THE REPUBLIC OF UGANDA

Ministry of Education and Sports

HOME-STUDY LEARNING

SENIOR 2

CHEMISTRY

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NCDC
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This material has been developed as a home-study intervention for schools during the lockdown caused by the COVID-19 pandemic to support continuity of learning.

National Curriculum Development Centre
P.O. Box 7002,
Kampala- Uganda
www.ncdc.go.ug

FOREWORD

Following the outbreak of the COVID-19 pandemic, government of Uganda closed all schools and other educational institutions to minimize the spread of the coronavirus. This has affected more than 36,314 primary schools, 3129 secondary schools, 430,778 teachers and 12,777,390 learners.

The COVID-19 outbreak and subsequent closure of all has had drastically impacted on learning especially curriculum coverage, loss of interest in education and learner readiness in case schools open. This could result in massive rates of learner dropouts due to unwanted pregnancies and lack of school fees among others.

To mitigate the impact of the pandemic on the education system in Uganda, the Ministry of Education and Sports (MoES) constituted a Sector Response Taskforce (SRT) to strengthen the sector's preparedness and response measures. The SRT and National Curriculum Development Centre developed print home-study materials, radio and television scripts for some selected subjects for all learners from Pre-Primary to Advanced Level. The materials will enhance continued learning and learning for progression during this period of the lockdown, and will still be relevant when schools resume.

The materials focused on critical competences in all subjects in the curricula to enable the learners to achieve without the teachers' guidance. Therefore effort should be made for all learners to access and use these materials during the lockdown. Similarly, teachers are advised to get these materials in order to plan appropriately for further learning when schools resume, while parents/guardians need to ensure that their children access copies of these materials and use them appropriately.
I recognise the effort of National Curriculum Development Centre in responding to this emergency through appropriate guidance and the timely development of these home study materials. I recommend them for use by all learners during the lockdown.

Alex Kakooza
Permanent Secretary
Ministry of Education and Sports

ACKNOWLEDGEMENTS

National Curriculum Development Centre (NCDC) would like to express its appreciation to all those who worked tirelessly towards the production of home–study materials for Pre-Primary, Primary and Secondary Levels of Education during the COVID-19 lockdown in Uganda.

The Centre appreciates the contribution from all those who guided the development of these materials to make sure they are of quality; Development partners - SESIL, Save the Children and UNICEF; all the Panel members of the various subjects; sister institutions - UNEB and DES for their valuable contributions.

NCDC takes the responsibility for any shortcomings that might be identified in this publication and welcomes suggestions for improvement. The comments and suggestions may be communicated to NCDC through P.O. Box 7002 Kampala or email admin@ncdc.go.ug or by visiting our website at http://ncdc.go.ug/node/13.

Grace K. Baguma
Director,
National Curriculum Development Centre

ABOUT THIS BOOKLET

Dear learner, you are welcome to this home-study package. This content focuses on critical competences in the syllabus.

The content is organised into lesson units. Each unit has lesson activities, summary notes and assessment activities. Some lessons have projects that you need to carry out at home during this period. You are free to use other reference materials to get more information for specific topics.

Seek guidance from people at home who are knowledgeable to clarify in case of a challenge. The knowledge you can acquire from this content can be supplemented with other learning options that may be offered on radio, television, newspaper learning programmes. More learning materials can also be accessed by visiting our website at www.ncdc.go.ug or ncdc-go-ug.digital/. You can access the website using an internet enabled computer or mobile phone.

We encourage you to present your work to your class teacher when schools resume so that your teacher is able to know what you learned during the time you have been away from school. This will form part of your assessment. Your teacher will also assess the assignments you will have done and do corrections where you might not have done it right.

The content has been developed with full awareness of the home learning environment without direct supervision of the teacher. The methods, examples and activities used in the materials have been carefully selected to facilitate continuity of learning.

You are therefore in charge of your own learning. You need to give yourself favourable time for learning. This material can as well be used beyond the home-study situation. Keep it for reference anytime.

Develop your learning timetable to ca ter for continuity of learning and other responsibilities given to you at home.

Enjoy learning

TERM 1

SENIOR TWO

Topic 1: Reactivity Series of Metals

Lesson Objectives

By the end of these lessons, you will be able to:

i) define the term affinity in relation to reaction of metals with oxygen and water.
ii) write the reactivity series.
iii) describe the ease of reaction of metals with water.

LESSON 1.1: Metal – oxygen affinity and the Order of the Reactivity Series for Metals

Introduction

Many metals react with oxygen however the urge with which they react with oxygen differs from one metal to another. The attractive force or tendency that binds atoms in molecules to form bonds in a chemical reaction with oxygen is termed as **affinity**.
By reacting different metals directly with oxygen or water, we can establish which metal has a high tendency/affinity to react and therefore generate the reactivity series of metals. In this lesson, you will **discover that reactivity series of metals is simply the** arrangement of the metals in order of their tendency to react with oxygen or water.

Materials you will need:

- Experimental results on reactivity of metals with water.

ACTIVITY 1: Establishing order of reactivity of metals with water

Step 1

A learner carried out an experiment to find out the tendency or extent of affinity with which metals react with water and steam. He summarized his observations and then recorded them in the table below.

METAL	OBSERVATIONS
Gold	NO reaction at all conditions.
Sodium	Reacts violently with cold water. Hydrogen gas may catch fire.
Silver	No reaction with water, but will react at a super-heated temperature.
Potassium	Reacts violently with cold water. Hydrogen gas catches fire and explodes.
Calcium	Reacts moderately with cold water.
Zinc	Hot zinc reacts readily with steam. Zinc oxide produced is yellow when hot and white when cold.
Magnesium	Reacts slowly with cold water. Hot magnesium reacts violently with steam and burns with a white glow.
Copper	No reaction with water but will react at a very high temperature.
Aluminium	Reacts readily with steam. Reaction slows down due to the formation of a protective oxide layer.
Lead	No reaction with water, but reacts with oxygen when heated.
Zinc	Hot zinc reacts readily with steam. Zinc oxide produced is yellow when hot and white when cold.

Step 2
Instructions

1. Study the table above carefully.
2. Arrange the metals in the order which shows the ease of reaction that is; has high tendency or affinity water or oxygen (starting from the fastest to the least)
3. Suggest a term that can best describe the order you have constructed in 2 above.
4. Describe the difference in reactivity between:
    i) calcium and aluminium.
    ii) zinc and silver.
5. Why do you think metallic utensils for cooking such as saucepans are made of iron and not calcium?

Summary

- Metals do not react with water and oxygen with the same urge as shown by the order of arrangement of metals called the reactivity series.
- The reactivity series enables you to identify which metal can be used for different purposes under different conditions.

Follow–up Question

1. A Senior Two learner made the following observations when he/she reacted the elements represented by A, B, C, D with water and he/she was required to arrange them in the order from the least to the most reactive.

ELEMENT	OBSERVATION OF REACTION WITH WATER OR STEAM
A	Reacts readily with steam.
B	Reacts moderately with cold water.
C	No reaction.
D	Reacts slowly with cold water.

Arrange the elements in the order from the least to the most reactive.

Topic 2: Water

Learning Objectives

By the end of these lessons, you will be able to:

i) state the composition of water.
ii) describe the water cycle.

LESSON 2.1: Composition of Water

Introduction

Have you ever thought of life without water? Water is considered to be the most abundant compound on earth. It is present in the atmosphere as moisture, on the surface of the earth and in the bodies of all living organisms. Which other places can we find water? Name them. Water is important as it is used for domestic, industrial and recreational purposes. Think of other specific uses of water at home and at school.

The water cycle ensures that water exists in all states of matter at all times. This property makes it accessible to all living organisms. Water provides a habitat for growth and multiplication of bacteria as well.

To understand the importance and properties of water, you need to know its composition. Therefore, in the next activity you will find out the composition of water.

Procedure

In this activity, you will find out the composition of water.

Material you need:

- pen
- paper

Activity 1: Finding the Composition of Water

Step 1

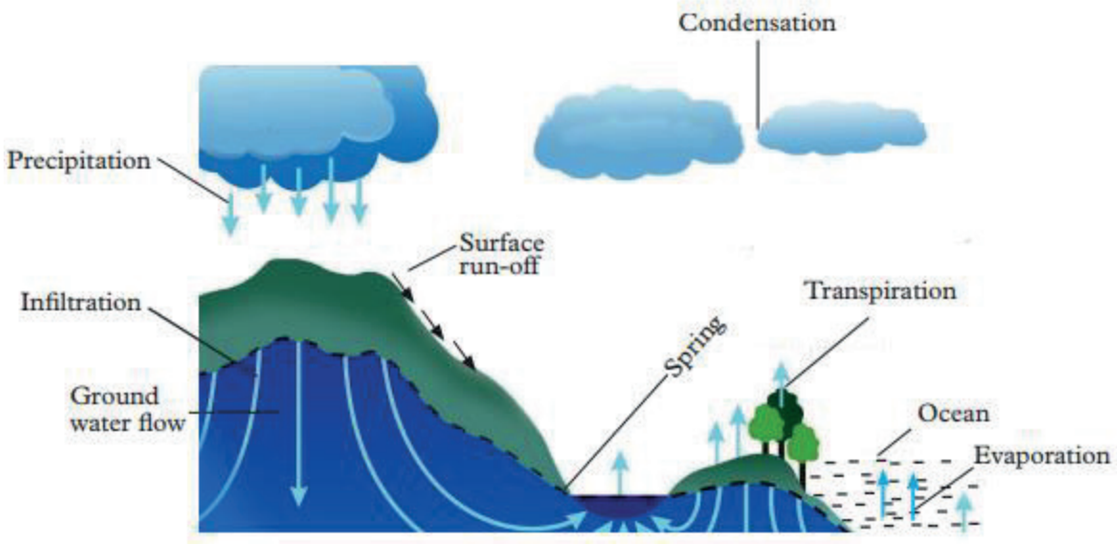
Instructions

1. consult a friend, text book or use internet to find out the elements which makeup water
2. From you findings how do the chemical elements that makeup water combine to form the chemical formula of water.

Step 2

Activity 2: Sources of water and the water cycle

Research has shown that over 70% of the surface of the earth is covered by water. Where does the water come from? Look at the picture below.



Materials needed: A pen, a sheet of paper, and a ruler

Procedure

1. Identify the sources of naturally occurring water:
   i) on the land surface.
   ii) above land surface/the atmosphere.
2. On a clean sheet of paper construct several boxes each representing a particular source of water identified in in 1 above.
3. With the help of arrows draw linkages from one source of water to another.
4. Name the processes that link the different sources shown by the arrows in 3 above.
5. Why do you think the water cycle you have constructed is important for decision making?

Summary

There are several sources of water on the earth's surface. There is continuous circulation of water between the different sources. This is known as the water cycle. It occurs through natural processes of evaporation, transpiration, condensation, precipitation and runoff. The water cycle helps us to understand how to conserve the water by the activities that link the different sources. Activities like deforestation, land reclamation may affect the effectiveness of the water cycle.

Follow–up Activity

Reflect upon the following occurrences and answer the questions related to them.

1 Every morning you see water droplets on materials left outdoors. But in the course of the day, the droplets disappear. Explain where the water droplets come from and why they disappear during day

2 When it rains, surface runoff goes to the seas, oceans and lakes. Use any internet search engine, text book or consult any person who knows the concept. Explain how such water comes back as rainfall.

Questions

1. Explain the meaning of the following terms as are used in reference to water cycle.
   i) Earth's atmosphere
   ii) Evaporation
   iii) Transpiration
   iv) Condensation
   v) Precipitation
2. a) Why is water called a hydride of oxygen?
   b) Write an equation to show how water is formed from its constituent elements.
3. What is the role of forests in the water cycle?
4. How can surface runoff become groundwater?
5. Most of the water that humans use comes from?
6. The repeated movement of water between Earth's surface and the atmosphere is called?
7. What are the components of the water cycle?

Topic 3: Hydrogen

Learning Objectives

By the end of these lessons, you will be able to

i) describe the preparation of hydrogen gas in the laboratory with the help of a diagram
ii) describe the physical and chemical properties of hydrogen gas.
iii) outline the uses of hydrogen gas.

Lesson 3.1: Laboratory Preparation of Hydrogen

Introduction

The hydrogen atoms are the building blocks of over 90 per cent of all matter. Some compounds containing the element hydrogen are glucose, baking powder, sugar and many others. In this lesson you will learn how hydrogen gas is prepared in the laboratory.

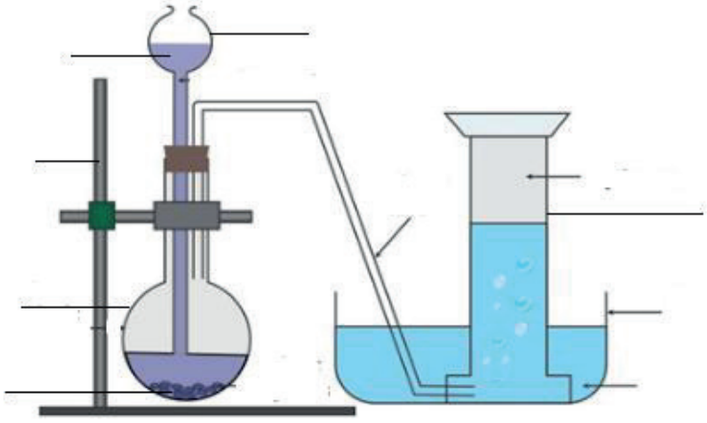
ACTIVITY 1: With the help of a diagram, describe how hydrogen gas is prepared in the laboratory

Materials needed:

- A pen
- A sheet of paper
- Sketch of the set-up diagram for the preparation of hydrogen gas

Procedure

1. Study the sketch of the set-up diagram for the preparation of hydrogen gas below.



2. Label the diagram of the set-up above, using the list of names of apparatus and reagents given in the hint**.** (**Hint:** Zinc metal, dilute hydrochloric acid, flat bottomed flask, delivery tube, water, beehive shelf, gas jar, hydrogen gas.)
3. Describe the above process.

Conclusion/Comments

1. The chemical process for the preparation of hydrogen gas from a metal and acid can be described as ……..
2. The method used for collecting hydrogen gas in the diagram was chosen because…….
3. Write the equation of the reaction for preparation of hydrogen gas.

Question

1. Describe the test you would use to identify the hydrogen gas produced.

Lesson 3.2: Physical and Chemical Properties of Hydrogen

ACTIVITY 2: Finding out about the properties of hydrogen gas

In this activity you are required to classify the properties of hydrogen gas from results of the experiments.

Materials required: A pen, a sheet of paper, a summary of experimental results.

Procedure

1. Study the table of results below obtained when some experiments were carried out on hydrogen gas.

TABLE OF RESULTS

Experiment	Observation
1. Colour	Colourless
2. Burning	Burns explosively with a pop sound and blue flame.
3. Litmus	No effect
4. Taste	tasteless
5. Reaction with Chlorine	Produces hydrogen chloride gas
6. Smell	Odourless
7. Reaction with nitrogen	Produces ammonia gas
8. Exposure to oxides	Reduces the metal oxides to respective metals

2. Classify the observations into the following:
   i) Physical properties
   ii) Chemical properties

Question

1. Hydrogen gas has got several uses both at home and in industry. Write an essay in which you *state and explain the uses of hydrogen gas.*
2. Hydrogen is a reducing agent i.e. it reduces oxides of copper, lead and iron to their metals and is itself oxidized to water. Write the equations of the reaction taking place.
3. Hydrogen reacts with non-metals e.g. chlorine in the presence of sunlight to produce hydrogen chloride. Write the equation of the reaction taking place**.**

Topic 4: Atomic Structure

Learning Objectives

By the end of these lessons, you will be able to:

i) list the sub–atomic particles of an atom and their properties.
ii) state the meaning of the terms *atomic number, mass number*, *isotopes*.
iii) write the electronic configuration of the first twenty elements.

Lesson 4.1: Sub–Atomic Particles of an Atom and their Properties

Introduction

An atom is the smallest electrically neutral indivisible particle of an element that takes part in a chemical reaction. It is spherical in shape. It consists of a small dense region in the centre called a **nucleus.** It contains the **protons** and **neutrons.** The nucleus is surrounded by circular paths called **energy levels,** which contain the **electrons**.

Activity 1: Identifying the sub-atomic particles in an atom of an element

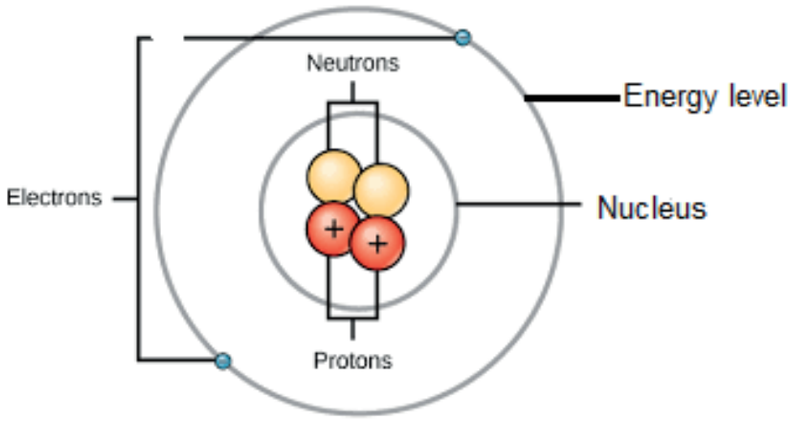
Materials required:

- A pen
- A sheet of paper
- A diagram of atomic model
- Information table on properties of sub-atomic particles

Procedure

Step 1

a) Study the diagram of the atomic model given.



b) Identify the sub-atomic particles found in:

i) the nucleus

ii) energy levels

Step 2

a) Study the information in the table below about properties of the sub-atomic particles when passed in a magnetic field**.**

Sub-atomic particle	**Effect when passed through electric field**
Proton	Attracted to negative plate
Electron	Attracted to negative plate
Neutron	NO effect

b) Complete the table below to summarize the information from the activities above particles in an atom.

Particle	**Symbol**	**Charge**	**Position in atom**
Proton			
Neutron			
Electron			

Conclusion

The sub-atomic particles found in an atom are the ones responsible for characteristics of each element.

Questions

1. Why are atoms neutral yet it contains protons and electrons that are electrically charged.

Lesson 4.2: Atomic Number, Mass Number, Isotopes

Introduction

Each element is represented as follows ${}^{A}_{Z}X$. **A** represents ***atomic mass*** or ***mass number.*** This is the sum of protons and neutrons in the nucleus of an atom. **Z** is the ***atomic number.*** It refers to the number of protons in the nucleus. It is also equal to the number of electrons in the neutral atom. **X** is the chemical symbol of the atom of a given element.

For some atoms of the same element, the proton number is the same however the mass number differs. Such atoms are called Isotopes. For example carbon has two common isotopes written as ${}^{12}_{6}C$ and ${}^{14}_{6}C$

Activity 2: Finding the mass numbers and atomic numbers of atoms of elements

The table below shows mass numbers and atomic numbers of atoms of elements represented by letters W, X, Y, and Z. Answer the questions that follow.

Atom	Mass Number	Atomic Number
W	35	17
X	23	11
Y	12	6
Z	37	17

Questions

1. List the atoms which are isotopes.
2. State the number of neutrons in atom X.
3. State the number of protons in Y.
4. State the number of electrons in Z.

Lesson 4.3: Electronic Configurations of the First Twenty Elements

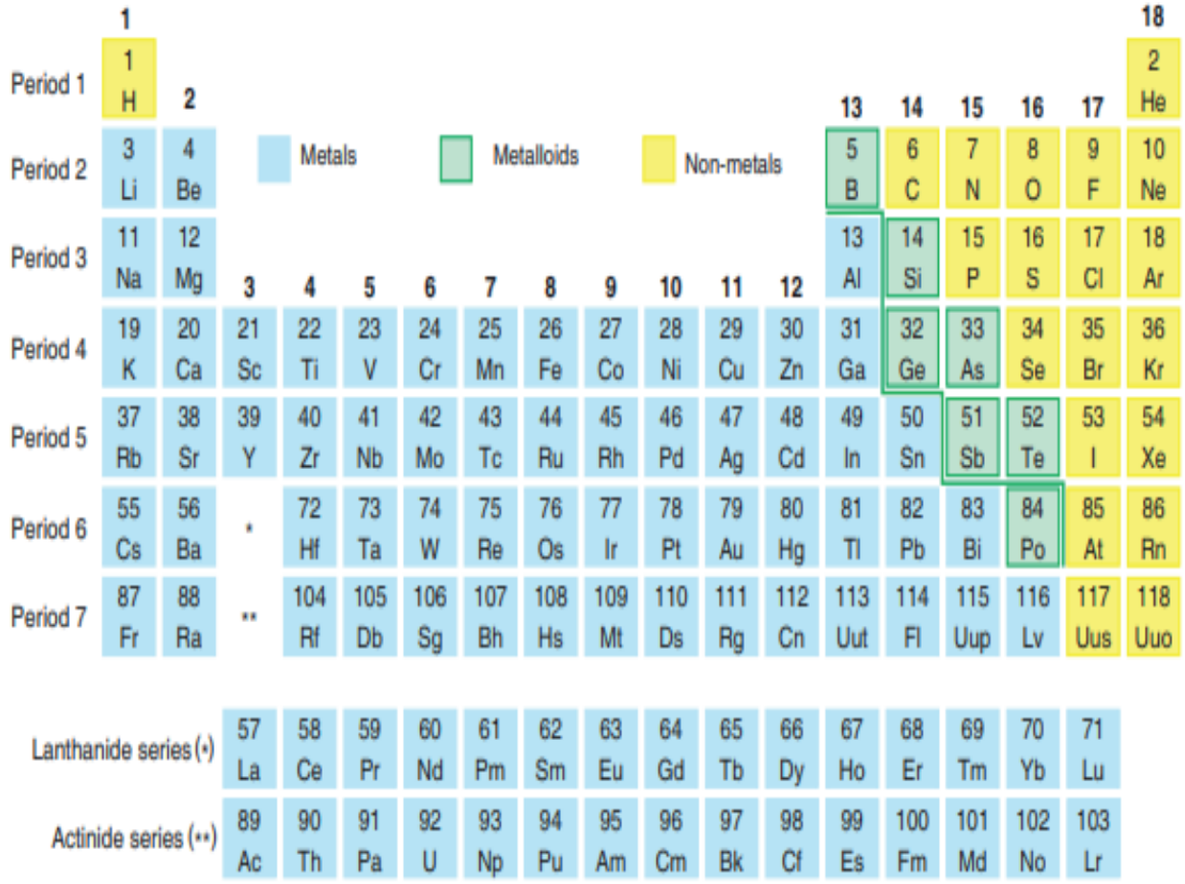
Introduction

Electronic configuration is the arrangement of electrons in the energy levels around the nucleus. The first energy level takes a ***maximum of 2 electrons***, the second energy level takes ***a maximum of 8 electrons. The*** third energy level takes a maximum ***8 electrons*** as well. The general representation is thus N_1:N_2: N_3:N_4. . .Where **N** is the maximum number of electrons that can be accommodated in a given energy shell.

ACTIVITY 3: Writing the electronic configuration of atoms of elements

Materials you will need:

- The periodic table
- A pen
- A notebook



Source: www.researchgate.com

Step 1: The table below shows the first twenty elements **in order** of the atomic numbers. Study it well and complete it correctly.

Element	Symbol	Atomic Number	No. of Electrons	Electronic Configuration
Hydrogen				
Helium				
Lithium				
Beryllium				
Boron				
	C			
		7		
			8	
				2:7
Neon				
	Na			
		12		
			13	
				2: 8: 8
Phosphorous				
	S			
		17		
			18	
Potassium				
				2:8:8:2

PROJECTY WORK

MAKING MODELS OF ATOMS

Materials needed: Small size seeds or beads or small stones, glue, large sheets of paper e.g. newspaper

Using the above materials construct a model of three atoms of elements of your own choice to be displayed in the next science fair after the lifting of the lockdown of COVID-19 to show your understanding of the topic.

Topic 5: The Periodic Table

Learning Objectives

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

i) arrange the first 20 elements in the periodic table.
ii) classify the elements in the periodic table as metals and non-metal.
iii) name the periods and groups in the periodic table.

Introduction

There are over 118 elements so far discovered by scientists with different properties and characteristics. In order to be able to **distinguish** and **classify** all these elements, they are displayed and arranged in a tabular form using atomic numbers, or the way their electrons arrange in orbitals (electronic configurations) and chemical and physical properties in what is known as a PERIODIC TABLE OF ELEMENTS.

In this lesson, you will locate the position of the different elements in the Periodic Table using electronic configuration.

LESSON 5.1: Constructing the Periodic Table of the First 20 Elements

The picture below shows how chopped/sliced fruits were arranged in a fridge. Basing on your observation how are the tins with fruits organised? How useful can such orderliness be important at home?

Like fruits or any other items can be arranged in shops, kitchen or any other place basing on

shape, materials or use, elements with atomic numbers 1 – 20 form the first twenty elements. They include: hydrogen, helium, lithium, beryllium, boron, carbon, nitrogen, oxygen, fluorine, neon, sodium, magnesium, aluminium, silicon, phosphorous, sulphur, chlorine, argon, potassium and calcium.

ACTIVITY 1: Constructing a template of the Periodic Table to display the arrangement of the first twenty elements

Procedure

a) Use the Constructed template below to arrange the first twenty elements of the Periodic Table.

PG								

b) Write the initials **PG** in the TOP LEFT BOX of the constructed table. Insert a pointing arrow on the letter **P DOWNWARDS** and a pointing arrow on the letter **G** from **LEFT TO RIGHT**.

c) Use ROMAN NUMERALS to number the top columns and ARABIC NUMBERING for the ROWS**. (DO NOT WRITE** in the box with the letters **PG)**

d) Fill in the periodic table to show the arrangement of the first 20 elements in the following order using their chemical symbols.

(Hydrogen is in box 1; I, followed by Helium in box 1, VIII). The rest of the elements should be filled in the table systematically) Lithium, Beryllium, Boron, Carbon, Nitrogen etc. up to Calcium.

Conclusion

Metals are found in Groups I, II and III while the non-metals are found in groups IV, V, VI, VII and VIII of the Periodic Table.

Questions

1. How many columns do you have in your table and what is the name used to describe the columns in the Periodic Table?
2. The outer most shell of each atom is called the **VALENCE ELECTRON SHELL.** What is common about the number of electrons of atoms found in the same column?

3. What is the name given to the rows in a periodic table?
4. What is common about the elements in the same row regarding the number of electron shells?

Topic 6: Chemical Families, Patterns and Properties

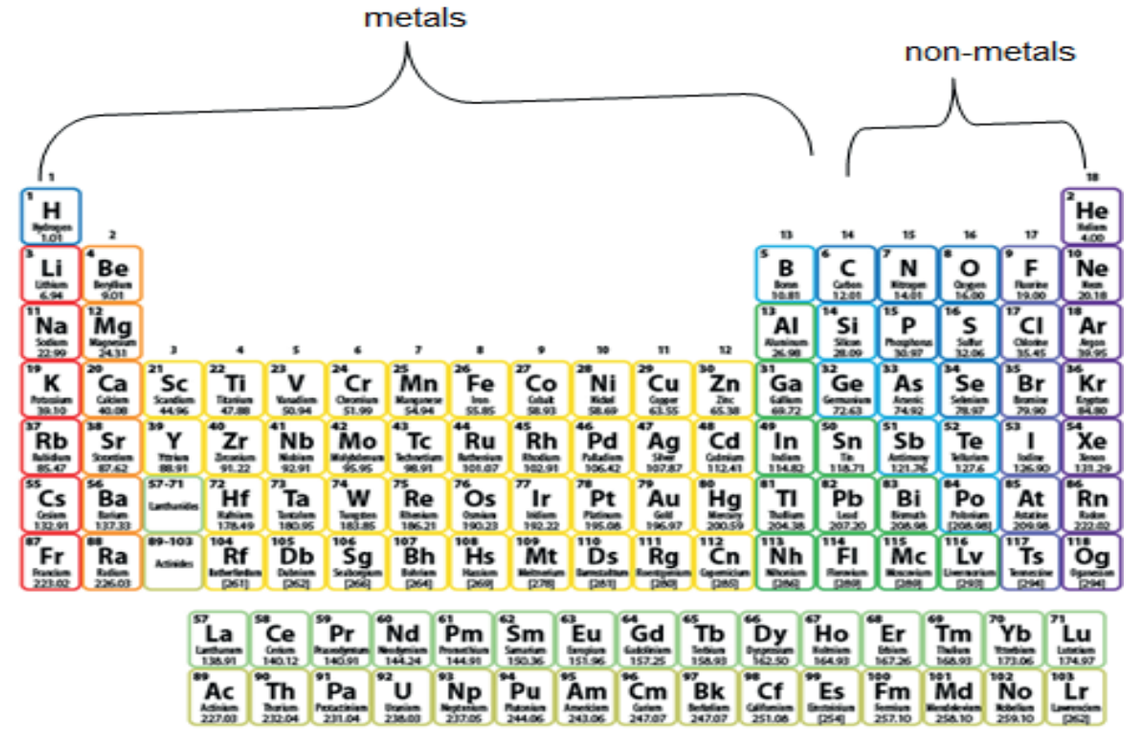
Learning Objectives

By the end of these lessons, you will be able to:

i) state the specified reactions of the alkali, alkaline-earth metals and halogens.
ii) describe the difference in reactivity within these chemical families
iii) state the properties of noble gas family and its non-reactivity.
iv) predict the reactions and reactivity of elements within each family on qualitative basis.

Introduction

Previously you observed how fruits were packed and organise in stalls. Elements in the Periodic Table are placed in groups (families) and periods because of similarity in properties and patterns like electronic configuration, valency, electron shells, and similarity in pattern of reactions. Below is the Periodic Table to illustrate the classification of the elements.



source: www.researchgate.com

In these lessons, you will explain the reactions of the chemical families in terms of their

electronic arrangement.

Lesson 6.1: Reactions of the Chemical Families in Terms of their Electronic Arrangement

ACTIVITY 1: Studying properties of group I

Materials needed:

- The Periodic Table
- A pen and a sheet of paper

Procedure

Steps

1. List the elements in group 1 of the Periodic Table and write their electronic configuration. State the number of electrons in their outer most shells and the valence of group I elements.
2. All these metals react vigorously or even explosively with cold water. In each case, a solution of the metal hydroxide is produced together with hydrogen gas.

$$2\,M(s) + 2H_2O(l) \longrightarrow 2MOH(aq) + \_H_2(g)$$

Where M = any group I metal

Write an equation for the reaction for each of the group 1 metals with water.

3. Oxygen reacts rapidly with group I elements to form **alkali metal oxides.** They form basic solutions when dissolved in water. That is why the elements are known as the **alkali metals**. For example, with careful control of oxygen, the oxide form oxides of the formula M_2O (where M represents any alkali metal).

$$4M(s)+O_2(g) \longrightarrow 2M_2O(s)$$

Write an equation for the reaction of each of the group 1 metals with oxygen.

4. Elements of group 1 react with chlorine to form the corresponding metal chloride.

$$2M(s)+Cl2(g) \longrightarrow 2MCl(s)$$

Write an equation for each of the group 1 metals with chlorine.

Follow-up Activity

Summarise the properties and reactions of group 1 elements in the table below.

Element	Electronic configuration	Valence	Equation for reaction with water	Equation for reaction with oxygen	Equation for reaction with Chlorine
Lithium					
Sodium					
Potassium					

Lesson 6.2: Chemical Reactions of Group II Elements

ACTIVITY 2: Studying properties of group II elements

Materials you will need: The periodic table, a pen and a piece of paper

Procedure

Steps

1. List the elements in group II of the Periodic Table.
2. Write their electronic configuration.
3. State the number of electrons in their outermost shells.
4. State the valence of group II elements.

NOTE:

- The group II metals become more reactive towards water as you go down the group.
- They react with cold water with increasing vigour down the group to give metal hydroxide and hydrogen.
- Magnesium burns in steam to produce white magnesium oxide and hydrogen gas.
- The general equation for the reactions of any of these metals would be:

  $M(s) + 2H_2O(l) \longrightarrow M(OH)(aq) + H_2(g)$

  Where M represents any group II metal

Write an equation for the reaction of each of the group II metals with water.

5. The metals burn in oxygen to form a simple metal oxide. A general equation is below.

   $2M(s)+O_2(g) \longrightarrow 2MO(s)$

   Where M represents any group II metal

Write an equation for the reaction of each of the group II metals with Oxygen.

6. Elements of group II react with chlorine to form the corresponding metal chloride. A general equation is below.

   $M(s)+Cl_2(g) \longrightarrow MCl_2(s)$

   Where M represents any group II metal

Follow-up Activity

Write an equation for the reaction of each of the group II metals with Chlorine. Summarize the properties and reactions of group II elements in the table below.

Element	Electronic configuration	Valence	Equation for reaction with water	Equation for reaction with oxygen	Equation for reaction with chlorine
Beryllium					
Magnesium					
Calcium					

Lesson 6.3: Chemical Reactions of Group VII Elements

Activity 3. Studying properties of group VII elements

Materials you will need:

- The Periodic Table
- A pen and a sheet of paper

Procedure

Steps

1. List the elements in group VII of the periodic table.
2. Write their electronic configuration and state the number of electrons in their outermost shells.
3. State the valence of group VII elements.
   NOTE: The halogens become less reactive going down group VII
4. **Reactions with metals**

The halogens react with metals to produce salts. (The word 'halogen' means 'salt former'.)
For example, chlorine reacts with sodium:

Sodium + chlorine ⟶ sodium chloride

Now write the chemical equation of the reaction.

5. **Reactions with hydrogen**

The halogens react with hydrogen to produce compounds called hydrogen halides. For example, chlorine reacts with hydrogen:

Hydrogen + chlorine ⟶ hydrogen chloride

Now write the equation of the reaction.

Lesson 6.4: Properties of Group VIII Elements

Activity 4: Studying the properties of group VIII elements

1. List the elements in group VIII of the Periodic Table.
2. Write their electronic configuration and state the number of electrons in their outermost shells.
3. What do you notice about the electronic structure of the elements?

Conclusion

Why are the elements in group VIII non-reactive in nature?

Topic 7: Bonding

Learning Objectives

By the end of these lessons, you will be able to:

i) describe the formation of ionic/electrovalent bond, covalent bond and metallic bond.
ii) identify different elements which form the above bonds.

Introduction

When atoms or the elements combine to form molecules, a force of attraction is developed between the atoms (or ions) which holds them together. **The force which links the atoms (or ions) in a compound is called a chemical bond** (or just "bond").

A bond is formed so that each atom acquires a stable electronic configuration similar to that

Electronic Configurations of Noble Gases (or Inert Gases)								
Noble gas (Inert gas)	Symbol	Atomic number	Electronic configuration					Number of electrons in outermost shell
			K	L	M	N	O	P	
Helium	He	2	2						2
Neon	Ne	10	2,	8					8
Argon	Ar	18	2,	8,	8				8
Krypton	Kr	36	2,	8,	18,	8			8
Xenon	Xe	54	2,	8,	18,	18,	8		8
Radon	Rn	86	2,	8,	18,	32,	18,	8	8

of a noble gas.

In these lessons, you will study the formation of the different types of bonds and identify the different elements which form them.

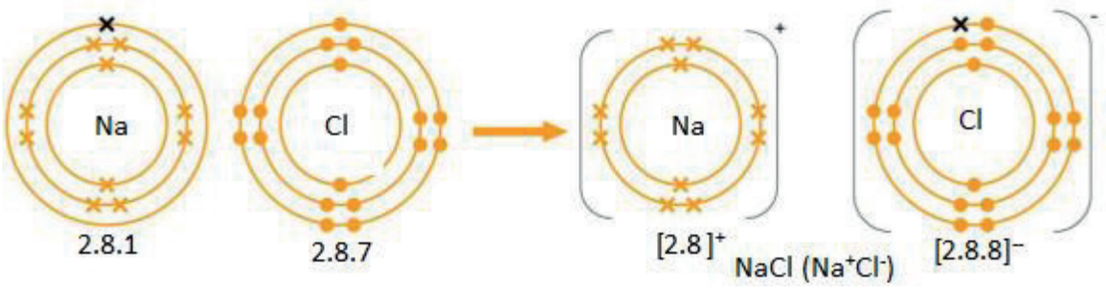
Lesson 7.1: Formation of Ionic Compounds

Metals atoms form **positive ions** by losing electrons while non-metal atoms form **negative ions** by gaining electrons. When these ions combine, they form **ionic compounds**. And the bond formed between them is then called an **IONIC** or **ELECTROVALENT BOND** e.g. the one formed between Sodium and chlorine to form sodium chloride.

ACTIVITY 1: Illustration for the reaction between sodium and chlorine

PARTICLE	PROTONS= number of positive charges	ELECTRONS	OVERALL CHARGE OF PARTICLE
Sodium atom ***before*** reaction	11 (+11)	11(-11)	0 (Zero) sodium atom not charged (Na)
Sodium ion ***after*** reaction	11 (+11)	10(-10) one electron ***lost*** to chlorine atom	+1, sodium ion with a positive one charge (Na^+)
Chlorine atom ***before*** reaction	17 (+17)	17 (-17)	0 (Zero) chlorine atom not charged (Cl)
Chloride ion ***after*** reaction	17 (+17)	18 (-18) one electron ***gained*** from sodium atom	-1 chloride ion with a negative one charge (Cl^-)

Dot and cross diagram showing bonding between sodium and chlorine



Follow-up Activity

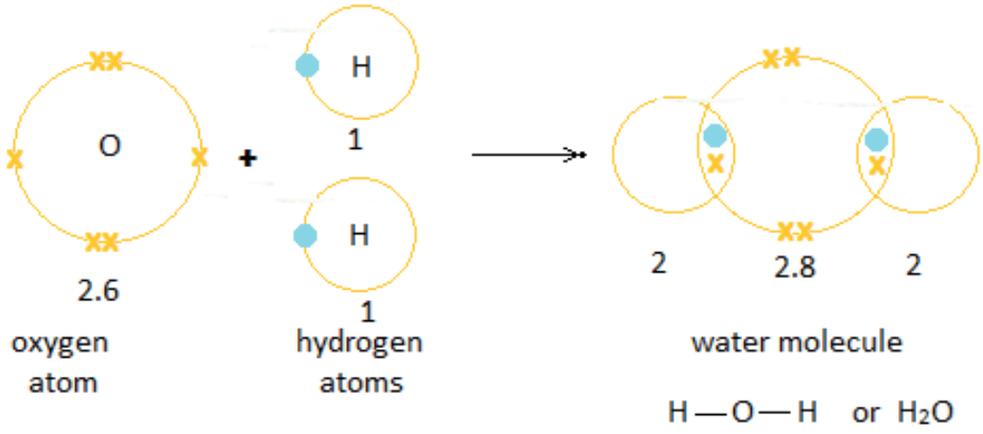
1) Using your knowledge acquired from activity 1, use dot and cross diagrams to illustrate the formation of the following ionic compounds between
   a) Magnesium and oxygen
   b) Potassium and oxygen
   c) Aluminium and chlorine

Lesson 7.2: Formation of Covalent Bonds

This bonding occurs mostly between **non-metals.** Covalent bonding or sharing of electrons only takes place in the outermost shells of atoms to attain inert gas electron arrangement.

ACTIVITY 2: Using dot and cross diagrams to show covalent bonding between oxygen and hydrogen atoms

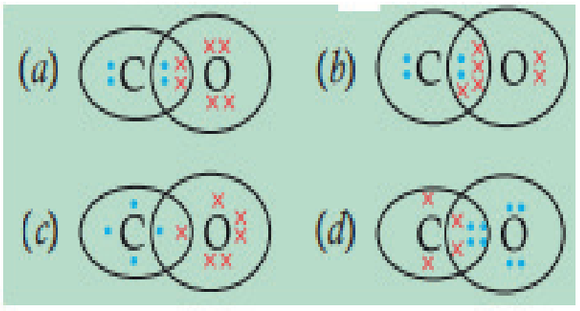
Consider formation of a water molecule. Two (2) hydrogen atoms share electrons with one oxygen atom. atom.



A covalent bond is formed when both the reacting atoms need electrons to achieve the inert gas electron arrangement. Now, the non-metals have usually 5, 6 or 7 electrons in the outermost shells of their atoms. So, all the non-metal atoms need electrons to achieve the inert gas structure. They get these electrons by mutual sharing. Thus, whenever a non-metal combines with another non-metal, covalent bond is formed.

Follow-up Activity

1) Using your knowledge acquired from **Activity 2**, use the dot and cross diagrams to illustrate the formation of the following ionic compounds between:
   a) nitrogen and hydrogen
   b) hydrogen and carbon
2) i) Using the cross and dot diagram, show the formation of carbon dioxide.
   ii) Which of the following is correct?

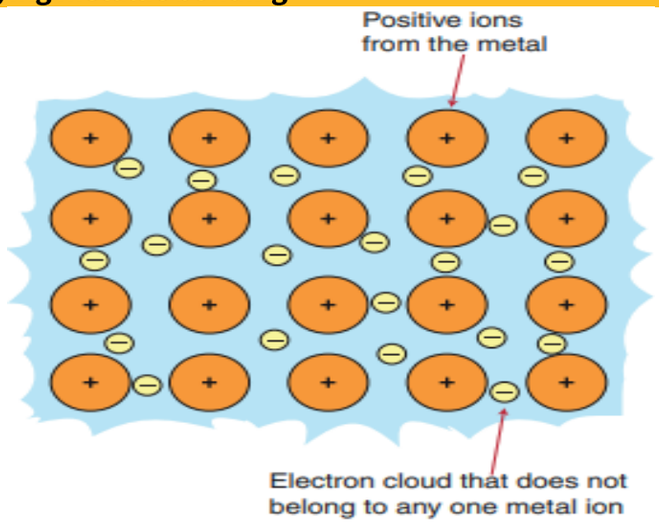


3) Carbon tetrachloride and urea are not covalent compounds. (True or False)
4) In the formation of covalent bonding, _____ of electrons takes place in the_____ shells of atoms.

Lesson 7.3: Metallic Bonding

This is bonding within atoms of metals caused by attractive force between **positively charged metal ions and negatively charged free electrons.** The atoms are packed closely together and have a regular, repeating arrangement called **giant lattice structure**. The lattice is formed because the atoms attract each other and form a regular pattern with oppositely charged ions next to each other.

Activity 3: Studying metallic bonding



Carefully study the diagram above and use it to answer the questions below.

In this model, the metal is pictured as an array of metal cations in a “sea” of electrons. The atoms in a metallic solid contribute their valence electrons to form a “sea” of electrons that surrounds metallic cations. Delocalised electrons are not held by any specific atom and can move easily throughout the solid. A metallic bond is the attraction between these electrons and the metallic cation.

Follow-up Activity

1. List the properties of metals.
2. Name the scientist who proposed the theory of electron sea model.
3. Metallic bond is neither a covalent bond nor an electrovalent bond. (True or False)
4. The force which binds various metal atoms together is called _____.
5. Make a 3D structure of electron sea model.
6. Write a short note on the formation of metallic bonding.

- An atom achieves a stable electronic configuration by losing, gaining or sharing electrons.
  - Metal atoms with one, two or three electrons in the outermost shell lose electron(s) to form positively charged ions (cations).
  - Non-metal atoms with five, six or seven electrons in the outermost shell gain three, two and one electron(s) to form negatively charged ions (anions).
  - Non-metal atoms with four to seven outermost electrons may gain electrons by sharing them with each other.
- A chemical bond is a force that holds ions, molecules or atoms together. A bond is formed when each atom acquires a stable electronic configuration like noble gas.
- The electrostatic binding force is called an ionic bond or electrovalent bond.
- Ionic compounds are formed by attraction of positive and negative ions. These compounds are crystalline solid. They conduct electricity. Ionic compounds have high melting and boiling points.
- A covalent bond is formed between two or more atoms of non-metals that are unable to form ions.
- Covalent compound is formed when atoms achieve a stable electronic configuration by sharing of electrons. Covalent compounds are solids, liquid or gases. Covalent compounds have low melting and boiling points.
- The two forms of carbon that join covalently to form giant structure are diamond and graphite.
- The force which binds various metal atoms together is called metallic bond.
- Metals are generally hard, lustrous, strong, malleable and ductile. They conduct heat and electricity in both molten and solid state.

Questions

Use a table of three columns to illustrate the differences between **ionic**, **covalent** and **metallic bonding**.

Differences between Ionic Compounds and Covalent Compounds	
Ionic compounds	**Covalent compounds**
Ionic compounds are usually crystalline solids.	Covalent compounds are usually solids, liquids or gases.
Ionic compounds have high melting points and boiling points. That is, ionic compounds are non-volatile.	Covalent compounds have usually low melting and boiling points.
Ionic compounds conduct electricity when dissolved in water or melted.	Most covalent compounds do not conduct electricity.
Ionic compounds are usually soluble in water.	Covalent compounds are usually insoluble in water (except, glucose, sugar, urea, etc.).
Ionic compounds are insoluble in organic solvents (like alcohol, ether, acetone, etc.)	Covalent compounds are soluble in organic solvents.

TERM 2

Topic 8: Ions and Ionic Compounds

Learning Objectives

By the end of these lessons, you will be able to:

i) explain ion formation.
ii) outline common examples of ions.
iii) determine valences of different elements.
iv) define a radical.

Lesson 8.1: Formation of Positive (Cation) Ions

Introduction

All atoms would like to have a stable electronic structure similar to that of group (VIII) or noble gases i.e. **a duplet structure** like the one of Helium (He) or an **octet of 8 electrons** as in the outermost energy level shell of the other noble gas elements.

In order to acquire this stable electronic structure, ***metals lose electrons*** to acquire this structure while ***non-metals gain electrons*** to acquire this stable structure.

Note

1) The number of electrons **lost** or **gained** in acquiring the stable structure is the **VALENCE** of the element.
2) The atom that has lost or gained electron(s) acquires a positive or negative charge and is known as an **ion**.

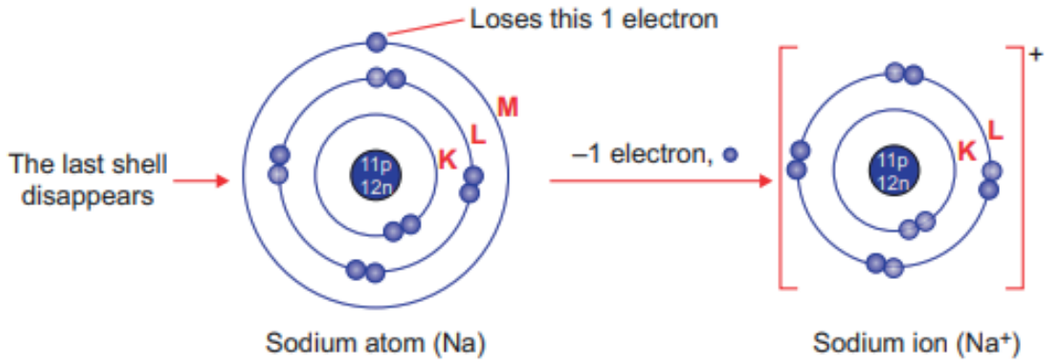
Example 1:

Lithium (Li) a metal atom has atomic number 3. Its electronic configuration (E.C) is 2:1. It **loses 1** electron to acquire a stable **duplet** structure of Helium with an electronic configuration of 2. The ion formed has a charge of **+1** and the ion is written as Li^+

Representation

Element/atomic no	Protons/electrons in neutral atom	E.C	Acquire stable electronic structure	Equation of ion formation	Protons/electrons in ion formed
Li (3)	3 protons, 3 electrons	2.1	***Lose*** 1 electron	$Li - 1e^- \longrightarrow Li^+$	3 protons, 2 electrons

Also consider, sodium (Na) atom with atomic number of 11. It will lose one electron in its outermost shell and form a sodium ion, Na^+.



Question: Draw a diagram to illustrate how magnesium form its ion.

Lesson 8.2: Formation of Negative (Anion) Ions

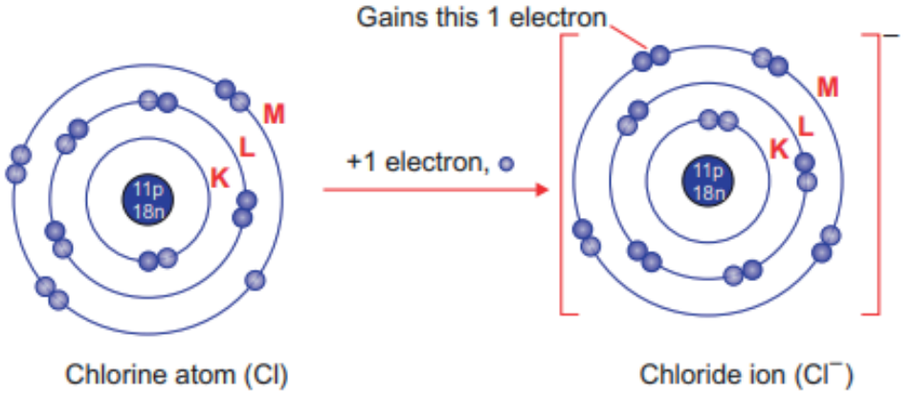
Non-metals readily gain one or more electrons into their outermost shell to form a negative ion or anion (except hydrogen, which can either gain or lose). The number of negative charges an anion carries is equal to the number of electron(s) gained by the non-metal atom.

Example

Chlorine (Cl), a non-metal atom, has atomic number 17. Its electronic configuration (E.C) is 2.8.7. It **gains 1** electron to acquire a stable **octet** structure of neon with an electronic configuration of 2.8.8. The ion formed has a charge of **-1** and the ion is written as **Cl^-**.

Representation

Element/atomic no	Protons/electrons in neutral atom	E.C	Acquire stable electronic structure	Equation of ion formation	Protons/electrons in ion formed
Cl (17)	9 protons, 9 electrons	2.8.7	***Gains*** 1 electron	$Cl + 1e^- \rightarrow Cl^-$	9 protons, 10 electrons



Question: Draw a diagram to illustrate how Sulphur forms its ion.

ACTIVITY 1: Formation of ions from atoms of elements

Copy and complete the table below regarding the formation of ions of some common elements.

Atom/formula/ (Z)	E.C	Protons/Electrons	Electrons Gained/Lost	Equation of Ion Formation	Ion Formula	Valency
Beryllium – Be - (4)						
Boron – B - (5)	2.3	5/5	3	$B - 3e^- \longrightarrow B^{3+}$	B^{3+}	3
Carbon – C – (6)	T5	6/6				
Oxygen						
Calcium						
Phosphorous						
Magnesium						
Chlorine						
Sodium						
Aluminium						
Silicon						
Nitrogen						
Potassium						
Sulphur						

Revision Question

1. Draw diagrams to illustrate how atoms of the elements in the table above form their respective ions.

Research Questions

1. Identify elements that are multivalent.
2. a) Define a radical.
   b) Give examples of radicals and their valences.

Topic 9: Chemical Equations

Learning Objectives

By the end of these lessons, you will be able to:

i) define word equation.
ii) write word equations.
iii) define formulae equation.
iv) write formulae equations.
v) balance formulae equations

Introduction

Chemical reactions play an important role in our daily lives. When we look around us, we see a variety of things that are products of chemical reactions. Can you name some of these things? Also, life sustaining processes such as respiration, digestion and photosynthesis occur through chemical reactions.

Lesson 9.1: Chemical Equations

Procedure

Step 1

Understanding chemical equations

During chemical reactions, the starting substances (**reactants**) are changed into new substances (**products**). The changes that take place during chemical reactions are normally represented using **chemical equations**. Therefore, a chemical equation is a shorter way of representing a reaction. A chemical reaction can be represented by a word equation or by use of chemical symbols. For example:

$$A + B \longrightarrow C + D$$

where A and B are reactants, and C and D are products. The arrow means "**to give**"

It must include state symbols, which show the physical states of each substance. It must be balanced (equal number of atoms of the reactants and products).

A balanced equation must have the same number and types of atoms after a chemical change as were present before the chemical reaction took place. Thus, a chemical equation is a shorter way of representing a chemical reaction. Moreover, it is a convenient and efficient way to communicate chemical information. It is used as an international code for describing chemical change.

Step 2

Questions

1. What is a chemical equation?
2. What does a balanced equation mean?

Activity 9.1: Identifying the guidelines on steps for balancing chemical equations

To write an equation, one must know the reactants and the products.

First: Write a word equation to show the reactants and products.

Second: Write the correct chemical formula under each reactant and each product.

Third: Count the number of atoms of each element on the left-hand side of the equation and on the right-hand side. **Check if**:

1) the number of atoms of each element on each side of the equation is the **SAME** and that the equation is **BALANCED.**
2) the number of atoms of each element on each side of the equation is NOT **the SAME** and that the equation is **NOT BALANCED**.**BALANCE** the equation by inserting an appropriate number in front of the whole chemical formula. The chemical formula of the substance must **never** be changed.

Work example

Write a balanced equation for the reaction between hydrogen and oxygen to form water.

SOLUTION

STEPS	**DEVELOPMENT OF EQUATION**
1. Word equation	Hydrogen + Oxygen ⟶ Water
2. Correct chemical formula	$H_2 + O_2$ ⟶ H_2O
3. Count atoms of each element on each side	LEFRT SIDE RIGH SIDE 2 **H** 2 **O** 2 **H** 1 **O** The equation is not balanced, multiply the formula of water by 2
4. Multiply H_2 by 2	$H_2 + O_2$ ⟶ $2H_2O$
	LEFRT SIDE RIGH SIDE 4 **H** 2 **O** 2 **H** 2 **O** The equation is still not balanced, multiply the formula hydrogen by 2
5. CHECK IF all atoms are balancing on both sides	$2H_2 + O_2$ ⟶ $2H_2O$ LEFRT SIDE RIGH SIDE 4 **H** 4 **H** 2 **O** 2 **O** -The equation is balanced
6. Add correct state symbols for all the reagents	$2H_2(g) + O_2(g)$ ⟶ $2H_2O(l)$

ACTIVITY 1: Balancing chemical equations

Following the steps used in the work example above, balance the following equations.

1. Magnesium plus oxygen to form magnesium oxide.
2. Sodium plus chlorine to form sodium chloride.
3. Hydrogen peroxide decomposes to form water and oxygen.
4. Hydrogen burns in chlorine to form hydrogen chloride.

Topic 10: Acids, Bases and Indicators

Learning Objectives

By the end of these lessons, you will be able to:

i) define an acid, base and indicator.
ii) prepare and use plant extracts as acid–base indicators.
iii) use universal indicator to determine the pH of solution.
iv) give examples of acids and bases.
v) outline some applications of acid–base neutralization.

Introduction

Acids and bases are substances which are important in our everyday lives. The sharp taste of lemon juice is by citric acid, the smell of urine is ammonia which is a base. Tasting using the tongue or smell is not a very scientific way of testing for an acid or a base. This is because it is subjective to an individual and it is also dangerous. This topic looks at methods of identifying if a substance is an acid or a base, using an indicator.

Lesson 10.1: Identifying Acids and Bases using Indicators

ACTIVITY 1: Preparing the indicator using plant extracts

Materials needed:

- A pestle and a mortar
- Petals preferably of hibiscus
- Alcohol
- Improvised beaker containers (empty mineral water bottles)

Procedure

Steps

1. Collect the petals of a hibiscus flower
2. Put the petals of one flower in the mortar or pestle and add a small amount of alcohol (ethanol).
3. Crush the petals in the mortar using the pestle.
4. Decant the liquid off from the crushed mixture into a container.

Question: What is the colour of the indicator you have prepared?

(Keep the prepared indicator for the next lesson.)

Lesson 10.2: Investigating pH of solutions

ACTIVITY 2: Testing various solutions using the plant extract indicator

Materials needed:

- Lemon juice
- Soap solution
- Wood ash solution
- Water
- Improvised transparent containers (empty water bottles)

Procedure

1. Pour a small amount of one of the solutions to be tested in an empty y water bottle.
2. Add a few drops of the plant extract indicator prepared in **Activity 1**.
3. Observe the colour it changes to and record your results in the table below.

TABLE 1.

Solution	Nature of liquid	Colour Change on Addition of Indicator
Water	Neutral	
Lemon Juice	Acidic	
Soap Solution	Alkaline	
Wood ash solution	Alkaline	

Discussion/Summary

From the observations in table 1 above:

1. State how your indicators changes under different pH media.

Topic 11: Salts (Ionic Compounds)

Learning Objectives

By the end of these lessons, you will be able to:

1. define salt.
2. identify soluble and insoluble salts.

Introduction

Common salt or sodium chloride is a material that is very familiar, important in the diet and in industry. A salt is formed when an acid is neutralized by a base. While salts are ionic compounds, not all salts are soluble in water. The solubility of a salt has to be considered before deciding on the method of its preparation. This topic looks at classification of salts, their preparation and the effect of heat on them.

Lesson 11.1: Finding the Solubility of Salts in Water

ACTIVITY 1: Investigating the solubility of substances in water

Materials Needed:

- Common salt
- Sugar
- Baby powder
- Sand
- Clean empty containers
- water

Procedure

1. Add a table spoonful of each of the above substances in separate containers.
2. Add 10 ml of water to each container and stir with the table spoonful.
3. Record your observations in the table below.

Substance	Observation on addition of water
Sand	
Sugar	
Baby powder	
Common salt	

Questions

1. a) From your experiment above, identify the substances which are
   i) Soluble
   ii) Insoluble
   b) In each case give a reason for your answer?

Summary of Solubility of Salts

SOLUBLE	INSOLUBLE
ALL NITRATES	-
ALL SULPHATES	Barium sulphate, lead sulphate, calcium sulphate is slightly soluble
All chlorides	Lead (II) chloride, silver chloride
Potassium, sodium, ammonium salts	
Potassium carbonate, sodium carbonate, ammonium carbonate	All carbonates
Potassium oxide, sodium oxide	All oxides
Oxides and hydroxides of potassium, sodium and ammonium	All other oxides and hydroxides (calcium and magnesium are slightly soluble)

Question

1. Indicate if the following salts are soluble or insoluble
   a) Sodium chloride
   b) Silver chloride
   c) Lead (II)nitrate
   d) Barium sulphate
   e) Copper (II) chloride
   f) Magnesium sulphate
   g) Ammonium chloride

Topic 12: Effect of Electricity on Substances

Learning Objectives

By the end of these lessons, you will be able to:

i) define conductor/non-conductor and electrolyte/non-electrolyte.
ii) state the relationship between electrolytes, non-electrolytes and the particles they contain (ions, molecules).
iii) name the products of electrolysis of simple binary electrolytes.
iv) explain what electrolysis means.

Introduction

When an electric current is passed through a solution which can conduct electricity, it is decomposed and new substances are formed. They are classified as **ELECTROLYTES**. This knowledge finds application in processes like extraction of elements from their solutions e.g. production of sodium and chlorine from strong sodium chloride solution, in the purification of substances e.g. making impure copper, the **ANODE** and in electroplating of substance, the **CATHODE.**

NOTE: Solutions which do not conduct an electric current are called **NON-ELECTROLYTES.**

Lesson 12.1: Conductors/Non-conductors and Electrolytes/Non-electrolytes

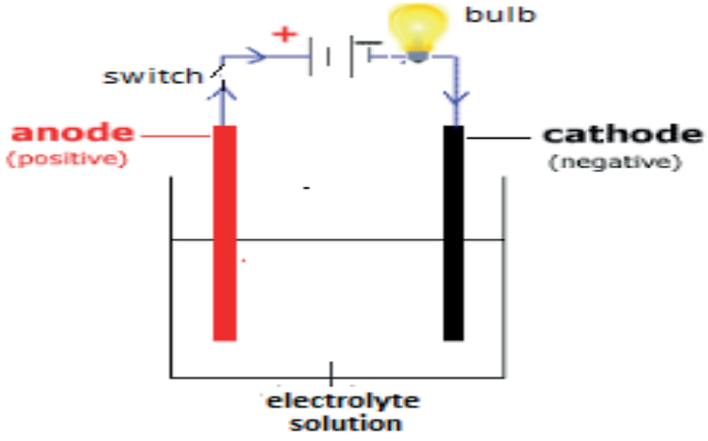
ACTIVITY 1. Investigating which substances conduct electricity

Materials needed:

- Improvised battery (6V, DC supply circuit)
- A bulb
- Wires
- Different solutions
- Solids

Method/Procedure

1. Below is a set-up of the electrolytic circuit for experiments on the effect of electricity on substances.



Hope, a Senior Two student, set up the above experiment to investigate the different common substances which can conduct electricity. She summarized her findings in the table below. In the experiments, she indicated **(YES**) when the bulb lights and (**NO**) when the bulb does not light.

2. Record your results/observations in the table below and answer questions that follow.

Results

Substance	In Molten Form	In Solution	In Solid Form
Sodium Chloride	YES	YES	NO
Sugar	NO	NO	NO
Copper strip	YES	insoluble	YES
Wax	NO	NO	NO

Questions

1) Categories each of the substances in the experiment as either an electrolyte, non-electrolyte, conductor or a non-conductor.

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