Form 2

CHEMISTRY

Success criteria, Revision notes and Practical work

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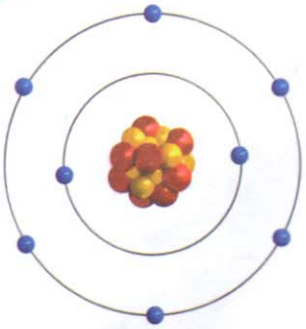
CHEMISTRY



CHAPTER 1

ELEMENTS AND THE PERIODIC TABLE

Success criteria

By the end of this chapter, students should be able to:

1. Describe the patterns in properties of elements in the periodic table.
2. State uses of groups 1, 2, 7 and 8 elements in the periodic table.

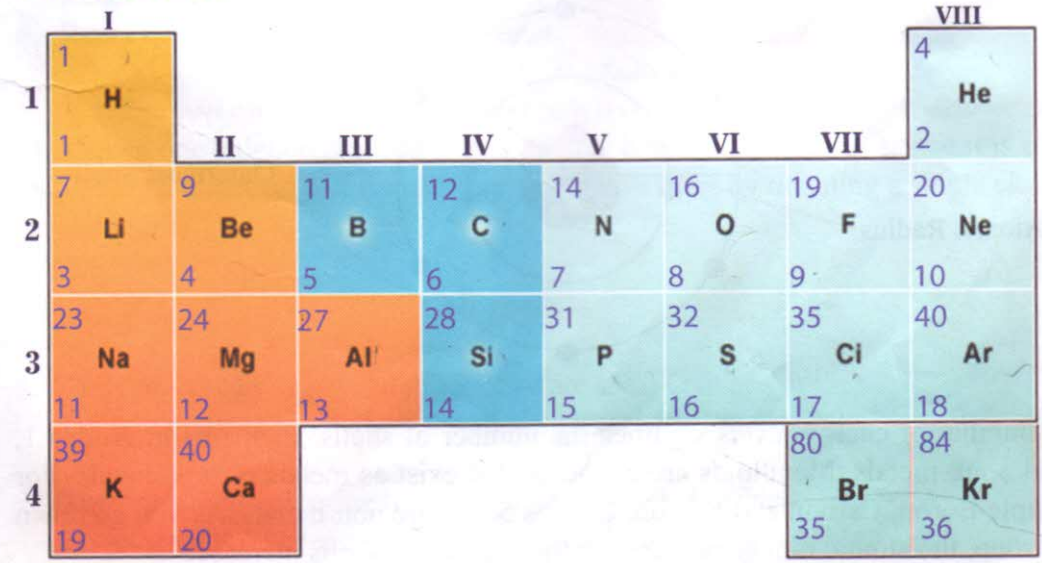
The periodic table

Periodic table is a chart in which elements are arranged according to their atomic numbers. Periodic means something that repeat itself. It also means that something that take place at regular intervals.

Activity 1

1. *Name the gaseous element in group one.*
2. *In which period is potassium? Element B has a mass of 39 amu and atomic number 19.*
   a. *How many protons are in element B*
   b. *What would happen if element B was mixed with water. Give a reason for your answer.*
3. *Write the electron configuration of element B.*

Periodic table



Symbol	Name	Symbol	Name
H	Hydrogen	O	Oxygen
He	Helium	F	Fluorine
Li	Lithium	Ne	Neon
Be	Beryllium	Na	Sodium
B	Boron	Mg	Magnesium
C	Carbon	Al	Aluminum
N	Nitrogen	Si	Silicon
P	Phosphorus	S	Sulphur
Cl	Chlorine	Ar	Argon
K	Potassium	Ca	Calcium

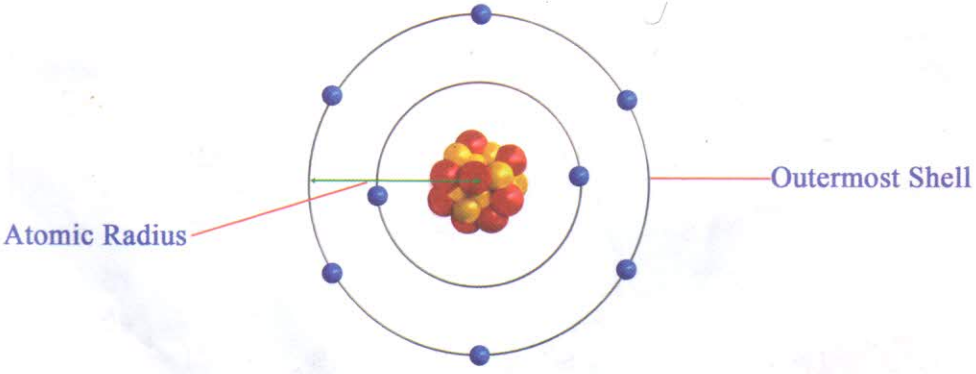
Periodic table is a chart in which elements are arranged according to their atomic numbers.

Periodicity is the arrangement of elements in a table according to their properties. **Groups** are the vertical columns of elements in the periodic table. The number of the group indicates number of electrons in the outermost shell.

Periods are the horizontal rows of elements in the periodic table. The number of the period indicates the number of shells in an atom.

Trends in the periodic table

Atomic radius increases with increase in number of shells or energy levels. **Atomic radius** is the distance from the centre of the nucleus to the outermost shell.



The number of energy levels signifies the number of shells. Elements in groups 1, 2 and 3 are metals. Metalloids are elements that exist as metals or non-metals. For example Boron, Carbon and Silicon. Groups 5 to 8 are non-metals. As you go down the group, the atomic radius increases as the number of shells increase.

Elements in the same group have:

The same number of electrons in the outermost shell.
Similar chemical properties.
Related melting and boiling point.
Similar electron configuration.

GROUP 1 ELEMENTS: ALKALI METALS

Group 1 elements are called alkali metals because when they react with water, they produce a basic solution and hydrogen gas. Examples of alkali metals are Lithium, Sodium, Potassium, Rubidium, and Caesium. Group 1 elements are the most reactive metals in the periodic table.

Physical properties of alkali metals

1. They are soft metals.
2. They are easily cut by a knife.
3. They have low density.
4. They are good conductors of heat and electricity.
5. They are malleable. That is, they can be hammered into any shape.
6. They are ductile. That is, they can easily be drawn into wires.
7. They are shiny when freshly cut.

What happens as you go down the group 1 elements?

As you go down the group 1 elements, atomic radius increases. The number of shells is increased; hence valence electrons experience less attractive forces by the nucleus.

Therefore

1. Metals become softer.
2. Density of metals decreases.
3. Melting and boiling points decreases.
4. Burn more easily in air.
5. React faster with chlorine.
6. React faster and vigorously with water.

Sodium reacting with Chlorine

Why are group one elements the most reactive elements in the periodic table?

They have one valence electron that is loosely held by the nucleus hence it is easily lost during a chemical reaction. Group 1 elements react by donating a single electron to nonmetals.

Chemical properties of alkali metals

1. They react with oxygen to produce white solid Oxide
   For example: $4Li(s) + O_2(g) \longrightarrow 2Li_2O(s)$ **(Lithium Oxide)**

2. They react with chlorine to produce white solid chlorides.
   For example:. $2Na(s) + Cl_2(g) \longrightarrow 2NaCl$ **(Sodium Chloride)**

3. They react with water to produce basic solution and Hydrogen gas.
   For example: $2Na(s) + 2H_2O(l) \longrightarrow 2NaOH + H_2(g)$

Uses of Lithium

1. Lithium is used in heat resistive ceramics and glasses.
2. Alloy of Lithium is used in aircraft building.
3. Lithium batteries are packed with lot of energy as compared to other metals Revolutionized devices like cell phones, computers use lithium batteries.
4. Lithium salts are used as mood stabilizing drug.
5. Lithium is used in deoxidizing copper and copper alloys.
6. Lithium compounds are used as pyrotechnic colourants in fireworks that produces red luminance.
7. Lubricating greases are produced from Lithium.

Uses of Sodium

1. Sodium is used as luster in metals.
2. Liquid Sodium is used as coolant in Nuclear reactors.
3. Sodium salts of fatty acids are used in soap.
4. Sodium compounds are used in paper, textile, petroleum and chemical industries.
5. Sodium Iodide is used to treat extensive ringworm.
6. Sodium is used in street lights and sodium vapour lamps as it can give yellow glow with bright luminance.

Uses of Potassium

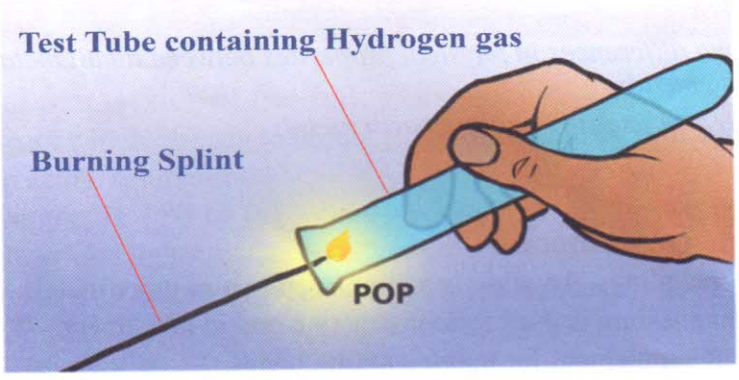
1. Potassium chloride is essential for the growth of plants. It is used in fertilizers.
2. Potassium chlorate and potassium nitrate are used in explosives and fireworks.
3. Potassium nitrate is used as a food preservative.
4. Potassium maintains blood pressure and acidity levels in our body.
5. Potassium chromate is used in the tanning of leather and in the manufacture of inks, gun powder, dyes, safety matches etc.,
6. Potassium is essential for normal cell respiration and electrolyte function as 95% of our cells are made of potassium.
7. Potassium hydroxide is used to make detergents.
8. Potassium helps to pump fluids inside the heart and the nerves.
9. Rubidium vapour is used in laser cooling.

Test for a basic or alkaline solution

A basic or alkaline solution turns the colour of red litmus paper to blue.

Test for hydrogen gas

Hydrogen gas collected in a test tube produces a pop sound when a burning splint is brought close to its mouth.



Activity 2

1. *Outline any four uses of group 1 elements.*
2. *State any two physical properties of sodium metal.*
3. *Give any two chemical properties of group one elements..*
4. *A newly discovered element represented by A is suspected to belong to group 1 of the periodic table. Describe an experiment you would do to prove that the element is an alkali metal.*

Group 2 elements: Alkaline earth metals

These are Alkaline earth metals with shiny silvery white colour. For example Beryllium, Magnesium and Calcium.

Activity 3

Write and draw the electron configuration of the following elements:

1. ***Beryllium***
2. ***Magnesium***
3. ***Calcium.***

Physical properties of the Alkaline earth metals

1. They are good conductors of heat and electricity because they have free delocalized electrons.
2. They are harder and denser than alkali metals.
3. They have higher boiling points and melting points than alkali metals.

Chemical properties of the Alkaline earth metals

1. They react with oxygen to form oxides except beryllium.
   For example:
   $Mg(s) + O_2(g) \longrightarrow 2MgO(s)$
   $Ca(s) + O_2(g) \longrightarrow 2CaO(s)$
2. They react with water except beryllium.
3. They react with halogens to form salts.

Activity 4

1. *Describe two differences in physical properties between alkali metals and alkaline metals*
2. *Identify any* ***two uses of Alkaline earth metals***

Uses of Alkaline earth metals

1. For making some alloys. An alloy is a mixture of two or more metals.
2. For example magnesium is used for construction and in machinery.
3. Used as nutrient supplement for making strong bones and teeth, for example calcium.
4. Magnesium is a constituent of chlorophyll responsible for photosynthesis in plants.
5. Beryllium is used for military application and in electronics as semiconductors.
6. As a constituent of lime.

Metalloids

They are chemical elements that have properties that are between metal and non-metals. They show characteristics of both metals and non-metals. For example silicon, boron and carbon.

- Silicon possesses a metallic luster yet it is a bad conductor of heat and electricity. It is also brittle.
- Boron acts as a non-metal when reacting with sodium yet as a metal when reacting with fluorine.
- Carbon in graphite is a good conductor of electricity while carbon in diamond is a bad conductor of electricity.

Activity 5

In small groups discuss how metalloids behave as metals and as non metals.

GROUP 7 ELEMENTS: THE HALOGENS

They are poisonous non-metals. They are made up of diatomic molecules. For example: Fluorine, chlorine, bromine and iodine.

Physical properties of the halogens

1. They have pungent smell.
2. They are slightly soluble water.
3. They have varying colour.

Halogen	Colour
Fluorine	very pale yellow gas
Chlorine	yellowish green gas
Bromine	reddish brown liquid
Iodine	blue-black shiny solid

4. They exist as diatomic molecules e.g. F_2, Cl_2, Br_2
5. They have relatively low boiling and melting point.

Chemical properties of the halogens

1. They react with hydrogen to produce hydrogen halides, which dissolve in water to form acidic solutions.
   For example: $H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$ **(Hydrogen chloride)** explodes with ultraviolet light.
2. They react with metals to produce ionic metal halides.
   For example:. $2Fe(s) + 3Cl_2(g) \longrightarrow 2FeCl_3(g)$
3. They react with phosphorous to produce covalent Phosphorous pentahalide.
   For example: $2P(s) + 5Cl_2(g) \longrightarrow 2PCl_5(s)$ **Phosphorous pentachloride.**

Activity 6

1. *With the aid of equations only describe any two chemical properties of halogens.*
2. *Explain why halogens have relatively low boiling points and low melting points?*
3. *In small groups discuss the following:*
   a. *Why does the boiling point of halogens increase as you go down the group?*
   b. *Why are group 7 elements (halogens) the most reactive of all non-metals?*
   c. *Why does the reactivity decrease as you go down group 7?*

Why does the boiling point of halogens increase as you go down the group?

Going down group 7, the melting and boiling point increases because the sizes of the molecules increase as you go down the group. This in turn causes larger attractive forces or intermolecular forces holding the molecules together to increase. Greater heat and higher temperatures are needed to separate the molecules of the elements, thus increasing melting points and boiling points as you go down the group.

Why are group 7 elements (halogens) the most reactive of all non-metals?

Group 7 elements have 7 electrons in their outermost shell. When they react they gain one electron in order to reach an electron configuration of a noble gas. Therefore, halogens are the most reactive non-metals in the periodic table because each element requires a single electron to reach octet rule (noble gas electron configuration).

Why does the reactivity decrease as you go down group 7?

As you go down the group, the atomic radius increases, and the reactivity of the

elements decreases. As the atomic radius increases the reactivity of the elements decreases because the incoming electron is less attracted to the nucleus. It experiences less force of attraction **(effective nuclear charge)**. Fluorine is the most reactive halogen because the incoming electron is being more strongly attracted into the outer energy level since Fluorine has the smallest atomic radius.

Uses of halogens

Fluorine

It is used in the form of fluorides in toothpaste because it reduces tooth decay by hardening the enamel.

Chlorine

It is used to make PVC plastics as well as detergents for killing bacteria in drinking water.

Bromine and Iodine

1. They are used to make disinfectants and medicine.
2. They are also used as photographic chemicals.

Activity 7

Mention any two uses of each of the following halogens:

1. *Fluorine*
2. *Chlorine*
3. *Bromine and Iodine*

GROUP 8 ELEMENTS

They are known as noble gases or inert gases. These are Helium, Neon, Argon, Krypton, Xenon, and Radon. Their outermost shells are completely filled hence they cannot gain neither lose an electron. Therefore, they are unreactive.

Physical properties

1. They are all gases at room temperature.
2. They have no smell or colour.
3. They are non-metals.

Uses of noble gases

a. Argon is used

1. To fill ordinary and long life light bulbs to prevent the tungsten filament from reacting with oxygen in the air and forming an oxide
2. To provide an inert atmosphere in arc welding and in the production of titanium metal.

b. Neon is used

1. In advertising signs, because it glows red when electricity is passed through it.
2. In the helium – neon gas laser used in eye surgery.
3. In Geiger – Muller tubes which are used for the detection of radioactivity.

c. Helium is used

1. To provide an inert atmosphere for welding.
2. As a coolant in nuclear reactor.
3. With 20% oxygen as a breathing gas used by deep sea divers.
4. To inflate the tyre of large aircrafts.
5. In the Helium – Neon laser.
6. To fill ships and weather balloons.

Activity 8

In small groups

1. *Discuss why group 8 elements are unreactive.*
2. *Analyse any two uses of the following noble gases:*
   a. *Neon*
   b. *Argon*
   c. *Helium*

Trends of reactivity across the periodic table

The reactivity of metallic elements in the periodic table decreases as you move to the right of the periodic table. Group 1 elements have 1 valence electron in the outermost energy level; hence they require the least energy to lose the single electron unlike elements in group 2 and 3 which have 2 and 3 valence electrons respectively. In metals as the valence electrons increase more energy is required to lose the electrons therefore reactivity decreases. The reactivity of non-metals decreases as you move to the left of periodic table. Group 7 elements require one electron only in order to reach octet rule unlike elements in group 6 and 5, which require 2 and 3 electrons respectively in order to be stable.

Revision questions

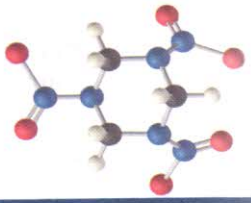
1. State any two physical properties of halogens.
2. Symbol **X** represents an element.

   $$^{A}_{Z}X$$

   a. What do the letters A and Z represent?
   b. Calculate the value of A if the element has 8 neutrons and the value of Z is 6.
3. Use the periodic table of elements on page 5 to answer the following questions:.
   a. What is the atomic number of boron **(B)**?
   b. In which period is phosphorus **(P)**?
   c. Draw an atomic shell diagram of a sodium atom (Na) showing protons and electrons.

CHAPTER 2

CHEMICAL BONDING



Success criteria

By the end of this chapter, students must be able to:

1. Define a chemical bond.
2. Name the three types of chemical bonds.
3. Describe ionic bonding.
4. Describe covalent bonding.
5. Draw cross and dot structures showing ionic and covalent bonding.
6. Describe metallic bonding.

CHEMICAL BONDING

Chemical bonding is the joining of two or more atoms together to attain stability.

Chemical bond

A Chemical bond is when two or more atoms have joined together.

Reasons for chemical bonding

1. To attain stability.
2. To attain low potential energy.
3. To experience more attractive forces.

Localised and delocalised

Localised refers to an object that is unstable, has high potential energy and experiences less attractive force.

Delocalised refers to an object that is stable, has low potential energy and experiences more attractive forces. Hence the ions which are not combined are **localized ions**: those which are combined are called **delocalized ions.**

Activity 9

Illustrate the following molecular bonding using molecular models

1. H_2O
2. CO_2
3. N_2

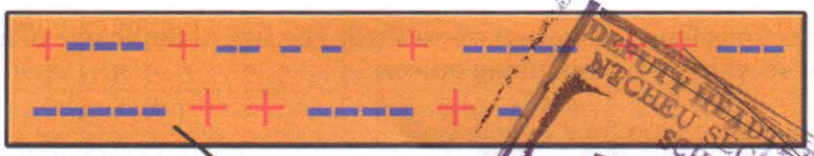
TYPES OF CHEMICAL BONDING

There are three types of chemical bonding

1. Metallic bonding.
2. Ionic bonding.
3. Covalent bonding.

1. Metallic bonding

It is the electrostatic attraction between fixed positive ions and free delocalised electrons that move and surround them.



Physical properties of metals

Metals are: -

1. Shiny. They are used for jewelry and ornaments for example silver and gold.
2. Good conductors of heat and electricity hence they are used for electrical wires for example copper.
3. Hard wearing hence they are used for bridge structures for example steel.
4. Strong.
5. Insoluble in water.
6. Sonorous. They produce a ringing sound.
7. Ductile. They are easily drawn into wires.
8. Malleable. They are easily hammered into any shape.
9. They have high density.
10. Metals have high melting and boiling points hence they are used for cooking utensils.

Activity 10

In small groups discuss any four Physical properties of metals

2. Ionic or electrovalent bonding

It is the electrical attraction between oppositely charged ions, which are produced when electrons are transferred from one atom to another during a chemical reaction.

Elements attain stability by gaining or losing electrons so that their outermost shell has the highest number of electrons. Metals lose electrons and Non-metals gain electrons in order to be stable, that is, to reach an inert gas electron configuration.

Activity 11

1. Explain any two differences between metallic bonding and ionic bonding.
2. Briefly describe how ionic compounds attain stability.
3. What is the difference between valeny and valence.

Why do chemical reactions take place?

Chemical reactions take place so that elements attain stability, have low potential energy and experience more attractive forces.

Valency

Valency is the combining power of an ion or atom. The size of the charge of an ion is the measure of its valency or the combining power.

Valence electrons

It is the number of electrons found in the outermost shell. The size of the charge of an ion is the measure of its valency or combining power.

Cation is a positively charged ion for example Ca^{2+}
Anion is a negatively charged ion for example Cl^-

Metals lose electrons to become cations. The charge and valency of metals is equal to number of valence electrons

Metal	Valence electrons	Valency	Charge	Cation	Name
Li	1	1	+1	Li^+	Lithium
K	1	1	+1	K^+	Potassium
Na	1	1	+1	Na^+	Sodium
Be	2	2	+2	Be^{2+}	Beryllium
Mg	2	2	+2	Mg^{2+}	Magnesium
Ca	2	2	+2	Ca^{2+}	Calcium
Al	3	3	+3	Al^{3+}	Aluminium

The charge and valency of non-metals is equal to the difference between valence electrons and inert gas configuration. They form anion by gaining electrons.

Non metal	Valence electrons	Valency	Charge	Anion	Name
F	7	8 - 7 =1	-1	F^-	Fluoride
Cl	7	8 – 7 = 1	-1	Cl^-	Chloride
Br	7	8 – 7 = 1	-1	Br^-	Bromide
O	6	8 – 6 = 2	-2	O^{2-}	Oxide

Valence of some common substances

ANIONS		
Valency 1	Valency 2	Valency3
Fluoride (F^-)	Sulphide (SO_3^{2-})	Phosphate ($PO_4$3-)
Chloride (Cl^-)	Sulphate (SO_4^{2-})	Nitride (N^{3-})
Bromide (Br^-)	Carbonate CO_3^{2-})	
Hydroxide (OH^-)	Chromate (CrO_4^{2-})	
Bicarbonate (HCO^{3-})	Dichromate ($Cr_2O_7^{2-}$)	
Iodate (IO^{3-})	Oxide (O^{2-})	
Nitrate (NO^{3-})		

CATIONS		
Valency 1	Valency 2	Valency3
Lithium (Li^+)	Calcium (Ca^{2+})	Aluminium (Al^{3+})
Sodium (Na^+)	Copper (Cu^{2+})	Iron III (Fe^{3+})
Silver (Ag^+)	Zinc (Zn^{2+})	Chromium (Cr^{3+})
Hydrogen (H^+)	Magnesium (Mg^{2+})	
Ammonium (NH_4^+)	Iron II (Fe^{2+})	
Potassium (K^+)	Lead (Pb^{2+})	

Deducing molecular formulae

When deducing a molecular formula make sure that the charges on the cations and anions cancel each other so that the total or overall charge should be that of the molecule. For example, as shown in the table below, one Mg ion has 2 positive charges and one Cl ion has 1 negative charge. Hence to have a total of zero charge we need 2Cl $^-$ to combine with 1 Mg $^{2+}$ (Mg^{2+} +2Cl^-) to have a total charge of O. Hence **$MgCl_2$** (not Mg 2Cl).

Examples

Magnesium Chloride	$Mg^{2+} + 2Cl^-$	$MgCl_2$
Sodium Hydroxide	$Na^+ + OH^-$	$NaOH$
Calcium Hydroxide	$Ca^{2+} + 2OH^-$	$Ca(OH)_2$
Copper Hydroxide	$CU^{2+} + 2OH^-$	$CU(OH)_2$
Lead Bromide	$Pb^{2+} + 2Br^-$	$PbBr_2$
Magnesium Carbonate	$Mg^{2+} + CO_3^{2-}$	$MgCO_3$
Magnesium Sulphate	$Mg^{2+} + SO_4^{2-}$	$MgSO_4$
Aluminium Sulphate	$2Al^{3+} + 3SO_4^{2-}$	$Al_2(SO_4)_3$
Potassium Iodide	$K^+ + I^-$	KI
Sodium Bicarbonate	$Na^+ + HCO_3^-$	$NaHCO_3$

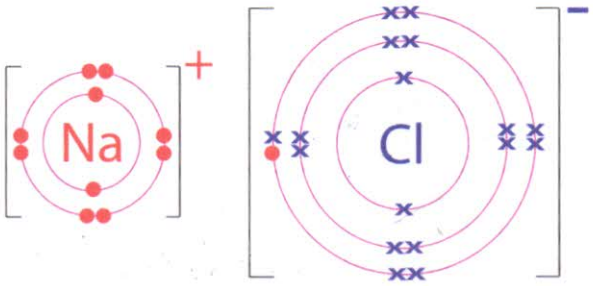
Activity 12a

Magnesium and Chlorine can be represented as Mg and Cl respectively.

- *What are the valences of Magnesium and Chlorine?*
- *Write the molecular formula formed when Magnesium reacts with Chlorine.*

Dot and cross diagrams of ionic compounds

Example: NaCl



Activity 12b

Draw dot and cross diagrams of the following ionic compounds

1. $MgCl_2$

2. CaO

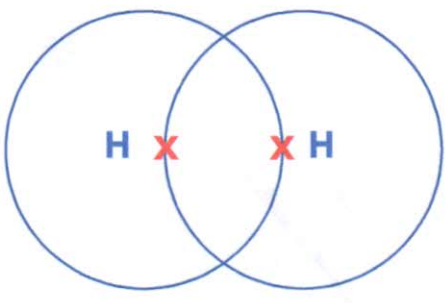
Properties of ionic compounds

1. They are made up of ions and not atoms neither molecules.
2. When fused (melted) they conduct electricity.
3. They have strong electrostatic force.
4. They have high boiling and melting points.
5. They are hard brittle solids at room temperature.
6. They are soluble in water.
7. They are good electrolytes.

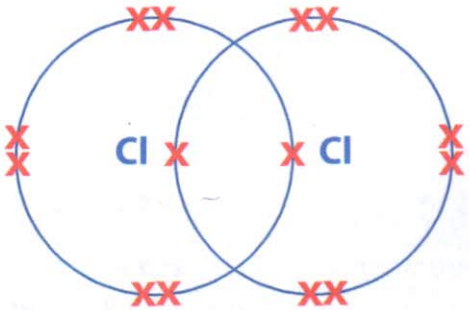
3. Covalent bonding

It is the sharing of valence electrons between atoms. This takes place between non metallic elements.

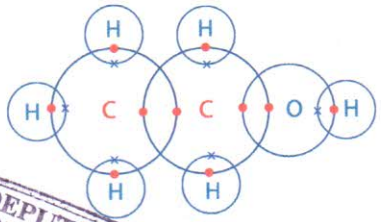
Examples



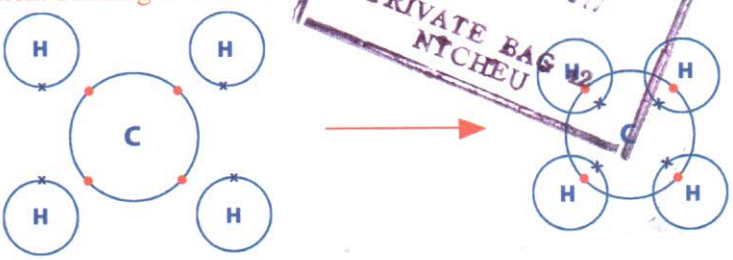
Hydrogen (H_2)



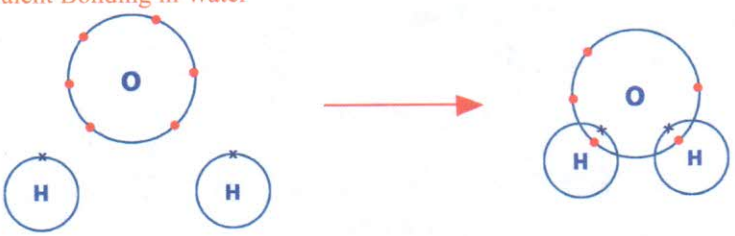
Chlorine (Cl_2)

ELECTON DOT AND CROSS DIAGRAMS	OVERLAP PICTURE
H_2 → H × H	
Cl_2 → Cl × Cl	
H_2O → H × O × H	
HCl → H × Cl	
N_2 → N ⋮ N	

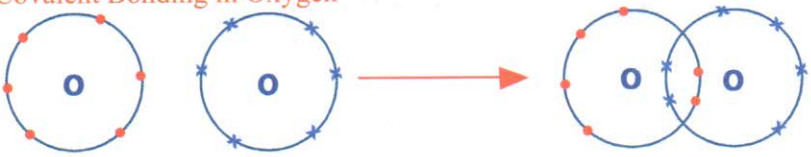
Covalent bonding in methane



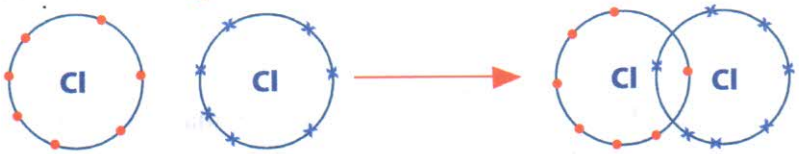
Covalent Bonding in Water



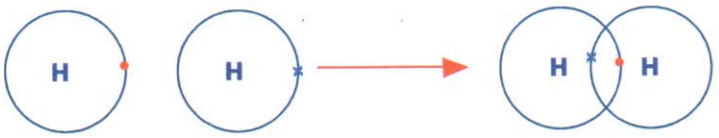
Covalent Bonding in Oxygen



Covalent Bonding in Chlorine



Covalent Bonding in Hydrogen



Activity 13

Draw dot and cross diagrams of the following:

1. C_2H_6
2. N_2
3. O_2
4. CO_2

Properties of covalent bonding (molecular compounds).

1. They have low intermolecular force.
2. They have low melting and boiling points.
3. They are volatile (can easily be vapourised) and have a particular smell for example . Camphor.
4. They are non electrolytes.
5. They are not very soluble in water.
6. They are made up of molecules and not ions.

How are molecular compounds different from ionic compounds?

Ionic compounds	Covalent or molecular compounds
Have high melting and boiling points.	Have low melting and boiling points.
They are good electrolytes.	Non electrolytes.
They are bonded by electrical attraction between positively and negatively charged ions.	They are bonded by sharing of electrons.
Are soluble in water for example. NaCl	Insoluble in water for example Paraffin.
Have strong electrostatic force.	Have weak intermolecular force.

How do atoms attain stability?

1. By losing valence electrons for example metals
2. By gaining electrons for example non metals
3. By sharing electrons

NOTE

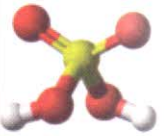
Atoms become stable when their outermost electrons have a maximum of 8 except for Hydrogen and Helium whose maximum is 1 and 2.

Revision exercise

1. Draw an electron dot and cross diagram for the following and identify the type of bonding:
   a. CO_2.
   b. NH_3.
2. Explain two differences between ionic compounds and molecular compounds.
3. Explain why metals are able to conduct heat and electricity.
4. Briefly explain why sodium chloride, which is an ionic compound, does not conduct electricity when solid.
5. Magnesium and Chlorine can be represented as Mg and Cl respectively.
   a. What are the valences of Magnesium and Chlorine?
   b. Write the molecular formula formed when Magnesium reacts with Chlorine
6. Explain briefly why the bond in a nitrogen molecule is very strong, yet the melting and boiling points of Nitrogen are very low.
7. Write down the molecular formula of the following artificial fertilizers.
   a. Ammonium sulphate.
   b. Ammonium phosphate.
   c. Ammonium nitrate.

CHAPTER 3

ACIDS AND BASES



Success criteria

By the end of this chapter, students must be able to:

a. Describe the properties of acids and bases.
b. Prepare acid base indicators from local materials.
c. Determine the strength of an acid and a base using universal indicator and ph scale
d. Describe uses of acids and bases.
e. Describe neutralization reaction.
f. Explain the applications of neutralization reaction

Acids and bases affect the colours of indicators.

What are indicators?

They are coloured dyes usually obtained from plants. Examples of indicators are litmus paper, universal paper or universal solution, phenolphthalein. An indicator tells you whether a given substance is an acid or a base or a neutral substance.

Activity 14

1. *Describe how a homemade indicator for acids could be produced from flowers.*
2. *Describe briefly how substance in coloured flowers can be extracted and used as indicators.*

Preparation of acid –base indicator from Hibiscus flowers.

Aim: to prepare acid –base indicator from Hibiscus flowers

Materials: hibiscus flowers, crucible, water, gas burner, vinegar, baking soda

Procedure

1. Collect hibiscus flowers and cut into small pieces.
2. Place them in a hibiscus flowers crucible and add enough water to just cover the pieces.
3. Boil gently in a crucible for 10 minutes
4. Cool the mixture.
5. Pour off the liquid, leaving the solid behind.
6. Record the colour of the solution.

7. Add some of the solution to an equal volume of vinegar, shake and record the natural indicator colour in an acidic substance.
8. Add some of the solution to sodium bicarbonate (baking soda), shake and record the natural indicator colour in a basic substance.
9. If you obtained different colours for a solution with the acidic substance and with the basic substance, then you have prepared an acid-base indicator solution. This solution will give one colour in contact with an acidic substance and another colour with a basic substance.

Note: Keep the unused solution for later activities.

Activity 15

Design an experiment on how you can prepare an acid –base indicator from

1. *Tomato leaves.*
2. *Acacia leaves*

Properties of acids

1. They have a sour taste for example: Lemons, Malambe.

Lemons

Malambe

2. They have a pH less than 7.
3. They turn blue litmus paper red.
4. They react with metals.
5. They react with bases.
6. They conduct electricity.
7. They enhance rusting.

A car rusting

A Car Battery

Leather Shoes

Activity 16

In small groups discuss any five uses of:

a. Acids.

b. bases

Uses of acids

1. Acids are used in car batteries for example sulphuric acid.
2. They are used in the manufacture of paint.
3. They are used in the manufacture of plastics.
4. They are used in the manufacture of detergents.
5. They are used in the manufacture of fertilizers.
6. They are used in food preservatives.
7. They aid in digestion for example hydrochloric acid.
8. They are used in dyeing and electroplating for example methanoic acid.
9. They are used as solvent for example ethanoic acid.
10. They are used in plant growth.
11. They are used for tarring of leather.

Properties of bases

1. They have a bitter taste.
2. They have a pH greater than 7.
3. They turn red litmus paper blue.
4. They react with acids.
5. They conduct electricity.
6. They enhance rusting.

Litmus paper

Examples of bases are:

Chidulo, soap, ammonium hydroxide, sodium carbonate and sodium hydroxide.

Uses of Bases

1. Sodium hydroxide (caustic soda) is used in the manufacture of soap. It is used in petroleum-refining, in making medicines and paper, pulp.
2. Calcium hydroxide is also known as slaked lime. It is also used by farmers on the fields to neutralize acidic soil.
3. Ammonium hydroxide is used to remove ink spots from clothes and to remove grease from window-panes.

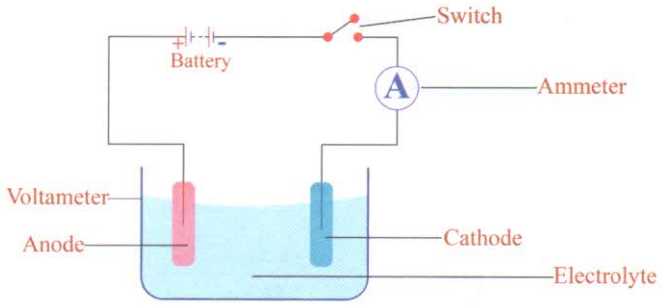
Activity 17

1. A girl was stung by a bee and she rubbed sodium bicarbonate solution onto the area that was stung to relieve pain.

a. Was the liquid that the bee injected into the boy's body acidic or basic?

b. Give a reason for your answer.

2. *What happens to zinc metal when it is placed in acidic solution?*
3. *Explain the meaning of neutralization.*
4. *Describe how the diagram below can be used to test conductivity of acids and bases.*



NEUTRALISATION

It is the process by which the acidity of a solution is reduced or removed by a basic solution. The products of neutralization are salt and water.

Acid + Base ⟶ Salt + Water.
For example HCl + NaOH ⟶ NaCl + H_2O

A substance with pH 7 is neither acidic nor basic but a neutral substance.

Activity 18

In small groups discuss the following applications of neutralization reaction:

1. *Drinking of milk by people with ulcers.*
2. *Drinking of anti acid such as milk of magnesia (magnesium trisilicate) and (soda) sodium bicarbonate.*
3. *Addition of lime to acidic soil.*
4. *Insect bite.*
5. *Toothpaste for mouth cleaning.*

Uses of neutralization

1. **It is used in Agriculture.**
   Acidic soils are neutralized by application of a base such as calcium hydroxide (lime).
2. **It is used in food digestion.**
   Food enzymes work better in either acidic or basic conditions.
3. **It is used in neutralizing excess acid in the stomach.**

Acidic stomach is neutralized by taking anti acids such as magnesium trisilicate.

EXPERIMENT 1

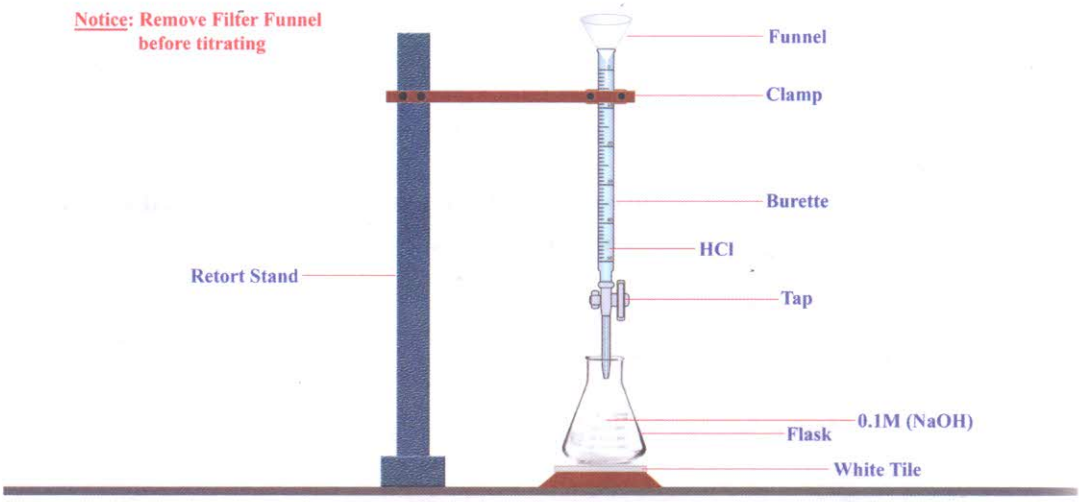
Aim: Conducting experiments to show neutralization reaction

Materials

Burette, Funnel, Measuring cylinder, Beaker, Clamp, Clamp stand, O.1M NaOH, Phenolphthalein indicator, white tile or paper and 0.1 M Hydrochloric Acid

Procedure

1. Set up the apparatus as shown below



2. Fill the burette with Hydrochloric Acid (HCl) to the zero mark.
3. Pour 10ml of Sodium hydroxide into a beaker
4. Add a drop of phenolphthalein indicator to the Sodium hydroxide; note the colour change.
5. Slowly add Hydrochloric Acid from the burette to Sodium hydroxide, shaking the beaker all the time until pink colour disappears. at this point the acid has just been neutralized by the base.

NOTE and record the volume of hydrochloric acid used.

Initial volume of HCl in (ml)	Final volume of HCl (ml)	Volume of HCl used (ml)

What conclusion can you make from this experiment?

Acidic stomach is neutralized by taking anti acids such as magnesium trisilicate.

EXPERIMENT 1

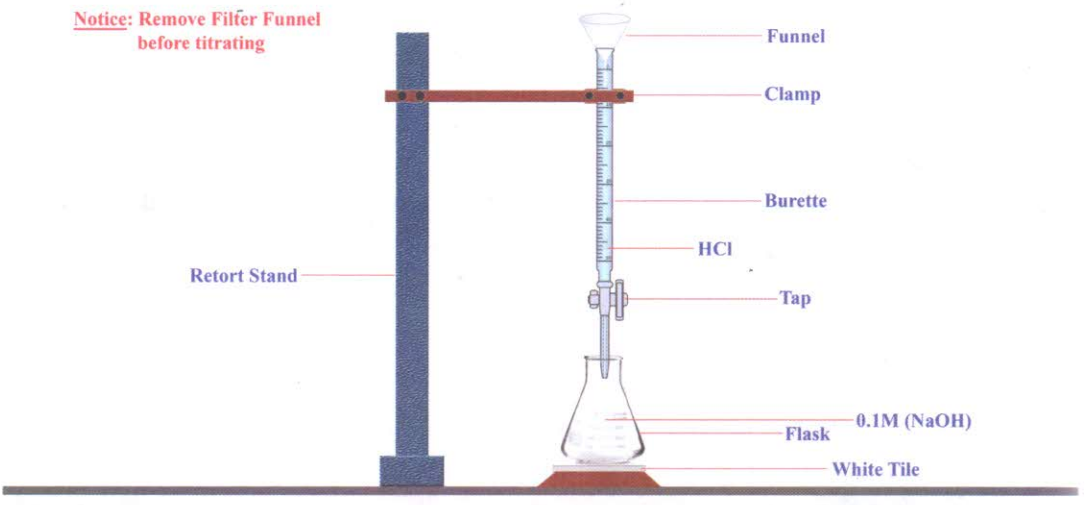
Aim: Conducting experiments to show neutralization reaction

Materials

Burette, Funnel, Measuring cylinder, Beaker, Clamp, Clamp stand, O.1M NaOH, Phenolphthalein indicator, white tile or paper and 0.1 M Hydrochloric Acid

Procedure

1. Set up the apparatus as shown below



2. Fill the burette with Hydrochloric Acid (HCI) to the zero mark.
3. Pour 10ml of Sodium hydroxide into a beaker
4. Add a drop of phenolphthalein indicator to the Sodium hydroxide; note the colour change.
5. Slowly add Hydrochloric Acid from the burette to Sodium hydroxide, shaking the beaker all the time until pink colour disappears. at this point the acid has just been neutralized by the base.

NOTE and record the volume of hydrochloric acid used.

Initial volume of HCl in (ml)	Final volume of HCl (ml)	Volume of HCl used (ml)

What conclusion can you make from this experiment?

PH SCALE

It is a measure of alkalinity (basicity) or acidity of a solution. PH means power of hydrogen ions. The pH value changes as the colour of solution changes. Stronger acids have lower pH values. Stronger bases have greater pH values.

Activity 19

In small groups

1. *Discuss how a universal indicator chart is used to determine the ph value of an acid or a base*
2. *Distinguish acids and bases using universal indicator and noting their strength*

pH SCALE

Ph	0 and 1	2	3 and 4	5	6	7	8	9 and 10	11	12/13/14
Colour	Dark Red	Red	Orange	Yellow	Light Green	Green	Dark Green	Blue	Dark Blue	Purple

pH means power of Hydrogen ions in a solution. **pH scale** is a measure of alkalinity (basicity) or acidity of solution. **The pH value** changes as the colour of solution changes.

pH 0 – 6 means that the solution is acidic.

pH 7 means the solution is neutral

pH 8 – 14 means the solution is alkaline / basic.

The smaller the value of pH, the more acidic the substance.

The greater the pH the more alkaline / basic the substance is.

A universal indicator is preferred when measuring pH value of a solution because it gives a wide range of colour. Acid/base indicators are made from natural dyes.

Examples

Name of indicator	Basic colour	Acidic colour
Litmus paper	Blue	Red
Phenolphthalein	Pink	Colourless
Bromothymol blue	Blue	Yellow
Universal indicator	Blue	Red

The difference between strength and concentration of an acid

The strength of an acid tells you how easily it dissociates (ionizes) to produce Hydrogen ions while the concentration of an acid indicates the proportion of water and acid present in aqueous solution.

Activity 20

Suppose you are given two acids in beakers X and Y , describe an experiment you would carry out to find out which acid is stronger clearly stating the materials, procedure, expected results and conclusion.

EXPERIMENT 2

Aim: To identify solutions as strong acid, or strong base or weak acids or weak base.
Materials: 4 test tubes in a rack, diluted Hydrochloric Acid, Sodium Hydroxide Solution, Acetic Acid, distilled water, and Universal indicator in a dropper.

Procedure

1. To each of the 3 test tubes add diluted Hydrochloric Acid, Sodium Hydroxide solution, acetic acid to a height of about 2cm.
2. Add 2 drops of Universal indicator to each of the three test tubes. Note the colour of the solution and determine the pH of the solution using pH Universal Indicator below: -

colour of universal indicator	Red	Orange	light orange	yellow	green	green blue	light blue	dark blue	violet	purple
PH	1	3	5	6	7	8	9	10	12	14

3. Record the colour of the solution and its pH.

Table of results

	Diluted Hydrochloric Acid	Sodium Hydroxide	Acetic Acid
Colour observed			
PH			

4. Identify solutions A, B, and C as strong base or strong acid or weak base and strong base.

   a. Diluted Hydrochloric Acid: _____

   b. Sodium Hydroxide: _____

   c. Acetic Acid: _____

Comparing the strength of acids of the same concentration by reacting with magnesium ribbon

The reaction of magnesium metal with different acids is used to measure their relative strengths. Hydrogen gas is formed during the reaction. Stronger acids will produce a more vigorous reaction with more bubbling. The increased bubbling with acids of different concentrations also demonstrates the affect of concentration on a reaction.

EXPERIMENT 3

Investigating the strength of acids of the same concentration by reacting with magnesium ribbon.

Materials:

* 0.1M Hydrochloric acid
* O.1M Acetic acid
* Magnesium ribbon
* beakers
* pH meters

Magnesium Ribbon

pH Meter

Procedure:

Be sure that the Mg ribbon is clean.

1. Label beakers with each acid.
2. Pour acids into respective beakers and add a clean magnesium ribbon. Observe the evolvement hydrogen gas to indicate relative strength of each acid.
3. Identify which acid showed a faster rate of reaction.

Discussion:

Rate of dissolution of magnesium is dependent upon strength of acid in solution. The reaction of magnesium with HCl is given below:

$Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$

Hydrogen gas is produced along with the metal halide. The stronger the acid, the faster the rate of reaction and thus the amount of time that effervescence is observed becomes shorter.

Activity 22

Design an experiment on how you can test the following samples of food whether they are acidic or basic:

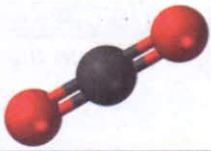
a. Bwemba
b. Malambe
c. Nsima
d. Thobwa
e. Lemons.
f. Pepper.

Revision questions

1. Explain why lime is added to acidic soils.
2. Why is it not proper to carry acidic substance in a metal container?
3. State any three uses of acids.
4. Describe an experiment that could be done to find the pH of water soluble solid substance using universal indicator.
5. State the three properties of a basic solution.
6. State any one effect of acids on metals.
7. Explain any two applications of neutralization reactions in everyday life.

CHAPTER 4

ORGANIC CHEMISTRY



Success criteria

By the end of this chapter, students must be able to:

1. Classify organic compounds.
2. Name and draw the formulae of alkanes and alkenes up to ten carbon atoms.
3. Write the molecular and condensed formulae of alkanes and alkenes given the number of carbon atoms.
4. Explain sources of alkanes and alkenes.
5. Describe physical properties of alkanes and alkenes.
6. Describe combustion of alkanes and alkenes.
7. Describe substitution reactions of alkanes.
8. Describe the addition reactions of alkenes.
9. State the uses of alkanes and alkenes.

Organic compounds

These are compounds that contain carbon except carbon dioxide, carbon monoxide and calcium carbonate. Many millions of years ago a lot of plants and animals lived in the sea. The plants and animals contain organic compounds in their bodies. When they died layers of earth and rock covered their bodies. Bacteria attacked the remains of these plants and animals which eventually decomposed producing petroleum.

Petroleum being drilled

Activity 23

1. *Explain the meaning of organic compounds*
2. *Classify organic compounds.*

Families of organic compounds

Families of organic compounds are :Hydrocarbons and oxycarbons

OXYCARBONS

These are organic compounds that are made up of carbon, hydrogen and oxygen atoms .

HYDROCARBONS

These are organic compounds that are made up of carbon and hydrogen only.

ALKANES

Another name for alkane is **paraffin.** They are hydrocarbons, that is, they consist of carbon and hydrogen atoms only. Alkanes are unreactive. Their general formula is C_nH_{2n+2} where $n > 1$. The smallest alkane is methane. Alkanes are inert compounds hence they are used for keeping elements such as alkali metals.

NAME	CHEMICAL FORMULA	STRUCTURAL FORMULA	PHYSICAL STATE
Methane	CH_4		Gas
Ethane	C_2H_6		Gas
Propane	C_3H_8		Gas
Butane	C_4H_{10}		Gas
Pentane	C_5H_{12}		Liquid
Hexane	C_6H_{14}		Liquid
Heptane	C_7H_{16}		Liquid
Octane	C_8H_{18}		Liquid
Nonane	C_9H_{20}		Liquid
Decane	$C_{10}H_{22}$		Liquid

Name	Chemical formula	Physical state at r.t.p	Condensed formula
Methane	CH_4	Gas	CH_4
Ethane	C_2H_6	Gas	$CH_3\,CH_3$
Propane	C_3H_8	Gas	$CH_3\,CH_2\,CH_3$
Butane	C_4H_{10}	Gas	$CH_3\,CH_2\,CH_2\,CH_3$
Pentane	C_5H_{12}	Liquid	$CH_3\,CH_2\,CH_2\,CH_2\,CH_3$
Hexane	C_6H_{14}	Liquid	$CH_3\,CH_2\,CH_2\,CH_2\,CH_2\,CH_3$
Heptane	C_7H_{16}	Liquid	$CH_3\,CH_2\,CH_2\,CH_2\,CH_2\,CH_2\,CH_3$
Octane	C_8H_{18}	Liquid	$CH_3\,CH_2\,CH_2\,CH_2CH_2\,CH_2\,CH_2\,CH_3$
Nonane	C_9H_{20}	Liquid	$CH_3\,CH_2\,CH_2\,CH_2CH_2CH_2\,CH_2\,CH_2\,CH_3$
Decane	$C_{10}H_{22}$	Liquid	$CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$

Activity 24

Draw skeletons of the following organic compounds

1. *Methane*
2. *Ethane*
3. *Propane*
4. *Butane*
5. *Pentane*
6. *Hexane*
7. *Heptanes*
8. *Octane*
9. *Nonane*
10. *Decane*

Example 1

Write the molecular formula of alkane whose molecule contain 5 carbons atoms

Solution

$C_nH_{2n+2} = C_5H_{(5\times2)+2} = C_5H_{12}$

Example 2

Calculate the molecular formula of an alkane whose molecule has 6 hydrogen atoms

Solution: $C_nH_{2n} = C_6H_{(6\times2)+2} = C_6H_{14}$

Activity 25

Write the molecular formula and condensed formulae of an alkane whose molecule has:

1. *12 hydrogen atoms*
2. *8 carbon atoms*

Sources of alkanes

Natural gas

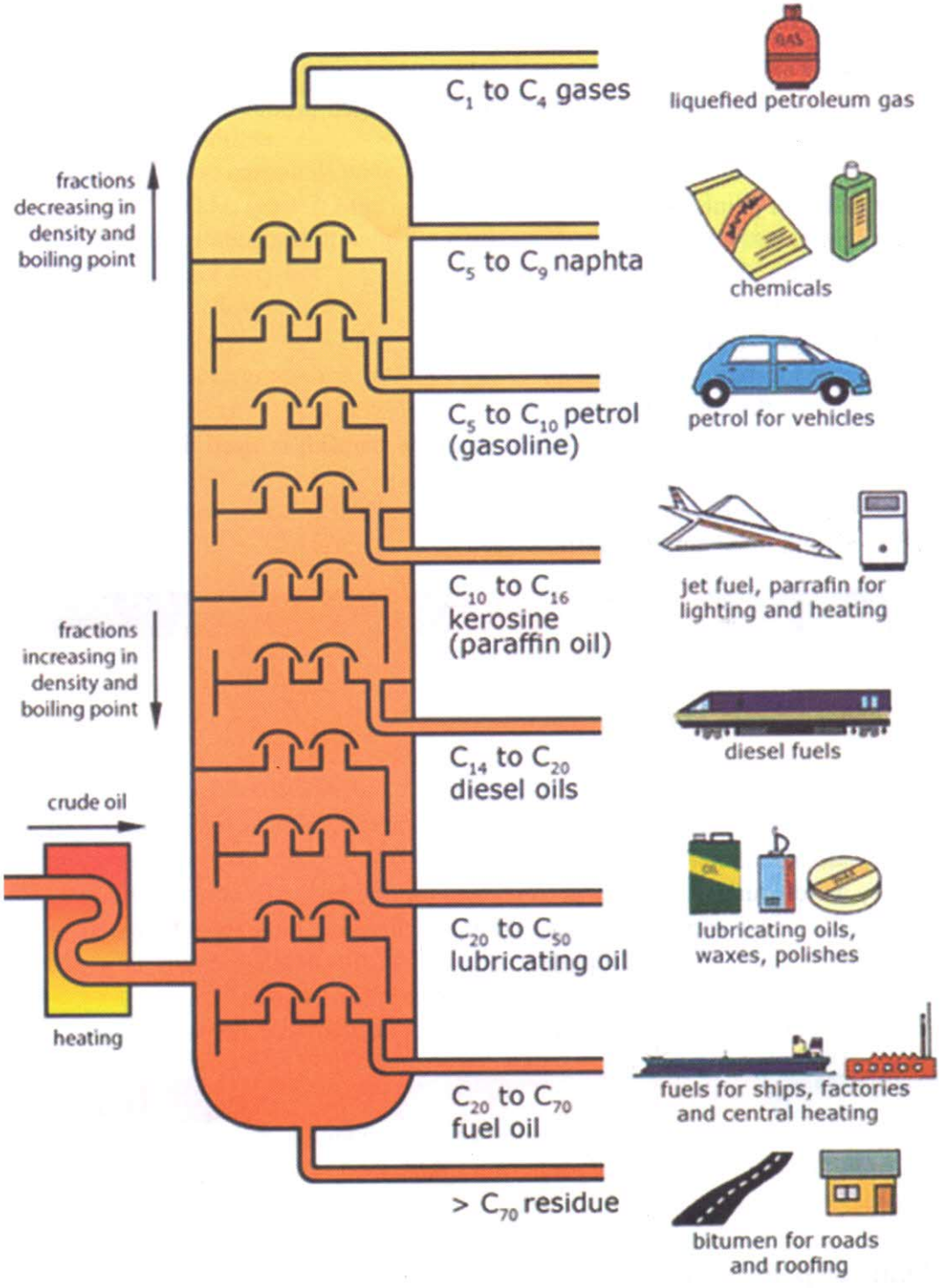
For small alkanes that contain 1 to 4 carbons atoms.

Petroleum

Alkanes are obtained from petroleum by a process called Fractional Distillation. **Fractional Distillation** is a process which is used to separate substances of different boiling points.

Activity 26 a

Briefly explain how long chain alkanes are cracked to form alkenes.



Fractional distillation of crude oil

Uses of alkanes

For Fuels for automobiles.

1. A fuel is a substance which when burnt in oxygen produces energy e.g. petrol, kerosene.
2. For solvents.
3. For example paint dissolves in petrol
4. For lubricants.
5. For example Vaseline and grease
6. For surfacing roads.
7. For example Bitumen
8. It is used for making candle wax.
9. For making floor polish.
10. For storage of reactive metals. For example paraffin is used for storing alkali metals.
11. For lighting for example paraffin lamp.
12. For heating for example paraffin stove.

Activity 26 b

In small groups

1. *Discuss two sources of alkanes*
2. *Analyse any four uses of alkanes*

Physical properties of alkanes

1. They are insoluble (immiscible) in water.
2. They are colourless.
3. Viscosity of alkanes increases as the molecular size increases. **Viscosity** is the resistance to the flow of a liquid.
4. Density of alkanes increases as the molecular size increases.
5. Melting and boiling points increases as the molecular size increases.

Activity

1. *Describe any four Physical properties of alkanes*
2. *Outline any two Physical properties of alkanes*

Chemical properties of alkanes

1. Combustion

It is the burning of fuel in oxygen to produce carbon dioxide, water and energy.
That is Fuel + Oxygen $\longrightarrow$ carbon dioxide + water + energy

Types of combustion

a. Complete combustion for example gas burner. Oxygen supplied is enough.
   i. Flame is very hot.
   ii. Flame is blue.
   iii. Flame is sootless.
   iv. Products are carbon dioxide and water.
   E.g. $2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(g)$

b. Incomplete combustion. It happens when oxygen supplied is less
   i. Flame is not very hot
   ii. Flame is yellow
   iii. Flame is sooty
   iv. Products are carbon and water or carbon monoxide and water.
   E.g $2C_2H_6(g) + 3O_2(g) \rightarrow 4C(g) + 6H_2O(g)$
   $2C_2H_6(g) + 5O(g) \rightarrow 4CO(g) + 6H_2O(g)$

Note: Alkanes with smaller molecules burn more readily than those with larger molecules.

Activity

Clearly explain the difference between a complete combustion and incomplete combustion.

2. Substitution reaction

In a substitution reaction an atom or group is replaced (substituted) by another atom or group. In alkanes, Hydrogen atoms are substituted by Halogens for example chlorine, Bromine, Fluorine and Iodine.

Steps by step substitution with chlorine

Step 1	CH_4	+	Cl_2	$\rightarrow$	CH_3Cl	+	HCl
Step 2	CH_3Cl	+	Cl_2	$\rightarrow$	CH_2Cl_2	+	HCl
Step 3	CH_2Cl_2	+	Cl_2	$\rightarrow$	$CHCl_3$	+	HCl
Step 4	$CHCl_3$	+	Cl_2	$\rightarrow$	CCl_4	+	HCl
Overall equation	CH_4	+	$4Cl_2$	$\rightarrow$	CCl_4	+	4 HCl

Note

CH_3Cl represents Monochloromethane
CH_2Cl_2 represents Dichloromethane
$CHCl_3$ represents Trichloromethane
CCl_4 represents Tetrachloro methane or carbon tetrachloride

Unwanted effects of alkanes

1. They pollute air through combustion.
2. They cause water pollution if spilt in water.

Activity 27

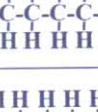
1. *Give two uses of hydrocarbons.*
2. *Explain why increase in size of molecules of alkanes affect their boiling points.*

ALKENES

Alkenes are Hydrocarbons. They contain carbon and Hydrogen atoms only. They have C=C functional group hence they are reactive. The smallest alkene is ethene. Alkenes can be produced by cracking alkanes. **Cracking** is the splitting of larger hydrocarbon molecules into smaller hydrocarbon molecules by subjecting these larger molecules to high pressure at high temperature in the presence of catalyst. A **catalyst** is a substance that speeds up reaction.

For example.

$$\text{Pentane} \xrightarrow[\text{High Pressure + High Temperature}]{\text{Catalyst}} \text{propane} + \text{ethene}$$

NAME	CHEMICAL FORMULA	STRUCTURAL FORMULA
Ethene	C_2H_4	
Propene	C_3H_6	
Butene	C_4H_8	
Pentene	C_5H_{10}	
Hexene	C_6H_{12}	
Heptene	C_7H_{14}	
Octene	C_8H_{16}	
Nonene	C_9H_{18}	
Decene	$C_{10}H_{20}$	

Activity 28 a

Write the condensed formulae of the following alkenes

1. *Methane*
2. *Ethane*
3. *Propane*
4. *Butane*
5. *Pentane*
6. *Hexane*
7. *Heptanes*
8. *Octane*
9. *Nonane*
10. *Decane*

Example

Write the molecular formula of an alkene with 8 carbon atoms.

Solution

$C_nH_{2n} = C_8H_{(8\times2)} = C_8H_{16}$

Write down the molecular formula of an alkene with 24 Hydrogen atoms.

Solution

If 2n=24

Therefore **n** $= \frac{24}{2} = 12$

$C_nH_{2n} = C_{12}H_{(12\times2)} = C_{12}H_{24}$

Activity 28 b

Write the molecular formula and condensed formulae of an alkane whose molecule has :

1. *10 hydrogen atoms*
2. *6 carbon atoms*

Physical properties of alkenes

1. They are insoluble (immiscible) in water
2. They are colourless .
3. Viscosity of alkenes increase as the molecular size increases.
4. Melting and boiling points increase as the molecular size increases.

Activity 26

In small groups

1. *Discuss two sources of alkenes*
2. *Analyse any four uses of alkenes*
3. *Describe any four Physical properties of alkenes*
4. *Outline any two chemical properties of alkenes*

Chemical properties of alkene

1. Combustion

Alkenes undergo complete combustion if oxygen is in excess. If oxygen supply is not enough they undergo incomplete combustion.

2. Alkenes undergo addition reactions with Halogens and Hydrogen.

   a. **Halogenation**

   It is the addition reaction with Halogens.

b. Hydrogenation

It is the addition reaction with Hydrogen.

NOTE

An alkene decolourises bromine solution.

Activity 29

1. *With the aid of chemical equations only describe the hydration of alkenes*
2. *The equation below shows part of an equation of the reaction between ethane and bromine.*

$$CH_4 + Br_2 \longrightarrow$$

   a. *Complete the equation by drawing the structure of the products.*
   b. *What is the name of this chemical reaction?*

Uses of alkenes

1. For fruit ripening.
2. For flower maturation.
3. For seed germination.
4. For production of alkanols.
5. For synthesis of polymers and plastics.

Revision questions

1. Give two uses of alkenes?
2. Name the following organic compounds
   a. $CH_3CH_2CH_3$
   b. CCl_4
3. Explain two differences between complete combustion and incomplete combustion.
4. Explain two chemical properties of the following:
   a. Alkanes.
   b. Alkenes.
5. Methane reacts with chlorine to form carbon tetrachloride in a substitution reaction. Describe a step-by-step formation of carbon tetrachloride.

CHAPTER 5

AIR

Success criteria

By the end of this chapter, students should be able to:

1. Describe the composition of gases present in dry air.
2. State the uses of the gases present in dry air.
3. Describe the importance of oxygen.
4. Describe common atmospheric pollutants and their sources.
5. Explain the effects of pollutants on human health and the environment.

Air

Air is a mixture of gases such as nitrogen 78%, oxygen 21%, carbon dioxide 0.4 % and other smaller amounts of other gases and water vapour.

Gas	Colour	Special property
Oxygen	Colourless	Relights glowing splint
Carbon dioxide	Colourless	Turns limewater milky
Hydrogen	Colourless	Explodes when flame is held at the mouth of its container
Nitrogen dioxide	Brown	Brown colour

Experiment 7

You are provided with three gas jars labeled X , Y and Z respectively. These jars have been filled with oxygen. The other has been filled with carbon dioxide. Is it possible to see which gas was put into jar X.

Procedure

1. In each test tube plunged a glowing splint. Did the gas Relights glowing splint?
2. In each test tube bring a flame close to the mouth of its container. Did the gas produce a pop sound when flame was held at the mouth of its container?
3. In each test tube add limewater and shake well. Did the gas turn limewater milky?

Results

Copy and complete the table below

	Result		
Procedure	**X**	**Y**	**Z**
A glowing splint was plunged into the gas			
A burning splint was held at the mouth of its container			
A few cm3 of limewater			

Identify the gases in X, Y and Z. in each case give a reason for your answer.

Activity 30

Discuss any two uses of each of the following noble gases:

1. *Argon*
2. *Neon*
3. *Helium*

Uses of noble gases

Argon is used

1. To fill ordinary and long life light bulbs to prevent the tungsten filament from reacting with oxygen in the air and forming an oxide.
2. To provide an inert atmosphere in arc welding and in the production of titanium metal.

Neon is used

1. In advertising signs, because it glows red when electricity is passed through it.
2. In the helium – neon gas laser used in eye surgery.
3. In Geiger – Muller tubes which are used for the detection of radioactivity.

Helium is used

1. To provide an inert atmosphere for welding.
2. As a coolant in nuclear reactor.
3. With 20% oxygen as a breathing gas used by deep sea divers.
4. To inflate the tyre of large aircrafts.
5. In the Helium – Neon laser.
6. To fill ships and weather balloons.

NITROGEN

Nitrogen gas has no smell. It is colourless and very unreactive. It is a diatomic molecule covalently bonded together by a triple bond. This triple bond is very strong requiring large amount of energy to break it.

Uses of nitrogen

1. For making Ammonia gas and Nitric acid.
2. Liquid nitrogen is used as a refrigerant.

3. It is filled in an empty oil tanker to prevent fire because of its inertness.
4. It is used in food packaging For example in crisps packet to keep the food fresh .
5. For making artificial fertilizers

Activity 31

1. ***Explain briefly why the bond in a nitrogen molecule is very strong, yet the melting and boiling points of Nitrogen are very low.***
2. *Analyse any two uses of nitrogen gas*

Oxygen

It comprises 21% of air.

Physical properties of oxygen

1. Oxygen is a tasteless odourless.
2. It is colourless gas.
3. It has no smell or colour.

Chemical properties of oxygen

It reacts with metals and non metals to form oxides.
It supports combustion
It aids corrosion
Oxygen causes decaying. Decaying is an example of oxygen reacting with compounds.

Uses of oxygen

1. It is used to make acids such as sulphuric acids, nitric acids
2. Hot oxygen is used in making steel and iron blast furnaces
3. Some mining companies use oxygen to destroy rocks
4. Industries use oxygen for cutting, welding and melting melts. Oxygen gas can generate temperatures of 3000^0C. For example in oxy-acetylene blow torches.
5. Oxygen is used in combustion of fuels in cars and airplanes.
6. For breathing in human e.g. scuba divers, mountaineers and astronauts
7. Used in aerobic respiration by all living things

Activity 32

In small groups discuss :

1. *Physical properties of oxygen*
2. *Chemical properties of oxygen*
3. *uses of oxygen*

Carbon dioxide

It comprises 0.4% of air

Physical properties Carbon dioxide

1. Carbon dioxide is a colourless gas.
2. It melting point -55.6^{0}C boiling point is -78.5^{0}C
3. It is soluble in water, ethanol and acetone.
4. It is linear covalent molecule.

Chemical properties Carbon dioxide

1. It reacts with water to form carbonic acids.
2. It reacts with alkali compounds to give carbonates bicarbonate

$$NaOH\,(aq) + CO_2\,(g) \longrightarrow CO_2\,(g) + NaHCO_3(aq)$$

Uses of carbon dioxide

1. It is used in process requiring large scale refrigeration that is in the form of dry ice.
2. It is used in fire extinguisher as a desirable alternative of water.
3. It is used in carbonated drinks

Activity 33

In small groups discuss :

1. *Physical properties of Carbon dioxide*
2. *Chemical properties of Carbon dioxide*
3. *uses of Carbon dioxide*

POLLUTION

It is the addition of harmful chemical substance or a form of energy such as heat or any disturbance such as sound to the environment.

ENVIRONMENT

It is the surrounding of an organism and all things around it.

AIR POLLUTION

It is the addition of harmful chemical substance to air e.g. dust particles, sulphur dioxide, Nitric oxide, carbon monoxide, smoke.

Causes of air pollution

1. **Carbon dioxide**

   It is produced from the complete combustion of fuel in oxygen. Increased amount of carbon dioxide in the air causes global warming and greenhouse effect. Carbon dioxide dissolved in water produces acidic rain that damages most infrastructures and plants. Carbon dioxide is primarily greenhouse gas emitted through human activities. Carbon dioxide is naturally part of the earth's carbon cycle.

Human activities that increase carbon dioxide in the atmosphere are;

a. Carbon dioxide emitted from incomplete combustion of fuels in cars, buses, lorries and trains
b. Industrial gases for example the factory that produces cement releases carbon dioxide.
c. Carbon dioxide from firewood used for cooking.

Smoke from factories produce carbon dioxide

2. Carbon Monoxide

It is a very poisonous gas. It is produced from incomplete combustion of fuel. When inhaled carbon monoxide mixes with haemoglobin in the blood and stops it from carrying oxygen to the brain and other parts of the body where it is needed for respiration. It also destroys ozone layer as shown below.

$CO + O_2 \longrightarrow CO_2 + O_2$ equation 1

$CO_2 + O \longrightarrow CO + O_2$ equation 2

$O_3 + O \longrightarrow O_2 + O_2$

3. Sulphur Oxide

It is produced from combustion of fuel that contains sulphur. Inhaling sulphur dioxide causes irritation of the eyes and the lungs. When sulphur is dissolved in water it forms sulphuric acid. As a result, the rain is acidic.

4. Metal Particles

When leaded petrol burns, the lead particles are released into the atmosphere. Lead particles are poisonous. They affect the brain.

5. **Nitrogen oxide(NO)**

78% of air is Nitrogen. When combustion takes place, Nitrogen burns in oxygen to produce Nitrogen dioxide. Nitrogen dioxide irritates the eyes and lungs. When it dissolves in water, it forms Nitric acid.

6. **Particulate matter and pesticides**

Examples of particulate matter are: dust particles, pollen grains and smoke. These dirten your clothes, furniture and windows. Pesticides such as doom and **DDT** (dichlorodiphenyltrichloroethane) are poisonous and can irritate the skin and even kill human beings.

7. **Methane**

Atmospheric methane is a greenhouse gas. Methane is emitted from industry, agriculture, and waste management activities and natural sources.

- **Industry**

  Methane is the primary component of natural gas. Some CH_4 is emitted to the atmosphere during the production, processing, storage, transmission, and distribution of natural gas. Because gas is often found alongside petroleum, the production, refinement, transportation, and storage of crude oil is also a source of CH_4 emissions.

- **Agriculture**

  Domestic livestock such as cattle, buffalo, sheep, goats, and camels produce large amounts of CH_4 as part of their normal digestive process. Also, when animals' manure is stored or managed in lagoons or holding tanks, CH_4 is produced. Because humans raise these animals for food, the emissions are considered human-related. Globally, the Agriculture sector is the primary source of CH_4 emissions. For more.

- **Waste from Homes and Businesses**

  Methane is generated in rubbish pits and pit latrine. Methane is also emitted from a number of natural sources. Wetlands are the largest source, emitting Methane from bacteria that decompose organic materials in the absence of oxygen. Smaller sources include termites, oceans, sediments, volcanoes, and wildfires.

OZONE LAYER

It is a region located in the stratosphere several miles above the surface of the earth that contains ozone. **Ozone (O_3)** is a gas that occurs naturally in our atmosphere.

Ozone layer depletion

The ChloroFluoroCarbons(CFCs) destroy the ozone layer. Large holes have been

discovered in the ozone layer and scientists believe that CFCs have produced these holes. CFCs escape into the atmosphere and because of their inertness they remain constant without further reaction until they reach the stratosphere and ozone layer. In the stratosphere the high-energy ultraviolet radiation causes a chlorine atom to split off from the CFC molecules. This chlorine atom or free radical then reacts with the ozone.

Activity 34

1. *Write down the chemical formula of ozone gas.*
2. *Why is the ozone layer in the atmosphere important?*
3. *Mention the gas that is responsible for the green house effect*

The effects of pollutants on human health and the environment.

Pollutants are a threat to our ecosystem and health hazard to human beings. Pollutants are contaminated by products that cause instability or harm to our environment and ecosystem. These pollutants can be manmade or naturally occurring.

Effects

1. Causes lung cancer and stomach cancer eg HC
2. It leads to heart diseases, TB, brain and lungs congestion, pneumonia, strokes eg CO
3. Irritation, coughing and exhaustion headaches.
4. Chronic bronchitis and pulmonary edema e.g. NO.
5. Asthma acute respiratory infections e.g. aerosols.
6. Causes cardiac disorder and respiratory infections.

Revision questions

1. Define "air pollution"
2. Describe two ways by which air can be polluted.
3. Mention one effect of air pollution on humans.
4. Explain one negative effect of bush fires on the environment.
5. What is the main source of carbon dioxide that is released into the atmosphere?
6. Explain how rural electrification would assist in reducing pollution of the environment.
7. Explain why the use of petroleum products as a source of fuel is a danger to the environment

CHAPTER 6

SOIL

Success criteria

By the end of this chapter, students should be able to:

1. Describe the components of soil.
2. Describe the chemical properties of soil.
3. Describe sources of soil pollutants and their effects.
4. Explain ways of preventing soil pollution.

Soil Components

It consists of four major components namely

1. Mineral (or inorganic).
2. Organic matter. It is made of decaying plant and animal matter.
3. Water.
4. Air.

The relative proportions of these four soil components vary with soil type and climatic conditions. Soil is made of living things and non living things.

Chemical properties of soil

1. pH
2. Salinity (EC)
3. Cat ion exchange capacity (CEC)
4. Carbon to nitrogen

Soil pH

It is a measure of the acidity or alkalinity of the soil

Neutral = 7

Acid < 7

Alkaline > 7

Soil pH and plant growth

1. Affects availability of plant nutrients
2. Low pH soils (acidic) results in an increase in aluminium ions which are toxic to plants
3. Affects availability of toxic metals
4. Affects activity of soil microorganisms thus affecting nutrient cycling and disease

Importance of controlling soil pH

Increasing soil pH

Lime (ie pure calcium carbonate) will increase soil pH. Alternately wood ashes can be used to increase soil pH

Activity 35

1. *Describe the components of soil.*
2. *Describe the chemical properties of soil*

SOIL POLLUTION

Soil pollution is the addition of harmful chemical substance to soil or any activity that has a negative impact on the quality of the soil.

Sources of soil pollution

1. **Erosion**

   It washes out all the top soil.

2. **Dumping** of non- biodegradable substances such as plastic papers and dangerous substances such as sulphuric acid, lead compounds leads to soil pollution.

Non biodegradable materials are thrown onto the ground

3. Agricultural practices such as chemical pest control methods and fertilizer application.

4. Over irrigation.
   Too much irrigation causes soil to become waterlogged.

5. Overgrazing.
   This leaves the soil bare and loose making it easy for the wind to blow it away.

6. Bush fires.
   It leaves the soil bare leading to soil erosion.

7. **Desertification**
   It is caused by cutting down and burning vegetation which leaves the soil bare which can lead to **natural** disasters such as floods. Floods are the most common natural disaster in Malawi. Floods refer to a natural process that occurs when quantity of water in a water-shed exceeds the capacity of stream, river and lake. It is a temporary covering of land by water usually as a result of heavy rainfall

Effects of floods

- Loss of life and property. Many people die or get injured and lose property.
- Destruction of the environment. The natural environment gets destroyed making the landscape change completely.
- The disasters can make communication difficult.

Effects of floods

Ways of managing disasters

In general disasters can be managed through Disaster Risk Management which is a collecting process by which government and individuals plan for and reduce the impact of disasters and also do something after disaster has occurred.

Disasters may be prevented by:

- Avoiding having settlements and farms in lower areas that are prone to flooding.
- Constructing houses using strong materials so that the houses should not collapse easily in the face of such disasters such as earthquake.
- Early warning system. For example listening to weather and other information to avoid the risk of a disaster.

Activity 36

Define "soil pollution".
Give any two ways in which soil can be polluted.
Explain one effect of soil pollution on human beings.
Explain ways of preventing soil pollution.

Preventing soil pollution.

1. Reducing Usage of Chemicals

Overuse of chemicals such as pesticides, insecticides and fungicides in gardens is considered to be one of the prime factors leading to soil pollution. Reducing or even avoiding the use of such chemicals is one of the most elementary and important preventive measures. Manures can be used as alternatives to chemicals.

2. Weed Control

Another common measure used to minimize soil pollution is controlling the growth of weeds. Weeds are unwanted plants that grow alongside the main plant and often result in the accumulation of various minerals into the soil layer.

3. Reforestation and Recycling Wastes

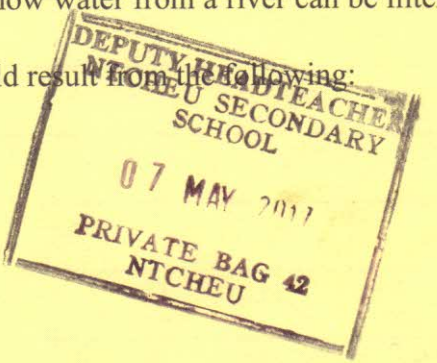
Other common methods of preventing soil pollution include reforestation. Deforestation or the cutting down of trees often leads to erosion of the soil, which leads to soil pollution due to the loss of fertility of the soil.

Reforestation

4. Recycling materials such as plastics, papers and various other materials is another effective and common method of preventing the phenomenon of soil pollution. **Thermoplastics** can be recycled to make cardboards and chairs. Plastic can also be reused.

Revision questions

1. Give any one way of proper disposal of wastes.
2. Explain how disposing sewage into rivers may eventually kill fish.
3. Explain how polluting water bodies with oil affect aquatic life
4. Explain one negative effect of bush fires on the environment.
5. What is the main source of carbon dioxide that is released into the atmosphere?
6. Explain how rural electrification would assist in reducing pollution of the environment.
7. Explain why the use of petroleum products as a source of fuel is a danger to the environment
8. Define a "pollutant".
9. Explain any one way of reducing soil pollution.
10. Define "soil pollution".
11. Give any two ways in which soil can be polluted.
12. Explain one effect of soil pollution on human beings.
13. With the aid of a diagram, explain how water from a river can be filtered using a filtration bed.
14. State the type of pollution that would result from the following:
    a. Domestic fires.
    b. Release of sewage into rivers.



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Form 2

CHEMISTRY

Success criteria, Revision notes and Practical work

This book is primarily intended to be used by students doing the Junior Certificate of Education in Malawi. The book has been presented in simple language so that the reader can easily understand. The book contains Success criteria, Revision notes and Practical work. Review questions at the end of each chapter are meant to reflect and examine the reader's understanding of the content covered

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