symbol equation is **balanced**. If it is not balanced, it is not correct.

## Adding state symbols

Reactants and products may be solids, liquids, gases, or in solution. You can show their states by adding **state symbols** to the equations:

| | |
|---|---|
| (*s*) for solid | (*l*) for liquid |
| (*g*) for gas | (*aq*) for aqueous solution (solution in water) |

For the two reactions above, the equations with state symbols are:

$C\ (s) + O_2\ (g) \longrightarrow CO_2\ (g)$

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

***Example 1*** Calcium burns in chlorine to form calcium chloride, a solid. Write an equation for the reaction, using the steps above.

**1** calcium + chlorine $\longrightarrow$ calcium chloride

**2** $Ca + Cl_2 \longrightarrow CaCl_2$

**3** Ca: 1 atom on the left and 1 atom on the right.
Cl: 2 atoms on the left and 2 atoms on the right.
The equation is balanced.

**4** $Ca\ (s) + Cl_2\ (g) \longrightarrow CaCl_2\ (s)$

***Example 2*** Hydrogen chloride is formed by burning hydrogen in chlorine. Write an equation for the reaction.

1 hydrogen + chlorine ⟶ hydrogen chloride
2 $H_2 + Cl_2 \longrightarrow HCl$
3 H: 2 atoms on the left and 1 atom on the right.
Cl: 2 atoms on the left and 1 atom on the right.
The equation is *not* balanced. It needs another molecule of hydrogen chloride on the right. So a 2 is put *in front of* the HCl.
$H_2 + Cl_2 \longrightarrow 2HCl$
The equation is now balanced. Do you agree?
4 $H_2\,(g) + Cl_2\,(g) \longrightarrow 2HCl\,(g)$

***Example 3*** Magnesium burns in oxygen to form magnesium oxide, a white solid. Write an equation for the reaction.

1 magnesium + oxygen ⟶ magnesium oxide
2 $Mg + O_2 \longrightarrow MgO$
3 Mg: 1 atom on the left and 1 atom on the right.
O: 2 atoms on the left and 1 atom on the right.
The equation is *not* balanced. Try this:
$Mg + O_2 \longrightarrow 2MgO$ (The 2 goes *in front of* the MgO.)
Another magnesium atom is now needed on the left:
$2Mg + O_2 \longrightarrow 2MgO$
The equation is balanced.
4 $2Mg\,(s) + O_2\,(g) \longrightarrow 2MgO\,(s)$

3. LAVOISIER´S LAW

Lavoisier stated that:
In a chemical reaction the masses of the reactants are equal to the masses of the products .
So matter is neither created nor destroyed.
This is also known as the conservation of mass law or The Law of Conservation of mass.

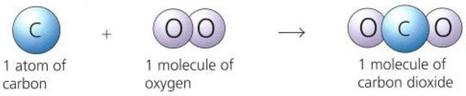
Mass of the reactants = Mass of the products

4.WHAT IS THE MEANING OF THE STOICHIOMETRIC COEFFICIENTS?

These coefficients are very important to understand how chemical reactions behave.
They give us the proportions in atoms and molecules or moles that react in the reaction.
Here are some examples:

## What an equation tells you

When carbon burns in oxygen, the reaction can be shown as:




or in a short way, using the symbol equation:

$C\,(s) + O_2\,(g) \longrightarrow CO_2\,(g)$

This equation tells you that:

| | | | | |
|---|---|---|---|---|
| 1 carbon atom | reacts with | 1 molecule of oxygen | to give | 1 molecule of carbon dioxide |

Now suppose there is 1 *mole* of carbon atoms. Then we can say that:

| | | | | |
|---|---|---|---|---|
| 1 mole of carbon atoms | reacts with | 1 mole of oxygen molecules | to give | 1 mole of carbon dioxide molecules |

So from the equation, we can tell how many moles react.
But moles can be changed to grams, using $A_r$ and $M_r$.
The $A_r$ values are: C = 12, O = 16.
So the $M_r$ values are: $O_2 = 32$, $CO_2 = (12 + 32) = 44$, and we can write:

| | | | | |
|---|---|---|---|---|
| 12 g of carbon | reacts with | 32 g of oxygen | to give | 44 g of carbon dioxide |

Since substances always react in the same ratio, this also means that:

| | | | | |
|---|---|---|---|---|
| 6 g of carbon | reacts with | 16 g of oxygen | to give | 22 g of carbon dioxide |

and so on.

So we have gained a great deal of information from the equation.
In fact you can obtain the same information from any equation.

**From the equation for a reaction you can tell:**

- **how many moles of each substance take part**
- **how many grams of each substance take part.**

## Reminder: the total mass does not change

Look what happens to the total mass, during the reaction above:

mass of carbon and oxygen at the start: 12 g + 32 g = **44 g**
mass of carbon dioxide at the end: **44 g**

The total mass has not changed, during the reaction. This is because no atoms have disappeared. They have just been rearranged.

That is one of the two laws of chemistry that you met on page 72:
**The total mass does not change, during a chemical reaction.**

▲ Iron and sulfur reacting: the total mass is the same before and after.

Do the same with the next reactions:

| |
|---|
| $2H_2 + O_2 \longrightarrow 2H_2O$ |
| ____ molecule of ____ reacts with ____ molecule of_____ to give ____ moleculae of _______ |
| ___mol |
| ____ g |
| 8 g |

| |
|---|
| $3H_2 + N_2 \longrightarrow 2\ NH_3$ |
| |
| |
| |
| 3 g |

## Laboratory activity
## Chemical reactions hints

It´s not easy to know the difference between chemical changes from physical changes.
Chemical changes are permanent transformations, they come with different hints that allow us to recognize them. When a chemical reaction occurs, one of these things happens:

- Colour changes
- Temperature changes
- A new solid is formed
- A gas is formed.

You are going to make three reactions:
1.-put a small amount of lead nitrate (Nitrato de plomo) in a test tube, add a little water and stir to dissolve it.
Do the same with potassium iodine (yoduro de potasio)
Mix both solutions.

2.-Introduce a scoop of calcium carbonate (carbonato de calcio) in a test tube and add a solution of hydrochloric acid drop by drop.

3.-Put a very small amount of permanganate of potassium (permanganto de potasio) in a conic flask and add about 20 ml of water to dissolve it.
Slowly pour a dilute solution of oxygenated water.
Touch the flask while the reaction is taking place.

Complete the following paragraphs about the previous reactions:
1.-Balance the equation for the first reaction:

$$Pb(NO_3)_{2\,(ac)} + KI_{(ac)} \longrightarrow PbI_{2\,(s)} + KNO_{3(ac)}$$

The____________ coloured compound is __________ and solved in the solution we have__________.

2.-

$$CaCO_{3\,(s)} + HCl_{\,(ac)} \longrightarrow CaCl_{2\,(ac)} + CO_{2\,(g)} + H_2O_{(l)}$$

The bubbles produced are made of_______________

3.-The reaction in which heat is released is called exothermic.

$4KMnO_{4\ (ac)} + 2\ H_2O_{2\ (ac)} \longrightarrow 4\ MnO_{2\ (s)} + 4\ KOH_{(ac)} + O_{2(g)}$

In this reaction a _____________ colured precipitate of _______________ is produced, also a gas made of _____________ is released and _____________ remains solved in the solution

## UNIT 6
## GLOSSARY

balanced /ˈbælənst/
chemical /ˈkemɪkəl/
coefficients /ˌkəʊɪˈfɪʃənts/
equations /ɪˈkweɪʒənz/
formula /ˈfɔːmjʊlə/ (pl formulae /ˈfɔːmjʊliː/)
products /ˈprɒdʌkts/
reactants /riːˈæktənz/
reactions /riːˈækʃənz/
reversible /rɪˈv3ːsəbl/
stoichiometric /ˌstɔɪkɪˈɒmɪtrɪk/

## UNIT 6
## ACTIVITIES

A1- Identify the following changes as physical or chemical change. Write complete sentences.

To evaporate water

...Evaporating water is ..........................................................................................

To separate salt and sand

..............................................................................................

To burn a piece of paper.

..........................................................................................

To distillate alcohol and water.

......................................................................................

To mix sodium bicarbonate and vinegar.

……………………………………………………………………………………………

To mix tin foil with an acid.

………………………………………………………………………………………

To dissolve milk and Coca-Cola.

………………………………………………………………………………………………

A2-Rates of reaction.

We are going to carry out an experiment to demostrate the influence of the concentration in the rate of reaction.

We are going to do the next reaction:

$Na_2S_2O_3$ (ac) + 2HCl (ac) $\longrightarrow$ $SO_2$ (g) + 1/8 $S_8$ (s) + $H_2O$(l) + NaCl (ac)

We are going to do it five times, each one with a different concentration of the $Na_2S_2O_3$ solution.

In each case you have to register the time that it takes to have enough $S_8$ to hide a cross drawn in a piece of paper placed under the flask where the reaction is taking place.

Write the data in the following table:

| | | | | | |
|---|---|---|---|---|---|
| Conc (g/ml) | | | | | |
| T ( seconds) | | | | | |

Draw a graph representing concentration/time.

Write a conclusion:

A3- Write and balance the following equations:

Hidrógeno + oxígeno ⟶ Agua oxigenada

Berilio + cloro ⟶ Cloruro de berilio

Carbono + oxígeno ⟶ Óxido de carbono (II)

Magnesio + Acido clorhídrico ⟶ Cloruro de Magnesio + hidrógeno

Cobre + ácido fluorhídrico ⟶ Fluoruro de cobre (II)

Azufre + Hidrógeno ⟶ Sulfuro de hidrógeno

$C_6 H_{14}$ + oxígeno ⟶ Óxido de carbono (IV) + agua

A4- Answer the questions below:

a)

$2Mg + O_2 \longrightarrow 2MgO$

How many moles of MgO do you get if 3 Mg moles react with a lot of $O_2$?

b) $2Mg + O_2 \longrightarrow 2MgO$

What mass of Mg (Mr= 24) does react with 64 g of $O_2$ (Mr= 32)

c)

$Mg + 2HCl \longrightarrow MgCl2 + H_2$

How many moles of $H_2$ do you get if 48 g of Mg react with a lot of HCl?

d)

$Mg + 2HCl \longrightarrow MgCl_2 + H2$

What mass of $H_2$ (Mr=2) do you get if 4 moles of HCl react with 2 moles of Mg)

e) $N_2 + 3H_2 \longrightarrow 2NH_3$

What mass of $NH_3$ do you get if 12 g of $H_2$ react with a lot of $N_2$?

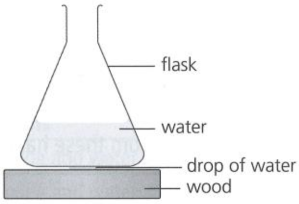
Make up, 5 more questions following the same pattern but with different numbers and substances. (Try to make easy calculations).
Write each question on a piece of paper.
Write each answer on a piece of paper.
You have made play-cards.
Now lend your set of cards to the couple next to you and borrow theirs.
Play with the set of cards once.

UNIT 6

EXERCISES

**1** Mr Stillwell sets up this apparatus. He dissolves some ammonium chloride in the water in the flask.

Use the words and phrases from the box to complete the sentences below. Use each word or phrase once, more than once, or not at all.




| | | | | |
|---|---|---|---|---|
| freezes | releases | cools down | to | takes in |
| from | heats up | melts | | |

When ammonium chloride dissolves in water, it ........................ heat ........................ the surroundings, including the drop of water. The drop of water ........................ It ........................ to become ice. The ice sticks the flask to the wood.

Is dissolving a physical or a chemical change?

**2** Write balanced symbol equations for the following reactions:

**a** $Na + Cl_2 \longrightarrow NaCl$

**b** $Cl_2 + H_2 \longrightarrow HCl$

**c** $Na + O_2 \longrightarrow Na_2O_2$

**3** Balance these equations.

**(a)** $Ca + O_2 \longrightarrow CaO$

**(b)** $SO_2 + O_2 \longrightarrow SO_3$

**(c)** $Na + Cl_2 \longrightarrow NaCl$

**(d)** $C_4H_8 + O_2 \longrightarrow CO_2 + H_2O$

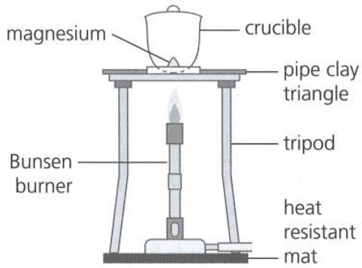
**(e)** $Fe_2O_3 + CO \longrightarrow Fe + CO_2$

**(f)** $PbO + C \longrightarrow Pb + CO_2$

**4** Calculate the mass of oxygen needed to react with 12 g of magnesium. $A_r$ values: Mg = 24; O = 16

$$2Mg + O_2 \longrightarrow 2MgO$$

**5** Marc plans to make magnesium oxide. He will heat magnesium in air. He sets up the apparatus to the right and makes some notes.




~ At 20 °C magnesium is in the solid state, so is magnesium oxide.

~ Magnesium and oxygen are elements. Magnesium oxide is a compound.

~ If you heat magnesium in air, it reacts with oxygen to make magnesium oxide and with nitrogen to make magnesium nitride.

~ Magnesium atoms and oxygen atoms have mass.

THINK AND SPEAK

**a** Suggest how Marc will know if, after heating, he has made a compound.

..........................................................................................................

**b** Marc writes down his results.

Mass of crucible + lid = 30.50 g
Mass of crucible + lid + magnesium ribbon before heating = 30.74 g
Mass of crucible + lid + contents after heating = 30.90 g

**i** Calculate the mass of magnesium ribbon before heating. Show your working.

..........................................................................................................

**ii** Calculate the mass of the contents of the crucible after heating.

..........................................................................................................

**iii** Do you think that Marc has made a compound? Give a reason for your decision.

..........................................................................................................

**iv** Write a conclusion for Marc's experiment. Use science ideas to explain his result.

..........................................................................................................

..........................................................................................................

6 Calculate the number of moles formed when 45g of Zn react with a lot of O2

$Zn + O_2 \rightarrow ZnO$

7 Calculate the mass of Na that we need to get 80 g of NaOH . Consider that you have a lot of water.

$Na + H_2O \rightarrow NaOH + H_2$

8 Calculate the mass of CuO that has to react with enough amount of Mg to get 2 mole of Cu.

$Mg + CuO \rightarrow MgO + Cu$