Chemistry Syllabus,Grade 10

General Objectives of Grade 10 Chemistry

To develop understanding and acquire knowledge of:

- Classes of organic and inorganic compounds and some of their agricultural and industrial applications
- The interconvert ion of electrical and chemical energies and their applications
- Importance of natural resources and their protection
- Industrial application of chemistry in the production of chemical elements, compounds and variety of materials

To develop skills and abilities of:

- Handling and using science apparatuses and laboratory substances correctly
- Using experimental methods in their everyday life to acquire more knowledge
- Designing and conducting simple experiments appropriate to their level
- Applying Faraday's laws to calculate relevant quantities
- Using necessary precautions while working with hazardous chemicals

To develop the habit and attitude of:

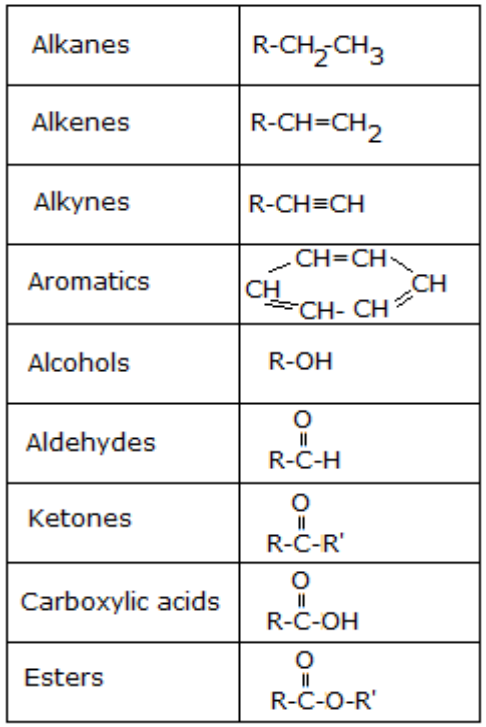
- Appreciating the roles of chemistry in agriculture, industry and energy production
- Having an interest and curiosity towards environment
- Being responsible about safety of oneself, others and the environment
- Being honest and accurate in recording and validating data

Unit 1: Introduction to organic chemistry *(34 periods)*

Unit outcomes: Students will be able to:

- know the historical development of organic chemistry and classification of organic compounds;
- know the general formulas of alkanes, alkenes, alkynes, alcohols, aldehydes, ketones, carboxylic acids and esters;
- develop skills in naming and writing the molecular and structural formulas of simple alkanes, branched chain alkanes, simple alkenes, branched chain alkenes, simple alkynes, alcohols, aldehydes, Ketones, carboxylic acids and esters;
- understand isomerism and know possible isomers of alkanes and alkenes;
- know the major natural sources of hydrocarbons;
- understand the physical and chemical properties; and general methods of preparation of alkanes, alkenes, alkynes, benzene and alcohols;
- know the uses of organic compounds in the manufacture of beverages, pharmaceuticals, soaps and detergents, dry-cleaning, fuels, pesticides and herbicides;
- demonstrate scientific inquiry skills: observing, classifying, communicating, measuring, asking questions, interpreting data, drawing conclusions, applying concepts, predicting and problem solving.

Competencies	***Contents***	***Suggested Activities***
Students will be able to: • Narrate the historical development of organic chemistry.	***1. Introduction to organic chemistry*** **1.1 Introduction** *(1 period)* • History of organic chemistry	Students should appreciate that chemicals found in and derived from living things, both animals and plants, were once thought to contain a life force, the 'force vitals', which was absent in chemicals obtained from the ground. On this basis, all chemicals were divided into two groups: • Organic chemicals • Inorganic chemicals Students should understand that, although the theory of life force has long since been discarded after Wohler's synthesis of Urea, this classification is still used but the definition of organic chemistry has changed. Organic chemistry is now described as the chemistry of carbon with the exception of the oxides of carbon, carbonates and hydrogen carbonates.
• Classify organic compounds	• Classification of organic compounds	Students should understand that organic compounds are classified into groups on the basis of a functional group. It is the functional group in a molecule that determines much of the chemistry of a compound. The functional groups of organic chemicals studied in this unit could be given as a table.

Competencies	*Contents*	*Suggested Activities*
• Define the term functional group		
	1.2 Saturated hydrocarbons (alkanes) *(9 periods)*	
• Define hydrocarbon		Students should understand that the term hydrocarbon is used to describe organic chemicals that contain hydrogen and carbon only.
• Define saturated hydrocarbon		• Compounds that contain only carbon-carbon single bonds, the alkanes to be studied now, are described as saturated hydrocarbons. • Compounds that contain carbon-carbon double or triple bonds, the alkenes, alkynes and aromatic compounds to be studied later, are described as unsaturated hydrocarbons.
• Define homologous series • Write the general formula of alkanes	• Homologous series	Students should know that a series of compounds that differ by a certain same group are called a homologous series. The alkanes are a homologous series which have the general formula C_nH_{2n+2}.

<table>
<tr><th>Competencies</th><th>Contents</th><th>Suggested Activities</th></tr>
<tr><td>• Write the first ten members of alkanes homologous series
• Write the molecular formulas of alkanes from the given numbers of carbon atom</td><td></td><td>Students could use the general formula to generate the chemical formulas of the first ten alkanes in the series. For example: n=1, CH_4, n=2, C_2H_6 etc.</td></tr>
<tr><td>• Explain the physical properties of alkanes</td><td>• Physical properties</td><td>Students should understand that there are forces of attraction between molecules in alkanes (van der Waals' forces). As the size of the molecule increases so do the forces. At room temperature:
• Alkanes up to and including C_4 are gases
• Alkanes from $C_5 - C_{17}$ are liquids
• Alkanes C_{18} and above are solids</td></tr>
<tr><td>• Write the structural formulas of the first ten alkanes
• Apply IUPAC rules to name straight and branched chain alkanes.</td><td>• Nomenclature</td><td>Students should appreciate that the name of an organic chemical is derived from:
• a prefix indicating the number of carbons present
• a suffix indicating the functional group present
Students should learn the prefixes for compounds containing up to ten carbon atoms as these are widely used in organic chemistry.
<table><tr><th>Prefix</th><th>Number of carbon atoms</th><th>Prefix</th><th>Number of carbon atoms</th></tr><tr><td>Meth</td><td>1</td><td>hex</td><td>6</td></tr><tr><td>Eth</td><td>2</td><td>hept</td><td>7</td></tr><tr><td>Prop</td><td>3</td><td>oct</td><td>8</td></tr><tr><td>But</td><td>4</td><td>non</td><td>9</td></tr><tr><td>Pent</td><td>5</td><td>dec</td><td>10</td></tr></table>
Students should use the suffix 'ane' to generate the names of the first ten alkanes e.g. meth + ane = methane, eth + ane= ethane, etc.
Students could draw structures and name the first ten alkanes in the series.
Students should understand the principles of naming branched chain alkanes:
• identify the longest possible carbon chain which gives the base name
• number the carbon atoms in the longest carbon chain. Any side groups are on the lowest possible numbered carbon
• name the side chains on the basis of the prefix which indicates the number of carbon atoms, followed by the suffix –yl
• combine the side chains and the base name to give the name of the compound as one word</td></tr>
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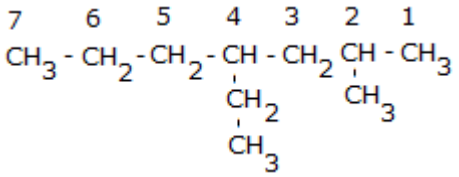
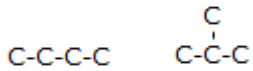
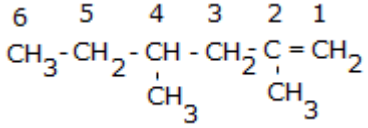
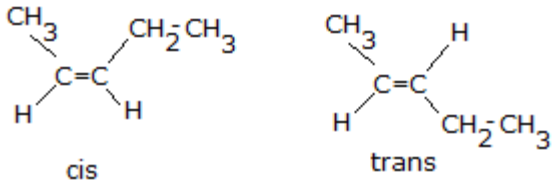
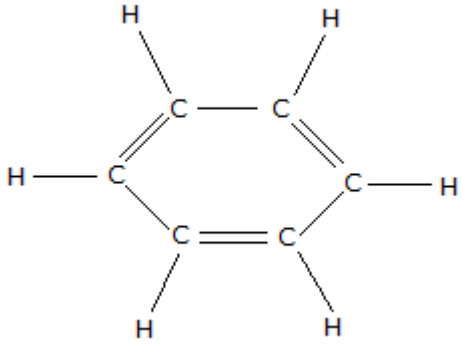
Competencies	***Contents***	***Suggested Activities***
		Students should work through an example with the help of the teacher.  • The longest carbon chain contains 7 carbon atoms therefore it is a heptane • The carbon chain is numbered from right to left to ensure the numbers of the carbon atoms which have groups attached are as low as possible • There is a methyl group on carbon 2 • There is an ethyl group on carbon 4 Combining this information gives 4-ethyl 2-methylheptane
• Define isomerism as the way how compounds having the same formula differ in the way their atoms are arranged. • Define structural isomerism • Write possible structural isomers for C_4H_{10}, C_5H_{12} and C_6H_{14}.	• Isomerism	Students should know that the first three members of alkanes- CH_4 , C_2H_6 and C_3H_8 etc have only one possible arrangement for their structures. Students should be shown the possible isomers of butane, C_4H_{10}. They should appreciate that it is easier simply to draw the carbon skeletons and omit the hydrogen atoms.  Students should be aware that when the number of carbons in an alkane reaches four or more there are different ways of arranging them in a molecule. This is called isomerism. The isomers have the same chemical formula but different structures and different physical properties such as melting point and boiling point. Students should experiment by drawing as many possible different structures as they can for pentane, C_5H_{12} (3 isomers) and hexane, C_6H_{14} (5 isomers). Students could practice this technique by naming the different isomers of pentane and hexane.
• Describe the general methods for preparation of alkanes in a laboratory • Prepare methane in a laboratory by decarboxylation method	• Preparation	Students should appreciate that crude oil is a mixture of many different alkanes and that industrially, alkanes are obtained by the refining of crude oil. In the laboratory alkanes can be made by a number of different routes including: • The hydrogenation of alkenes $R\text{-}CH{=}CH_2 + H_2 \rightarrow R\text{-}CH_2\text{-}CH_3$ • The Wurtz synthesis using halogenated hydrocarbons and sodium $2R\text{-}Br + 2Na \rightarrow R\text{-}R + 2NaBr$ • The decarboxylation of the sodium salt of a carboxylic acid $RCOONa + NaOH \rightarrow Na_2CO_3 + R\text{-}H$ Student should appreciate evolution of methane gas in marshy areas.

Competencies	*Contents*	*Suggested Activities*
• Carryout a project work to produce biogas from cow dung		Students should prepare methane by the decarboxylation of sodium ethanoate. Students should make methane on a small scale by the fermentation of cow dung. They should appreciate the significance of methane made in this way, as the main component of biogas, and how it provides a renewable source of energy
• Explain the chemical properties of alkanes	• Chemical properties	Students should appreciate that alkanes are generally considered unreactive chemicals. • Like all hydrocarbons, alkanes burn in air to give carbon dioxide and water. In limited supplies of air some carbon monoxide is also formed. • Alkanes react with chlorine in the presence of sunlight to produce chloroalkanes. This is an example of a free radical reaction.
	1.3 Unsaturated hydrocarbons – alkenes and alkynes *(9 periods)*	
• Define unsaturated hydrocarbons • Define alkenes • Write the general formula of alkenes • Write the molecular formula first nine homologous series of alkenes	• Homologous series	Students should recall the definition of an unsaturated hydrocarbon from the previous section in terms of the presence of carbon-carbon double or triple bonds. Students should appreciate that alkenes are a homologous series of unsaturated hydrocarbons: • Alkenes contain the functional group C=C • The general formula for alkenes is C_nH_{2n} • The suffix used for alkenes is 'ene' Students should write the molecular formulas of the first nine alkenes in the series. Students could use the prefixes given in the previous section together with the suffix 'ene' to name the first nine alkenes in the series.
• Define alkynes • Write the general formula of alkynes • Write the molecular formula first nine homologous series of alkynes • Write the molecular formulas of alkenes and alkynes from the given number of carbon atoms		Students should appreciate that alkynes are also a homologous series of unsaturated hydrocarbons: • Alkynes contain the functional group C≡C • The general formula for alkynes is C_nH_{2n-2} • The suffix used for alkynes is 'yne' Students should write the molecular formulas of the first nine alkynes in the series. Students could use the prefixes given in the previous section together with the suffix 'yne' to name the first nine alkynes in the series. Students should be able to write the molecular formulas of alkenes and alkynes provided with number of carbon atoms .
• Describe the physical properties of alkenes and	• Physical properties	Students should appreciate that, as was the case with alkanes, there are forces of attraction between the molecules in both alkenes and alkynes. Those with small molecules are gases at room temperature but as the carbon chain increases in size the attractive forces also increase giving higher melting points and boiling points. Alkenes and alkynes with large molecules are liquids and larger still, are solids.

Competencies	*Contents*	*Suggested Activities*
alkynes • Apply IUPAC rules to name straight and branched chain alkenes and alkynes. • Write the structural formulas alkenes and alkynes up to nine carbon atoms.	• Nomenclature	Students should appreciate that within the carbon chain of an alkene, a carbon-carbon double bond might be between any pair of adjacent carbon atoms. The same is true of the carbon-carbon triple bond in alkynes. In order to differentiate between two molecules with the same formula but in which the carbon-carbon double or triple bond is in a different position, we: • number the carbon atoms in such a way that the carbon atoms joined by the double or triple bond have the lowest number • give the number of the first carbon atom involved in the bond Students should consider some examples. C-C-C≡C C-C≡C-C but -1-yne but-2-yne (1-but yne) (2-but yne) C-C-C-C-C=C C-C-C-C=C-C C-C-C=C-C-C Hex-1-ene hex-2-ene hex-3-ene (1-hex ene) (2-hex ene) (3-hex ene) Students could draw and name different straight chain alkenes and alkynes up to nine carbon atoms. Students should understand that the rules given for naming branched chain alkenes and alkynes are the same as those for alkanes with the additional requirement of identifying the position of the carbon-carbon double or triple bond. Students should work through an example with the help of the teacher.  • The longest carbon chain contains 6 carbon atoms therefore it is a hexene • The carbon chain is numbered from right to left to ensure the numbers of the carbon atoms which have groups attached are as low as possible • The carbon-carbon double bond is between carbons 1 and 2 • There are methyl groups on carbons 2 and 4 Combining this information gives 2,4-dimethylhex-1-ene. Students could practice this technique by naming the same other branched chain alkenes.
• Write possible structural isomers for C_4H_8 and C_5H_{10}	• Isomerism	Students should appreciate that isomers of C_5H_{10} exist because the carbon-carbon double bond can be in two different positions, giving pent-1-ene and pent-2-ene.

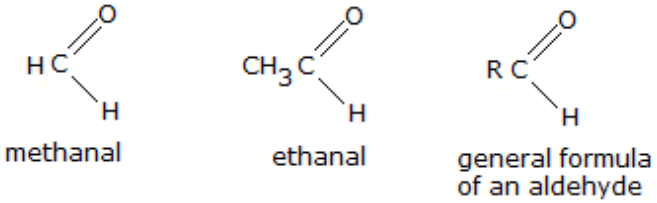
Competencies	***Contents***	***Suggested Activities***
• Define geometric (cis-trans) isomerism • Give examples of molecules that show geometric isomerism		Show students the two possible structures of pent-2-ene and point out that it is not possible to rotate about a carbon-carbon double bond. Students could also understand that there are branched chain isomers with the formula C_5H_{10}  cis trans
• Construct models that show cis-trans isomerism		Introduce the term geometric isomerism to describe this type of isomerism. Explain that we use the terms: • cis to describe when different groups are attached to the same side of a plane through the carbon-carbon double bond • trans to describe when different groups are attached to opposite sides of a plane through the carbon-carbon double bond Students should appreciate that the structures given above are cis-pent-2-ene and trans-pent-2-ene. Students should consider some other examples of alkenes that give cis and trans isomers. Students should be given a project work to construct model that show cis and trans isomerism.
• Describe the general method for preparation of alkenes in a laboratory • Prepare ethylene in a laboratory by dehydration of ethanol	• Preparation	Students should appreciate that alkenes are obtained on an industrial scale by the cracking of fractions obtained from the distillation of crude oil. In the laboratory alkenes can be made by a number of different routes including: • The dehydration of alcohols with alumina or concentrated sulphuric acid. $R\text{-}CH_2\text{-}CH_2\text{-}OH \rightarrow R\text{-}CH{=}CH_2 + H_2O$ • The dehydrohalogenation of haloalkanes by refluxing them with a base. $R\text{-}CH_2\text{-}CH_2\text{-}X \rightarrow R\text{-}CH{=}CH_2 + HX$ Students should prepare ethene by the dehydration of ethanol.
• Describe the general method for preparation of alkynes in a laboratory. • Prepare acetylene in a laboratory by the reaction of CaC_2 with water.		In the laboratory alkynes can be made by a number of different routes including: • The dehydrohalogenation of 1,2-dihaloalkanes by refluxing them with a base. $R\text{-}CHX\text{-}CH_2\text{-}X \rightarrow R\text{-}C{\equiv}CH + 2HX$ • The alkylation of sodium dicarbide with a primary haloalkane $HC{\equiv}CNa + RX \rightarrow HC{\equiv}C\text{-}R + NaX$ • Ethyne can be made by the reaction of calcium carbide and water.

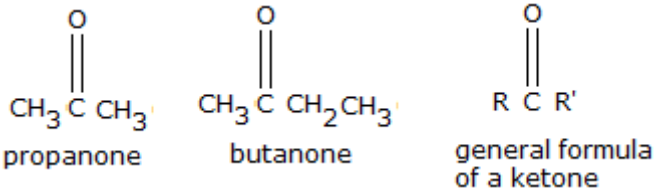
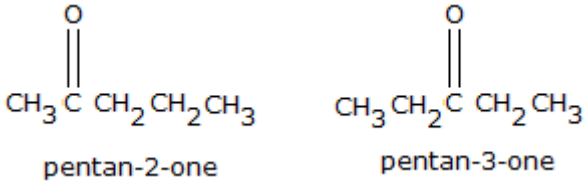
Competencies	***Contents***	***Suggested Activities***
• Test for unsaturation of ethylene and ethyne • Explain chemical properties of alkenes • Explain chemical properties of alkynes. • Explain the uses of ethylene and acetylene. • Compare and contrast the properties of ethane, ethene and ethyne	• Chemical properties • Uses of ethylene and acetylene.	$CaC_2 + 2H_2O \rightarrow HC{\equiv}CH + Ca(OH)_2$ Students should prepare ethyne by hydrolysis of calcium carbide. Apart from combustion, the chemistry of ethene and ethyne is determined by the presence of the carbon-carbon double or triple bond. Unsaturated hydrocarbons readily undergo addition reactions. The addition reaction with bromine in tetra chloromethane is used as a test for unsaturation. • $R\text{-}CH{=}CH_2 + Br_2 \rightarrow R\text{-}CHBr\text{-}CH_2Br$ • $R\text{-}C{\equiv}CH + 2Br_2 \rightarrow R\text{-}CBr_2\text{-}CHBr_2$ The tetra chloromethane loses its colour as the bromine adds across the carbon-carbon double or triple bond. Students should appreciate that alkenes are generally considered reactive chemicals and this is due to addition across the carbon-carbon double bond. • Addition of halogens to form 1,2 dihaloalkanes $R\text{-}CH{=}CH_2 + X_2 \rightarrow R\text{-}CHX\text{-}CH_2X$ • Addition of hydrogen halides to form haloalkanes $R\text{-}CH{=}CH_2 + HX \rightarrow R\text{-}CH_2\text{-}CH_2X$ • Addition of water to form an alcohol. $R\text{-}CH{=}CH_2 + H_2O \rightarrow R\text{-}CH_2\text{-}CH_2OH$ • Oxidation with cold alkaline potassium manganate(VII) solution to form a 1,2 diol. $R\text{-}CH{=}CH_2 \rightarrow R\text{-}CHOH\text{-}CH_2OH$ Students should appreciate that the chemical properties of alkynes are similar to those of alkenes and are determined largely by addition reactions about the triple bond. Students should know that the addition reactions of alkynes proceed in two steps. Students should give particular attention to the combustion of ethyne (acetylene) as this has important industrial applications. $2C_2H_2 + 5O_2 \rightarrow 4CO_2 + 2H_2O$ + a large amount of heat Oxy-acetylene burners reach temperatures high enough to melt steel. They are widely used in metal 'cutting'. Students should appreciate the importance of ethylene and acetylene Students should deduce that comparing the chemistry of ethane with that of ethene and ethyne they are: • Similar in that they undergo combustion to form carbon dioxide and water • Different because ethene and ethyne are unsaturated and take part in addition reactions whereas ethane does not

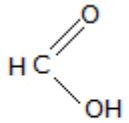
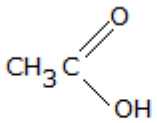
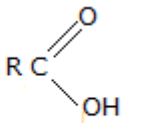
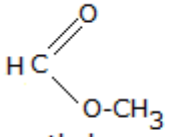
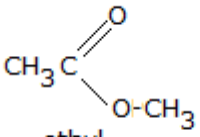
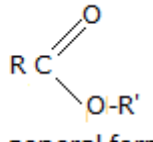
Competencies	Contents	Suggested Activities
	1.4 Aromatic hydrocarbons - benzene *(2 periods)*	
• Define the term aromatic hydrocarbon • Draw the structure of benzene	• Structure	Students should understand that the term aromatic is used to describe compounds which contain benzene rings or similar structures. Students should consider the structure of benzene, C_6H_6.  Students should be shown the different diagrams used to show the structure of benzene. At first glance students may assume that since benzene has three carbon-carbon double bonds it is an alkene and has the same chemistry as the alkenes. But this is not true.
• Describe the main physical properties of benzene	• Physical properties	Students should know that benzene is a liquid at room temperature and that it is carcinogenic therefore, for the purposes of experimenting, a safer alternative with similar structure, toluene or methylbenzene, $C_6H_5CH_3$ is used.
• Explain the chemical reactions of benzene • Carryout test tube reactions of benzene with (i) Br_2/CCl_4 (ii) $KMnO_4$ (iii) Concentrated H_2SO_4	• Chemical properties	Students should carry out the following reactions with methylbenzene. • Reaction with bromine in tetra chloromethane (no reaction) • Reaction with cold potassium manganate(VII) solution (no reaction) • Reaction with concentrated sulphuric acid (forms a substitute product, methylbenzene sulphonic acid, when heated) From the results of these experiments students should deduce that their first ideas about benzene being a typical alkene are incorrect. Benzene: • Does not undergo addition reactions like an alkene • Undergoes substitution reactions Students should conclude that there is something about the aromatic structure what makes aromatic compounds more stable and less reactive than might be first thought.

Competencies	*Contents*	*Suggested Activities*
	1.5 Natural sources of Hydrocarbons *(2 periods)*	
• List the major natural sources of hydrocarbons • Describe natural gas	• Natural gas	Students should be able to list the major natural sources of hydrocarbons- natural gas, crude oil and coal. Students should appreciate that natural gas is composed mainly of methane with smaller amounts of ethane and traces of carbon dioxide and nitrogen. The composition of natural gas varies depending on the source but is always over 90% methane.
• Define crude oil • Explain fractional distillation of crude oil • Mention products of fractional distillation of crude oil • Discuss the uses of petroleum products	• Crude oil	Students should understand that the use of the following terms: • Crude oil describes the raw material obtained from the ground • Petroleum describes the products after the refining of crude oil • Students should understand how fractions of crude oil are obtained by fractional distillation. Students should be aware that crude oil is a complex mixture of alkanes which is of little use in the form in which it leaves the ground. The first stage in refining involves fractional distillation which separates the crude oil into a series of fractions which boil over different temperature ranges. Students should be able to name the main fractions and describe their uses. These could include: • Refinery gases – used for heating in the refinery and bottled gases • Petroleum ether – solvents • Gasoline – petrol fuel for internal combustion engine • Kerosene – jet engine fuel • Diesel oil – fuel for diesel engines • Lubricating oil – lubricants • Paraffin wax – candles and polishes • Residue – bitumen for roof sealing and road surfaces From this discussion, students could understand that as the temperature increases the fractions become: • more coloured • more viscous • less inflammable
• Tell the composition of coal • Explain destructive distillation of coal	• Coal	Students should appreciate that coal is essentially an impure form of carbon. In addition to carbon it contains hydrocarbons which are given off as volatiles when the coal is heated in the absence of air. What remains after heating is a purer form of carbon called coke which is used in the blast furnace for the manufacture of iron.

Competencies	*Contents*	*Suggested Activities*
• Define alcohols • Tell the functional group of alcohols. • Classify alcohols based on the number of hydroxyl (OH^-)groups. • Write the general formula of monohydric alcohols • Write the molecular formulas and the names of the first six members of monohydric alcohols • Give the IUPAC names for given alcohols.	**1.6 Alcohols** *(9 periods)* • Classification and nomenclature of alcohols	Students should understand that the alcohols are a homologous group of organic chemicals which have the general structural formula R-OH, where R= alkyl or aryl group. The functional group in alcohols is –OH and the suffix used to denote this group is 'anol'. Students could apply the general formula to find the molecular formulas of the first six members of monohydric alcohols Students could use the prefixes given in a previous section together with the suffix 'anol' to name the first six alcohols in the series. Students should appreciate that alcohols can be classified on the basis of the number of hydroxyl groups in the molecule. These are described as: • Monohydric e.g. ethanol CH_3-CH_2-OH • Dihydric e.g. ethane-1,2- diol HO-CH_2-CH_2-OH • Trihydric e.g. propane-1,2,3-triol HO-CH_2-CH OH- CH_2-OH Students should understand that monohydric alcohols have the general formula $C_nH_{2n+1}OH$
• Classify monohydric alcohols based on the number of alkyl groups attached to the carbon atom carrying the hydroxyl group • Give some examples for primary, secondary and tertiary alcohols	• Classifications of monohydric alcohols	Students should appreciate that alcohols can be classified according to the nature of the groups attached to the carbon atom which carries the hydroxyl group: • Primary alcohols – the carbon carrying the hydroxyl group is attached to only one alkyl group (and two hydrogen atoms) RCH_2OH • Secondary alcohols – the carbon carrying the hydroxyl group is attached to two alkyl groups (and one hydrogen atom) RR'CHOH • Tertiary alcohols – the carbon carrying the hydroxyl group is attached to three alkyl groups (and no hydrogen atoms) RR'R''COH Students should draw the structure of alcohols and state whether they are primary, secondary or tertiary alcohols.
• Classify alcohols based on the number of hydroxyl (-OH) groups • Describe the physical properties of alcohols	• Physical properties	Students should appreciate that: • the hydroxyl group in an alcohol is polar due to the high electro negativity of oxygen: $-O^{\delta-}-H^{\delta+}$ • as a result of this there is significant hydrogen bonding in alcohols • the melting points and boiling points of alcohols are much higher than those of alkanes of similar relative molecular mass • even the first alcohol in the series, methanol, is a liquid at room temperature Students could compare the boiling points of ethanol (RMM = 46) and propane (RMM = 44)

Competencies	***Contents***	***Suggested Activities***
• Explain general methods of preparation of alcohols • Explain the industrial preparation of ethanol • Perform an activity to prepare ethanol from sugar	• Preparation	In the laboratory alcohols can be made by a number of different routes including: • Hydrolysis of alkyl halides by heating with sodium hydroxide solution $R\text{-}Cl + NaOH \rightarrow R\text{-}OH + NaCl$ • Hydrolysis of esters by heating with potassium hydroxide solution $R\text{-}COO\text{-}R' + KOH \rightarrow R\text{-}COOK + R'\text{-}OH$ These are both examples of replacement reactions since different groups are replaced by –OH. Students should know that there are two main industrial processes for the manufacture of ethanol: • the fermentation of carbohydrates such as sugars $C_6H_{12}O_6(aq) \rightarrow 2C_2H_5OH(aq) + 2CO_2(g)$ • the hydration of ethene with steam at 573 K and 60 atmospheres in the presence of a phosphoric acid catalyst Students should prepare a small sample of ethanol by fermentation followed by distillation.
• Explain the chemical reactions of alcohols such as oxidation, reaction with active metals, esterification and dehydration. • Carryout an activity to show chemical reaction of alcohols with active metal • Write the general structural formula of aldehydes • Write the molecular formulas and names of simple aldehydes	• Chemical properties	Students should understand that alcohols can be oxidised using suitable reagents such as acidified potassium manganate(VII) solution or acidified potassium dichromate solution. The nature of the oxidation product depends on whether the alcohol is primary, secondary or tertiary. • Primary alcohols are oxidised to form aldehydes $R\text{-}CH_2\text{-}OH + [O] \rightarrow R\text{-}COH$ • Students should carryout some experimental activities to investigate properties of alcohols Aldehydes are named on the basis of the number of carbon atoms present and the suffix ‘anal’.  methanal ethanal general formula of an aldehyde Students could draw and name the aldehydes up to those containing six carbon atoms.

Competencies	*Contents*	*Suggested Activities*
• Write the general structural formula of ketones • Write the molecular formulas and names of simple ketones • Write the general structural formula of carboxylic acids		• Secondary alcohols are oxidised to form ketones R-CHOH-R' + [O] → R-CO-R' Ketones are named on the basis of the number of carbon atoms present and the suffix 'anone'.  Students should appreciate that with large numbers of carbon atoms it is necessary to identify the carbon atom which is bonded to the oxygen atom.  (2-pentanone) (3-pentanone) Students could draw and name ketones up to those containing six carbon atoms. • Tertiary alcohols undergo destructive oxidation to form mixtures of carboxylic acids. RR'R''-COH + [O] → mixture of carboxylic acids Students should know that further oxidation of aldehydes and ketones is possible, and that the final products are carboxylic acids. Students should understand that the carboxylic acids are a homologous group of organic chemicals which have the general structure R-COOH. The functional group in carboxylic acids is -COOH and the suffix used to denote this group is 'anoic acid'. Students could use the prefixes given in a previous section together with the suffix 'anoic acid' to name the first six carboxylic acids in the series.

Competencies	*Contents*	*Suggested Activities*
• Write the molecular formulas and names of simple carboxylic acids		 methanoic acid  ethanoic acid  general formula of a carboxylic acid
• Write the general structural formula of esters • Write the molecular formulas and names of simple esters		Students should know that carboxylic acids and alcohols react together with the loss of water to form another group of organic chemicals called esters. The general structure of esters is R-COO-R'. $R\text{-}COOH + R'OH \rightarrow R\text{-}COO\text{-}R' + H_2O$  methyl methanoate  ethyl methanoate  general formula of an ester Students should understand that the name of an ester is derived from the name of the alcohol and the name of the carboxylic acid from which it is formed e.g. propanol + ethanoic acid propyl + ethanoate = propyl ethanoate Students could practice drawing the structures and naming esters formed from alcohols and carboxylic acids which each have up to six carbon atoms.
• Discuss the uses of organic compounds in the manufacture of beverages, • Discuss the uses of organic compounds in the manufacture of pharmaceuticals	**1.7 Industrial and agricultural applications of organic compounds** *(2 periods)* • Industrial application - Beverages - Pharmaceuticals	Students should appreciate that organic chemicals are used to prepare a huge range of industrial products. Students should research into specific examples and discuss them with the class. These could include: • Alcoholic beverages containing ethanol • Pharmaceuticals - analgesics (pain killers) e.g. aspirin and paracetamol - sulphonamides e.g. penicillin - antiseptics e.g. acriflavine - sedatives e.g. barbiturates

Competencies	***Contents***	***Suggested Activities***
		- disinfectants e.g. Dettol
• Discuss the uses of organic compounds in the manufacture of soaps and detergents.	- Soaps and detergents	• Soaps and detergents - sodium and potassium salts of long-chain carboxylic acids - sodium laurylsulphate
• Discuss the uses of organic compounds in the manufacture of dry-cleaning agents.	- Dry cleaning	• Dry cleaning - tertrachloromethane and others
• Discuss the uses of organic compounds in the manufacture of fuels • Conduct an experiment to prepare soap from naturally existing esters (fats or oils)	- Fuels	• Fuels - alkanes e.g. natural gas, gasoline, paraffin - ethanol - bio fuels Students should prepare a sample of soap by the saponification of animal fat or oil using sodium hydroxide. Perfume and colouring agents could be added. Students could carry out a similar reaction using potassium hydroxide to make a soft soap.
• Discuss the uses of organic compounds in the manufacture of pesticides and herbicides.	• Agricultural application - Pesticides - Herbicides	Students should appreciate that organic chemicals are used to prepare a huge range of agricultural products. Students should research into specific examples and discuss them with the class. These could include: • Pesticides - fungicides e.g. Bordeaux mixture - insecticides e.g. malathion, DDT • Herbicides e.g. paraquat, diquat, ammonium sulphamate, ammonium glyphosinate, sodium chlorate
• Discuss the importance and manufacture of urea	- urea	Students should appreciate the importance of nitrogen for plant growth and understand that artificial fertilisers are often applied to agricultural land. These include ammonium salts, nitrates and urea. Students should be aware that urea is a component of urine. It is made industrially by the dehydration of ammonium carbamate: $N_2N\text{-}COO^-NH_4^+ \rightarrow H_2NCONH_2 + H_2O$

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: narrate the historical development of organic chemistry; define the terms functional group, hydrocarbons, saturated hydrocarbons, homologous series , isomerism, unsaturated hydrocarbon, alkenes, alkynes, aromatic hydrocarbons, natural gas, coal, alcohols, aldehydes, ketones, carboxylic acid and esters; Writ the general formulas of alkanes, alkenes, alkynes, alcohols, aldehydes, ketones, carboxylic acids and esters; Write the molecular formulas of the first ten members of alkanes, nine members of alkenes and alkynes and six members of alcohols, aldehydes, ketones, carboxylic acids and esters; explain the physical and chemical properties of alkanes, alkenes, alkynes, benzene and alcohols; write possible isomers for C_4H_{10}, C_5H_{12}, C_6H_{14}, C_4H_8, and C_5H_{10}, give the IUPAC names for branched chain alkanes branched chain alkenes, and alcohols; describe different methods for the preparation of alkanes, alkenes, alkynes and alcohols; carryout a project to produce biogas from cow dung; test the unsaturation of ethylene and acetylene and explain their uses; compare and contrast the properties of ethane, ethylene and acetylene; draw the structure of benzene, carryout test tube reactions of benzenes with Br_2/CCl_4, $KMnO_4$ and Conc - H_2SO_4; list the major natural sources of hydrocarbons; explain fractional distillation of crude oil and mention the products and their uses; tell the composition of coal and explain its destructive distillation; classify alcohols and give same examples of each group; perform an activity of preparing ethanol from sugar; discuss the uses of organic compounds in the manufacture of beverages, pharmaceuticals, soaps and detergents, dry-cleaning, fuels, pesticides, herbicides and urea.

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: Important inorganic compounds *(21 periods)*

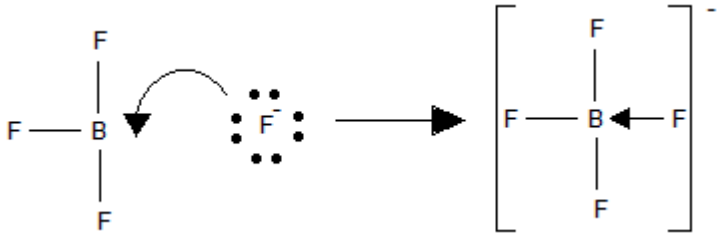
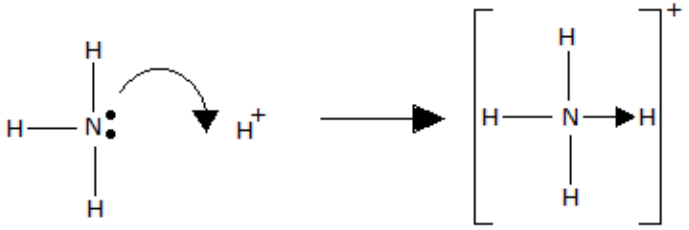
Unit outcomes: Students will be able to:

- understand the classification of inorganic compounds on the basis of their composition and/ or their chemistry;
- Know types of oxides and their chemical properties;
- Understand the Arrhenius, Bronsted - Lowry and Lewis concepts of acids and bases;
- Understand the classification of acids and salts;
- Know the general properties, preparation and uses of common acids, bases and salts;
- Understand the differences between strong and weak acids/ bases; and concentrated and dilute acids/ bases;
- Recognize the corrosive nature of acids and bases, and exercise the necessary precautions in handling and using them;
- Develop skills for identifying acidic, basic and neutral compounds;
- Develop skills in calculating P^{H}, P^{OH}, H^{+} ion concentration and OH^{-} ion concentration of a solution;
- Know essential plant nutrients, fertilizers and pesticides (which are salts).
- Demonstrate scientific inquiry skills: observing, classifying, comparing and contrasting, inferring, predicting, communicating, measuring, asking questions, interpreting data, drawing conclusion, applying concepts, relating cause and effect and problem solving.

Competencies	***Contents***	***Suggested Activities***
Students will be able to: • Define inorganic compounds	***2. Important inorganic compounds*** **2.1. Introduction** *(1 period)*	Students should understand that the term 'inorganic' is used to describe chemicals that are, in the main, obtained from the ground and are not associated with living things. These chemicals are largely, but not exclusively, compounds of metals. Students could recall the names of inorganic compounds with which they are already familiar. Write these on the board. Students should appreciate that there are different ways of classifying compounds on the basis of their composition and/or their chemistry. For example, they could be classified on the basis of the metals they contain e.g. copper compounds, or on the basis of the groups present e.g. sulphates.
• Classify inorganic compounds as oxides, acids, bases and salts		Students should know that in this unit they will study four groups of inorganic chemicals: oxides, acids, bases and salts.
• Define oxides • Classify oxides as acidic, basic, neutral, amphoteric and peroxides	**2.2. Oxides** *(3 periods)*	Students should be aware that oxides are formed when an element combines chemically with the element oxygen. They should understand that oxides themselves can be divided into different groups on the basis of their chemical behaviour and, in the case of peroxides, their structure.

Competencies	***Contents***	***Suggested Activities***
• Define acidic oxides • Give examples of acidic oxides • Explain the chemical properties of acidic oxides	• Acidic oxides	Students should understand that most non-metals form oxides which exhibit acidic properties. They dissolve in water to give acidic solutions, they react with bases and basic oxides. Students could burn a small amount of sulphur or carbon on a deflagrating spoon in a gas jar of oxygen. If water is added to the gaseous product, followed by a few drops of universal indicator, the solution is red (in the case of sulphur) or yellow-orange (in the case of carbon) indicating it is acidic. $S(s) + O_2(g) \rightarrow SO_2(g)$ $SO_2(g) + H_2O(l) \rightarrow H_2SO_3(aq)$ $H_2SO_3(aq) \rightleftharpoons 2H^+(aq) + SO_3^{2-}(aq)$
• Define basic oxides • Give examples of basic oxides • Explain the chemical properties of basic oxides	• Basic oxides	Students should understand that most metals form oxides which exhibit basic properties and dissolve in water to give alkaline solutions. They react with acids and acidic oxides. Students could burn a small amount magnesium or calcium on a deflagrating spoon in a gas jar of oxygen. If water is added to the ash followed by a few drops of universal indicator, the solution is blue-purple indicating it is alkaline. $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$ $MgO(s) + H_2O(l) \rightarrow Mg(OH)_2(aq)$ $Mg(OH)_2(aq) \rightleftharpoons Mg^{2+}(aq) + 2OH^-(aq)$
• Distinguish basic oxides from acidic oxides by conducting experiments • Compare and contrast acidic and basic oxides		Students should appreciate that acidic and basic oxides can be distinguished by their chemical properties. In addition to their effects on indicators acidic oxides react with bases while basic oxides react with acids. Students should be reminded that acids and bases are chemical opposites and react together in neutralisation reactions. Explain that: • non-metallic oxides are acidic because they will react with bases • metallic oxides are basic because they react with acids
• Define amphoteric oxides • Give examples of amphoteric oxides • Explain the chemical properties of amphoteric oxides • Discuss the salt forming nature of acidic oxide, basic oxide and amphoteric oxide	• Amphoteric oxides	Students could investigate the chemical reactions of aluminium oxide. Students should react aluminium oxide with a dilute acid, such as hydrochloric acid. $Al_2O_3(s) + 6H^+(aq) \rightarrow 2Al^{3+}(aq) + 3H_2O(l)$ Students should then react Al_2O_3 with sodium hydroxide solution. $Al_2O_3(s) + 2OH^-(aq) + 3H_2O(l) \rightarrow 2Al(OH)_4^-{}_{aq)}$ Students should appreciate the amphoteric behaviour of Al_2O_3. It reacts both with an acid and a base, hence the name amphoteric oxide. Students should understand that oxides and hydroxides which react with both bases and with acids are described as amphoteric oxides. Students could investigate the amphoteric properties of zinc oxide and of lead oxide.

Competencies	*Contents*	*Suggested Activities*
• Define neutral oxides • Give examples of neutral oxides	• Neutral oxides	Students should appreciate that a small number of oxides react neither with acids nor with bases. In other words they don't show basic or acid properties but are neutral, and therefore described as neutral oxides. Students should recall carbon monoxide and nitrogen monoxide as examples of neutral oxides.
• Define peroxides • Give examples of peroxides • Explain the chemical properties of peroxides • Distinguish peroxides from other oxides by conducting an experiment	• Peroxides	Students should understand that a small number of oxides exist in which two oxygen atoms are linked together as –O-O- and that this structure is called a peroxide. Students could observe sodium burning in sufficient oxygen to form sodium peroxide. $2Na(s) + O_2(g) \rightarrow Na_2O_2(s)$ Students should appreciate that peroxides are powerful oxidising agents and react with the loss of oxygen. There are many organic peroxides which are important activators in polymerisation reactions. Students should investigate the chemistry of hydrogen peroxide, which has the peroxide structure H-O-O-H. Hydrogen peroxide decomposes to release oxygen. This reaction occurs very slowly but can be speeded up by the addition of a suitable catalyst such as manganese(IV) oxide. $2H_2O_2(aq) \rightarrow H_2O(l) + O_2(g)$ Students should observe the effect of adding hydrogen peroxide to a coloured dye. The dye is oxidised and the molecule responsible for the colour is destroyed.
	2.3. Acids *(7 periods)*	
• Define acids in terms of the concepts of Arrhenius, Brønsted-Lowry and Lewis • Give examples of acids based on Arrhenius, Brønsted-Lowry and Lewis concepts	• Definitions of acids	Students should be reminded of the simple definition of an acid as a substance that releases hydrogen ions or protons, H^+, when in solution. Ask students to give some examples of common acids.
	- Arrhenius	Students should appreciate that this definition of an acid, first proposed by Arrhenius, is limited to the chemistry in aqueous solutions. Demonstrate what happens when ammonia solution and hydrochloric acid are brought together and ask students to consider the reaction that takes place: $NH_3(g) + HCl(g) \rightleftharpoons NH_4Cl(s)$ The hydrogen chloride provides a hydrogen ion or proton but this is not released into aqueous solution since the reaction is carried out between gases. A more general definition of an acid was proposed by Brønsted and Lowry, in which an acid is something that donates protons. This holds for both aqueous and non-aqueous reactions.
	- Brønsted-Lowry	Students should appreciate that although the Brønsted-Lowry definition of an acid is more general than proposed by Arrhenius, it still depends on the transfer of protons. However, there are many chemical reactions which do not involve proton transfer.

Competencies	*Contents*	*Suggested Activities*
	- Lewis	In 1938 an American chemist called Lewis proposed an even more general definition of an acid based not on proton transfer but on electron pair transfer. Students should consider the following reaction: $BF_3 + F^- \rightarrow BF_4^-$ They should consider what is happening in terms of electron transfer.  The boron tri fluoride is acting as a Lewis acid as it is accepting a pair of electrons from the fluoride ion. Students should appreciate that the Lewis definition of an acid is also valid for the Arrhenius model of an acid as a substance that releases protons in aqueous solution, since a proton in aqueous solution accepts a pair of electrons donated by a water molecule, to form a hydroxonium ion, H_3O^+. $H^+(aq) + H_2O(l) \rightleftharpoons H_3O^+(aq)$ The Lewis definition of an acid is also valid for the Brønsted-Lowry model of an acid as a substance that provides protons since the proton accepts a pair of electrons. Students should look again at the reaction between ammonia and hydrochloric acid.  Reverting back to the Arrhenius definition of an acid, students should appreciate that acids can be classified according to the number of hydrogen ions or protons that can be released. They should compare hydrochloric acid with sulphuric acid: $HCl(aq) \rightleftharpoons H^+(aq) + Cl^-(aq)$ $H_2SO_4(aq) \rightleftharpoons 2H^+(aq) + SO_4^{2-}(aq)$

Competencies	***Contents***	***Suggested Activities***
• Classify acids as monoprotic and poly protic based on the number of ionizable (replaceable) hydrogen atom • Group acids as binary and ternary based on the number of elements they contain	• Classification of acids	Students should use the term 'monoprotic' to describe hydrochloric acid since it has only one replaceable hydrogen atom, and 'diprotic' (or polyprotic) to describe sulphuric acid since it has two (more than one) replaceable hydrogen atoms. Students should also appreciate that acids can be classified as binary or tertiary depending on the number of elements they contain e.g. hydrochloric acid is a binary acid while sulphuric acid is a ternary acid.
• Explain the general properties of acids	• General properties of acids	Students should review the properties of acids including: • Effect on common indicators such as litmus, phenolphthalein, methyl red and universal indicator • Reaction with more reactive metals • Reaction with carbonate and hydrogencarbonates • Reaction with sulphites • Neutralisation reactions with bases/alkalis
• Define strong and weak acids • Distinguish between strong and weak acids • Define concentrated and dilute acids • Describe the conceptual difference between strong and concentrated acids	• Strengths of acids (Strong and weak acids)	Students should appreciate that some substances dissociate when in aqueous solution. In acids like hydrochloric acid the dissociation is almost complete: $HCl \rightarrow H^+ + Cl^-$ Hydrochloric acid is described as a strong acid because it is almost fully dissociated. In acids like ethanoic acid only a small proportion of molecules dissociate: $CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ Ethanoic acid is described as a weak acid because it is only partially dissociated. Students should understand that whether an acid is described as strong or weak depends upon the degree which it dissociates and has nothing to do with its concentration.
• Describe the conceptual difference between weak and dilute acids	• Concentrated and diluted acids	The concentration of an acid is a measure of the number of moles of the acid dissolved in 1 liter and is therefore expressed in mol dm^{-3}. Both a strong acid and a weak acid may be concentrated or dilute depending on the number of moles present.
• Use the necessary precautions while working with acids	• Precautions in handling acids	Students should appreciate the corrosive nature of strong acids and some weak acids such as ethanoic acid. Precautions should be taken when handling acids including: • Wearing eye protection • Wiping spillages straight away

Competencies	*Contents*	*Suggested Activities*
		• Diluting any acid that gets onto clothes • Using a bellows to pipette acid
• Define pH • Describe the pH scale • Identify a given pH-labelled solution as acidic, basic or neutral • Perform activities to determine the pH of some common substances using universal indicators or pH meter • Calculate the pH of a given acidic solution • Calculate the concentration of hydrogen ion from the given information	• pH	Students should know that P^H is negative logarithm of hydrogen (H^+) ion concentration. Students should know that the pH scale is used to measure acidity and alkalinity. It runs from 0 to 14 and that pH 7 is neutral. The smaller the pH value the more acidic; the larger the pH value to more alkaline. Students should measure the pH of a number of common substances using universal indictor, pH paper and a pH meter if available. Students should appreciate that the pH of an acid is a measure of the concentration of hydrogen ions present and is therefore determined both by whether the acid is strong or weak, and by its concentration. Students should be given the mathematical definition of $pH = - \log_{10}[H^+]$. They should appreciate from this that pH is a logarithmic scale thus the hydrogen ion concentration of an acid of pH 3 is ten times that of an acid of pH 4. Students should be able to identify acidic, basic and neutral solutions using their labelled P^H values. Students could measure the pH values of concentrated and dilute, weak and strong acids. Students should be able to: • Calculate the pH of an acid given its concentration and assuming complete dissociation • Calculate the hydrogen ion concentration of a solution from its pH value
• Perform activities to investigate some physical properties of acids		Students should carry out an investigation into the physical properties of acids. These could include: • Effect on acid-alkali indicators • Measuring conductivity • Measuring relative density
• Perform activities to investigate some chemical properties of acids		Students should carry out an investigation into the chemical properties of acids. These could include: • Reaction with a metal e.g. magnesium, zinc, iron • Reaction with metal carbonates and hydrogencarbonates • Reaction with metal oxides and hydroxides
• Explain the direct combination of elements, the reaction of acidic oxides with water and formation of volatile acids from non volatile	• Preparation of acids	Students should be aware of different methods used to prepare acids. These could include: • The direct synthesis of hydrogen chloride gas by burning hydrogen in chlorine and the subsequent addition of water to form hydrochloric acid, HCl(aq). • The reaction of sulphur dioxide gas with water to form sulphurous acid, H_2SO_3(aq).

Competencies	*Contents*	*Suggested Activities*
acids as the three methods of preparation of acids • Conduct simple experiment to prepare acids in laboratory		• The reaction of concentrated sulphuric acid, H_2SO_4 , with sodium nitrate to form nitric acid, HNO_3 Students should attempt the preparation of chlorous acid from barium chlorite and sulphuric acid in the laboratory.
• Describe the uses of the three common laboratory acids.	• Common uses of HCl, HNO_3, H_2SO_4	Students should be able to identify the three common acids used in the laboratory and give some uses of each: • Hydrochloric acid – present in the stomach and needed for digestion; manufacture of aniline dyes; pickling iron to clean it before galvanising and tin plating • Nitric acid – manufacture of explosives, manufacture of nitrate fertilisers • Sulphuric acid – present in car batteries, used to make a variety of other chemicals and products including phosphate fertilisers, detergents, paints and pigments
	2.4. Bases *(5 periods)*	
• Define bases in terms of the concepts of Arrhenius, Brønsted-Lowry and Lewis	• Definition of bases - Arrhenius	Students should already be aware how the definition of an acid has changed over the years to provide something that is general in nature. They should understand that the definition of a base has changed in the same way: • Arrhenius defined a base as a substance which dissociates in aqueous solution to release hydroxide ions, OH^-. • e.g. Sodium hydroxide is a base by this definition because it releases OH^- in aqueous solution.
• Give examples of bases based on Arrhenius, Brønsted-Lowry and Lewis concepts	- Brønsted-Lowry - Lewis	• Brønsted-Lowry made the definition less specific by stating that a base is a substance that will accept protons from another substance. • e.g. In the reaction $NH_3 + H^+ \rightarrow NH_4^+$, ammonia acts as a Brønsted-Lowry base because it accepts a proton. • Lewis made this even more general by stating that a base is anything which can donate a pair of electrons. • e.g. In the reaction $BF_3 + F^- \rightarrow BF_4^-$, the fluoride ion is acting as a Lewis base because it is donating a pair of electrons to boron(III) fluoride.
• Explain the general properties of bases	• General properties of bases	Students should understand that an alkali is a base which is soluble in water. Students should review the properties of alkalis/bases including: • Effect on common indicators such as litmus, phenolphthalein, methyl red and universal indicators • Neutralisation reactions with acids

Competencies	*Contents*	*Suggested Activities*
• Define strong and weak bases • Distinguish between strong and weak alkalis(soluble bases)	• Strength of bases (Strong and weak bases)	Students should appreciate that substances dissociate when in aqueous solution. In alkalis like sodium hydroxide the dissociation of the ions is complete: $NaOH \rightarrow Na^+ + OH^-$ Sodium hydroxide is described as a strong alkali because it is fully dissociated. In alkalis like ammonia solution ionisation is only a partial. $NH_3 + H_2O \rightleftharpoons NH_4^+ + OH^-$ Ammonia solution is described as a weak alkali because it is only partially dissociated. Students should understand that whether an alkali is described as strong or weak depends upon the degree which it dissociates and has nothing to do with its concentration.
• Define concentrated and dilute alkalis • Distinguish between concentrated and dilute alkalis(soluble bases)	• Concentrated and dilute bases	The concentration of an alkali is a measure of the number of moles of the alkali dissolved in 1 liter and is therefore expressed in mol $liter^{-1}$. Both a strong alkali and a weak alkali may be concentrated or dilute depending on the number of moles present.
• Use the necessary precautions while working with bases	• Precautions in handling bases	Students should appreciate the corrosive nature of strong alkalis and some weak alkalis such as ammonia solution. Precautions should be taken when handling alkalis including: • Wearing eye protection • Wiping spillages straight away • Diluting any alkali that gets onto clothes • Using a bellows to pipette alkali
• Define pOH • Show the mathematical relationship between pH and pOH • Calculate the pOH of a given basic solution • Calculate the concentration of hydroxide ion from the given information	• P^{OH} - Relationship between pH and pOH	Students should appreciate that POH is a measure of the concentration of hydroxide ions in an acidic or a basic solution. Students should know that the pOH scale is used to measure alkalinity or acidity and be given the mathematical definition of $pOH = -\log_{10}[OH^-]$. Students should appreciate that pH and pOH are related mathematically as: $pH + pOH = 14$ Students could attempt to derive this using the ionic product of water, K_w, as follows: In a neutral substance such as distilled water: $K_w = [H^+][OH^-] = 10^{-14}$ $-\log_{10}\{[H^+][OH^-]\} = \log_{10}10^{-14}$ $\{-\log_{10}[H^+]\} + \{-\log_{10}[OH^-]\} = 14$ $pH + pOH = 14$ Students could measure the pOH values of concentrated and dilute, weak and strong acids. Students should be able to:

Competencies	*Contents*	*Suggested Activities*
		• Calculate the pOH of an alkali given its concentration and assuming complete dissociation • Calculate the hydroxide ion concentration of a solution from its pOH value
• Conduct activities to investigate some chemical properties of bases		Students should carry out an investigation into the chemical properties of bases. These could include: • Thermal stability • Reaction with acids
• Explain the reaction of active metals with water, the reaction of basic oxides with water and double displacement reactions as the three methods of preparation of bases	• Preparation of bases	Students should be aware of different methods used to prepare bases. These could include: • The reaction of a reactive metal from Group 1 or Group 2 with water to form the hydroxide. • The reaction of a Group 1 or Group 2 metal oxides with water to form the hydroxide. • Double displacement reactions in which the products of the reaction are a soluble base and an insoluble salt e.g. $K_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow 2\,KOH(aq) + BaSO_4(s)$
• Conduct simple experiments to prepare bases in laboratory		Students could prepare the hydroxides of lithium and/or calcium by reacting the metal directly with water. Students could prepare magnesium and/or calcium hydroxide by reacting the metal oxide with water. Students could prepare NaOH or KOH by reaction of a solution of Na or K metal sulphate with barium hydroxide solution.
• Describe the uses of the three common laboratory bases	• Common uses of NaOH, $Ca(OH)_2$ and NH_3 (aq)	Students should be able to identify the three common alkalis used in the laboratory and give some uses of each: • Sodium hydroxide – soap, degreasers, various chemicals • Calcium hydroxide – lime water test for carbon dioxide, slaked lime for reducing pH of soil • Ammonia solution – detergents, fertilisers
	2.5. Salts *(5 periods)*	
• Define salts		Students should recall that a salt is produced when an acid is neutralised by a base: acid + base = salt + water
• Give examples of salts		Students should recall the names of some common salts. They could be able to suggest a possible combination of acid and base to prepare each salt e.g. copper(II) sulphate: sulphuric acid and copper(II) oxide.

Competencies	***Contents***	***Suggested Activities***
• Classify salts as acidic and normal salts	• Classification - Acidic salts - Normal salts - Basic salts	Students should understand that salts can be classified in three groups: • Acidic salts – are salts in which not all of the hydrogen ions in an acid have been replaced e.g. sodium hydrogensulphate, $NaHSO_4$. Students should understand that when made into an aqueous solution it releases the ions Na^+, H^+, SO_4^{2-}. It releases hydrogen ions hence it is acidic. • Normal salts – are salts in which all of the hydrogen ions in an acid have been replaced e.g. sodium sulphate, Na_2SO_4. • Basic salts- are salts that contain ionizable hydroxide ions e.g Basic zinc chloride, Zn(OH)C1
• Explain the direct combination of elements, the reaction of acids with bases, neutralization and the reaction between acids and metals as the methods of salt preparation	• Preparation of salts	Students should explore different methods of preparing salts. These could include: • Metal + acid e.g. calcium, magnesium, aluminium, zinc, iron + dilute hydrochloric/nitric/sulphuric acid Students should appreciate that metals which are higher in the reactivity series(above calcium) are too vigorous for this method while metals below iron are either too slow or do not react at all. Students should be made aware that calcium sulphate is only sparingly soluble so in a reaction with dilute sulphuric acid, calcium tends to become coated with calcium sulphate which inhibits the reaction from proceeding • Metal oxide + acid e.g. transition metal oxides + dilute hydrochloric/nitric/sulphuric acid • Metal hydroxide + acid e.g. Group 1 metal hydroxides + dilute hydrochloric/nitric/sulphuric acid • Metal carbonate + acid e.g. any metal carbonate + dilute hydrochloric/nitric/sulphuric acid • Double decomposition reactions in which two soluble reactants form soluble and an insoluble products which are easily separated e.g. lead nitrate(aq) + sodium iodide solution(aq) = lead iodide(s) + sodium nitrate(aq) Students should appreciate that not every method can be used to make every salt. Students should prepare NaCl from NaOH and HCl and obtain it by evaporation.
• Conduct simple experiment to prepare a salt by neutralization. • List some important salts • Discuss the uses of some important salts	• Some important salts and their uses	Students should be aware that some salts are very important and be able to describe their uses. These could include: • Sodium chloride – preparation and preservation of food; raw material for the manufacture of sodium hydroxide and chlorine • Ammonium nitrate – nitrogenous fertiliser • Copper(II) sulphate – Bordeaux mixture and other fungicides • Iron(III) chloride – etching printed circuits • Potassium nitrate – explosives and fertilisers

Competencies	***Contents***	***Suggested Activities***
• Explain the properties of salts • Describe the chemical tests of some salts by conducting activities	• Properties of salts	Students should investigate the solubility of a range of salts. They could use their results to derive some simple rules about solubility. Students could investigate the properties of salts which are: • Hygroscopic – absorb water from the atmosphere but remain solid • Deliquescent – absorb so much water from the atmosphere that they form solutions • Efflorescent – lose water to the atmosphere Students could demonstrate that when salts dissolve in water they release ions therefore the solutions conduct electricity. Students could investigate the thermal stability of salts including: • Comparing the stability of Group 1 carbonates with those of Group 2 and the transition metals • Comparing the thermal decomposition of a Group 1 nitrate with those of Group 2 or transition metals Students could investigate the thermal stability of lithium carbonate and lithium nitrate and from this deduce that, in these reactions, lithium does not behave like the other Group 1 metals but as a Group 2 metal. Students could carry out simple tests to detect the presence of specific ions in solution. These could include: • Flame tests – lithium, sodium, potassium, calcium, strontium, barium • Ammonia solution – copper(II) • Sodium hydroxide – iron(II) and iron(III) • Silver nitrate solution – halides • Barium nitrate/chloride solution – sulphates • Dilute acid – carbonates and hydrogencarbonates • Brown ring test – nitrates
• Mention the essential nutrients of plants • Describe the functions of nitrogen, phosphorus and potassium	• Plant nutrients - Essential nutrients	Students should appreciate that plants need certain mineral nutrients in order to grow well. Students could carry out some research to identify macronutrients and micronutrients. Students should appreciate the importance and role of the following three nutrients in plant growth: • Nitrogen – synthesis of amino acids, proteins and other nitrogen compounds like chlorophyll • Phosphorus – formation of nucleic acids and high energy phosphate compounds like ATP • Potassium – activates enzymes in photosynthesis and increases sap concentration to increase osmotic uptake of water

Competencies	***Contents***	***Suggested Activities***
• Define fertilizers • List some common fertilizers • Explain the importance of fertilizers	- Fertilizers	Students should understand that plants use nutrients and it the plants are removed from the soil, such as a food crop, the nutrients are lost from the soil and must be replaced. Students should appreciate that fertilisers may either be: • Natural products like animal dung and rotted vegetable matter • Artificial chemicals such as ammonium sulphate and potassium nitrate Students should be familiar with the term NPK which is used to describe fertilisers containing nitrogen, phosphorus and potassium. Students could investigate the content of fertilisers which may be described as 10:10:10 or 40:25:15 and find out why fertilisers of different composition are used for different purposes. Students could calculate the percentage of nitrogen in different fertilisers such as ammonium nitrate (NH_4NO_3), potassium nitrate (KNO_3) and urea ($CO(NH_2)_2$.
• List some common inorganic compounds that are used as pesticides	- Pesticides	Students should appreciate that pesticides are chemicals used to kill pests which affect the growth of plants. These include: • Fungicides – control fungal infections • Insecticides – control insects Students should be able to name some inorganic chemicals used as pesticides including: • Copper(II) sulphate – fungicide • Sodium chlorate - herbicide

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 inorganic compounds, oxides, acidic oxides, basic oxides, amphoteric oxides, neutral oxides, peroxides, acids, bases and salts and give examples for each; define strong and weak acids, concentrated and dilute acids; P^H, P^{OH} and fertilizers; classify inorganic compounds, oxides, acids and salts; Explain the chemical Properties of acidic oxides, basic oxides, amphoteric oxides, peroxides; explain general properties of acids, bases and salts; explain preparations of acids, bases and salts, explain the importance of fertilizers; distinguish basic oxides and acidic oxides experimentally; discuss the salt forming nature of acidic, basic and amphoteric oxides; distinguish peroxides from other oxides experimentally; distinguish between strong and weak acids and between concentrated and dilute acids describe the P^H scale; determine the $P^H$of some common substances; calculate the P^H, P^{OH} and concentration of a solution from a given information; conduct activities to investigate the physical and chemical properties of acids and bases; prepare acids and bases in the laboratory; describe the uses of the three common acids and the three common bases; distinguish between strong bases and weak bases and between concentrated bases and dilute bases; list some important salts and discuss their uses; conduct activities to test the presence of some ions in some salt solutions; mention the essential nutrients of plants and describe the functions of nitrogen, phosphorus and potassium and list some common inorganic compounds that are used as pesticides.

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

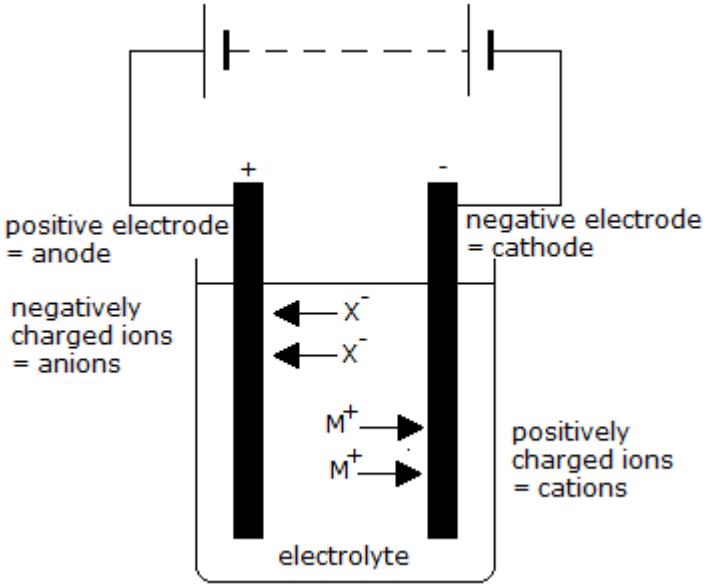
Students working below the minimum requirement level will require extra help if they are to catch up with the rest of the class. They should be given extra attention in class and additional lesson time during breaks or at the end of the day.

Unit 3: Electrochemistry *(10 periods)*

Unit outcomes: Students will be able to:

- Understand how a chemical reaction produces electric current and how electricity brings about a chemical reaction in electrochemical cells.
- Understand the difference between metallic conduction and electrolytic conduction;
- Develop skills in writing the oxidation half-reaction, reduction half-reaction and cell reaction for the electrolysis of molten electrolytes that occur in electrolytic cells;
- Know three types of Voltaic cells;
- Understand the difference between electrolytic cells and voltaic cells;
- Appreciate the industrial application of electrolysis in the production of certain metals, non-metals and chemicals and in purification and electroplating of metals;
- Demonstrate scientific inquiry skills: observing, comparing and contrasting, measuring, asking questions, designing experiments, interpreting data, predicting, classifying, communicating and problem solving.

Competencies	***Contents***	***Suggested Activities***
Students will be able to: • Explain electrochemistry	**3. Electrochemistry** **3.1 Introduction** *(1 period)*	Students should understand that electrochemistry is concerned with bringing about chemical change using an electric current or generating electrical energy from chemical reactions.
• Define electrical conductivity • Explain metallic conductivity	**3.2 Electrical conductivity** *(2 periods)* • Metallic conductivity	Students should understand that both metals and aqueous solutions conduct electricity but that the process is different in each case. Students should be aware that in metallic conductivity: • Metallic structure can be described as matrix of positive ions in a sea of mobile electrons • Metals contain delocalised valence electrons which are able to move • Electric charge is carried by electrons Students could investigate the ability of different materials to conduct electricity. Students could relate the ability of graphite, a non-metal, to conduct electricity to the delocalised electrons contained within its layered structure.
• Explain electrolytic conductivity • Distinguish between metallic conduction and electrolytic conduction • Distinguish between strong and weak electrolytes • Use conductivity apparatus to test conductivity of substances	• Electrolytic conductivity	Students should be aware that in electrolytic conductivity: • The electrolyte contains ions • The ions are able to move in the solution • Electric charge is carried by ions Students should be aware that ionic compounds are composed of ions but their ions are not mobile when the compound exists as a solid – and this is why ionic solids do not conduct an electric current. Students could investigate the ability of different soluble compounds to conduct electricity. These could include: • Ionic compounds such as salt • Organic compounds such as glucose and sucrose

Competencies	*Contents*	*Suggested Activities*
• Define the term electrolysis • Define the terms electrode, anode cathode, electrolyte, anion, and cation	**3.3 Electrolysis** *(2 periods)* • Electrolytic cell • Electrolysis of molten electrolytes	This could be done using a simple circuit composed of three cells and a lamp. Students should understand that electrolysis is the process of bringing about chemical change using an electric current. They should be familiar with the associated terminology. • Anode • Anions • Cathode • Cations • Electrolyte This could be given in the form of a diagram.  Students should understand that the ability of an electrolyte to conduct an electric current is determined by the concentration of ions. • Strong electrolyte – high concentration of ions e.g. very soluble ionic compound • Weak electrolyte – low concentration of ions e.g. sparingly soluble ionic compound
• Describe electrolytic cell • Draw labelled diagram of an electrolytic cell		Students should be able to draw an electrolytic cell and label: • Power source (must be d.c.) • Electrolyte • Anode

Competencies	*Contents*	*Suggested Activities*
• Define the terms half-reaction and cell reaction • Write the oxidation half-reaction, reduction half reaction and cell reaction for the electrolysis of molten or fused electrolytes • Perform an activity to show electrolysis of molten electrolytes		• Cathode Students should appreciate that during electrolysis: • Negatively charged ions or anions are attracted to the positive electrode or anode • The anions lose electrons to form atoms (that combine to form molecules) • The anions are therefore oxidised • The reaction at the anode can be shown by a half equation • Positively charged ions or cations are attracted to the negative electrode or cathode • The cations gain electrons to form atoms • The cations are therefore reduced • The reaction at the cathode can be shown by a half equation Students should carry out the electrolysis of molten lead bromide using graphite electrodes. Students should: • Observe bromine given off at the anode • Write a half equation for the reaction at the anode $2Br^- \rightarrow Br_2 + 2e^-$ • Identify the reaction at the anode as an oxidation reaction because it involves the loss of electrons • Observe lead produced at the cathode • Write a half equation for the reaction at the cathode $Pb^{2+} + 2e^- \rightarrow Pb$ • Identify the reaction at the cathode as a reduction reaction because it involves the gain of electrons Students should consolidate their understanding of the terms oxidation and reduction in terms of electron loss and gain. They should appreciate that equal number of electrons are lost at the anode and gained at the cathode, and since electrolysis overall is a redox reaction and oxidation or reduction cannot occur in isolation – if something is oxidised something else must be reduced.
• Construct a simple cell using strips of zinc, copper, $ZnSO_4$ and $CuSO_4$ solutions	**3.4 Galvanic cells (voltaic cells)** *(3 periods)* • Primary cells and secondary cells	Students should appreciate that just as an electric current can be used to bring about a chemical reaction; so a chemical reaction can be used to generate an electric current. This occurs in a voltaic cell (sometimes called a galvanic cell). Students should construct a simple cell using strips of zinc, copper, $ZnSO_4$ and $CuSO_4$. The small voltage produced should be measured with a sensitive voltmeter.

Competencies	*Contents*	*Suggested Activities*
• Mention different types of voltaic cells • Describe how voltaic cells can be used to make commercially useful batteries. • Distinguish between voltaic cell and an electrolytic cell • Describe voltaic cell		Students could make a simple cell by inserting pieces of different metals into a lemon or lime. This could be extended by investigating which metals give the greatest voltage and which the least. This could be related to the reactivity series. Students should appreciate that early cells consisted of metal rods suspended in electrolyte solutions. They are sometimes referred to as wet cells. Student could research to find out more about: • The wet Leclanché cell • The Daniell cell Students could discuss the practical problems of using wet cells and why dry cells were developed. Students should be able to draw and label the structure of a dry Leclanché cell. Students should appreciate that in a dry cell: • Oxidation occurs at the negative electrode (zinc) with the reaction $Zn(s) \rightarrow Zn^{2+} + 2e^-$ • Reduction occurs at the positive electrode (carbon) with the reaction $2\ 2NH_4^+(aq) + 2MnO_2 + 2e^- \rightarrow Mn_2O_3(s) + 2NH_3(aq) + H_2O(l)$ When the cell is connected in a circuit electrons are pumped from the negative electrode to the positive electrode. Students could research the terms 'conventional current' and 'actual current' and the reason for them. Students should appreciate that dry cells are described as primary cells because they cannot be recharged. Once the chemicals in the cell are exhausted no electricity flows and the cells are replaced. Students should compare this with a secondary cell which can be recharged when it becomes exhausted. A car battery could be used as an example of a secondary cell.
• Describe selected industrial applications of electrolysis.	**3.5 Industrial applications of electrolysis** *(2 periods)*	Students should appreciate that electrolysis has some important industrial applications including: • Production of chemicals • Production of metals and non-metals • Purification of metals • Electroplating

Competencies	*Contents*	*Suggested Activities*
		Students should investigate one example of each of these applications. These could be: • Electrolysis of sodium chloride solution to produce sodium hydroxide and chlorine. Anode: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ Cathode: $2H_2O(l) + 2e^- \rightarrow H_2(g) + 2OH^-(aq)$ • Electrolysis of molten alumina to produce aluminium. Anode: $6O^{2-} \rightarrow 3O_2(g) + 12e^-$ Cathode: $4Al^{3+}(l) + 12e^- \rightarrow 4Al(l)$ • Electrolysis of impure copper to give pure copper using an electrolyte of copper(II) sulphate solution. Anode: $Cu(s) \rightarrow Cu^{2+}(aq) + 3e^-$ Cathode: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ • Electroplating silver onto copper using a silver anode, copper cathode and an electrolyte of silver nitrate solution. Anode: $Ag(s) \rightarrow Ag^+(aq) + e^-$ Cathode: $Ag^+(aq) + e^- \rightarrow Ag(s)$ Students should appreciate that oxidation always occurs at the anode and reduction always occurs at the cathode.

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 electrical conductivity, electrolysis, electrode, anode, cathode, electrolyte, anion, cation, half-reaction and cell reaction; explain electrochemistry, electrolytic conductivity metallic conductivity; distinguish between metallic conduction and electrolytic conduction; strong electrolytes and weak electrolytes; voltaic cell and electrolytic cell; use conductivity apparatus to test conductivity of substances; describe electrolytic cell, Voltaic cell and selected industrial applications of electrolysis; draw labelled diagram of an electrolytic cell; write the oxidation half-reaction, reduction half-reaction and cell reaction for the electrolysis of molten electrolytes; perform an activity to show electrolysis of molten electrolytes; construct a simple cell using strips of Zn, Cu, $ZnSO_4$ and $CuSO_4$ solutions; Mention different types of Voltaic cells and describe how they can be used to make commercially useful batteries.

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 4: Chemistry in Industry and Environmental Pollution *(25 periods)*

Unit outcomes: Students will be able to:

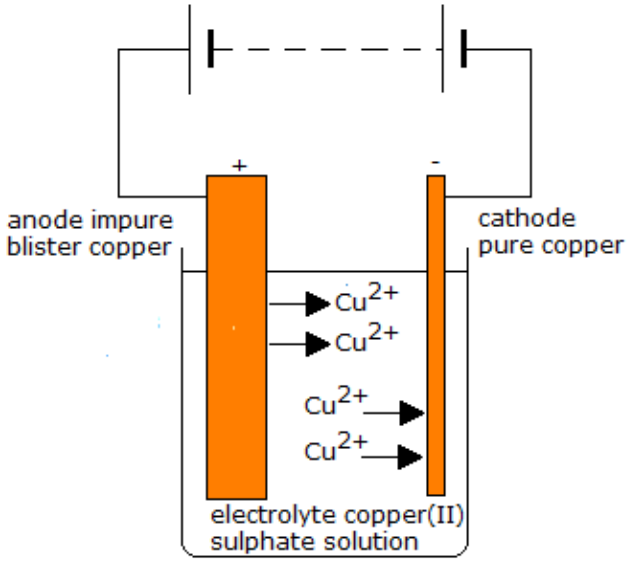
- Know the renewable and non-renewable natural resources and appreciate their importance in industry as raw materials;
- Know the extraction , chemical properties and uses of aluminium, iron, copper, nitrogen, phosphorus, oxygen, sulphur, and chlorine;
- Know the production and chemical properties of nitrogen, phosphorus, oxygen, sulphur and chlorine ;
- Know some important chemicals and related industries in Ethiopia.
- Understand the important steps in the production of glass, ceramics, cement, sugar and paper and pulp;
- Know how tanning is carried out and how food is packed and preserved;
- Know the three types of environmental pollution and names of the pollutants;
- Understand the causes and effects of air, water and land pollution and know the main methods to reduce them;
- Demonstrate scientific inquiry skills: observing, classifying, communicating, asking questions, applying concepts and problem solving.

Competencies	***Contents***	***Suggested Activities***
Students will be able to: • List general characteristics of chemical industries • Define natural resources • List natural resources	**4. Chemistry in Industry and Environmental Pollution.** **4.1 Introduction** *(1 period)* **4.2 Natural resources and industry** *(1 period)* • Definition of natural resources • Classification of natural resources	Students should discuss the general characteristics of chemical industries. Students should understand that natural resources are materials that are available on Earth for people to use. Students should make a list of natural resources. This could include: • Stone • Metal ores • Soil • Wood • Air • Food crops • Crude oil • Natural gas • Coal • Fibres such as wool and cotton
• Classify natural resources as renewable and non-renewable	• Importance of natural resources for industry	Students should appreciate that some resources are replenished by natural processes e.g. given time, trees grow and replenish supplies of wood. Other resources are not replaced by natural processes e.g. crude oil is being used up far more quickly than it forms on the Earth and one day supplies will be exhausted. Students should look back at their list of resources and classify the resources as either: • Renewable – replenished by natural processes • Non-renewable – not replenished

Competencies	*Contents*	*Suggested Activities*
• Define chemical industry as a firm that involves the taking of raw material from the environment and turning it into a usable product by chemical means • Describe the application of minerals in industry		Students should understand that natural resources provide many important raw materials which are the starting materials for industrial processes. Students could research some different raw materials and how they are used. These could include: • Crude oil – refining to give petroleum products • Air – fractional distillation of liquid air to give nitrogen, oxygen and argon • Rocks e.g. limestone for building, manufacture of lime, extraction of iron • Minerals e.g. metal ores, sodium chloride, sulphur
	4.3 Production of some important metals and non-metals **Aluminium** *(12 periods)*	
• Outline the extraction of aluminium by the Hall process	- Extraction	Students should discuss about the extraction of aluminium. This should include: • The main ore of aluminium is bauxite (Al_2O_3) • Aluminium is a reactive metal and cannot be extracted simply by heating the bauxite • Aluminium is extracted by electrolysis using the Hall cell • Bauxite is first purified and converted to alumina $Al(OH)_3$ and then decomposing the alumina back to aluminium oxide • Alumina is dissolved in molten cryolite in the electrolytic cell: the reactions at the graphite electrodes are: Anode: $6O^{2-} \rightarrow 3O_2 + 12e^-$ Cathode: $4Al^{3+} + 12e^- \rightarrow 4Al$ • Under the conditions in the cell the anode is gradually oxidised to carbon dioxide and must be replaced periodically • Molten aluminium is siphoned off or tapped off from the bottom of the cell
• Describe the main physical and chemical properties of aluminium	- chemical properties	Students should recall the physical properties of aluminium Students should describe and appreciate the chemical properties of aluminium. These should include: • Aluminium is a reactive metal and rapidly reacts with oxygen from the air to form a layer of aluminium oxide. This layer of aluminium oxide inhibits the reaction of aluminium thus aluminium sometimes appears less reactive that its position in the reactivity series would suggest. This can be removed with mercury(II) chloride solution. Freshly exposed aluminium reacts rapidly with oxygen from the air to form aluminium oxide. $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$

Competencies	***Contents***	***Suggested Activities***
• Describe the uses of aluminium	- Uses	• Aluminium reacts with dilute acids to form salts e.g. $2Al(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(aq) + 3H_2(g)$ • Aluminium burns in chlorine gas to form aluminium chloride. $2Al(s) + 3Cl_2(g) \rightarrow 2AlCl_3(s)$ • Aluminium reacts with sodium hydroxide solution $2Al(s) + 2NaOH(aq) + 6H_2O(l) \rightarrow 2NaAl(OH)_4(aq) + 3H_2(g)$ Students should search aluminium made materials Students should know about the uses of aluminium. These should include • The manufacture of light alloys e.g. duralumin • The construction of air crafts , ships and cars • The manufacture of household utensils • Window frames and roofing sheets • Packing material the food industry
• Outline the extraction of iron by the blast furnace	• **Iron** - Extraction	Students discuss about the extraction of iron. This should include: • The main ores of iron are haematite (Fe_2O_3) and magnetite (Fe_3O_4) • Iron is less reactive than aluminium and can be extracted by heating the ore with a reducing agent. • Iron is extracted in a blast furnace. A mixture of iron ore, coke and limestone are heated together and air is blown through them • Coke is essentially carbon and is oxidised to carbon dioxide. The carbon dioxide then reacts with excess carbon and is reduced to carbon monoxide $C + O_2 \rightarrow CO_2$ $CO_2 + C \rightarrow 2CO$ • Carbon monoxide is the main reducing agent in the blast furnace and reduces the iron ore to iron $Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$ • The heat decomposes the limestone to calcium oxide and carbon dioxide $CaCO_3 \rightarrow CaO + CO_2$ • Calcium oxide reacts with acidic impurities such as silicon dioxide to form a slag. This protects the lining of the furnace from damage $CaO + SiO_2 \rightarrow CaSiO_3$ • Molten iron falls to the bottom of the furnace and is tapped off • Slag floats on top of the molten iron and is scraped off and used as a foundation for road building • Students should be given a project to construct a model which shows the blast furnace form locally available materials.

Competencies	***Contents***	***Suggested Activities***
• Briefly describe conversion of pig iron to steel	- Conversion of pig iron to steel	Students should know the conversion of pig iron to steel. The iron obtained from blast furnace (called pig iron)contains impurities like carbon, that make it brittle. Steel can be made by blowing oxygen into molten iron to oxidize impurities and decrease the amount of carbon content.
• Describe wrought iron	- Wrought iron	Students should also know that wrought iron is the purest form of iron with very low carbon content and other impurities. Students should recall to the physical properties of iron.
• Describe the main chemical properties of iron	- Chemical properties	Students should know about the chemical properties of iron. These should include: • Iron reacts with dilute acids to form salts e.g. $Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$ • Iron rusts in the presence of air and moisture to form a hydrated iron oxide • Iron is a transition metal and has two common oxidation states Fe(II) and Fe(III) • Iron(II) and iron(III) compounds are coloured • Solutions of some iron(II) compounds are rapidly oxidised to the corresponding iron(III) compounds by air • Heated iron reacts with hydrogen chloride gas. $Fe(s) + 2HCl(g) \rightarrow FeCl_2(s) + H_2(g)$ • Heated iron reacts with chlorine gas. $2Fe(s) + 3Cl_2(g) \rightarrow 2FeCl_3(s)$ • Iron will displace ions of less reactive metals from solutions of their salts $Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s)$
• Describe the uses of iron	- Uses	Students should know about the use of iron. These could include: • as pig iron to make items like domestic boilers, castings and mouldings • as wrought iron to ornamental gates, door knockers, etc. • manufacture of alloys, e.g. Carbon steels and alloy steels.
• Outline the extraction of copper	• **Copper** - Extraction	Students should know about the extraction of copper. This should include: • Copper is an unreactive metal and can be found in the ground as native metal, but is more often found as sulphide ores such as bornite (Cu_5FeS_4), chalcopyrite ($CuFeS_2$) and chalcocite (Cu_2S) • Copper ore can be reduced to copper by roasting in air. The oxygen combines with the sulphur to form sulphur dioxide $Cu_2S(s) + O_2(g) \rightarrow 2Cu(s) + SO_2(g)$ The copper obtained by roasting is called blister copper and is too impure for use.

Competencies	*Contents*	*Suggested Activities*
• Describe the main chemical properties of copper	- Chemical properties	• Blister copper is further purified by electrolysis  Anode: $Cu(s) \rightarrow Cu^{2+}(aq) + 2e^-$ Cathode: $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ Students should recall the physical properties of copper Students should know about the chemical properties of copper. These should include: Copper reacts with oxygen forming copper oxide $2Cu(s) + O_2(g) \rightarrow 2CuO(s)$ • Over a period of time in damp air, copper turns green due to the formation of verdigris, a basic carbonate ($CuCO_3.Cu(OH)_2$) Copper is a transition metal and has two common oxidation states Cu(I) and Cu(II) Copper(II) compounds are coloured • Copper does not react with dilute acids. But it reacts with dilute and concentrated HNO_3 and hot concentrated H_2SO_4
• Describe the uses of copper	- Uses	Students should know about the uses of copper. These could include: • Manufacture of alloys • Electrical conductor

Competencies	*Contents*	*Suggested Activities*
• Outline the production of nitrogen	• **Nitrogen** - Production	Students should know about the production of nitrogen. This should include: • Nitrogen makes up about 80% by volume of air • Nitrogen is obtained by the fractional distillation of liquid air • Water vapour and carbon dioxide are removed from air and what remains is compressed and cooled to form liquid air • The temperature of the liquid air is allowed to rise and the gases in air boil off at different temperatures; nitrogen at -196 °C, argon at - 186° C and oxygen at -183 °C.
• Describe the main chemical properties of nitrogen	- Chemical properties	Students should recall the physical properties of nitrogen Students should know about the chemical properties of nitrogen. These should include: • Nitrogen is relatively inert • When heated with reactive metals in Groups 1and 2, nitrogen reacts to form nitrides $3Mg(s) + N_2(g) \rightarrow Mg_3N_2(s)$ • Nitrogen reacts with oxygen to form a number of different oxides: N_2O, NO, NO_2 • In the Haber process nitrogen and hydrogen combine to form ammonia $N_2(g) + 2H_2(g) \rightarrow 2NH_3(g)$
• Outline the production of phosphorous	• **Phosphorous** - Production	Students should know about the production of phosphorus. This should include: • Phosphorus has two common allotropes: white phosphorus and red phosphorus • White phosphorus can be made in a number of ways including heating calcium phosphate in an electric furnace in the presence of carbon and silica. White phosphorus given off as vapour and collected under phosphoric acid. • Red phosphorus can be made by heating white phosphorus to 250 °C or by leaving it in sunlight
• Describe the main chemical properties of phosphorus	- Chemical properties	Students should recall the physical properties of phosphorus. Students should know about the chemical properties of phosphorus. These should include: • Phosphorus reacts with oxygen to form phosphorus oxides, P_2O_3 and P_2O_5, e.g. phosphorus(V) oxide $P_4(s) + 5O_2(g) \rightarrow 2P_2O_5(s)$ • These oxides dissolve in water to form acids e.g. phosphoric(V) acid $P_2O_5(s) + 3H_2O(l) \rightarrow 2H_3PO_4(aq)$ • Phosphorus reacts with chlorine to form phosphorous chlorides, PCl_3 and PCl_5, e.g. phosphorus(V) chloride • $P_4(s) + 10Cl_2(g) \rightarrow 4PCl_5(s)$

Competencies	*Contents*	*Suggested Activities*
• Outline the production of oxygen	• **Oxygen** - Production	Students should know about the production of oxygen. This should include: • Oxygen makes up about 20% by volume of air • oxygen is obtained by the fractional distillation of liquid air • Water vapour and carbon dioxide are removed from air and what remains is compressed and cooled to form liquid air • The temperature of the liquid air is allowed to rise and the gases in air boil off at different temperatures; nitrogen at -196 °C, argon at - 186° C and oxygen at -183 °C.
• Describe the main chemical properties of oxygen	- Chemical properties	Students should know about the chemical properties of oxygen. These should include: • Oxygen is relatively reactive • Oxygen combines with metals to form basic oxides $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$ • Oxygen combines with non-metals to form acidic oxides $S(s) + O_2(g) \rightarrow SO_2(g)$ • Oxygen is required for combustion $CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$
• Outline the production of sulphur	• **Sulphur** - Production	Students should know about the extraction of sulphur. This should include: • Sulphur exists in the ground in elemental form • Elemental sulphur is extracted by the Frasch process. Hot water is pumped underground under high pressure and melts the sulphur. The molten sulphur is then brought to the surface • About half of the sulphur needed by industry is obtained as a waste product of other industrial processes. These are mainly from the removal of hydrogen sulphide from natural gas and refined crude oil, and the removal of sulphur dioxide obtained by roasting metal sulphide ores. • Using sulphur produced by other industries reduces the demand on natural resources and reduces atmospheric pollution and acid rain Students should recall the physical properties of sulphur
• Describe the main chemical properties of sulphur	- Chemical properties	Students should know about the chemical properties of sulphur. These should include: • When heated with metals, sulphur combines to give metal sulphides $Fe(s) + S(s) \rightarrow FeS(s)$ • Sulphur reacts with oxygen to form two different oxides: SO_2 and SO_3 • Sulphur is the raw product from which sulphuric acid is made: $S(s) + O_2(g) \rightarrow SO_2(g)$ $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$

Competencies	*Contents*	*Suggested Activities*
		$H_2SO_4(l) + SO_3(g) \rightarrow H_2S_2O_7(l)$ $H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(l)$
• Outline the production of chlorine	• **Chlorine** - Production	Students should know about the production of chlorine. This should include: • Chlorine is obtained by the electrolysis of concentrated sodium chloride solution or brine. Sodium hydroxide solution is produced at the same time Ions in solution Na^+, H^+, Cl^-, OH^- Anode: $2Cl^-(aq) \rightarrow Cl_2(g) + 2e^-$ Cathode: $2H^+ + 2e^- \rightarrow H_2(g)$ Ions remaining in solution: Na^+, OH^- • Chlorine and sodium hydroxide solution must be kept apart as they react together $NaOH(aq) + Cl_2(g) \rightarrow NaOCl(aq) + HCl(aq)$ Students should recall the physical properties of chlorine
• Describe the chemical properties of chlorine	- Chemical properties	Students should know about the chemical properties of chlorine. These should include: • Chlorine is a powerful oxidising agent • Chlorine reacts with heated metals to form chlorides $2Fe(s) + 3Cl_2(g) \rightarrow 2FeCl_3(s)$ • Chlorine reacts with hydrogen to form hydrogen chloride $H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$ • Chlorine will displace less reactive halide ions from solutions of their compounds $Cl_2(g) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(aq)$ • Chlorine dissolves in water to give an acidic solution $H_2O(l) + Cl_2(g) \rightarrow HCl(aq) + HOCl(aq)$ • Chlorine and chlorine water will bleach coloured material
• Define industry • List some industries in Ethiopia • Describe the general characteristics of industries. • Outline the important steps in glass production	**4.4 Some industries in Ethiopia** *(6 periods)* • Introduction • Glass	Students should define industry and understand the general characteristics of industries. Students Could list some common industries in Ethiopia. Students should be able to give a brief description of the manufacture of glass including: • The raw materials for the manufacture of glass are sand and sodium carbonate • Glass is a mixture of silicates • Ordinary glass is called soda glass and often cracks if heated to high temperatures • Borosilicate glasses, such as Pyrex, are made by adding boron compounds during manufacture • Borosilicate glasses can withstand being heated to high temperatures

Competencies	***Contents***	***Suggested Activities***
• Outline the important steps in ceramics production • Mention some use of ceramics	• Ceramics	Students should be able to give a brief description of the manufacture of ceramics including: • Ceramics are materials which are baked or fired at a very high temperature in a special oven called a kiln • Before firing ceramics can be painted and covered in a glaze which gives them a glossy finish • Pottery and tiles are examples of ceramics • Ceramics are very hard but often brittle • Ceramics can be patterned or coloured Students should be able to mention some uses of ceramics
• Outline the important steps in cement production	• Cement	Students should be able to give a brief description of the manufacture of cement including: • Cement is made by grinding a mixture of clay and sand • The resulting powder is heated in a kiln • The resulting mixture contains calcium oxide, silicon dioxide, aluminium oxide, iron(III) oxide and magnesium oxide • Small amounts of gypsum (calcium sulphate) are added to control the rate of setting • When water is added to the mixture a matrix of silicates is formed
• Outline the important steps in sugar production	• Sugar	Students should be able to give a brief description of the manufacture of sugar including: • Sugar cane as the raw material • Splitting the cane • Extracting the sugar by dissolving in warm water • Separation of sugar solution from remaining organic plant material • Removal of water to leave granulated sugar
• Outline the important steps in pulp and paper production	• Paper and pulp	Students should be able to give a brief description of the manufacture of pulp and paper including: • Wood pulp is made using all of the tree except the bark • Quick-growing softwood trees such as pines are normally used • The wood is chipped and ground to release fibres • Chemicals such as sodium carbonate, sodium hydroxide and sodium sulphite are added to break up the wood structure • The pulp may be bleached using oxidising agents such as chlorine, chlorine oxide, oxygen, ozone or hydrogen peroxide • Paper is made from a dilute suspension of fibres; often wood but sometimes cotton or other textiles • The suspension is poured onto a screen and the liquor is allowed to seep away • The resulting fibres are compressed and left to dry

Competencies	***Contents***	***Suggested Activities***
• Explain how tanning is carried out • Describe the application of chemical preservation of skin and hide • Mention some uses of skin and hide	• Tannery	Students should be able to give a brief description of the manufacture of leather including: • Tanning involves converting skin to leather using tannin • Tannin is an acidic chemical that alters the protein structure of the skin so once tanned, leather cannot turn back to skin • Skins are first cured by salting; this prevents the decomposition of collagen • After salting skins are limed using suitable chemicals such as calcium hydroxide to remove hairs and fats, and swell fibres • Finally skins are tanned; this may be by natural tanning or mineral tanning • In natural tannin the tannin is obtained from tree bark: trees frequently used include chestnut, oak, tanoak, hemlock, quebrancho, mangrove and wattle • Naturally tanned leather is very flexible and used for shoes, luggage and furniture • Mineral tanning uses chemicals like chromium sulphate and is a quicker process than natural tanning • Mineral tanning produces stretchable leather used for clothing and handbags
• Explain the process of food packing and preservation	• Food processing and preservation	Students should be able to review different methods of processing and preserving foods. These could include traditional methods e.g. • Salting • Pickling • Sugaring • Smoking • Drying • Canning And modern methods e.g. • Freezing • Freeze drying • Vacuum packing Students should investigate the processes in this unit in the context of traditional and modern methods used in Ethiopia
• Present a report in a class after visiting a near by factory.		Students should visit nearby factory and present a report in a class.

Competencies	*Contents*	*Suggested Activities*
• Define pollution • List the three types of pollution	**4.5 Environmental Pollution** *(5 periods)* • Introduction	Students should define pollution Students should appreciate as well as making many useful products which are essential to our modern way of life, industrial processes also produce waste products that have the potential to pollute our environment. Students could make a list of pollutants. Copy the names of some pollutants onto the board and show students that pollutants can conveniently be divided into three categories: those which cause air pollution, those which cause water pollution and those which cause land pollution
• List the names of common air pollutants	• Air pollution - Common air pollutants	Students should name some common air pollutants. These could include: • Sulphur dioxide • Nitrogen oxides • Carbon monoxide • Ozone • Hydrocarbons • Particulates • CFCs (Chloro Flouro Carbons) • Lead compounds
• Describe the effects of air pollutants	- Effects of air pollutants	Students should be able to describe some of the effects of air pollutants. These could include: • Sulphur dioxide and nitrogen oxides – acid rain, tree defoliation, release of heavy metal ions from soil into water courses, drop in pH of rivers and lakes • Hydrocarbons and ozone – smog • Particulates – irritates the lungs and affects breathing • CFCs – destroying the ozone layer in the upper atmosphere and thus allowing potentially dangerous ultraviolet radiation to reach the surface of the Earth • Excess carbon dioxide – enhanced greenhouse effect leading to global warming • Lead compounds and carbon monoxide are poisonous
• Describe some of the main methods used to reduce air pollution	- Methods of reducing air pollution	Students should be able to discuss methods used to reduce air pollution. These could include: • Flue-gas desulphurisation to remove sulphur dioxide from the flue gas of coal-fired power stations • Lower temperature furnaces and engines that reduce the amount of nitrogen oxides produced

Competencies	*Contents*	*Suggested Activities*
		• Catalytic converters fitted to car exhausts to convert unburnt hydrocarbons, nitrogen oxides and carbon monoxide to carbon dioxide, nitrogen and water • Banning of CFCs as aerosol propellant gases to be replaced by less harmful alternatives • Removal of lead compounds from gasoline and use lead-free fuels • Reducing CO_2 production (emission)
	• Water pollution - Common water pollutants	Students should be aware of pollution of rivers, lakes, ponds, streams, and sea is brought about by the discharge of untreated sewage, industrial and agricultural waste, and oil spillage. These could include: • Nitrate fertilisers washed out of soil • Phosphates from modern washing powders • Untreated sewage • Insecticides and herbicides washed off crops by rain or carelessly sprayed over water courses • Release of heavy metal ions from industrial processes • Acidic and/or alkaline residues from industrial processes
• Describe the different types of industrial water pollutants • Explain some of the factors involved in water pollution and their effects.	- Effects of water pollution	Students should be aware of water pollution can have a range of effects on the environment. These include: • Nitrates and phosphates accelerate the growth of surface water plants in a lake or river. Less light reaches the bottom-living plants and they die. Decomposer bacteria break down the dead organic material and as their population increases they take more and more oxygen out of the water. Eventually there is insufficient oxygen for aqueous animals such as fish and they die. This process is called eutrophication. • Insecticides and herbicides may enter food chains. Residues are stored in the organisms and eaten by the next organism. The result is an increasing amount of insecticide/herbicide residue in the bodies of animals which can have detrimental effects on health and behaviour • Changes in the pH of water or the concentrations of certain metal ions may cause the death of water organisms • Untreated sewage may allow the spread of water-borne disease such as cholera or typhoid. • Untreated sewage is broken down by bacteria which require oxygen therefore the oxygen concentration of the water falls, and aquatic animals that require oxygen from the water, such as fish, will die
• Describe some of the main methods used to reduce water pollution	- Methods of reducing water pollution	Students should be able to discuss methods of reducing water pollution. These could include: • Treatment of water • Recycling industries and agricultural wastes • Using moderate amounts of agriculture chemicals and increasing the use of fertilizers organic

Competencies	***Contents***	***Suggested Activities***
• Explain some of the factors involved in land pollution	• Land pollution - Factors involving in land pollution	Students should be able to describe some of the factors involved in land pollution. These could include: • Spillages of oil from leaking pipelines • Leaching of harmful heavy metal ions from buried waste into water systems • Leaching of harmful chemicals from corroded metal drums which have been buried in the ground, into water systems • Dumping of non-biodegradable waste like plastics that remain for tens and maybe hundreds of years without decaying
• Describe some of the main methods used to reduce land pollution	- Methods of reducing land pollution	Students should be able to discuss methods used to reduce land pollution. These could include: • Burning or recycling plastics and other non-biodegradable materials • Converting potentially dangerous chemical waste into harmless substances either by combustion at high temperatures or by other chemical reactions • Finding a use for the waste products of one industry in other industries e.g. sulphur dioxide from roasting metal sulphide ores used to make sulphuric acid
• Carry out a project on the effects(s) of an industry on environment		Students should carry out an investigation into the effects of an industry on the environment. If possible this should be an industry close to their school or home. They should determine such things as: • What the industry does • What raw materials are used • What the process involves • What waste products are produced • What happens to the waste products • How the environment is affected by the industry • How the environmental impact could be reduced

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, list and classify natural resources; define chemical industry; describe the application of minerals in industry; outline the extraction of aluminium, iron and copper; outline the production of nitrogen, phosphorus, oxygen, sulphur and chlorine; describe the main chemical properties of aluminium iron, copper, nitrogen, phosphorus, oxygen, sulphur and chlorine; describe the uses of aluminium, iron and copper; outline the important steps in the production of glass, ceramics, cement, sugar, and paper and pulp; explain how tanning is carried out; describe the application of chemical preservation of skin and hide; mention some uses of ceramics and skin and hide; explain the process of food packing and preservation; define pollution; list the three types of pollution; list the names of common air pollutants and describe their effects; describe the different types of industrial water pollutants; explain some of the factors involved in water pollution and their effects; explain some of the factors involved in land pollution; describe some of the main methods used to reduce air pollution, water pollution and land pollution; carry out a project on the effects of an industry on environment.

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.