Chemistry Syllabus
Grade 8

General Objectives of Grade 8 Chemistry

1. **To Develop Understanding and Acquire Knowledge of:**
   - classification of compounds into organic and inorganic.
   - importance and names of common organic and inorganic compounds.
   - Preparation and properties of common inorganic compounds.
   - general properties, occurrence and uses of some important metals and non-metals.
   - uses of some common compounds of non-metals.
   - composition of air, pollution of air and global warming.
   - hardness and softness of water, water pollution and purification.
   - composition, properties and methods of improving soil.
   - composition and uses of some fossil fuels.
   - techniques of calculations based on formulas.

2. **To Develop Skills and Abilities of:**
   - identifying acidic, basic and neutral solutions.
   - demonstrating effects of hardness of water and its removal.
   - using and interpret symbols, formulas, models and equations.
   - solving mathematical problems based on formulas.
   - using experimental methods in their daily life.
   - demonstrating scientific enquiry skills: observing, classifying, comparing and contrasting, communicating, asking questions, designing experiments, drawing conclusion, applying concepts and problem-solving.

3. **To Develop the Habit and Attitude of:**
   - having an interest and curiosity towards the environment.
   - being responsible about the safety of oneself, others and the environment.
   - appreciating and predicting clean and healthy living.
   - being cooperative, being systematic, thinking rationally.

Unit 1: Classification of compounds *(17 periods)*

Unit outcomes: Students will be able to:

- explain the classification of compounds into organic and inorganic.
- know the formulas, names and importance of hydrocarbons.
- explain the classification of inorganic compounds into oxides, acids, bases and salts.
- know the properties, preparations and uses of common oxides, acids, bases and salts.
- develop skills in identifying acidic, basic and neutral solutions.
- explain the safety precautions while working with acids and bases.
- demonstrate scientific inquiry skills along this unit: Observing, classifying, comparing and contrasting, communicating, asking questions, designing experiment, drawing conclusion, applying concepts and problem solving.

Competencies	*Contents*	*Suggested activities*
Students will be able to:	***1. Classification of compounds***	
• Tell that compounds are classified as organic and inorganic	**1.1 Introduction** *(1 period)*	Students should be aware that chemical compounds can be loosely divided into two groups called organic compounds and inorganic compounds. Students could discuss the historic origins of these terms, and in particular the relationship between organic chemicals and living things. More able students could find out about the 'vis vitalis' and the significance of Wohler's synthesis of urea, an organic chemical, from inorganic starting materials.
• Define organic compounds as the study of carbon containing compounds	• Organic compounds	Students should be aware of the modern definition of organic chemistry as the chemistry of carbon excluding the chemistry of carbonates, hydrogencarbonates, carbon monoxide and carbon dioxide which are inorganic
• Define inorganic compounds as the study of non-carbon containing compounds	• Inorganic compounds	Students should be aware of the modern definition of inorganic chemistry as the chemistry of elements and their compounds other than carbon
	1.2 Organic compounds *(4 periods)*	
• Write the general formula of alkanes, alkenes and alkynes	• Formula	Students should be aware that organic compounds are classified into groups – called homologous series – on the basis of a functional group. Students should understand that hydrocarbons are organic compounds whose molecules are composed of hydrogen and carbon only – hence the name. They should be made aware of the three groups of hydrocarbons: alkanes, alkenes and alkynes Students should appreciate that all members of a group can be represented by a general formula:

Competencies	***Contents***	***Suggested activities***
• Write the specific chemical formulas of the first ten members of alkanes, alkenes and alkynes		Alkanes – can be expressed by the general formula C_nH_{2n+2}, where n is the number of carbon atoms. Alkenes – have the general formulas C_nH_{2n} Alkynes –the general formula C_nH_{2n-2} Students should use the general formula to write the actual formulas of alkanes, alkenes and alkynes for different values of n. Students could be asked to give examples of molecular formulas of alkanes, alkenes and alkynes.
• Name the first ten members of alkanes, alkenes and alkynes	• Nomenclature	Students should understand that the name of a hydrocarbon is derived from the number of carbon atoms present (prefix) and the ending it contains (suffix). Students should be given the prefixes used for hydrocarbons containing up to 10 carbon atoms: 1 meth, 2 eth, 3 prop, 4 but, 5 pent, 6 hex, 7 hept, 8 oct, 9 non, 10 dec Students should be given the suffixes for the three groups of hydrocarbons: alkanes – ane, alkenes –ene, alkynes –yne. Students could be asked to construct the name of a compound from information given e.g. an alkene containing 7 carbon atoms is heptene. They could also be asked to deduce the molecular formula of a hydrocarbon from its name e.g. butane is an alkane containing 4 carbon atoms
• List some common uses of organic compounds	• Importance	Students should be able to identify important uses of some hydrocarbons. These could include: • Methane – fuel gas • Propane and butane – bottled gas (buta gas) • Octane – component of petrol (fuel for engines) • Decane-components of kerosene (for cooking and lighting) • Ethene and propene – feedstock for polymers(starting material for plastics) • Ethyne – at high temperature for cutting and welding Students could also identify important uses of organic chemicals other than hydrocarbons. These could include: • Ethanol – in alcoholic drinks • Ethanoic acid – in vinegar • Formalin - preservation
	1.3 Inorganic compounds *(12 periods)*	
• Tell that inorganic compounds are classified into oxides, acids, bases and salts		Students should be aware that, just as with organic compounds, inorganic compounds can be classified into groups according to their composition and their properties. These include: • Oxides • Acids

Competencies	***Contents***	***Suggested activities***
		• Bases • Salts
• Define oxides	• Oxides	Students should understand that oxides are formed when elements react with oxygen. Oxides can be classified as follows:
• Classify oxides into metallic and non metallic • Give examples of metallic and non metallic oxides. • Define acidic oxide and basic oxide, • Give examples of acidic and basic oxides.	- Types of oxides Metallic oxides Non metallic oxides	• Metallic oxides - binary compounds containing only metals and oxygen. eg. Na_2O, Al_2O_3, MgO • Non-metallic oxides - binary compounds containing non metals and oxygen. • eg. CO_2, , SO_3, H_2O • Basic oxides react with acids – most oxides of metals • Acidic oxides react with bases – most oxides of non-metals
• Describe the properties of acidic oxides and basic oxides.	- Properties of oxides	
• Explain the preparations of acidic oxides and basic oxides. • Prepare sulphur dioxide in the laboratory by burning sulphur in air • Use moist blue litmus paper to test the acidic nature of sulphur dioxide • Prepare magnesium oxide in the laboratory by burning magnesium ribbon in air • Use red litmus paper to test the basicity of magnesium oxide in water solution	• Preparation of oxides	Students should explore two of the methods of preparing oxides. These could include: • Direct synthesis • Thermal decomposition. Students could prepare oxides by heating elements in air or in pure oxygen. These could include: • Carbon – to form carbon dioxide, an acidic oxide • Iron wool – to form iron oxide, a basic oxide Students should prepare sulphur dioxide, an acidic oxide, by burning sulphur in air in a gas jar. The resulting gas should be shaken with a small amount of water and litmus solution or blue litmus paper should be added to demonstrate that the resulting solution is acidic. Students should prepare magnesium oxide, a basic oxide, by burning magnesium in air in a gas jar. The resulting powder should be shaken with a small amount of water and litmus solution or red litmus paper should be added to demonstrate that the resulting solution is alkaline (basic). Students could investigate the formation of oxides by the thermal decomposition of: • Copper hydroxide • Copper carbonate • Copper nitrate Students could be asked to predict the nature of the oxides formed by some metals, such as

Competencies	***Contents***	***Suggested activities***
		sodium and calcium, and some non-metals such as carbon and phosphorus.
• Define acid as a substance that releases hydrogen ions in water solution.	• Acids	Students should appreciate that acids are a group of substances that all release hydrogen ions, H+, when in aqueous solution. and they have soon taste. Students should give list of some acidic substances in their daily life. These could include lemon juice, vinegar, sour talla and milk.
• Give some common examples of acids.		Students should be able to name the three common laboratory acids: • Hydrochloric acid • Nitric acid • Sulphuric acid Students could also identify less common acids including: • Methanoic (formic) acid • Ethanoic (acetic) acid • Benzoic acid
• Define PH as the measure of acidity or alkalinity of a solution • Describe PH scale	- The PH scale	Students should be aware that the PH scale ranges from 0 - 14.
• Explain preparation of acids by direct combination of elements and reaction of acidic oxide with water	- Preparation	Students should be familiar with preparation of the three common laboratory acids. This could include the direct synthesis followed by dissolution in water and reaction of acid anhydride with water. • Dinitrogen penta oxide • Nitric acid • Sulphur trioxide • Sulfuric acid • Hydrogen and chlorine • Hydrochloric acid
• Describe the properties of acids • Conduct experiments on the properties of acids.	- Properties	Students should investigate the properties of acids by experiment. This could include: • Effect on acid-base indicators • Reaction with metals (e.g. iron, zinc, aluminium, magnesium), • Reaction with carbonates and hydrogencarbonates • Neutralising effects on bases As a result of these experiments students should deduce the general properties of acids.
• List some common uses of hydrochloric acid, nitric acid and sulphuric acid	- Uses of hydrochloric acid, nitric acid and sulphuric acid	Students should research the uses of the three common laboratory acids. These could include: • hydrochloric acid – pickling metals • nitric acid – fertilisers, explosives • sulphuric acid – fertilizer, carbatteries etc.

Competencies	***Contents***	***Suggested activities***
• Define base as a substance that neutralises an acid • Define an alkali as a substance that releases hydroxide ions in aqueous solution • Give some common examples of bases	• Bases	Students should appreciate that bases are a group of substances that all react with acids by neutralising them to form salts. They should also know that bases which are soluble in water are called alkalis. Alkalis release hydroxide ions, OH-, when in aqueous solution and have better taste. Students should be able to name the three common laboratory alkalis: • Sodium hydroxide solution • Calcium hydroxide solution • Ammonia solution Students should be able to name some common bases including metal oxides and hydroxides.
• Prepare bases by the reaction of metals with water and basic oxides with water	- Preparation	Students should already be familiar with the preparation of the alkali magnesium hydroxide from previous work on metal oxides. This could be extended to provide a general route to the preparation of alkalis. Students could prepare calcium hydroxide by heating calcium in air/oxygen and dissolving the resulting calcium oxide in water.
• Describe the properties of alkalis • Investigate properties of bases experimentally	- Properties	Students should investigate the properties of bases by experiment. This could include: • Effect on acid-base indicators • Neutralising effects on acids As a result of these experiments students should deduce the general properties of alkalis.
• List some common uses of sodium hydroxide, magnesium hydroxide and calcium hydroxide	- Uses of sodium hydroxide, magnesium hydroxide and calcium hydroxide	Students should research the uses of common bases. These could include: • Sodium hydroxide - oven cleaner, soap making, making artificial fibres such as rayon • Magnesium hydroxide – in anti-acid preparations • Calcium hydroxide – limewater, mortar, neutralises acidic soils
• Define dilute and concentrated acid and base • Describe concentrated acidic and alkaline solutions • Describe dilute acidic and alkaline solutions	• Dilute and concentrated acids and alkalis	Students should be able to define concentrated and dilute acidic and basic solutions. Students should appreciate that acids and alkalis may be used as concentrated and dilute solutions. For most laboratory experiments we work with dilute solutions since they are less hazardous.

Competencies	***Contents***	***Suggested activities***
• Explain the safety precautions while working with acids and bases	• Precautions in working with acids and bases	Students should be aware of the corrosive nature of both acids and alkalis and take suitable precautions when working with them. These precautions should include: • Wearing eye protection (goggle) • Wearing protective clothing such as an apron or laboratory coat • Keeping reagent bottles stoppered when not in use • Wiping up all spillages straight away with a wet cloth
• Give some common examples of salts	• Salts	Students should give some common salts. These could include: • Sodium chloride (table salt) • Sodium bicarbonate • Calcium carbonate • Diammonium phosphate (DAP) • Potassium nitrate Students should appreciate that in chemistry the term 'salt' applies to a group of compounds. In order to avoid confusion common salt should be referred to as table salt and not just salt. Students should already be aware from the work on acids and bases that acids react with bases to produce a group of chemicals called salts.
• Name some common salts	• Naming salts	Students could discuss groups of salts and relate their names to the acid from which they are derived e.g. • Chlorides (hydrochloric acid) • Nitrates (nitric acid) • Sulphates (sulphuric acid)
• Define salts as compounds that are composed of the positive ions of a base and the negative ions of an acid.		Students could derive the name of a salt prepared from a given base and acid e.g. sodium hydroxide + hydrochloric acid → sodium chloride. Students could suggest a combination of a base and an acid to make a named salt e.g. copper oxide + sulphuric acid → copper sulphate From the names of the salts, students should deduce that a salt consists of positive ions (provided by the base) and negative ions (provided by the acid).
• Tell that salts are classified as binary and ternary • Define binary salts • Define ternary salts • Give examples of binary and ternary salts	• Classification of normal salts - Binary salts - Ternary salts	Students should understand that salts can be classified according to the number of elements they contain. Binary salts, such as sodium chloride, contain two elements, sodium and chlorine while ternary salts, such as sodium sulphate, contain three elements, sodium, sulphur and oxygen. Students could be given examples of salts and asked to classify them as binary or ternary, and to write their formulas.

Competencies	*Contents*	*Suggested activities*
• Explain direct elemental combination and neutralization reactions as methods of salt preparation	• Preparation - Direct combination - Neutralization	Students should appreciate that some salts can be made by the direct combination of elements e.g. sodium chloride results from burning sodium in chlorine. They should appreciate that this works for some chlorides but not for nitrates and sulphates. Students should appreciate that the more general and useful method of preparing salts is by neutralisation reactions involving acids and bases. Students should prepare salts using different routes including: • Basic oxide + acid • Metal hydroxide + acid Students should appreciate that not every method is suitable for preparing every salt. Students could discuss suitable reactions for preparing samples of named salts.
• List some uses of common salts	• Uses	Students should research the important uses of particular salts. These could include: • Sodium chloride • Calcium carbonate • Sodium bicarbonate • Potassium nitrate • DAP Students could prepare a three-minute presentation on the preparation and uses of important salts.

Assessment

The teacher should assess each student's work continuously over the whole unit and compare it with the following description, based on the Competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level
Students working at the minimum requirement level will be able to define and explain the essence of chemistry, discuss the relationships between chemistry and other natural sciences, describe the application of chemistry in production and list some common chemical industries in Ethiopia, their raw materials and products.

Students above minimum requirement level
Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level
Students working below the minimum requirement level will require extra help if they are to catch up with the rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

Unit 2: Some important metals *(12 periods)*

Unit Outcomes: Students will be able to:

- know the general properties of metals
- explain the occurrence and uses of sodium, potassium, magnesium, calcium, aluminium, iron, copper, silver, gold, platinium and tantalum.
- recognize common and important ores of sodium, potassium, magnesium, calcium, aluminium, iron, copper, silver, gold, platinum and tantalum.
- describe some of the common properties of alloys and explain their uses
- describe scientific inquiry skills along this unit: observing, comparing and contrasting, communicating, asking questions, drawing conclusions, applying concepts, problem solving.

Competencies	***Contents***	***Suggested Activities***
Students will be able to: • Mention general properties of metals	***2. Some important metals*** **2.1 General properties of metals** *(1 period)*	As an introduction to this unit, students could name common metals and discuss their uses. Students should be able to identify general properties of most metals including: • Good thermal and electrical conductor • Solids at room temperature (except mercury) • Hard (some) • Malleable (some) • Ductile (some) • Lustrous (some) • Sonorous (some) • High melting and boiling points
• Investigate general properties of metals practically • Present a report of their project work on the properties of Fe, Ag and Au after visiting the works of blacks smith and goldsmith		Students could carry out an experiment to investigate some of the above mentioned properties of common metals including: • Iron • Copper • Aluminium • Lead • Zinc Students should be given a project work to visit the works of black smith and gold smith and present a report on the properties of Fe, Ag and Au to their class.
• Explain the occurrence of sodium and potassium	**2.2 Sodium and potassium** *(2 periods)* • Occurrence	Students should appreciate that sodium and potassium are in Group 1 of the Periodic Table and are therefore too reactive to occur as native metal.

Competencies	*Contents*	*Suggested Activities*
		Students could discuss what would happen if metallic sodium or potassium was left in soil for any length of time. Students could discuss why sodium and potassium were not isolated until the early nineteenth century while other metals like gold, silver and copper have been known since ancient times.
• List common ores of sodium and potassium	• Important ores	Students should identify the main ores of sodium and potassium including: • Sodium – halite (table salt) • Potassium – sylvite
• Discuss the uses of sodium and potassium	• Uses	Students should be aware that these elements are too reactive to be used as metals. Students could research the uses of potassium and sodium compounds including: • Some Potassium salts in fertilisers • Potassium nitrate and potassium chlorate in explosives • Potassium mangante(VII) as medicine (drying agent) Students could research the uses of sodium compounds including: • Sodium chloride as a preservative and as food additive • Sodium hydroxide in soap making and other industrial processes • Sodium carbonate and sodium sulphate in glass industry.
	2.3 Magnesium and calcium *(2 periods)*	
• Explain the occurrence of magnesium and calcium	• Occurrence	Students should appreciate that magnesium and calcium are in Group 2 of the Periodic Table and are therefore too reactive to occur as native metal. Students could carry out an experiment in which they leave samples of metallic magnesium or calcium in soil for a couple of weeks to observe the effect this has on the metals. Students could discuss why magnesium and calcium were not isolated until the early nineteenth century while other metals like gold, silver and copper have been known since ancient times.
• List common ores of magnesium and calcium	• Important ores	Students should identify the main ores of magnesium and calcium including: • Magnesium – dolomite, magnesite • Calcium – limestone, dolomite
• Discuss the uses of magnesium and calcium	• Uses	Students should be aware that magnesium is used in flares and fireworks. They should link this to the bright light emitted when magnesium burns in air. Magnesium is also used with aluminium to make low density alloys. Students could research the uses of some magnesium compounds. These could include: • Magnesium oxide – furnace lining • Magnesium hydroxide, chloride, sulphate, citrate – medical uses Students should be aware that calcium has limited use as a metal. It is used in the manufacture of some other metals, and in some alloys.

Competencies	*Contents*	*Suggested Activities*
		Students could research the uses of some calcium compounds. These could include: • Calcium oxide/hydroxide – soil acidity • Calcium compounds in building materials such as cement, mortar, gypsum and marble Students should remember that aluminium is in Group 3 of the Periodic Table and is too reactive to occur as native metal.
	2.4 Aluminium *(1 period)*	
• Explain the occurrence of aluminium	• Occurrence	Students could discuss why aluminium was not isolated until the early nineteenth century while other metals like gold, silver and copper have been known since ancient times. They could also discuss why, when first discovered, it was more expensive than gold.
• List common ores of aluminium	• Important ores	Students should identify the main ores of aluminium including: • Bauxite
• Discuss the uses of aluminium	• Uses	Students should be aware of the uses of aluminium including: • Cooking utensils • Door and window frames • Low density alloys
	2.5 Iron *(1 period)*	
• Explain the occurrence of iron	• Occurrence	Students should be aware that iron has been known since ancient times. From this they should deduce that it is easier to extract iron from its ores than the metals discussed in the previous sections.
• List common ores of iron	• Important ores	Students should identify the main ores of iron including: • haematite • magnetite
• Discuss the uses of iron	• Uses	Students should be aware that iron is most frequently used as the alloy steel, which is stronger than pure iron. Students should discuss the uses of iron/ steel including: • Building construction – girders (Ferro) • Fabrications – car bodies etc. • Common items e.g. bicycle frames, tin cans etc.
	2.6 Copper and silver *(1 period)*	
• Explain the occurrence of copper and silver	• Occurrence	Students should be aware that both copper and silver have been known since ancient times. Students should also be aware that both metals can be found as native metal i.e. as metal in the ground. From this they should deduce that copper and silver are easy to be extracted from their ores.
• List common ores of	• Important ores	Students should identify the main ores of copper and silver including:

Competencies	*Contents*	*Suggested Activities*
copper and silver		• Copper – native metal, chalcopyrite, chalcocite, malachite • Silver – native metal, argentite
• List the uses of copper and silver	• Uses	Students should discuss the uses of these metals including: • Copper – electrical wiring, piping, coinage • Silver – electrical wiring and ornaments
	2.7 Gold, platinum and tantalum *(2 periods)*	
• Explain the occurrence of gold platinum and tantalum	• Occurrence	Students should be aware that gold and platinum have been known since ancient times although very little attention was paid to platinum as it was neither prized nor used in the same way as gold. Students should be aware that both gold and platinum are found as native metal. From this they should be able to make certain deductions about their reactivity. Students should know that tantalum was discovered around two hundred years ago.
• List common ores of gold, platinum and tantalum	• Important ores	Students should identify the main ores of gold, platinum and tantalum including: • Gold – native metal, calaverite • Platinum - native metal, sperrylite • Tantalum – tantalite
• List the uses of gold platinum and tantalum.	• Uses	Students should discuss the uses of these metals including: • Gold – electrical wiring, jewellery • Platinum – jewellery, catalyst • Tantalum – capacitors, surgical uses
	2.8 Alloys *(2 periods)*	
• Define the term alloy	• Advantages of alloying metals	Students could be asked to define alloys Use some common alloys to introduce the idea of modifying the properties of a metal by mixing other elements (often but not always other metals).
• Give examples of some common alloys		These alloys could include: • Steel – iron and carbon • Brass – copper and zinc • Bronze – copper and tin • Cupronickel – copper and nickel • Electrum – gold and silver
		Students could discuss why alloys were often used in ancient times e.g. bronze and electrum, because people had no means of separating the metals.
• Describe the importance of alloying		Students could discuss why an alloy might be more useful than a pure metal. For example, pure gold is very soft and jewellery made of pure gold would soon wear away so other metals are added to harden the gold.

Competencies	*Contents*	*Suggested Activities*
• Identify the components of some common alloys • Describe some of the common properties of alloys • Explain the uses of some common alloys	• Some common alloys and their uses	Students could research how the purity of gold is expressed – 24 carat is pure gold thus 18 carat is 75% gold etc. Students could research other alloys and find out why they are used. These could include: • Duralumin – an alloy of aluminium, magnesium, copper and manganese which still has a low density but is stronger than pure aluminium. As the result it is used in air craft industry. • Solder – an alloy of lead and tin which has a low melting point so it can be easily melted to join copper wires and pipes • Bronze – an alloy of copper and tin which is harder than pure copper. It is used in making general metal work, medals, coins and sculptures. • Stainless steel – an alloy of iron, carbon, chromium, nickel which is strong but does not rust. It is used for making cuttlery, tools and surgical instruments • Brass - an alloy of copper and zinc. It is used to make ornaments, nuts and bolts and musical instruments. Students should link the properties of an alloy to the ways in which it is used.

Assessment

The teacher should assess each student's work continuously over the whole unit and compare it with the following description, based on the Competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level
Students working at the minimum requirement level will be able to: Know the general properties of metals, explain the occurrence and uses of Na, K, Mg, Ca, Al, Fe, Cu, Ag, Au, Pt and Ta, recognize common and important ores of Na, K, Mg, ca, Al, Fe, Cu, Ag, Au, Pt and Ta, describe some of the common properties of alloys and explain their uses.

Students above minimum requirement level
Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level
Students working below the minimum requirement level will require extra help if they are to catch up with the rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

Unit 3: Some important non-metals *(10 periods)*

Unit Outcomes: Students will be able to:

- know the general properties of non-metals and how to differentiate non-metals from metals.
- explain the occurrence and uses of carbon, nitrogen, phosphorous, oxygen and sulphur
- explain the uses of some common compounds of non-metals like carbon dioxide, sodium carbonate, nitric acid, phosphoric acid, calcium phosphate, sulphurdioxide and sulphuric acid.
- describe scientific inquiry skills along this unit: observing, comparing and contrasting, communicating, asking questions, drawing conclusions, applying concepts and problem solving.

Competencies	*Contents*	*Suggested Activities*
Students will be able to:	***3. Some important non-metals***	
• Mention the general properties of Non metals	**3.1 General properties of non-metals** *(1 period)*	Students should appreciate that some non-metals are just as important as metals although they are used in completely different ways. Let the students list some common non-metals and discuss their uses. Students should be able to identify general properties of most non-metals including: • Poor thermal and electrical conductor • Non-malleable and non-ductile, • Non-lustrous • Low M.P. and Low B.P.
	3.2 Carbon *(2 periods)*	
• Explain the occurrence of carbon	• Occurrence	Students should recognise carbon as the basis of all life forms on the Earth. They had already been introduced to carbon chemistry in Unit 1 and been made aware of the historic link between organic chemistry and living organisms. Students should be aware that carbon exists in three solid forms at room temperature: diamond, graphite and fullerenes. They should be aware of the term 'allotropes' which describes different forms of the same element in the same physical state. They should be able to understand properties of diamond – including rigid structure, hard, electrical insulator.
• Discuss the uses of elemental carbon	• Uses	Students should discuss the uses of diamond related to its properties. These could include: • Jewellery – attractive appearance • Cutting and grinding – very hard • Heat sinks – good thermal conductors Students should be able to understand some properties of graphite like electrical conductivity, softness and slippery. Students should discuss the uses of graphite related to its properties. These could include: • Pencils – softness • Graphite greases – slippery • Electrodes in motors – provides electrical contact but soft so wears out without wearing the motor parts

Competencies	*Contents*	*Suggested Activities*
		• Electrodes in dry cell – conducts electricity
	3.3 Nitrogen *(2 periods)*	
• Explain the occurrence of nitrogen	• Occurrence	Students should be aware that nitrogen forms around $^{4}/_{5}$ths of the air. Students should appreciate that nitrogen is much less reactive than oxygen and when substances are heated in air they react with oxygen far more than nitrogen.
• Conduct an experiment to estimate the nitrogen content		Students could investigate practical methods of estimating the nitrogen content of air by removing oxygen and carbon dioxide, and be aware of the limitations of accuracy of this method as it does not remove argon (bell jar experiment) Students should be aware that nitrogen is essential to the growth of plants. Most plants cannot absorb atmospheric nitrogen but obtain nitrogen by absorbing nitrogenous compounds (e.g. nitrates, ammonium compounds, urea) in soil water.
• Discuss the uses of elemental nitrogen	• Uses	Students could research the role of nitrogen-fixing and denitrifying bacteria in the root nodules of leguminous plants, and in the soil. Students should be aware that Nitrogen is used to produce ammonia.
	3.4 Phosphorous *(1 period)*	
• Explain the occurrence of phosphorous	• Occurrence	Students should appreciate that phosphorus has two common allotropes, white phosphorus and red phosphorus. Students should appreciate that, owing to its reactivity with air and other substances containing oxygen, phosphorus is not found as the element, but as compounds which are largely phosphates. For this reason phosphorous is usually kept under water.
• Discuss the uses of elemental phosphorus	• Uses	Students should investigate and discuss the uses of elemental phosphorus. These could include: • Formation of phosphoric acid • Military applications such as incendiary bombs • Matches • In alloys such as phosphor bronze Students could also research the uses of some important compounds of phosphorus including phosphoric acid, sodium tripolyphosphate, calcium phosphate and organophosphorus compounds. Students could investigate the importance of phosphorus in living things – both plants and animals.
	3.5 Oxygen *(1 period)*	
• Explain the occurrence of oxygen	• Occurrence	Students should be aware that oxygen forms around $^{1}/_{5}$ths of the air. They should appreciate that oxygen is the active component of air. Students could also be made aware that oxygen is present in water and that oxygen can be obtained from water by using electrical energy

Competencies	*Contents*	*Suggested Activities*
• Discuss the uses of elemental oxygen	• Uses	Students should be aware that oxygen is essential for combustion and for respiration (life giving) for cutting and welding and as rocket fuel.
• Explain the occurrence of sulphur	**3.6 Sulphur** *(1 period)* • Occurrence	Students should appreciate that sulphur has three allotropes: rhombic sulphur, monoclinic sulphur and plastic sulphur. Students should be aware that sulphur is commonly found as a yellow solid at room temperature and has been known since ancient times. Students could research the countries which are the main providers of elemental sulphur. They should be aware that it is found in Ethiopia (Afar region.)
• Discuss the uses of elemental sulphur	• Uses	Students could discuss the advantages of recycling elemental sulphur including: • Reducing demand on resources • Reducing atmospheric pollution resulting from sulphur dioxide Students should be aware of the uses of elemental sulphur including: • Preparation of match • Preparation of sulphurdioxide (fumigant) • Vulcanization of rubber • Preparation of sulphuric acid • Preparation of gunpowder
• Explain the uses of some common compounds of non-metals.	**3.7 Uses of common compounds of non metals** *(2 periods)* • Carbon dioxide • Sodium carbonate • Nitric acid • Phosphoric acid • Calcium phosphate • Sulphur dioxide • Sulphuric acid	Students should be familiar with the uses of a number of common non- metallic compounds. These could be dealt with isolation or integrated into the previous sections. For example, carbon dioxide could be discussed as part of the work on carbon. Groups of students could research the uses of one compound and prepare a brief summary that could be shared with the class. Uses could include: • Carbon dioxide – fire extinguishers, carbonated drinks • Sodium carbonate – washing soda, making glass • Nitric acid – fertilisers, explosives • Phosphoric acid – food processing, chemical reagent • Calcium phosphate – rising agent, fertilizers • Sulphur dioxide – bleaching agent, preparation of sulphuric acid, fumigant • Sulphuric acid – chemical reagent in most industries

Assessment

The teacher should assess each student's work continuously over the whole unit and compare it with the following description, based on the Competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level

Students working at the minimum requirement level will be able to: Know the general properties of non-metals and how to differentiate non-metals from metals, explain the occurrence and uses of carbon, nitrogen, phosphorus, oxygen and sulphur, explain the uses of some common compounds of non metals like carbon dioxide, sodium carbonate, nitric acid phosphoric acid, calcium phosphate, sulphur dioxide and sulphuric acid.

Students above minimum requirement level

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level

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Unit 4: Environmental chemistry *(20 periods)*

Unit Outcomes: Students will be able to:

- know the composition of air
- understand air pollution, causes of air pollution and effects of air pollutants.
- understand global warming, causes and effects of global warming.
- describe the hardness and softness of water.
- demonstrate the effect of hardness of water and describe the methods of softening of temporary and permanent hard water.'
- understand water pollution and water pollutants.
- understand water purification.
- describe the composition of soil and differentiate acidic, alkaline or neutral soils.
- know the major plant nutrients, explain methods of improving soil fertility and suggest some methods of correcting soil acidity and alkalinity.
- describe elemental composition of coal, natural gas and crude oil and explain their physical properties and uses.
- demonstrate scientific inquiry skills along this unit: observing, classifying, comparing and contrasting, communicating, asking questions, designing experiments, drawing conclusions, applying concepts and problem - solving.

Competencies	***Contents***	***Suggested Activities***
Students will be able to: • Describe the percentage of nitrogen, oxygen and carbon dioxide in the air	***4. Environmental chemistry*** **4.1 Air** *(5 periods)* • Composition	Students should appreciate that air is not a pure substance but a mixture of several gases. The composition should be restricted to oxygen, nitrogen, argon and carbon dioxide. There are traces of other noble gases but these should be ignored for the sake of clarity. Students could draw diagrams, such as a pie chart, to illustrate the composition of air using the values: nitrogen 78%, oxygen 21%, argon 1%, carbon dioxide 0.04%.
• List air pollutants	• Air pollution - Air pollutants	Students should appreciate that since air is a mixture, its composition varies from place to place. It sometimes contains substances which are regarded as pollutants since they are not normally present in air or not present in such high concentrations. Students should identify the following as air pollutants: • Sulphur dioxide • Carbon monoxide • Nitrogen oxides • Particulates • Pollen
• Discuss sources of SO_2, CO, NO_x		Students should understand that there is more than one oxide of nitrogen present in air. Students should discuss sources of the following specific pollutants: • Sulphur dioxide – combustion of fossil fuels • Nitrogen oxides – combustion of fuels in furnaces and car engines • Carbon monoxide – incomplete combustion of fuels

Competencies	***Contents***	***Suggested Activities***
• Explain effects of SO_2, CO and NO_2 in the air	• Effects of air pollutants	Students should research the effects of three pollutants and discuss their findings. The effects should include: • Sulphur dioxide and nitrogen oxides – acid rain – lowering of the pH of rivers and lakes; defoliation; release of heavy metals from soil; erosion of building materials like limestone; increase in iron/mild steel corrosion; respiratory diseases • Carbon monoxide – incomplete combustion of hydrocarbon fuels – absorption into the blood to replace oxygen leading to asphyxia
• Define global warming • Discuss the causes of global warming	• Global warming - Causes of global warming	Students should appreciate that although carbon dioxide occurs in the air as a result of natural processes, human activities have resulted in a small but significant increase in atmospheric levels. Students should understand that the Earth is heated by the Sun and that it, in turn, is constantly radiating heat back out into space. Certain gases in the upper atmosphere, including carbon dioxide, prevent some of this heat from escaping so it is directed back to Earth. This is called the greenhouse effect. This effect was essential for raising the temperature of the Earth to a level where life as we know it is able to live but there has been a small but significant increase in greenhouse gases which has led to an enhanced greenhouse effect resulting in global warming.
• Discuss the effects of global warming	- Effects of global warming	Students should discuss the effects of global warming including: • Climate change • Melting polar caps • Rising sea levels Students should discuss the effects on Ethiopia and the effects on the world as a whole.
	4.2 Water *(6 periods)*	
• Define hard water as a water that does not form lather with soap • State soluble salts of calcium and magnesium as the causes of hardness of water • Conduct an experiment to demonstrate the effect of hardness of water by taking rain water (tap water) and ground water	• Hardness of water	Students should understand that water hardness is related to the ability of water to form a permanent lather with soap and that it is caused by certain calcium and magnesium salts dissolved in the water. The salts dissolve in water as rain water collects on the ground and flows through rocks such as limestone and dolomite. Students could carry out experiments using distilled water, hard water (ground water) and soap solution to observe the effect of hardness. Students should be aware that water hardness can be classified as: • Temporary – caused by dissolved calcium/magnesium hydrogencarbonates • Permanent – caused by dissolved calcium/magnesium chlorides and/or sulphates
• Describe boiling of water and adding washing soda as methods of softening hard water	• Softening of water	Students should discuss the formation of calcium hydrogencarbonate by the reaction of carbonic acid (formed when carbon dioxide dissolves in rain water) and limestone. Students could experiment by blowing carbon dioxide through limewater. Initially it goes milky but then clears as additional carbon dioxide dissolves in the limestone causing the precipitate to redissolve forming temporary hard water ($Ca(HCO_3)_2$.)

Competencies	*Contents*	*Suggested Activities*
• Perform an experiment to soften hard water by boiling and adding washing soda.		Students should link this process to temporary hardness by appreciating that when temporary hard water is heated the carbon dioxide is driven off and soluble calcium hydrogencarbonate is converted to insoluble calcium carbonate. $CaCO_3(s) + H_2O(l) + CO_2(g) \rightleftharpoons Ca(HCO_3)_2$ Students could boil temporary hard water and test its ability, before and after, to form a permanent lather – in order to satisfy themselves that boiling does remove temporary hardness. Students should understand why limescale forms and discuss some of the problems resulting from lime scale. Students could discuss the formation of stalactites and stalagmites. Students could boil permanent hard water and test its ability, before and after, to form a permanent lather – in order to satisfy themselves that boiling does not remove permanent hardness. Students could try to form a permanent lather with permanent hard water and note the formation of scum. Students should appreciate that soap contains sodium stearate and that scum is the result of the formation of insoluble calcium stearate. In order to remove permanent hardness, the calcium (or magnesium) ions must be removed by precipitation using sodium carbonate or washing soda. Calcium ions are precipitated as insoluble calcium carbonate. $Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$ Students could add washing soda to permanent hard water and test its ability, before and after, to form a permanent lather – in order to satisfy themselves that adding washing soda removes permanent hardness.
• Describe the improper ways of disposing domestic and industrial wastes and excessive use of agricultural wastes as the causes of water pollution • Write a report on the causes, effects and prevention of water pollution.	• Water pollution - Water pollutants - Domestic waste - Agricultural chemicals - Industrial wastes	Students should appreciate that much of the water that leaves their homes is no longer pure. They could make a list of the sources of waste water e.g. water from toilets carrying human waste products, water from cleaning carrying detergents, water from washing, water from cooking. They should also appreciate that there are other sources of water pollution including: • Run off from fields carrying fertilisers which have not been absorbed from soil together with other agricultural chemicals which exist as residues on and in the soil • Liquid wastes from factories Students could investigate the effects of water pollution using the internet or other resources such as the library. They should be given key words such as sewage, eutrofication, effluent, acid rain, agricultural pollution and detergent pollution. They should choose one aspect of water pollution and write a report outlining the causes, effects and how it can be controlled or prevented. Students could investigate the problems caused by releasing nitrates and phosphates into the environment in waste water.

Competencies	*Contents*	*Suggested Activities*
		Students could visit a local body of water which is polluted. They should try to ascertain the cause of the pollution, observe the effects that the pollution is having on the organisms that live in the water and in surrounding area, and suggest how the pollution could be remedied.
• Describe the physical, biological and chemical water treatments	• Water purification - Physical treatment - Biological treatment - Chemical treatment	Students could carry out a simple analysis of a sample of polluted water by comparing it with pure water. They could compare properties such as pH, clarity, smell, amount of dissolved solids. Students could visit a local water treatment plant and find out about the processes necessary to turn raw sewage into water that is safe to release into lakes and rivers. Such processes include: • Screening to remove large pieces of solid waste • Filtration to remove fine suspended particles • Action of bacteria to break down waste products • Chlorination to kill harmful organisms • Addition of chemicals like aluminium sulphate to improve clarity
• Conduct simple experiment to purify dirty water		Students could make a model of a water treatment plant in which water is filtered and then chlorinated. They could test whether each of these procedures removed micro-organisms using agar gel plates to grow colonies of organisms.
	4.3 Soil *(6 periods)*	
• Define soil as a thin layer of natural material covering the surface of the Earth. • List the percentage composition of the solid, the liquid and the gaseous portions of soil. • Describe the composition of the solid, the liquid and the gaseous portions of soil. • Conduct an experiment to show composition of soil	• The solid, liquid and gas components of soil	Students could be asked to define soil. Students should appreciate that soil is a growing medium in which plants grow. The soil provides a plant with stability as well as water and minerals essential for growth. Students should be aware that soil consists of components that exist in three physical states, • The solid component - minerals and organic matter • The liquid component - water • The gas component - air. Students could investigate the components of soil by placing soil in a jar with water, shaking the mixture and leaving it to settle. They will see a gradation of particles starting with the largest at the bottom the finest at the top. Humus will float on the water. Students can investigate different characteristics of soil: • Water content – by drying a known mass in an oven at 100 °C • Humus content – by heating a known mass of dry soil on a tin lid with a Bunsen burner • Air content – by mixing 50 cm^3 of soil with 50 cm^3 of water and measuring the total volume • Particle size distribution – by passing a known volume of dry powdered soil through a series of sieves • Water retention – by timing how long it takes water to pass down a column of soil
• Tell that soil can be acidic, alkaline or	• Acidic and alkaline soil • Plant nutrients and soil	These experiments could be carried out on a single type of soil or on different soils and the results for each soil compared.

Competencies	***Contents***	***Suggested Activities***
neutral.	improvement	Students should appreciate that the pH of soil is an important factor in determining its suitability for growing different crops. Students could test samples of soil to determine their pH.
• List the major plant nutrients	• Major plant nutrients	Students should be aware that the major plant nutrients are: • Nitrogen • Potassium • Phosphorus • Magnesium • Calcium • Sulphur Students should be aware that plants need nutrients in order to grow and remain healthy, and that they obtain these minerals from the soil. Students could research the importance of major nutrients.
• Explain methods of improving soil fertility	• Methods of improving soil fertility	Students should be made aware that there are two main groups of fertilisers: naturally occurring fertilisers and chemical fertilisers. Students could identify different types of naturally-occurring fertilisers such as animal dung. They should also be made aware of green fertilisers. Students could investigate the effectiveness of different types of dung as fertilisers. Students could identify different types of chemical fertilisers such as urea, DAP, ammonium nitrate and potassium sulphate. Students should understand what is meant by an NPK fertiliser.
• Prepare ammonium nitrate		Students could make ammonium nitrate by mixing equivalent amounts of ammonia and nitric acid, and evaporating the solution to dryness. Students could discuss the advantages and disadvantages of the two main groups of fertilizers. The work on fertilisers could be linked in to the work on water pollution in Section 4.2 in this unit. Excessive use of fertilisers is a source of water pollution.
• Prepare compost in the school compound. • Apply the compost in school garden.		Students should be given a group project work to consult agricultural development agents to prepare compost and apply in school garden Students could discuss what materials will produce compost. Students should find out about: • The importance of ensuring aeration of compost. • Why it is necessary to water the compost • The function of compost accelerators
• Tell the type of soil that is favourable for crop production	• Acidity and alkalinity	Students should be aware that different crops require different nutrients in different proportions and, as a consequence, each crop grows best in soil within a particular pH range. Students could find the best pH range for growing different crops e.g.: • Potatoes 5.5 – 6.5 • Oats 5.5 – 7.0

Competencies	*Contents*	*Suggested Activities*
		• Beans 6.0 – 7.5 Students should understand that when organic materials, such as dead leaves, animal wastes etc. decay, organic acids are produced and these lower the pH of the soil so, over the years, soil naturally becomes more acidic. Students could measure the pH of different soil samples taken from different locations.
• Suggest some methods of correcting soil acidity and alkalinity		Students should appreciate that in order to prepare the soil to produce good yields of crops, it is often necessary to raise the pH by spreading lime in the form of limestone, quick lime or slaked lime. Students should appreciate that different amounts are needed to reduce the pH of different types of soil. Students could heat limestone strongly to make quicklime, and then add water to the quicklime to make slaked lime. Students could know the effect of lime on changing pH. Students could research how it is possible to reduce the pH of soil using sulphur and irrigation.
	4.4 Fuels *(3 periods)*	
• Define fuel as a substance which releases heat energy when it is burnt (combusted)	• Coal, natural gas and crude oil - Composition	Students could be asked to define fuel. Students should understand that coal, natural gas and crude oil are collectively called fossil fuels. Once refined, they provide a range of fuels. Students should know that coal is an impure form of carbon which formed by the decay of plant material in the absence of air.
• Describe elemental composition of coal, natural gas and crude oil		Students should know that crude oil and natural gas are mixtures of hydrocarbons which formed by the decay of huge deposits of plant and animal remains in the sea which decayed in the absence of air. The composition of hydrocarbons should be linked to the work already carried out in Unit 1. Students could carry out research to identify those areas of the world where large deposits of fossil fuels are to be found. Students should also be aware that it is expected that there are deposits of crude oil, coal, and natural gas in different parts of Ethiopia.
• Explain uses of coal, natural gas and crude oil	- Uses	Students should appreciate that coal is a solid fuel. For domestic use if it generally left as small pieces but when used in power stations it is first pulverised into a fine dust. This makes it easier to move within the power station and ensures a more efficient combustion. Students could research how coal is converted to another fuel called coke. Coke is used in the manufacture of iron. Students should be aware that heating coal in the absence of air produces coke, ammoical liquor, coal tar, coal gas.

Competencies	***Contents***	***Suggested Activities***
		Students could discuss the environmental problems associated with burning coal, and in particular the oxidation of any sulphur or sulphur compounds present in it to form acidic sulphur dioxide. Students could understand fuel gas desulphurisation processes to reduce the sulphur dioxide emissions from power stations. Students should appreciate that natural gas is a gaseous fuel. It can be transferred from place to place along pipes. Students should know that the main constituent of natural gas is methane, but that other small proportions of other gases like ethane and carbon dioxide are also present. Students should discuss the importance of natural gas as a domestic and industrial fuel. Students should appreciate that crude oil is a mixture of many different hydrocarbons and is of no use as a fuel in the form in which it appears out of the ground. The crude oil must undergo a number of different processes, collectively called refinning in order to obtain a range of different fuels and other useful products including: • Bottled gases • Petrol • Diesel oil • Kerosene • Fuel oils • Lubricating oils • Bitumen Students should appreciate that the term petroleum is often used to describe the products after refining thus crude oil produces petroleum products. Students could research the uses of the different petroleum products. Students should be aware that crude oil contains sulphur compounds and that these must be removed from the fuels to prevent the formation of acidic products when the fuels are burnt in engines, and atmospheric pollution when the waste gases are released.

Assessment

The teacher should assess each student's work continuously over the whole unit and compare it with the following description, based on the Competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level

Students working at the minimum requirement level will be able to: know the composition of air, understand air pollution, causes of air pollution and effects of air pollutants, understand global warming, causes and effects of global warming, describe hardness and softness of water, demonstrate the effect of hardness of water and describe the methods of softening of temporary and permanent hard water, understand water pollution and water pollutants, understand water purification, describe the composition of soil and differentiate acidic, alkaline and neutral soil, know the major plant nutrients, explain methods of soil fertility and suggest some methods of correcting soil acidity and alkalinity, describe elemental composition of coal, natural gas and crude oil and explain their uses.

Students above minimum requirement level

Students working above the minimum requirement level should be praised and their achievements recognized. They should be encouraged to continue working hard and not become complacent.

Students below minimum requirement level

Students working below the minimum requirement level will require extra help if they are to catch up with the rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

Unit 5: Calculations based on formulae *(11 periods)*

Unit Outcomes: Students will be able to:

- understand atomic mass, molecular mass, formula mass, the concept of mole, molar mass, percentage composition of compounds, empirical formula and molecular formula.
- know how to determine molecular mass or formula mass from a given atomic mass of elements.
- know how to determine percentage composition, empirical formula and molecular formula of a compound
- demonstrate scientific inquiry skills along this unit: observing , communicating, asking questions and problem solving.

Competencies	*Contents*	*Suggested Activities*
Students will be able to:	***5. Calculations based on formulas*** **5.1 Introduction** *(1 period)*	Students should understand that the chemical formula of a compound provides information about the type and proportion of atoms present. This information can be used to carry out different calculations relating to composition and reacting masses.
	5.2 Atomic mass, molecular mass and formula mass *(2 periods)*	
• Describe atomic mass	• Atomic mass	Students should understand that the atomic mass of an element is the mass of atoms of that element. Since atoms are very small, atomic masses are not measured in kilograms and grams, but in atomic mass units. Conventionally, scientists do not assign a unit to atomic masses, molecular masses or formula masses. Students could use the information given in a Periodic Table, or in data tables, to find the atomic masses of different elements.
• Define the terms molecular mass and formula mass.	• Molecular mass and formula mass	Students should link atomic mass back to the work on atomic structure carried out in Grade 7. Students could discuss the existence of isotopes and how the atomic mass of an element is a weighted average of the isotopes present which reflects their relative proportions.
• Describe the steps of calculating molecular mass and formula mass • Calculate molecular mass and formula mass using formula of a compound and atomic masses.	• Calculating molecular mass and formula mass	Students should appreciate that the mass of a molecule of an element or a compound is the sum of the masses of the individual atoms it contains. Students should calculate the molecular masses of molecules of elements and of covalent compounds by adding the atomic masses of all of the atoms present in the molecule. Students should appreciate that it is not possible to give the molecular mass of an ionic compound since ionic compounds do not exist as molecules. The concepts of ionic and covalent bond should be treated at the higher grades. Students should know that for ionic compounds we give the formula mass which is the mass of the ions present in their lowest possible ratio of whole numbers. Students should calculate the formula masses of ionic compounds, starting with simple binary compounds and progressing to more complex examples.

Competencies	*Contents*	*Suggested Activities*
• Define mole and molar mass • Calculate number of moles of atoms, molecules or formula units from a given mass or number of particles and vise versa. • Convert a given number of moles of atoms or molecules or formula units to number of atoms, molecules or formula units and vise versa.	**5.3 The mole concept** *(3 periods)* • Mole • Molar mass	Students should discuss how some things are grouped together e.g. • Eggs are sometimes sold in boxes containing a specific number • Tablets are sold in boxes containing specific numbers Use the idea of grouping to introduce the mole as a group of particles. Students should appreciate that since the mass of individual atoms and molecules is very small we use a scaling factor to convert these very small masses into masses in grams. This scaling factor is called the mole. Students should know that a mole of any substance is a group containing 6.022×10^{23} particles of that substance whether the particles are atoms, molecules or ions. This figure is referred to as avogadro number. Students should understand that the mass of one mole of a substance is its atomic, molecular or formula mass expressed in grams e.g. • One mole of carbon atoms has a mass of 12 g • One mole of water molecules has a mass of 18 g • One mole of sodium ions has a mass of 23 g Students should calculate the mass of moles of a substance first by working out its atomic, molecular or formula mass and then expressing this value in grams. Students should calculate the number of moles a substance from a given mass or number of particles. Students should be able to state the number of particles present in a given amount, in moles, of a substance. Students should be able to state the number of moles of a substance which is equivalent to a given number of particles.
• Describe percentage composition of a compound • Describe the steps of determining percentage composition • Calculate percentage composition of a compound from its formula	**5.4 Percentage composition of compounds** *(2 periods)*	Students should be aware that the composition of a compound can be expressed as the percentage, by mass, of each element in the compound. $\%\ \text{comp.} = \frac{\text{Mass of Element}}{\text{Formula mass of a comp.}} \times 100$ Students should use the atomic masses of the elements present together with the molecular or formula mass to determine the percentage composition of a compound. For example, to determine the percentage composition of magnesium carbonate ($MgCO_3$) proceed as follows: • the formula mass of $MgCO_3$ is 24 + 12 + (3 x 16) = 84 • atomic mass of magnesium = 24

Competencies	Contents	Suggested Activities
		• percentage by mass of magnesium = (24/84) x 100 = 28.57% • atomic mass of carbon = 12 • percentage by mass of carbon = (12/84) x 100 = 14.29% • atomic mass of oxygen = 16 • percentage by mass of oxygen = (3 x 16/84) x 100 = 57.14% Students should be aware that, owing to errors resulting from rounding, total percentages of the different elements in a compound may sometimes not add up to exactly 100%. Students should carry out similar calculations to determine the composition by mass of elements in other compounds. Students could carry out calculations to determine the percentage by mass of a particular element in a series of compounds e.g. • the percentage by mass of nitrogen in a series of fertilisers • the percentage by mass of oxygen in a series of metal oxides
	5.5 Determination of formulas *(3 periods)*	
• Define empirical and molecular formulas • Describe the steps of determining empirical formula	• Empirical formula • Molecular formula	Students should understand that the molecular formula of a compound gives the number of atoms of each type of element present. The empirical formula gives the number of atoms of each type of element in the lowest possible ratio. Students should appreciate that • sometimes the molecular formula and the empirical formula of a substance are the same, for example ethanol: molecular formula = C_2H_6O empirical formula = C_2H_6O • different compounds may have the same empirical formula, for example ethene (C_2H_4), butene (C_4H_8) and hexene (C_6H_{12}) all have the same empirical formula CH_2. Each of these compounds consists of carbon atoms and hydrogen atoms in the ratio of 1 to2
• Determine empirical formula of a compound from a given percentage composition or mass ratio • Describe the relationship between empirical formula and molecular formula • Describe the steps of determining molecular		Students should understand how to find the empirical formula of a compound from its composition expressed in percentage by mass of each element. For example: • The composition by mass of a compound is 92.3% carbon and 7.7% hydrogen. • The atomic mass of a carbon atom is 12 while the atomic mass of a hydrogen atom is 1. • Atoms of carbon and hydrogen must be present in the compound in the ratio of (92.3/12) : (7.7/1) = 7.7 : 7.7 • The simplest ratio of carbon to hydrogen is 1:1 therefore the empirical formula of the compound is CH Students should appreciate that the empirical formula only gives the ratio of the atoms present and tells nothing about the molecular formula.

Competencies	*Contents*	*Suggested Activities*
formula. • Determine molecular formula of a compound from empirical formula and molecular mass		Students should calculate the empirical formulas of compounds from their percentage composition by mass. Students should appreciate that to find the molecular formula of a compound from its percentage composition that an additional piece of information is required – the molecular mass of the compound. For example: • The empirical formula of a compound is CH_2. • The molecular mass of the compound is 70. • The mass of the CH_2 unit = 14 therefore the compound must contain 70/14 = 5 x CH_2 • The molecular formula of the compound is C_5H_{10}. Students should calculate the molecular formulas of compounds from their empirical formulas and molecular masses. Students should calculate the molecular formulas of compounds from their percentage by mass composition and molecular masses.

Assessment

The teacher should assess each student's work continuously over the whole unit and compare it with the following description, based on the Competencies, to determine whether the student has achieved the minimum required level.

Students at minimum requirement level
Students working at the minimum requirement level will be able to: Understand atomic mass, molecular mass, formula mass, the concept of mole, molar mass, percentage composition of compounds, empirical formula and molecular formula, know how to determine molecular mass or formula mass from a given mass of a substance, know how to determine percentage composition, empirical formula and molecular formula of a compound.

Students above minimum requirement level
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Students below minimum requirement level
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