CHEMISTRY

TEACHER'S GUIDE

GRADE 10

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Introduction

The study of chemistry at this cycle, Grades 9 -10, prepares your students for future nation building, both practically and philosophically. Studying chemistry provides students not only with specific concepts and theories in chemistry, but also with tools, confidence and attitudes for constructing their future prosperous society. Besides learning to think efficiently and effectively, your students come to understand how chemistry deals with the daily and routine lives of theirs and the citizens at large. On a higher level, the role of chemistry is also significant nationally as well as internationally.

To materialize the above stated major goals, encourage the students to apply high-level reasoning, and values to their daily life and also to their understanding of the social, economic, and cultural realities of the surrounding context. In turn, this will help the students to actively and effectively participate in the wide range of the development activities of their nation.

At this cycle, the students are expected to gain solid knowledge of the fundamental theories, rules and procedures of chemistry. It is also expected that they should develop reliable skills for using this knowledge to solve problems independently. To this end, the specific objectives of chemistry learning at this cycle are to enable them to:

- gain a solid knowledge of chemistry.
- appreciate the power, elegance and structure of chemistry.
- use chemistry in their daily lives.
- understand the essential contributions of chemistry to the fields of engineering, science, and economics at large.

Recent research gives strong arguments for changing the way in which chemistry has been taught. The traditional teaching-learning paradigm has been replaced by an active and participatory student-centered model. A student-centered classroom atmosphere and approach stimulates student inquiry. Your role in such a student-oriented approach would be as a mentor who guides the students constructing their own knowledge and skills. A primary goal when you teach a concept is for them to discover the concept by themselves, particularly as they recognize threads and patterns in the data and theories that they encounter under the teacher's guidance.

You are also encouraged to motivate students to develop personal qualities that will help them in real life. For example, student-oriented teachers encourage students' self confidence and their confidence in their knowledge, skills and general abilities. Motivate your students to express their ideas and observations with courage and confidence. As the students develop personal confidence and feel comfortable they will begin to address their material to groups and to present themselves and their ideas well. Support students and give them chances to stand before the class and present their work. Similarly, help them by creating favorable conditions for students to come together in groups and exchange ideas about what they have learned and about material they have read. In this

process, the students are given many opportunities to openly discuss the knowledge they have acquired and to talk about issues raised in the course of the discussion.

Teamwork is an acceptable approach in a student-centered classroom setting. For example, some experiments are performed by more than one student. Each student has a crucial role – one student might be responsible for carefully handling and mixing chemicals and another student may make quick and accurate measurements during the process.

This teacher's guide helps you only as a guide. It is very helpful for budgeting your teaching time as you plan how to approach a topic. The guide suggests teaching-time periods for each subject you will teach. The guide also contains answers to the review questions at the end of each topic.

Each section of your teacher's guide includes student-assessment guidelines. Use them to evaluate your students' work. Based on your conclusions, you will give special attention to students who are working either above or below the standard level of achievement. Check each student's performance against the learning competencies presented by the guide. Be sure to consider both the standard competencies and the minimum competencies. The ***minimum requirement*** *level* is not the ***standard level of achievement***. To achieve the standard level, your students must fulfill all of their grade-level's competencies successfully.

When you identify students who are working either below the standard level or the minimum level, give them extra help. For example, you can give them supplementary presentations and reviews of the materials in the class. Giving extra time to study, and develop extra activities to those who are performing below the minimum level is commendable. You can also encourage high-level students with advanced activities and extra exercises.

Some helpful references are listed at the end of this teacher's guide. For example, if you have access to the internet it could be a rich resource for you. Searching for new web sites is well worth your time as you investigate your subject matter. Use one of the many search engines that exist – for example, Yahoo and Google are widely accepted.

Do not forget that, although this guide provides many ideas and guidelines, you are encouraged to be innovative and creative in the ways you put them into practice in your classroom. Use your own full capacity, knowledge and insights in the same way as you encourage your students to use theirs.

General Information to the Teacher

The students' text is designed and prepared based on the participatory approach of the teaching – learning process. At present, it is believed that students should gain most of their knowledge from the teaching – learning process on their own and some from the teacher. The teacher is expected to give guidance and the necessary assistance, play a role as facilitator, harmonize concepts, provide students with materials required, create a conducive atmosphere for the teaching – learning process and evaluate of students' performance. The teacher needs to assist students to discover facts, realize concepts, develop skills in performing experiments, solving problems etc. So, he/she should not dominate the teaching – learning process by giving lecture or explaining concepts throughout the period.

Thus, whenever you have contact with your students, you need to plan how to promote active – learning. The following information will help you understand what you are expected to do before and during the entire teaching – learning process.

1. Organizing groups

You need to organize different groups in each section you are going to teach during your first contact with the students. To do so, you better have the list of all students in each section. You may organize the groups based on their seats, or on their ability as slow learners, medium and fast learners or by mixing them. After organizing groups, give them group numbers as group 1, group 2 etc. and register the names of students in each group. Every group needs to have a group leader and a secretary to jot down the main points during discussions. The groups as well as their members need not be permanent throughout the year. You can reorganize groups whenever necessary. You can do so per semester or mid-semester or even per month or two months etc.

2. Discussion

In all units, sections and subtopics, there are activities suggested for students to help them discuss and discover concepts. When you allow them to discuss points in each activity:

- follow up how every student participates in the discussion.
- be part of the discussion in some groups for a few minutes and see how the discussion among students is going on.
- give assistance and guidance when students are in need.
- give them hints when they face difficulties or have questions on the points suggested in the activities.
- ask questions related to the points in the activity to facilitate the interaction among students during discussion.

3. Presentation

Students are expected to present:

i) the concepts they gained during discussion in each activity in all units.

ii) their observation and analysis after performing experiments in groups to the class.

iii) the content prepared a specific topic. So you need to give emphasis to the following points in order to maximize student participation.

a. Groups should present their opinion turn by turn. For example, if you allow group 1 and group 2 to make a presentation on activity 1.1, the following groups 3 and 4 or others will present activity 1.2 etc.
b. Whenever a group gets the chance to make presentation for the second or third time, let other members of the group accomplish the task. Do not allow the same student from the same group to do so.
c. Give the opportunity to the rest of the class to ask questions or give their comments on the presentation of a particular group.

4. Experiment

Several experiments are suggested in the first three units. Most of these experiments should be performed by students. So, you are expected to accomplish the following tasks before or when students carry out the experiment.

a) To carry out the experiment by yourself before allowing students to do it.
b) To prepare chemicals and apparatus required for the experiment.
c) To give instruction on how students should handle chemicals and apparatus during every experiment.
d) To provide materials they need for the experiment.
e) Assist them whenever they have questions or difficulties in understanding the procedures suggested for the experiment.
f) Give instructions that students should perform the experiment only based on the procedures suggested for it.
g) Never allow them to conduct an experiment on their own other than the one they are supposed to do during the period.
h) Make them write a laboratory report in groups, present their observation to the rest of the class or submit it to you for correction as suggested in the students' text.
i) Make sure that every student in each group participates in the experiment.

5. Harmonizing Concepts

You are not expected to lecture throughout the period on most of the contents in the students' text. Your major role is harmonizing concepts suggested by students during presentations after discussing activities or performing an experiment with those they are expected to know. So, you need only to build a mini – lecture.

The concepts intended for students to discover in all activities, and answers to questions on the observation and analysis part of all experiments, are included as short notes in the subject matter presentation part of every section in this teachers' guide. So you are advised to use them. While harmonizing concepts in a mini – lecture, you better include other contents of the topic that have not been covered when students discuss activities.

6. Continuous Assessment

Previously, the performance of a student has been assessed in terms of his/her achievements in quizzes, tests, homework, mid – semester and semester final examinations. Although these evaluation techniques are useful tools for the assessment, they may not give a clear picture of the performance of a student. Therefore, a student's work should be assessed throughout every topic, section and unit as well as during each period. So, you need to have a record of every student's work as a student performance list. You can make a record about each student in the performance list, based on the following points.

- Involvement in discussions.
- Participation in presentations after discussion.
- Participation in answering questions during the process of harmonizing concepts or stabilization.
- Role of the student in performing experiments.
- Role of the student in presenting concepts gained from the experiment.
- Presentation of the project work.
- Presentation of research and writing.
- Presentation of topics given to the group as homework.
- Answering questions accordingly given as
  - class work
  - homework
  - quizzes
  - tests
  - mid – semester and semester final examinations

Here, it is very important to note that the assessment system is continuous assessment. That is, every performance of the student during the teaching-learning process should be given value and contribute its own share, as do quizzes, tests, mid-semester and semester final examinations, to the semester total. You are empowered to decide the percent of the contribution. However, your decision should not violate either the policy of the Ministry of Education or that of the Education Bureau of the regional state or that of your school.

7. Additional Questions

Some questions are given in this teachers' guide in each section before the answers to the exercises in the section. Use the questions indicated by an asterisk (*) for students working below the minimum requirement level, while students working above the minimum requirement level can attempt all of them. Give these questions as class work for fast learners after they complete their work during each period so that they will not sit idle and the period will not be boring for them.

8. Giving Note

You are not expected to write notes on the board related to the contents in each section. You need to give short notes on those contents left for students to discover after discussing the suggested activities and performing experiments. Be sure to offer any note that is available in the teachers guide, but not in the students' text. However you

can write short notes related to the main points as you harmonize concepts. Tell students how they can take notes, either from the text or during the teaching learning process. Tell them the main points they should emphasize, in taking notes from the text. Also tell them to jot down the main points as fast as they can as you harmonize concepts or give a mini-lecture.

9. Answers to Exercise

In all units, the answers to the suggested exercise are given at the end of each section, and answers to the review exercises in each unit at the end of the unit. So you can refer to them whenever you are in need.

10. Suggested methodologies

Teaching all contents of grade 10 chemistry requires implementing active learning methodologies. Active learning involves providing opportunities for students to participate in meaningful talk and to listen, write and reflect on the content, ideas, issues and concerns of an academic subject. It is more of a student activity. The teacher is a facilitator. The teacher guides and directs the students.

Rationale for active learning

- an increase in academic achievements
- an increase in critical thinking skills
- increased student retention
- a more positive attitude toward the subject matter
- improvement in communication skills

There are many methods that can be used to implement active learning. However, all of them are not suitable for teaching chemistry. So, some of the methodologies that can be used to promote active learning in teaching chemistry at this level are suggested as follows.

A. Gapped lectures

You divide your lecture into small sections (lecture for a period of 15 minutes) and give the students a quick activity of 5 to 10 minutes. After the activity, you proceed with another 15 minutes lecture followed by another activity. The activities usually emphasize the concepts included in the lecture. For example, you can apply this methodology to teach the informations on the production of metals and nonmetals.

B. Cooperative (collaborative) learning

This is a form of group work and it is helpful in group project work and group assignments. This can be applicable for students in doing their group assignments or in doing suggested project work. For example constructing a model of ethene or a blast furnace.

C. Group discussion

Is a simple interaction pattern in which 4 – 6 students work together on a given task and produce a written work or presentation. This method can be used in all sections and units at this level.

D. Presentation (peer teaching)

This is an activity where students present a topic in front of their classmates. This can be done individually or as a group. For example, you can use this method in unit 4 Natural Resources and Industry, and Environmental Pollution.

E. Demonstration

This is a method where the teacher shows the students how something is done. For example, preparation of ethyne from calcium carbide and water.

F. Experiments

It usually involves a very specific and controlled method of procedures, where results are usually recorded. This method is applicable in performing laboratory experiments throughout unit 1 – 3 at this level.

G. Concept map

It is a visual representation of ideas on any given topic. Students write the topic at the center of the page and then divide it into subtopics from which smaller branches will go off in different directions. For example, classification of organic compounds into hydrocarbons and oxygen containing hydrocarbons followed by the sub-classes and other smaller groups.

H. Question and answer (inquiry)

When this method is used, the teacher lectures and asks questions periodically relating to the information being given.

I. Investigation

This method is usually based on real life. For example, investigating the effects of an industry on the environment.

J. Spider diagram

Students write a topic at the middle and write ideas related to the topic around the topic and draw a line connecting each idea to the central idea.

K. Visual-based active learning

This method helps students learn using real object models, pictures, drawings and charts. For example, this method can help in teaching linkage of carbon-atoms, saturated and unsaturated hydrocarbons, substitution reactions of alkanes etc.

L. Brain storming

This is an activity in which students write everything they know or think about a given topic. The ideas might be right or wrong. This can be done individually, in pairs, small groups or as a whole class with the teacher or a student recording the ideas on the board. This method is used to find out what students already know on a topic before you start teaching. For example this method can be used while teaching traditional methods of food-preservation in unit 4.

M. Problem solving

Problems solving activities involve students finding solutions to problems. Problem solving can be done individually or in groups. The solution is not the focus. Instead, students are encouraged to explore different strategies and processes to find the solution. It creates students who are able to think for themselves or independent thinkers and look for solutions rather than become trapped in problems. This method can be applied for teaching pollution problems in the environments of students (unit-4).

You can use the following websites to get more information on active-learning methodologies.

1. **http://www.ntlf.com/html/lib/bib/91-9dig.htm**
2. **http:ctl.byu.edu/active-learning-techniques/**
3. **http:pdfcast.org/pdf/strategies-to-incorporate-active-learning-into-online-teaching**
4. **http://ijklo.org/volume5/IJELLOv5p215-232Pundak669.pdf**

11. Motivation of students and its importance

Motivation of students means getting students to exert a high degree of effort in their learning activities. The teacher is expected to motivate the students to create a conducive atmosphere for the teaching learning process. To motivate students, the teacher needs to encourage them to get ready for the lesson, appreciate students for their attempts in answering questions or any other activity they performe during the teaching-learning process and give them recognition. Motivating students helps the teacher.

To pass information to students according to the plan

- to make students active participants
- make students realize concepts easily
- make his/her teaching interesting
- achieve the desired goals etc.

Motivation also helps students to

- follow the lesson attentively
- increase their participation
- enhance their understanding
- develop interest in the subject
- achieve good results in their performance

Implementing active learning methodologies has a role of its own in motivating teachers as well. It is not as tiresome as that of lecturing although, the teacher has a lot of tasks to

accomplish when applying the methods. Using active learning methodologies during the teaching learning process motivate the teacher to:

- enjoy friendly and interesting relationships with students.
- develop new teaching skills by practicing the new teaching techniques, observing their results, and contrasting them with those of the old method of lecture-based teaching.
- become more interested in the teaching profession. For example, it is interesting and satisfying to develop new skills. The teaching-learning approach guides the teacher, helping him or her to develop professionally.
- investigate each student's talents and creativity. In this way, the teacher learns more about the age group of the students he or she teaches. This process is interesting in itself and helps the teacher develop professionally.
- guide students individually as they learn on their own. In this way, the teacher learns more about the dynamics of learning and also of teaching.
- actively engage in furthering the students' development. Because the students develop important social skills and attitudes, as well as increasing their knowledge and learning skills, the teacher has the satisfaction of contributing to their community and therefore to the country as a whole.
- expand his or her own creativity by developing appropriate presentations and assembling the apparatus and the local materials required for demonstrations and experiments.
- develops a greater interest in the teaching profession. As he or she assumes direct responsibility for each student's development.

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Unit 1 Introduction to Organic Chemistry

Unit Overview **Total Period Allotted 34**

Some of the contents of this unit are introduced in lower grade chemistry courses. At this level, those contents are treated in more detail. New subtopics and concepts are also included in the unit. The contents in the student text are presented in a more simplified way so that the learners can easily understand concepts.

This unit gives emphasis to introducing basic concepts in organic chemistry. The first section of the unit (1.1) deals with the history of organic chemistry and classification of organic compounds.

The emphasis of the next section (1.2) is on saturated hydrocarbons (Alkanes). It introduces what alkanes are, their nomenclature, physical and chemical properties, their methods of preparation and the type of isomerism they exhibit.

The following section (1.3) presents a detailed explanation of unsaturated hydrocarbons: mainly alkenes and alkynes. It includes their nomenclature, their physical and chemical properties, isomerism in alkenes and alkynes and their methods of preparations.

The emphasis of section 1.4 is on aromatic hydrocarbons, especially on the structure of benzene and its physical and chemical properties.

Section 1.5 introduces the natural sources of hydrocarbons: petroleum, natural gas and coal gas.

Section 1.6 gives emphasize to alcohols, their classification, nomenclature, physical and chemical properties and preparations. It also introduces industrial methods of production of ethanol. This section also gives information about aldehydes, ketones, carboxylic acids and esters.

The last part of the unit (1.7) introduces the industrial and agricultural applications of organic compounds in the production of alcoholic beverages, pharmaceuticals, dry cleaning agents, pesticides, weed killers and fertilizers. Some experiments are also suggested in the unit to help students develop skills in managing laboratory activities.

To deal with the contents in the unit, gapped lecture, inquiry, group discussion, experiment, demonstration and visual-based learning are suggested as major methodologies.

Unit Outcomes

After completing this unit, 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 alkanes, simple and branched 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 the general methods of preparation of alkanes, alkenes, alkynes, benzene and alcohols;
- know the uses of organic compounds in the manufacturing of alcoholic 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.

Main contents

1.1 Introduction

Period Allotted 1

Competencies

At the end of this section, students will be able to:

- narrate the historical development of organic compounds;
- classify organic compounds;
- define the term functional group.

Forward Planning

The teacher is expected to read the section thoroughly and make the necessary preparations. Prepare a chart that shows the different classes and functional groups of organic compounds. Set your own plan for organizing students in groups, conducting discussions on the suggested activities and managing them. Also make a plan for how to implement the suggested methodologies for the section.

Teaching Aids

Charts that show the classification of chemical compounds and the different classes of organic compounds.

Subject Matter Presentation

It is advisable to use group discussion, question and answer and visual-based methodologies to deal with the contents in the lesson.

This section begins with Activity 1.1. The activity helps students to realize the "life force theory" and also to discover how linkage of carbon atoms in different ways contributed to the presence of millions of organic compounds.

After introducing the topic of the section, allow the students to discuss Activity 1.1 for a few minutes. After the discussion, let the students make presentations to the class. Following this, you can start a mini - lecture on this section by introducing the two broad classes of chemical compounds as organic and inorganic compounds. Then introduce them to the differences between these groups of compounds according to the belief of early chemists by discussing the "life force" theory. Give emphasis to the central idea of the "life force" theory and what it states. Make your presentation in such a manner as to harmonize the concepts suggested by the students in Activity 1.1, question number one. Inform them that the "life force" theory was disproved by Friedrich Wohler after he synthesized urea in 1828 for the first time. Discuss the fact

that the term organic compound currently refers to the compounds contained in and derived from plants and animals as well as those synthesized by man artificially.

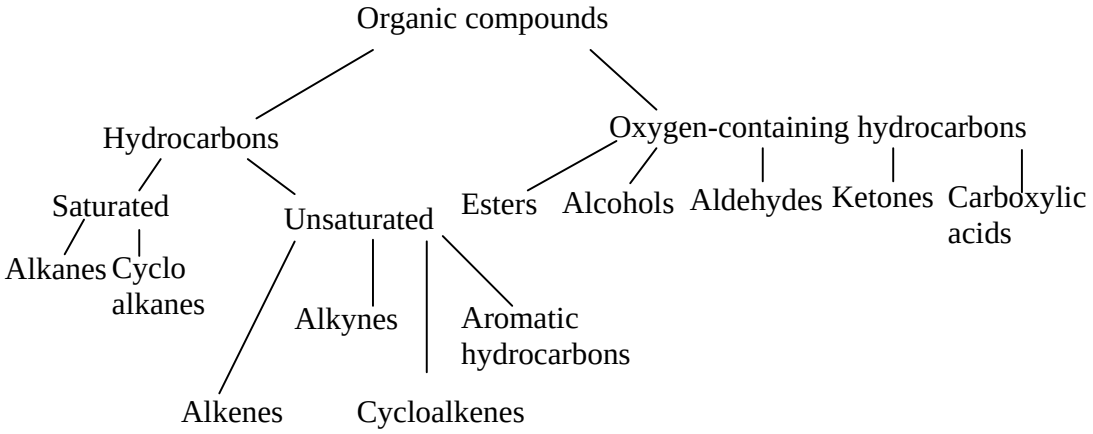
You can proceed further by asking what organic chemistry is and why organic chemistry is devoted to the study of carbon compounds only. After getting answers from the students, tell them the reasons and the cause for the presence of millions of carbon compounds (catenation). Show them how carbon atoms can link with one another to form a variety of compound after checking how the students managed the second question of Activity 1.1. Then, proceed to Activity 1.2. This activity enables students to understand how differences in functional groups lead to differences in properties and identify the basis for the classification of organic compounds. Let students discuss Activity 1.2 in groups for a few minutes and let two students from different groups suggest concepts they gained in their discussion on the activity. After you get responses from the students, tell them that the two compounds are different even though they have the same chemical formula. They differ in their functional group and hence have different chemical and physical properties. CH_3CH_2CHO is an aldehyde while CH_3COCH_3 is a ketone. Then continue introducing the basis for the classification of organic compounds and define functional group. To teach the different classes of organic compounds and their functional groups, it is advisable to use a chart prepared using Table 1.1 in the student text.

After you give the hint on the classification of organic compounds, list the following words on the blackboard and let volunteer students try to construct a concept map of the words.

- Hydrocarbons
- Saturated hydrocarbons
- Unsaturated hydrocarbons
- Organic compounds
- Oxygen-containing hydrocarbons
- Alkanes
- Alkenes
- Alkynes
- Aromatic hydrocarbons
- Aldehydes
- Alcohols

- Esters
- Carboxylic acids
- Ketones
- Cycloalkanes
- Cycloalkene

Concept mapping



Assessment

Prepare a list of all students in each section you are going to teach. The list serves as your students' performance list where you can make a record of how every student is working in discussion and in the teaching-learning process as a whole.

You can use your own oral questions and Exercise 1.1 for assessment. Check their exercise books and make a record. Make sure that the students working at the minimum requirement level have fulfilled the competencies suggested in the section. For students below the minimum requirement level, give additional lesson time. Appreciate the students working above the minimum requirement level.

Additional Questions

1. Mention at least two organic compounds synthesized from inorganic substances after the synthesis of urea by Friedrich Wohler.

*2. In addition to catenation, what other property of carbon is responsible for the presence of millions of organic compounds?

*3. Draw as many diagrams as possible to show how carbon atoms can link with one another in open chains (straight and branched) and ring structures using five carbon atoms.

Answers to Additional Questions

1. Acetylene, C_2H_2 from CaC_2 and H_2O, methanol (CH_3OH) from CO and H_2.
2. The ability of carbon atoms to form single, double and triple bonds.
3. Show them linkages of carbon atoms in straight chains, branched chains and ring structures.

Answers to Exercise 1.1

1. Compounds contained in or derived from plants and animals.
2. Organic compounds.
3. Sources of organic compounds are living things and these compounds contain a special 'life force'. Inorganic compounds are obtained from non-living things.
4. Organic compounds can be synthesized by plants and animals only. Man cannot synthesize them artificially.
5. Friedrich Wohler, by synthesizing urea for the first time.
6. Urea
7. a) ketone b) ester c) carboxylic acids d) alcohol
8. The study of carbon compounds or hydrocarbons and their derivatives.
9. Because of the presence of millions of carbon compounds.
10. Their functional group.
11. See Table 1.1 on page 4.

1.2 Saturated Hydrocarbons (ALKANES)

Period Allotted 9

Competencies

At the end of this section, students will be able to:

- define hydrocarbons;
- define saturated hydrocarbons;
- define homologous series;

- write the general formula of alkanes;
- write the first ten members of alkanes homologous series;
- write the molecular formulas of alkanes from the given number of carbon atoms;
- explain the physical properties of alkanes;
- write the molecular formulas of the first ten alkanes;
- apply IUPAC rules to name straight and branched chain alkanes;
- 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};
- describe the general methods for preparation of alkanes in a laboratory;
- prepare methane in the laboratory by decarboxylation method;
- carry out a project work to produce biogas from cow dung;
- explain the chemical properties of alkanes.

Forward Planning

Read this section thoroughly and prepare your own plan on how to cover the contents within the given number of periods. Your plan should be prepared in such a manner to show the sub – topics and activities to be treated during each period. You also need to prepare a plan on how to budget your time during each period for students to discuss activities, make presentations, harmonize concepts, and perform stabilization and evaluation.

In this section, two experiments and one project work are suggested in the students' text. Arrange the necessary chemicals and apparatus required for the experiments. You are advised to carry out the experiment before allowing students to do it. Arrange a trip for students to visit a biogas plant near your school or the town where your school is located.

Teaching Aids

See the student text for the suggested apparatus and chemicals you should use for Experiments 1.1 and 1.2.

Subject Matter Presentation

Saturated Hydrocarbons (Alkanes)

To teach the lesson, we suggest that you use group discussion and question and answer methodologies.

This section starts with Activity 1.3. The objective of this activity is to assist students to understand how carbon atoms form single, double and triple bonds between them in hydrocarbons and thereby define saturated and unsaturated hydrocarbons.

After introducing the topic of the lesson for the period, let the students discuss Activity 1.3 for a few minutes. Then, let some groups explain what they discussed to the class. To harmonize the concepts suggested by the students with what they are expected to know, start with electron configuration of a carbon atom ($1s^2 2s^2 2p^2$). Inform them that a carbon atom has four valence electrons and can form four covalent bonds. To make your presentation effective, proceed by answering the questions in the activity. Tell them that the two carbon atoms can form single, double and triple bonds in the first, second and third compounds, respectively. Each carbon atom can form bonds with three, two and one hydrogen in the first, second and third compounds, respectively. Show them the line formulas of the compounds and define hydrocarbons. Introduce saturated and unsaturated hydrocarbons. Saturated hydrocarbons are those in which every carbon atom is bonded to four other atoms so that all the bonds between carbon atoms are single bonds. In the case of unsaturated hydrocarbons, there are at least two carbon atoms that do not form bonds with another four atoms. So, these carbon atoms form a double or a triple bond, using the unshared electrons to fulfill their octet.

After introducing saturated and unsaturated hydrocarbons, proceed to Activity 1.4. This activity enables students to determine molecular formulas of some alkanes. Let the students discuss Activity 1.4, draw the graph and determine the molecular formulas. You can help the students by suggesting that they can plot the number of carbon atoms on the x-axis and the number of hydrogen atoms on the y-axis. After they determine the molecular formulas, continue defining alkanes or paraffins and homologous series. Introduce the general formula of alkanes and let students determine the chemical formulas of some alkanes and realize that the consecutive members differ by a $– CH_2 –$ (methylene) group.

Physical Properties of Alkanes

Make sure that students know the general formula of alkanes, can write the molecular formulas of alkanes from a given number of carbon atoms and can define homologous series. After that, continue with physical properties of alkanes. Activity 1.5 is suggested

in this part to assist students to discover the change in physical state and other physical properties of alkanes with increasing carbon number and also help them identify petroleum products they encounter everyday life containing alkanes. Before you continue with the details, let students discuss Activity 1.5 in groups for a few minutes and let two students from different groups present what they discussed. Based on their presentation, build your mini-lecture to harmonize the main facts. While you are dealing with physical properties of alkanes, inform them that the percentage by mass of hydrogen decreases with increasing carbon number. Introduce the alkanes that exist as solid, liquid and gas at room temperature, the nature of the force existing between molecules in alkanes, the cause for their insolubility in water and the trends in densities, melting points and boiling points with increasing carbon number. Inform them that alkanes are the main constituents of petroleum and that the gaseous fuel used for stoves, gasoline, kerosene and asphalt contains alkanes.

Check whether the students have realized the physical properties of alkanes or not and continue with the nomenclature of alkanes.

Nomenclature of Alkanes

To deal with the contents in this subtopic, we suggest that you use group discussion, question and answer methodologies.

Before you deal with the IUPAC system of naming alkanes, Activity 1.6 is given to start the lesson. The activity helps the students to discover the importance of rules in naming organic compounds and also the prefixes used in naming organic compounds. Let the students discuss Activity 1.6 in groups and let some groups suggest their opinions to the class. When you harmonize concepts suggested by students with the facts, inform them that there are rules to be followed in naming organic compounds so that a given compound can have the same name all over the world. As the prefixes pent, hex, hept, oct are used to indicate the number of sides of polygons in mathematics, the names of alkanes are obtained by using prefixes that indicate the number of carbon atoms in the molecules and the suffix '-ane' which signifies the presence of carbon -carbon single bonds. After harmonizing the concepts, proceed to Activity 1.7. This activity will help them to realize why number of carbon atoms is used as the prefixes in names of organic compounds. Let them discuss the activity in groups and have some groups present their opinions. Then tell them that number of carbon atoms is used as the prefix in names of alkanes to indicate how many of them are present in a given alkane. Discuss when to use 'n-', 'Iso' and 'Neo' as prefixes in the common names of alkanes.

After you complete harmonizing concepts suggested by students in relation to activities 1.6 and 1.7, write the following information on the board.

1. Alkylradical = Alkane minus one hydrogen atom.
2. Name of alkane is methane and that of the corresponding alkyl radical is methyl.

Let students discuss the given information in groups for a few minutes and

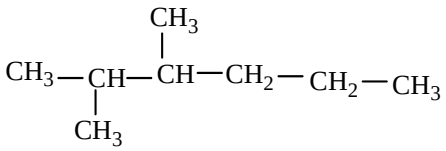
a) define alkyl radical

b) derive the general formula for alkyl radicals

c) suggest how the names of alkyl radicals are obtained. Give a chance for two groups to present their opinions and then inform them of the facts by correcting they if have suggested wrong views.

Then inform them: what alkyl radicals are, their general formula and how their names are obtained based on their opinions. Then continue with the IUPAC system.

In dealing with the IUPAC system of nomenclature of alkanes, first let the students discuss the rules to be followed in groups for a few minutes. After they complete the discussion, write the following structure on the board.



Then, invite one student from a given group, and provide him/her with chalk to apply the rules in naming the given hydrocarbon on the blackboard. In doing so he/she should explain the individual steps to his/her classmates. If he/she missed a step or misunderstood what the step means, ask students from other groups to give corrections on the step. Finally, make sure that the student named the compound as 2, 3-dimethyl hexane. Write the structure of another branched chain alkane on the blackboard and let a student from another group make an attempt to name it in the same manner. After this, you can give independent work for students to practice naming alkanes and check their work. At the end, revise the rules to be followed in the IUPAC system of naming branched chain alkanes. While applying the rules, students face problems in deciding from which end they should start assigning numbers to the carbon atoms of the longest chain. Inform them that they can assign numbers from both ends. However, the right direction of numbering is the one for which the sum of locants is smaller. Use some examples on how to apply IUPAC rules to name alkanes. Introduce students to writing the structure of alkanes when their names are given. Give them exercises to practice naming alkanes and to write structures when the names are given. Check how students are doing. After that, proceed to Activity 1.8, which enables them to realize why IUPAC rules are important. Let them discuss Activity 1.8 in groups and let members of some

groups present their opinions to the class. Then, inform them that the IUPAC rules are established based on scientific background. This is to enable chemists worldwide to have a common understanding of the names of organic compounds.

Isomerism

We suggest that you use group discussion and question and answer methodologies while dealing with this subtopic.

After completing the IUPAC system of nomenclature of alkanes, you can start introducing isomerism, using Activity 1.9. The activity is aimed at enabling students to identify what isomers are and in what manner they differ. Let students discuss Activity 1.9 in groups for a few minutes and let students from some groups suggest their conclusions after the discussion. To harmonize their suggestions with the facts, inform them that the compounds given in the activity have similar molecular formulas. They differ in their physical properties. But, their chemical properties are similar. These types of compounds are known as isomers.

Then, let the students discuss what isomers are and what isomerism means in groups for a few minutes and have one or two students from different groups present their opinions. After the presentations, introduce them to the actual definitions of isomers and isomerism. Inform them also of the type of isomerism alkanes, exhibit, using examples. Give them class work to ensure that students can draw isomers of a given alkane and name them. You can use Exercise 1.3, question number 2. Check how students are doing. At the end, give them corrections. After completing this subtopic, continue with the preparation of alkanes.

Preparation of Alkanes

While teaching this topic, we suggest that you use group discussion, question and answer, cooperative learning and experiment as methodologies.

When you deal with preparation of alkanes, first inform students that alkanes are the major constituents of petroleum and natural gas. However, they can also be synthesized in the laboratory using different methods. Introduce them to the three methods suggested in the students' text. Write chemical equations related to each method of preparation on the board so that students can suggest the products. Check the work of the students and give them corrections.

After introducing methods for the preparation of alkanes, proceed by introducing the following content, using Activity 1.10. The objective of the activity is to help students discover where and how methane is produced and realize the importance of biogas technology. Let the students discuss Activity 1.10 in groups. Allow two or three groups

to make presentations on the points they have discussed. After their presentations, harmonize the concepts suggested by the students with the facts. Inform students that, when one walks near a marshy area, the smell he/she perceives is that of methane. The same is true for the unusual smell perceived resulting from decomposition of materials from the mud used for constructing walls for houses. Here, discuss why methane is named marsh gas. Inform them that if Ethiopia introduces the technology of producing biogas to its residents, it saves millions of dollars required to import kerosene, diesel fuel and gaseous fuels. Other advantages of biogas technology are: a) decreasing local deforestation, b) easier and cleaner cooking c) savings on kerosene, diesel fuel, wood and charcoal.

Following this, proceed to deal with the laboratory method of preparation of methane and its properties. Let students discuss in groups for a few minutes how methane can be produced in a biogas plant and suggest the substances used as starting materials for generating methane. Invite some groups to present their opinions to the class. After this, harmonize concepts and let students perform Experiments 1.1 and 1.2. In the case of Experiment 1.2, students should bring cow dung and prepare the mixture four days before the period you plan to perform the experiment. Collect the laboratory reports and correct them accordingly.

Experiment 1.1

You can use the following information for the questions on observation and analysis of Experiment 1.1. The gas is colorless and insoluble in water. It is combustible. The equation for its combustion reaction is:

$$CH_4 + O_2 \rightarrow CO_2 + 2H_2O$$

When $Ca(OH)_2$ is added to the gas jar in which methane is burned, the solution turns milky. This is due to the formation of calcium carbonate. The equation for the reaction is:

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O.$$

There will be no change when bromine water is added to the gas jar filled with methane.

Experiment 1.2

The answers to the questions raised in the observation and analysis part of Experiment 1.2 are the following:

a. To keep the flask warm and facilitate decomposition.

b. The gas at the outlet of the tube catches fire.

c. Fermentation is responsible for the formation of methane.

Finally, let the students do the suggested project work (1.1) and present a model and a report to the class. Then, you can proceed to dealing with chemical properties of alkanes.

Chemical Properties of Alkanes

To deal with the contents in this lesson, use group discussion, question and answer and visual-based learning methodologies.

We suggest that you start teaching the lesson with Activity 1.11. The activity enables students to identify the chemical property of alkanes responsible for producing energy and also to realize that complete combustion of alkanes produces more energy.

First, let students discuss Activity 1.11 in groups for a few minutes. Allow some groups to make presentations about their discussions. Based on their presentations, continue to harmonize their suggestions with the actual truth. First, introduce that alkanes are saturated hydrocarbons and are inert towards many reagents. However, they can undergo the following reactions.

Alkanes undergo combustion (oxidation) reaction. They burn in excess and limited amounts of oxygen to form carbondioxide and carbon monoxide, respectively, as well as water. In the reaction, they release heat energy. This reaction is responsible for generating electricity in diesel power stations and for moving motor vehicles.

Be sure the students are familiar with the fact that combustion of alkanes gives CO_2 and water produces more energy than the same process that gives CO and H_2O. Introduce the general equation for the complete oxidation of alkanes to carbondioixde and water. Next, proceed to Activity 1.12, which enables students to write a general equation for the combustion of alkanes that gives carbon monoxide and water. Let the students discuss Activity 1.12 and let some groups present their ideas to the class. Then, introduce the general equation for the combustion of alkanes that gives carbonmonoxide and water as:

$$C_nH_{2n+2} + \frac{2n + 1}{2} O_2 \rightarrow nCO + (n + 1) H_2O + \text{heat}$$

Inform students that petroleum refineries are built in the open air in order to reduce fire hazards and health problems that can be caused by gaseous petroleum fractions that escape from the refinery.

To introduce substitution reactions of alkanes, you better apply visual-based active learning methodology. First, provide balls and sticks and then tell them to construct ball and stick models of methane in groups. They should use four balls of the same color (may be blue) to represent the hydrogen atom and a ball of a different colour to represent the carbon atom. After that, let every group replace one of the balls representing a

hydrogen atom with another ball having a different colour (may be yellow). Following this, inform them that the model they obtained is a substituted product and ask them to define substitution reaction with examples. Then proceed to Activity 1.13 which is suggested to help students to reason out why Br_2 and Cl_2 do not react with alkanes in the dark. Let them give the appropriate definition and allow them discuss Activity 1.13 for a few minutes. Let some groups present their views to the class. Harmonize their ideas with the facts. Tell them that reactions of alkanes with chlorine and bromine are photochemical reactions. Light or heat energy is required to decompose bromine and chlorine to their respective atoms, as shown in the chain initiating step in the students' text. Unless the free radicals Cl• and Br• are formed, there cannot be a reaction. That is why Br_2 and Cl_2 cannot react with alkanes in the dark. Then proceed to elimination reaction of alkanes.

To introduce this reaction of alkanes, you need to implement visual-based active learning method. First, let them construct the ball and stick model of ethane in groups. After they do so, tell them to remove one ball representing a hydrogen atom from each of the carbon atoms and also one of the sticks. Then, let them join the two balls representing the carbon atoms, using the stick that has remained on one of the two balls after removing the ball representing a hydrogen atom. Following this, tell them that the activity they performed can be an example of an elimination reaction. Allow them to discuss in groups for a few minutes what an elimination reaction is and the nature of the compound that results from this reaction. Encourage some groups to present their opinion to the class.

After the presentations, inform them of the definitions of an elimination reaction and the nature of the substances obtained when alkanes undergo this type of reaction.

At the end of the section, introduce cycloalkanes, their general formula, structure and names.

Assessment

Use the students' performance list to keep a record of how every student is taking part in discussing Activities 1.3 – 1.13. Presenting concepts after discussion, give Exercises 1.2 – 1.4 as class work or homework. Check their exercise books to see how every student does his/her work accordingly. Register the performance of each student in your record list. Then make sure that most of the students have accomplished the competencies suggested for the section. Appreciate students working above the minimum requirement level. Give assistance to students working below the minimum requirement level, either by arranging additional lesson time or giving more exercise.

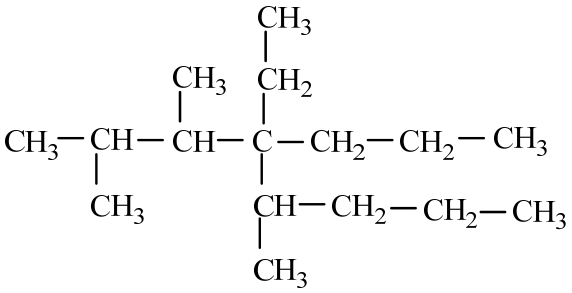
Additional Questions

1. What is the molecular formula of an alkane containing the following carbon number?

   a) 15 b) 18 c) 26

2. Derive a formula that can be used to determine the number of isomers of alkanes containing 4 – 7 carbon atoms, based on Table 1.2.

*3. Give the IUPAC name of the following alkane.



*4. What are the advantages of biogas technology?

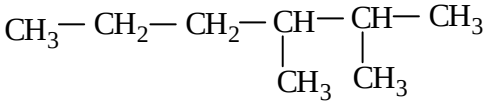
Answers to Additional Questions

1. a) $C_{15}H_{32}$ b) $C_{18}H_{38}$ c) $C_{26}H_{54}$
2. $2^{n-4} + 1$
3. 4 – Ethyl – 2, 3, 5 – trimethyl – 4 – n – propyl octane.
4. Saving on fuel such as kerosene, wood and charcoal, decrease in deforestation, clean cooking, saving foreign currency etc.

Answers to Exercise 1.2

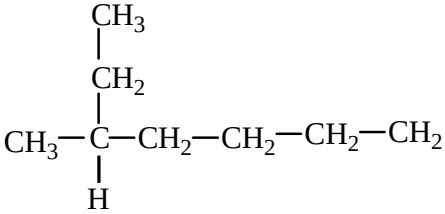
1. Sample answer

a)



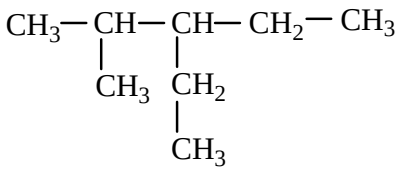
2,3-dimethyl hexane

b)



3 – methyl heptane

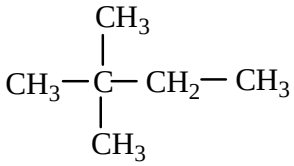
c)



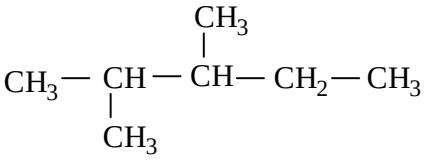
3 – ethyl – 2 – methyl pentane

2. 3 – bromo – 4 – ethyl – 2,2,5 – trimethyloctane

3.



4.

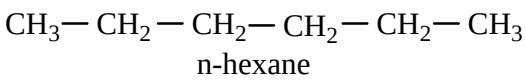


5. F, Cl and Br are named as Fluoro, Chloro and Bromo respectively

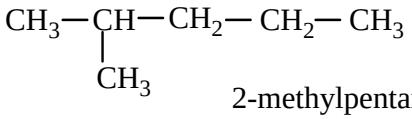
Answers to Exercise 1.3

1. All are true statements.

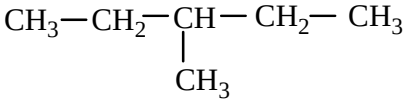
2.



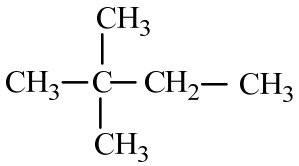
n-hexane



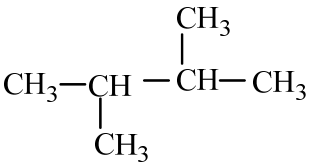
2-methylpentane



3-methylpentane



2,2-Dimethylbutane



2,3-Dimethylbutane

Answers to Exercise 1.4

1. a) C_5H_{12} b) C_8H_{18} c) $C_{15}H_{32}$
2. Refer to the students' text on page

   a) 8 d) 24

   b) 13 e) 23

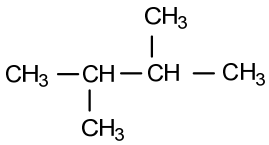
   c) 17 f) 4
3. $2\,C_8H_{18} + 25O_2 \longrightarrow 16CO_2 + 18H_2O$
4. 9
5. a) 2, 3-Dichloropentane

   b) 2, 2, 3-Trimethylbutane

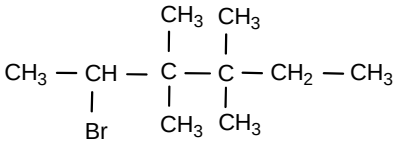
   c) 3-Bromo-2, 3-dimethylpentane

   d) 3, 4-Dimethylhexane

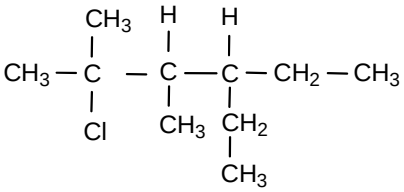
   e 4-Ethyl -2, 2, 6-trimethylheptane
6. a)



   b)



   c)



7. $C_5H_{12} + 8O_2 \xrightarrow[\text{combustion}]{\text{Complete}} 5CO_2 + 6H_2O$

1.3 Unsaturated Hydrocarbons (Alkenes and Alkynes)

Period Allotted 9

Cometencies

At the end of this subtopic, students will be able to:

- define unsaturated hydrocarbons;
- define alkenes;
- write the general formula of alkenes;
- write the molecular formula for the first nine members in the homologous series of alkenes;
- define alkynes;
- write the general formula of alkynes;
- write the molecular formula for the first nine homologous series of alkynes;
- write the molecular formulas of alkenes and alkynes from the given number of carbon atoms;
- describe the physical properties of alkenes and alkynes;
- apply IUPAC rules to name straight and branched chain alkenes and alkynes;
- write the structural formulas of alkenes and alkynes up to ten carbon atoms;
- write the possible structural isomers for C_4H_8 and C_5H_{10};
- define geometric (cis-trans) isomerism;
- give examples of molecules that show geometric isomerism;
- construct models that show cis-trans isomerism;
- describe the general method for the preparation of alkenes in a laboratory;
- prepare ethylene in a laboratory by dehydration of ethanol;
- describe the general method for the preparation of alkynes in a laboratory;
- prepare acetylene in a laboratory by the reaction of CaC_2 with water;
- 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.

Forward Planning

Read this section thoroughly. Prepare a plan related to the contents and activities you should treat during each period so that the whole content in the section can be covered within nine periods.

In this section, two experiments and one project work are suggested in the students' text. Arrange the necessary chemicals and apparatus required for the experiments. You are advised to carry out the experiment before you allow students to perform it. You should plan when to conduct and how students can participate in performing the experiments. You need also to plan how to allot the time required for students to discuss activities, make presentations, harmonize concepts, and perform stabilization and evaluation during each period.

Teaching Aids

Refer to the students' text for the apparatus and chemicals you should use to perform Experiments 1.3 and 1.4.

Subject Matter Presentation

Alkenes and their Physical Properties

We suggest that you use group discussion and question and answer methodologies for this subtopic.

To start teaching contents on this subtopic, let students recall saturated and unsaturated hydrocarbon and suggest their definition. After their response, use Activity 1.14 to begin with the contents. The activity enables students to derive the general formula for alkenes and identify the differences between alkenes and alkanes. Besides this, they also discover the trends in some properties of alkenes. So allow them to discuss Activity 1.14 for a few minutes. After completing their discussion, give a chance to students from two different groups suggest their opinion to the class on what they have discussed. Then, harmonize the facts they are supposed to know with the feedback of the students.

First, introduce the general formula for alkenes to be C_nH_{2n}. From this general formula, it can be noted that alkenes possess two hydrogen atoms less than the corresponding alkanes. Hence, they possess a carbon – carbon double bond as their functional group. The presence of a double bond makes them unsaturated hydrocarbons. Ask the students

to get chemical formulas for alkenes containing 2 to 10 carbon atoms. Then continue with physical properties of alkenes. Use Activity 1.15 for this part of the lesson. The activity helps students to discover the reason why alkenes exist in different states and the trends in melting point, boiling point and density with increasing carbon number. Let them discuss the activity and have some groups present their opinion to the class. To harmonize concepts, introduce that, the melting point, boiling point and density of alkenes increases with increasing carbon number. This is due to an increase in the strength of intermolecular forces of attraction between molecules. Finally, explain the reason for the insolubility of alkenes in water. Alkenes are nonpolar molecules and are insoluble in polar solvents like water. Make sure that students can write the molecular formulas of alkenes from a given number of carbon atoms, and that they have realized the physical properties of alkenes and then continue with their nomenclature.

Nomenclature of Alkenes

It is advisable to implement group discussion and question and answer methodologies in dealing with contents in this sub topic.

In dealing with the nomenclature, introduce to them that common names of alkenes are derived from the prefixes that indicate the number of carbon atoms in the molecule and the suffix '–ylene'. After introducing common names of alkenes or olefins, continue with the IUPAC system. To deal with the details, start with Activity 1.16. It helps the students to realize the difference in the IUPAC system in naming alkanes and alkenes. Let the students discuss activity 1.16 for a few minutes and let some groups present their ideas to the class. Then, continue harmonizing the concepts suggested by the students with those they are supposed to know. In doing so, inform them that IUPAC names are obtained from prefixes indicating the number of carbon atoms and the suffix '–ene', which indicates the functional group (double bond). Introduce the rules applied in the IUPAC system of naming alkenes, emphasizing that the parent structure should include the double bond, and numbering the carbon atoms of the parent structure should begin from the end closer to the double bond. While introducing the rules, use Activity 1.17. The activity is suggested to enable students to reason out that the longest chain should include the functional groups. Then, let them discuss Activity 1.17 and suggest their views. Following their suggestions, inform them that the double bond should be included in the longest chain since it is the functional group. Write the structure of the alkene given in Activity 1.16 on the blackboard and let one student apply the rules in naming this alkene. Tell him/her to do it by explaining the steps on the board. Assist him/her when he/she faces a problem. After the student completes the task, give additional explanations so that the students can understand the rules clearly. Then, give more examples to show how to name alkenes. Let students practice independently how

to apply the rules in the IUPAC system of nomenclature and write the structure of an alkene from its name. So, give them class work or home work.

Isomerism in Alkenes

We advise you to use group discussion and short question and answer methodologies for this subtopic.

After the students have understood how to name alkenes, let them recall isomerism. Ask them to define isomers and isomerism. After you get feedback from the students, remind them of the definitions and continue to deal with isomerism in alkenes. To do so, divide the blackboard into three equal parts by drawing lines. Then write the structures of 1-pentene and 2-pentene on the first part, those of 1-pentene and 2-methyl-1-butene on the second part, and those of cis-2-pentene and trans-2-pentene on the third part. Then, let the students discuss these issues in groups for a few minutes:

a) whether or not the compounds given by each pair of structures are isomers

b) in what manner each structure differs from the other in each pair. After the discussion, let two students from different groups suggest their opinions to the class.

Following the presentations, harmonize their views with the facts. In doing so, inform them that the compounds given by all structures are isomers of C_5H_{10}. 1-pentene and 2-pentene differ in the position of the double bond and hence are **position isomers**. 1-pentene and 2-methyl-1-butene differ in the arrangement of the carbon chain and are chain isomers. cis-2-pentene and trans-2-pentene differ in the arrangement of atoms or groups about the double bond and are geometrical isomers. Then introduce to the students that alkenes exhibit chain isomerism, position isomerism and cis-trans (geometrical) isomerism.

Also inform them that all alkenes do not have geometrical (cis-trans) isomers, and that alkenes cannot have geometrical isomers if two identical groups are attached to any one of the carbon atoms linked by a double bond. Mention 1-butene and 1-pentene as examples of alkenes that do not exhibit geometrical isomerism. Finally, let them do project work 1.2 in groups. When you allow them to do this project work in groups, you are implementing the cooperative learning method.

Preparation of Alkenes

To teach the contents in this subtopic, we suggest that you better apply experiment, group discussion and question and answer methods.

Evaluate whether students can write different structures for a given alkene, identify the types of isomers and name them. Next, present the preparation of alkenes. In treating the preparation of alkenes, explain that alkenes are primarily obtained during fractional distillation of petroleum when the process called cracking is carried out. Let students also know that alkens can be prepared in the laboratory. Introduce the two laboratory methods of preparation.

To realize the first method of preparation, let the students perform Experiment 1.3 in groups under your supervision. Students should write a laboratory report and submit it to you. Collect the laboratory reports and correct them. Use the following note for observation and analysis of Experiment 1.3 and compare it to the data in the reports of the students.

a. Colorless gas with a sweet smell.

b. Carbon dioxide.

c. It decolorizes bromine water and alkaline potassium permanganate solution. The reddish brown color of bromine water disappears due to the addition of bromine to the double bond. The purple color of alkaline $KMnO_4$ disappears due to oxidation of ethene. The reactions are as follows:

$$CH_2 = CH_2 + Br_2 \longrightarrow \underset{Br}{CH_2} - \underset{Br}{CH_2}$$

Ethene 1,2 Dibromoethane

$$CH_2 = CH_2 \xrightarrow[KMnO_4]{\text{Alkaline}} \underset{OH}{CH_2} - \underset{OH}{CH_2}$$

1,2 Ethanediol

d. Concentrated sulphuric acid.

e. Dehydration of alcohols.

Then, continue with the second method; Dehydrohalogenation of alkyl halides with a base. First, ask the students to explain what dehydrohalogenation is and what alkyl halide means. After you introduce dehydrohalogenation, proceed to Activity 1.18. The aim of the activity is to enable students to discover the products of dehydrohalogenation of alkyl halides and what type of reaction it is. So, let them know the appropriate meanings and introduce the second method for the preparation of alkenes. After that, let the students discuss Activity 1.18 in groups for a few minutes and let some groups present their ideas to the class. To harmonize their ideas with the actual concepts, inform

them that in both reactions, the reactants are saturated and the products are unsaturated. Besides this, the reaction involves the removal of hydrogen and the hydroxyl group in the first method and hydrogen and a halogen in the second. So, the reactions are elimination reactions. Finally, give them Exercise 1.7 as class work or home work and check their works.

Chemical Properties of Akenes

Use group discussion, and question and answer methodologies to teach the contents in this subtopic.

Before you introduce chemical properties of alkenes, let the students discuss in groups for a few minutes the following questions:

a) Why are alkenes more reactive than alkanes?

b) Why do alkenes mainly undergo addition reaction and where does the addition occur?

c) What products do alkenes form when reacted with hydrogen and halogens?

When the discussion is over, let some students from different groups present their opinions to the class. After the presentation, harmonize the concepts suggested by students with the facts they are supposed to know. In addition, be sure that the students are familiar with the product of combustion reaction of alkenes, why they decolorize Br_2 in CCl_4 and alkaline potassium permanganate and what polymerization is.

Inform students that addition reaction of alkenes with hydrogen halides and water proceeds according to Markonikov's rule. Let students practice predicting the products and writing their structures independently, when you introduce each of the chemical properties of alkenes. Finally, introduce the uses of ethene.

In relation to the uses of ethene, use Activity 1.19. The objective of the activity is to help students relate the use of ethene to real life. Let the students discuss Activity 1.19 in groups. Invite some groups to present their ideas to the class. After they respond, let them know that green tomatoes in a basket containing a ripe banana between them ripen at a faster rate. This is because the ripe banana produces ethene gas. At the end of this part, introduce cycloalkenes, their general formula, structures of some members and their names.

Alkynes and Their Physical Properties

Apply question and answer, and group discussion methodologies to teach the contents in this lesson.

After having completed the contents on alkenes and proved that students have understood the basic concepts, proceed to deal with alkynes. Ask them to define alkynes and suggest the trends in some physical properties such as density, boiling and melting points in relation to number of carbon atoms. After they respond, continue with your explanation.

Introduce the functional group of alkynes and their general formula ($C_n H_{2n-2}$). Then, you can proceed to the following part of the lesson using Activity 1.20. The activity assists students to determine molecular formulas and structures of few alkynes. It also enables them to realize the trends in physical properties of alkynes with increasing carbon number. Thus, let the students discuss Activity 1.20 in groups for a few minutes and let some groups present their views. After their presentation, tell them that alkynes containing 9 and 10 carbon atoms have the formula C_9H_{16} and $C_{10}H_{18}$ and are named nonyne and decyne, respectively. The physical properties of alkynes are similar to those of alkanes and alkenes. Make sure that students can write the molecular formulas of alkynes from a given number of carbon atoms and that they have realized their physical properties. Then, continue with nomenclature of alkynes.

Nomenclature and Isomerism in Alkynes

We advise you to see mainly group discussion and also question and answer methodologies.

Inform the students that the IUPAC system of naming alkynes is similar to that for alkenes. Write some structures of alkynes and let them practice how to name them in groups. After that, ask them to suggest what type of isomers alkynes exhibit. Give them class work to write all possible structures of C_6H_{10}, name them and identify those that are to be position and chain isomers. Check how they are doing and give them corrections. Activity 1.21 is suggested to help students consolidate their knowledge of isomers. So allow them to discuss the activity and present their ideas to the class. Inform them that pentane, pentene and pentyne are not isomers. This is because their molecular formulas and functional groups are different.

Preparation of Alkynes

To teach the contents in this subtopic, use question and answer, and demonstration as methods.

Introduce some methods for the preparation of alkynes such as dehydrohalogenation of vicinal dihalides and alkylation of sodium acetylide. In dealing with the preparation of alkynes, allow students to suggest the products after writing the formulas of the reactants on the board. You can also give Exercise 1.10 as class work or home work. Then perform Experiment 1.4. Here, use demonstration as the method of teaching. Do the

experiment yourself. This is because of the possibility that if students are allowed to do it, they may add too much water at a time which will lead to the release of too much gas, leading to too much pressure in the flask which may cause an explosion of the flask. Students should write a laboratory report on the experiment. Collect the laboratory reports and correct them accordingly. Use the following note on the observation and analysis part of the experiment for comparison with their report.

1. The flask is hotter, the reaction is exothermic.
2. The flame is smoky and luminous due to high carbon content.

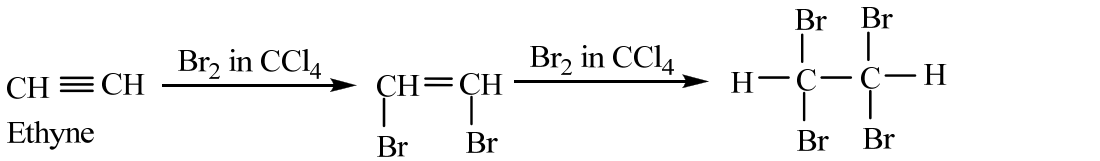
Following the experiment, continue dealing with chemical properties of alkynes.

Chemical Properties of Alkynes

We suggest that you use gapped lecture as a methodology to teach the lesson. You can use the suggested activities and others of your own in between the lectures.

Ask students why alkynes are more reactive than alkenes and alkanes. After their response, introduce the chemical properties of alkynes. This should include combustion reaction, addition reactions (addition of H_2, halogens and hydrogen halides) and trimerization. While you are treating the chemical properties, allow the students to suggest the products of the reactions and write balanced chemical equations. When you are dealing with addition reaction of alkynes and halogens, use Activity 1.22. This activity will help students to understand how to prove that alkynes are unsaturated and also will help them to predict reaction products of alkynes and halogens. Let the students discuss Activity 1.22 in groups for a few minutes. Give the opportunity for some groups to present their ideas to the class. After their presentation, use the following note to harmonize their concepts with what they are expected to know.

Alkynes also decolourize Br_2 in CCl_4, due to the addition of bromine atoms to the triple bond, forming dibromoalkenes and tetrabromoalkanes. For example, the reaction of bromine with acetylene (ethyne) is as follows:

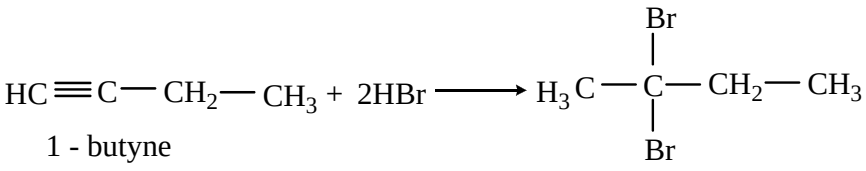


Ethyne — 1, 2 - Dibromoethene — 1, 1, 2,2 - Tetrabromoethane

Before you deal with reaction of alkynes with hydrogen halides, let the students discuss Activity 1.23 in groups for a few minutes. This will help them to recall and understand Markonikov's rule, to predict formulas and structures of compounds that can be formed when a molecule of an alkyne reacts with one and two molecules of hydrogen halides.

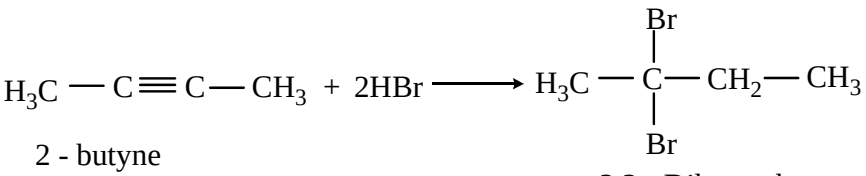
Following the discussion, encourage some groups to present their conclusions to the class. After their presentation, harmonize the concepts they suggested with what they are supposed to know. Help them understand that Markonikov's rule is applied in the reactions of alkynes with hydrogen halides. This is because the hydrogen atom of HX in the general reaction, and that of HBr in the example, formed bonds with the carbon atoms of the multiple bonds that have a greater number of hydrogen atom(s). On the other hand, X in the general reaction, and Br in the example, formed bonds with the carbon atoms of the multiple bonds that have fewer hydrogen atoms(s). In addition to this, let the students know that addition reaction of alkynes proceed in two steps. The triple bond between the carbon atoms changes to a double bond in the first, and the double bond changes to single bond in the second step.

You can compare the reaction products of 1 – butyne and 2 – butyne with hydrobromic acid as follows.



1 - butyne

2,2 - Dibromobutane



2 - butyne

2,2 - Dibromobutane

In the reaction of 1 – butyne with HBr, hydrogen atoms of HBr form a bond with the carbon atom of the triple bond containing one hydrogen atom. But, in the reaction of 2 – butyne and HBr, hydrogen and bromine have equal chances to form bonds with any one of the carbon atoms linked by a triple bond because the two carbon atoms do not contain hydrogen. However, the reaction product is the same in both cases.

At the end of this section, introduce the properties and uses of acetylene. Let the students compare and contrast the properties of ethane, ethene and ethyne.

Assessment

You should assess each student's work throughout the section. Using your students' performance list, monitor how every student participates in discussion and during explanation. Give them the suggested exercises in this section; check their exercise books and see how the students perform accordingly in answering the questions. You

can also give them a test on the section and make a record of their performances. Make sure that most of the students have achieved the minimum requirement level. Appreciate students working above the minimum requirement level and encourage them to continue working hard. In the case of students working below the minimum requirement level, arrange extra lesson time or give them additional exercises.

Additional Questions

1. The name olefin given to alkenes is derived from a Latin word which means "oil forming". Explain why.

*2. How many position isomers (not chain isomers) are possible for decene? Write their structures and name them.

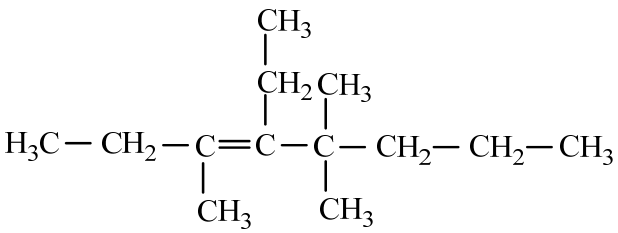
*3. Name the saturated hydrocarbon and unsaturated hydrocarbon that can be represented by the molecular formula C_6H_{12}.

4. Which of the following compounds exhibit geometrical isomerism? Draw diagrams to show the isomers and name them.

   a) 1, 2 – Dichloroethene b) 3 – Hexene

5. Write the general equations for the combustion of alkenes and alkynes to give carbonmonoxide and water.

*6. Name the following Alkene.



7. Polyvinyl chloride, PVC, used as floor tiles is made by polymerizing vinyl chloride, $CH_2 = CHCl$. How can one prepare this polymer, using ethyne and HCl as starting materials?

Answers to Additional Questions

1. This is because alkenes, like ethene, when reacted with halogens, form oily compounds of dihaloalkanes.
2. Five position isomers

   $CH_2 = CH - (CH_2)_7 - CH_3$ $CH_3 - CH = CH\ (CH_2)_6 - CH_3$

   1 – Decene 2 – Decene

$CH_3 - CH_2 - CH = CH\ (CH_2)_5 - CH_3$ $CH_3 - (CH_2)_2 - CH = CH - (CH_2)_4 - CH_3$

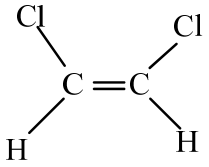
3 – Decene 4 – Decene

$CH_3 - (CH_2)_3 - CH = CH - (CH_2)_3 - CH_3$

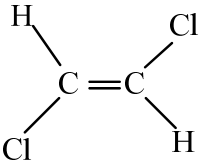
5 – Decene

3. The saturated hydrocarbon with the formula C_6H_{12} is cyclohexane. Unsaturated hydrocarbons having the formula C_6H_{12} can be 1 – hexene, 2 – hexene, 3 – hexene and other branched isomers.
4. Both compounds have geometrical isomers

a)

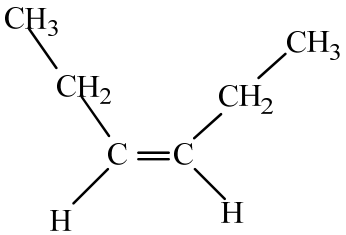


C is -1, 2 - dichloro ethene

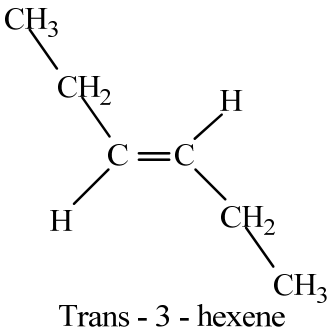


Trans - 1 - 2 dichloro ethene

b)



C is - 3 - hexene



Trans - 3 - hexene

5. For the combustion of Alkenes to give carbon monoxide and water, the general equation is

$$CnH_{2n} + nO_2 \rightarrow nCO + nH_2O$$

For Alkynes, the equation is

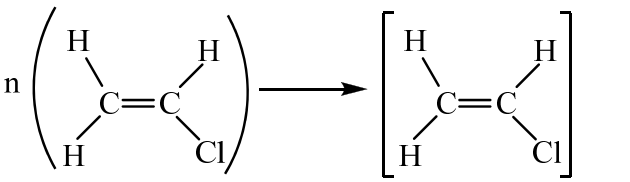
$$CnH_{2n-2} + \frac{2n-1}{2}O_2 \rightarrow nCO + (n-1)H_2O$$

6. 4 – Ethyl – 3, 5, 5 – trimethyl – 3 – octene.
7. i) By reacting HCl and ethyne to get vinylchloride in the first step.

$CH \equiv CH + HCl \rightarrow CH_2 = CHCl$

ethyne vinyl chloride

ii) polymerizing vinyl chloride to get polyvinyl chloride



vinyl chloride polyvinyl chloride (pvc)

Answers to Exercise 1.5

1. a) 3,4 - dimethyl -3-heptene

   b) 3 – ethyl -2-pentene

2. a) $CH_3-CH_2-\underset{\displaystyle CH_3}{\overset{\displaystyle |}{C}}=CH-CH_2-CH_2-CH_3$

   b) $CH_2=CH-\underset{\displaystyle CH_2\ CH_3}{\overset{\displaystyle |\quad\ |}{CH}}-\underset{\displaystyle CH_2\ CH_3}{\overset{\displaystyle |\quad\ |}{CH}}-CH_2-CH_3$

Answers to Exercise 1.6

$CH_2=CH-CH_2-CH_2-CH_2-CH_3$

1 - Hexene

$CH_3-CH=CH-CH_2-CH_2-CH_3$

2 - Hexene

$CH_3-CH_2-CH=CH-CH_2-CH_3$

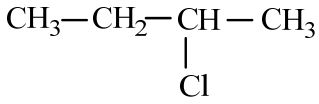
3 - Hexene

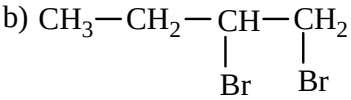
Answers to Exercise 1.7

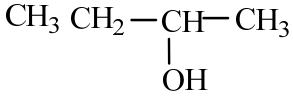
a) $CH_3-\underset{\displaystyle OH}{\overset{\displaystyle |}{CH}}-CH_3 \xrightarrow[\text{heat}]{H_2SO_4} CH_2=CH-CH_3 + H_2O$

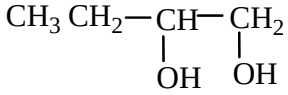
$CH_3-\underset{\displaystyle Br}{\overset{\displaystyle |}{CH}}-CH_3 + KOH \longrightarrow CH_2=CH-CH_3 + KBr + H_2O$

Answers to Exercise 1.8

a)  2 - Chlorobutane

b)  1, 2 - Dibromobutane

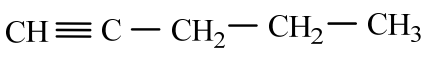
c)  2 - Butanol

d)  Butane -1, 2 - diol

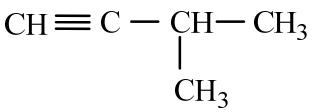
Answers to Exercise 1.9

1. a) 3-methylbut-1-yne and 1- pentyne

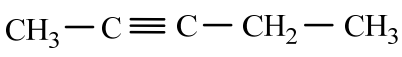
   b) 1- pentyne and 2-pentyne.

2. 

   1 - pentyne

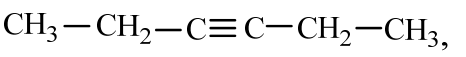
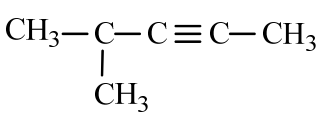
   3 - Methyl - 1 - butyne

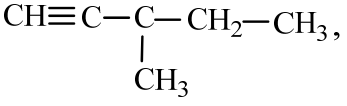
   2 - pentyne

3. $CH \equiv C - CH_2 - CH_2 - CH_2 - CH_3$, $CH_3 - C \equiv C - CH_2 - CH_2 - CH_3$

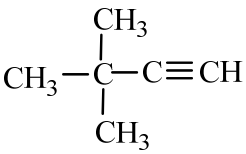
   1 – Hexyne 2 – Hexyne

    , 

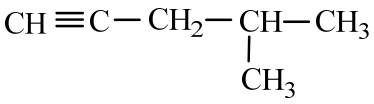
   3 - Hexyne 4 - methyl - 2 - pentyne

   3-Methyl - 1 - pentyne

   3,3- Dimethyl - 1 - butyne



4 - Methyl -1- pentyne

Seven isomers are possible for hexyne.

Answers to Exercise 1.10

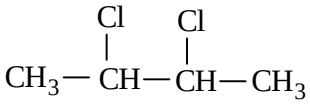
a) $CH_3-C\equiv C-H + 2KBr + 2H_2O$

b) $H-C\equiv C-CH_3$ + NaBr

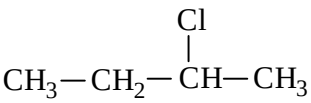
Answers to Exercise 1.11

1. Bromine in CCl_4 and alkaline $KMnO_4$
2. a. 2, 3 – Dimethylbut – 2 – ene
   b. 4, 4 – Dimethylpent – 2 – ene
   c. 2 – Ethylbut – 1 – ene
   d. 3 – Ethyl – 3, 4 – dimethylhex – 1 – yne
   e. 5 – Ethyl – 2, 2 – dimethylhept – 3 – yne
3. b and d only
4. a) $CH_3 – CH = CH_2 + KCl + H_2O$

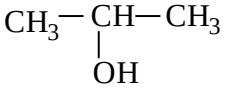
   Propene

   b) 

   2,3 - Dichlorobutane

   c) 

   2 - Chlorobutane

   d) 

   2 - Propanol

   e) $Ca(OH)_2$ + C_2H_2 Acetylene (Ethyne)

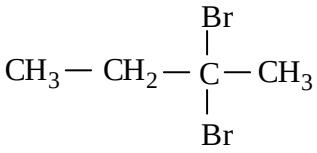
f) $CH_3 - C \equiv C - CH_2 - CH_3$ + NaBr

2 - Pentyne

g) $CH_3 - CH_2 - CH_3$

Propane

h)



2,2 - Dibromobutene

i) CHBr = CHBr

1, 2 – Dibromoethane

j) $CHBr_2 - CHBr_2$

1, 1, 2, 2 – Tetrabromoethane

1.4. Aromatic Hydrocarbons

Period Allotted 2

Competencies

At the end of this section, students will be able to:

- define aromatic hydrocarbons;
- draw the structure of benzene;
- describe the main physical properties of benzene;
- explain the chemical reactions of benzene;
- carry out test tube reactions with Br_2 in CCl_4, $KMnO_4$ and concentrated H_2SO_4.

Forward Planning

Make the necessary preparation by reading this section thoroughly and plan how to cover the contents of the section within two periods. Experiment 1.5 is suggested in this section. Arrange the necessary chemicals and apparatus for the experiment. Perform the experiment in advance and let the students do it in groups under your supervision.

Teaching Aids

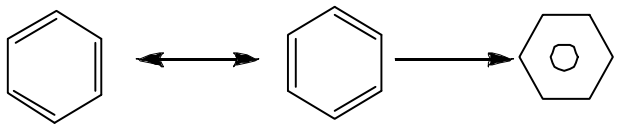
Refer to the students' text for a list the apparatuses and chemicals required to perform Experiment 1.5.

Subject Matter Presentation

Apply group discussion, inquiry and experiment as methodologies to teach the contents of this subtopic.

This section starts with an activity. Activity 1.24 is suggested in order to assist students to discover facts about benzene and other aromatic hydrocarbons.

As usual, before you deal with the details of this section, let students discuss Activity 1.24 for a few minutes in groups and let members of some groups suggest their views about the points they discussed. Then proceed to harmonize students' reflection with the facts to be taught. Help them understand that most people think of the petroleum fraction used as a motor fuel when they hear the word "benzene". Then continue introducing the word "aroma" and its meaning from which the term aromatic is originated. The word "aroma" means pleasant smell. Substances like rose, banana, orange, pineapple and perfume have an aroma. Tell them that the word aromatic is now used without its original significance. Define aromatic hydrocarbons as compounds containing the benzene ring. Give some examples of aromatic hydrocarbons, indicating their names and structures such as benzene, Toluene, naphthalene etc. Tell them that benzene is the simplest aromatic hydrocarbon. Ask students if they have any ideas about resonance structures and continue introducing the resonating structures of benzene suggested by Friedrich A. Kekule.



I II

Resonance structures of benzene

Inform students that neither of the two structures are the true structures of benzene nor do they clearly describe benzene. However, each structure makes an equal contribution for the resonance hybrid.

Let the students know that not all of the six bonds between carbon atoms are neither single nor double, but have an intermediate character between those of single and double bonds. Inform students that benzene and other aromatic hydrocarbons are not as unsaturated as alkenes. This is because the three double bonds in benzene are

delocalized. After the students understand about benzene, introduce its physical properties.

While you are dealing with chemical properties of benzene, emphasize that aromatic hydrocarbons are more stable than alkenes and alkynes due to the nature of the bonds between the carbon atoms in the ring.

Let them also know why benzene burns with a smoky luminous flame. Inform students that the reactions of benzene are chiefly substitution even though it is an unsaturated hydrocarbon. Show the substitution reaction of benzene with chlorine, nitration and sulphonation, using chemical equations. Finally, introduce them that benzene can undergo addition reaction under special conditions. Mention the reaction of benzene with hydrogen as an example. Let students perform Experiment 1.5 while you are dealing with properties of benzene. Following the experiment, let them write a laboratory report. In their report, be sure that they observed a reaction occurring in the third test tube between toluene and sulphuric acid. You need to collect and correct the laboratory reports.

Assessment

Assess each student's work throughout the section. Record how every student participates in discussion, during presentation and in answering questions given as class and home work. From your record, check how many of the students have achieved the competencies suggested for the section. Give assistance to students working below the minimum requirement level by arranging extra lesson time or giving them additional exercises.

Additional Questions

*1. Write the molecular formula of naphthalene. (see Figure 1.9).

*2. Benzene is an unsaturated hydrocarbon. However, its reaction is chiefly substitution. What is the reason for this?

Answers to Additional Questions

1. $C_{10}H_8$
2. This is due to the stability of the aromatic ring. The nature of the bonds between carbon atoms in the ring is responsible for the stability.

Answers to Exercise 1.12

1. A compound of carbon and hydrogen containing a benzene ring
2. Unsaturated

3. Benzene
4. Combustion, substitution
5. It neither adds bromine atoms nor is oxidized by $KMnO_4$ solution.
6. By the reaction of
    a) benzene with chlorine
    b) benzene with concentrated HNO_3
    c) benzene with concentrated H_2SO_4

1.5 Natural Sources of Hydrocarbons

Period Allotted 2

Competencies

After completing the subunit, students will be able to:

- list the major natural sources of hydrocarbons;
- describe natural gas;
- define crude oil;
- explain fractional distillation of crude oil;
- mention products of fractional distillation of crude oil;
- discuss the uses of petroleum products;
- tell the composition of coal;
- explain destructive distillation of coal.

Forward Planning

Read this section thoroughly. Plan which contents of the section to cover during each period. Prepare a diagram that shows fractional distillation of crude oil.

Teaching Aids

No experiment is suggested in this section. You need to prepare a chart to show the different fractions of petroleum and a diagram of the fractionating tower.

Subject Matter Presentation

We advise you to use group discussion, question and answer and visual-based learning methodologies for the subtopic.

We advise you to start teaching this section using Activity 1.25. The activity enables students to identify the natural sources of hydrocarbons and components of natural gas, to gain knowledge about how petroleum, natural gas and coal are formed in nature and to understand how different fractions are obtained from petroleum.

Before you start dealing with the content in this section, allow the students to discuss Activity 1.25 in groups for a few minutes. Let some students from different groups make presentations on points they discussed. After the presentations, inform them about the natural sources of hydrocarbons as natural gas, petroleum and mineral coal. Tell students how natural gas, petroleum and coal are formed in nature. Inform students that natural gas, petroleum and coal cannot be recycled. Tell them that natural gas mainly contains methane (90%), ethane, propane, butane, higher alkanes and gases like CO_2, N_2, O_2 and H_2S in very small amounts. Let students know that petroleum is a dark-colored viscous liquid, whose composition varies from place to place and is a complex mixture of hydrocarbons chiefly alkanes, and also contain cycloalkanes and aromatics. Help them understand the difference between petroleum and crude oil. Continue your explanation by asking students what petroleum refining is and how it is separated into different fractions. Discuss the major fractions of petroleum, their composition, boiling ranges and uses. Define what cracking is and the importance of carrying out the process. Finally, explain what destructive distillation of coal is, the products obtained and the major hydrocarbons that can be separated by fractional distillation of coal tar.

At the end of this section, let the students do the research and writing part suggested in the students' text and submit it to you for correction.

Assessment

Assess each student's work throughout the section.

Give class work or homework (you can use questions from the suggested exercise or your own). Correct the works of students and record their performances. Follow strictly how every student participates in discussion, presentation, and answering questions. Correct the research done by the students and make a record in the students' performance list. From your record, see whether the competencies suggested for the section are achieved or not.

Additional Questions

1. Petroleum fractions containing straight chain alkanes are not good fuels and cause engine knocking. What is the reason for this? What is engine knocking? What process is carried out to improve the quality of these petroleum fractions?

Answers to Additional Questions

1. Engine knocking is combustion of fuels in the combustion chamber of engines of vehicles with explosions. Engine knocking is caused by fuels containing straight chain alkanes such as n – heptane and n – octane. The quality of petroleum fractions containing this type of alkanes can be improved by the process known as reforming. It is a process used to convert straight chain alkanes to branched chain alkanes.

Answers to Exercise 1.13

1. Petroleum, natural gas and coal.
2. Alkanes.
3. Heating substances in absence of air.
4. Destructive distillation of coal gives coke, coal gas, ammonical liquid and coal tar. Fractional distillation of coal tar yields different aromatic hydrocarbons and related compounds.
5. Gasoline or petrol.
6. Cracking.
7. a) as a solvent.

   b) as a fuel in jet engines and kerosene stoves.

   c) motor fuel.

   d) diesel engine fuel, furnace fuel.

   e) as fuel for stoves.

1.6 Alcohols

Period Allotted 9

Competencies

After completing this section, students will be able to:

- define alcohols;
- tell the functional group of alcohols;
- classify alcohols based on the number of hydroxyl groups;
- write the general formulas of monohydric alcohols;

- write the molecular formulas and the names of the first six members of the monohydric alcohols;
- give the lUPAC names for given alcohols;
- classify monohydric alcohols based on the number of alkyl groups attached to the carbon atom carrying the hydroxyl group;
- describe the physical properties of alcohols;
- explain general methods of preparation of alcohols;
- explain the industrial preparation of ethanol;
- perform an experiment to prepare ethanol from sugar;
- explain the chemical reactions of alcohols such as oxidation, reaction with active metals, esterification and dehydration;
- carry out an activity to show chemical reactions of alcohols with active metals;
- write the general structural formula of aldehydes;
- write the molecular formulas and names of simple aldehydes;
- write the general structural formula of ketones;
- write the molecular formulas and names of simple ketones;
- write the general structural formulas of carboxylic acids;
- write the molecular formulas and names of simple carboxylic acids;
- write the general structural formula of simple esters;
- write the molecular formulas and names of simple esters.

Forward Planning

Read the section thoroughly and make appropriate preparations. Prepare a plan of your own that shows the contents you treat and the activities students discuss during each period so that the entire content of the section will be covered within nine periods. In your plan, include when students should conduct the suggested experiments. Two experiments are suggested in this section. Prepare the necessary chemicals and apparatus required for Experiment 1.6, 1.7 and 1.8. Carry out the experiments beforehand and set a plan of how students can perform the experiments in groups. You need also to plan how to manage students during the discussions and when they do the experiments.

Teaching Aids

Refer to the students' text for the apparatus and chemicals required to perform Experiments 1.6, 1.7 and 1.8.

Subject Matter presentation

Classification of Alcohols

We advise you to use group discussion and inquiry as methodologies for this subtopic.

Start teaching this section by asking students to suggest their ideas about alcohols. Use Activity 1.26 for this purpose. The activity enables students to discover the uses of alcohols in industry and in daily life. So, let them discuss Activity 1.26 for a few minutes. After they complete the discussion, encourage students from different groups to present their opinions to the class. Based on their presentations, mention some examples of alcohols such as methanol, ethanol, ethane -1, 2 - diol, and glycerol. Tell them that ethanol is the constituent of all alcoholic beverages. In industries, alcohols can be used as solvents and to manufacture other organic chemicals such as aldehydes, ketones and esters. Tell them also that ethanol manufactured by fermentation of molasses is mixed with benzene and used as a fuel to drive cars in our country. Let them recall the functional group present in alcohols. Following their response, define alcohols as hydroxyl derivatives of hydrocarbons. Then, write the structures of ethanol, ethane-1,2-diol and glycerol on the blackboard. Let them discuss in groups the number of hydroxyl groups present in each alcohol and why the alcohols are classified as monohydric, dihydric and trihydric, respectively. Let them also guess the basis for the classification of alcohols and present their ideas to the class. Following the presentations, inform them that alcohols can be classified depending on the number of functional groups (hydroxyl group, OH) they contain as monohydric, dihydric, trihydric and polyhydric. Give examples of each class of alcohols and continue with the nomenclature of alcohols.

Nomenclature of Alcohols

Use mostly group discussion and also a mini-lecture as methodologies for this subtopic.

Inform them that IUPAC names of alcohols are obtained by replacing the last letter – e of the name of an alkane with the suffix – ol. Give some examples on the nomenclature of branched chain alcohols, using the **IUPAC system.** Write structures of some alcohols and let the students practice naming alcohols. After checking that they have done well in naming alcohols, continue with Activity 1.27. This activity will help them to determine the general formula of monohydric alcohols. Allow them to discuss Activity 1.27 in groups and present their opinions to the class. Following their presentations, tell

them the general formula of monohydric alcohols: $C_nH_{2n+1}OH$, where $n \geq 1$. Write the structures of 1-butanol, 2-butanol and 2-methyl-2-propanol on the board and tell them that the alcohols are primary, secondary and tertiary, respectively. However, all the three alcohols are monohydric. Then, have the students discuss in groups for a few minutes to discover the basis for the classification of monohydric alcohols and present their opinions to the class. After the presentations, tell them the basis for this classification and introduce the general structural formulas of primary, secondary and tertiary alcohols and give specific examples. Let the students practice classifying monohydric alcohols. You can give them Exercise 1.14 as class work or home work. Make sure that students can classify alcohols as primary, secondary, and tertiary, and then proceed to deal with physical properties of alcohols.

Physical Properties of Alcohols

We advise you to start teaching the contents in this part by using Activity 1.28, which helps students to discover the physical properties of alcohols.

Let the students discuss Activity 1.28 for a few minutes in groups. Encourage some group representatives to present their opinions to the class. Then, harmonize the ideas of students with the facts they are supposed to know. Let them know that alcohols have higher melting points and boiling points than hydrocarbons of the same molecular mass, due to the presence of hydrogen bonding. This hydrogen bonding is also responsible for the solubility of lower alcohols in water.

In addition to this, inform them that the presence of more than one hydroxyl group in dihydric and trihydric alcohols results in stronger intermolecular forces. Because of this fact, dihydric and polyhydric alcohols boil at higher temperatures than monohydric alcohols of comparable molecular size. Tell them also that hydrogen bonding in water is stronger than in methanol so that water boils at a higher temperature (100^oC) than methanol (B.Pt: 64.7^oC)

Preparation of Alcohols

To teach this subtopic, apply group discussion, question and answer and experiment as methodologies.

After treating physical properties of alcohols, continue with general laboratory methods for the preparation of alcohols. This should include the preparation of alcohols by acid – catalyzed hydration of alkenes, hydrolysis of alkylhalids and hydrolysis of esters with a base. Write chemical equations for each method and give students the chance to complete and predict the products. Next, use Activity 1.29 to start teaching about ethanol. The Activity is suggested to help students understand how ethanol is prepared from locally available materials and industrial method of production. Students should

discuss Activity 1.29 for a few minutes in groups. Let group representatives present their conclusions to the class. Harmonize the points raised by the students after their discussion using a mini - lecture. Let the students know that ethanol is the alcohol present in all alcoholic drinks. Tell them how the local people in Ethiopia prepare alcoholic beverages such as "Tella", "Tej" and "Katikalla". Introduce them to the raw materials and apparatus they use for the preparation. After that, acquaint them with the process of manufacturing ethanol from sugar and catalytic hydration of ethene on an industrial scale.

You can support the lesson on the preparation of ethanol by allowing students to perform Experiment 1.6 in groups. They should prepare the solution and allow it to ferment before three or four days in advance so that they can use it at the right time. At the end of the experiment, let the students write laboratory reports in groups and submit it to you. Collect the reports and correct them. Use the following note for the observation and analysis part of Experiment 1.6 for comparison with the laboratory reports of students.

Observation and analysis for Experiment 1.6

a) Yeast catalyzes the fermentation process.

b) It serves as a food for yeast.

c) It turns milky. Carbondioxide is produced.

d) It has the smell of an alcohol.

e) Fermentation has taken place; alcohol (ethanol) and carbondioxide are formed. The distillate obtained after distillation of fermented sugar solution catches fire when we bring the flame of a burning splint close to it.

Following the experiment, introduce the properties and uses of ethanol. Next to this, proceed to deal with the chemical properties of alcohols.

Chemical Properties of Alcohols

We advise you to apply experiment, group discussion and question and answer methodologies to this subtopic.

We advise that you start dealing with the chemical properties of alcohols by having students perform Experiment 1.7 in groups under your supervision. Have the students produce laboratory reports on their observations in groups. Check whether their reports coincide with the following observation and analysis for Experiment 1.7.

1. a) Reaction takes place vigorously.

b) No change is observed.

2. Yes, a gas is evolved in the first test tube, and the gas is hydrogen.

3. Slow reaction takes place upon heating.

4. The bond between O and H in the hydroxyl group.

5. $2R - O - H + 2Na \rightarrow 2R - O^{-}Na^{+} + H_2$

6. Very active metals like Na, K and Ca.

After completing the reaction of active metals with alcohols, proceed to deal with Activity 1.30. The activity will help students to relate chemical properties of alcohols to real life, and also to discover the cause for the souring of alcoholic beverages. So, let the students discuss Activity 1.30 in groups for a few minutes and then have members of some groups present the results of their discussion to the class. Then harmonize their ideas with the facts. Alcoholic beverages like "Tella", "Tej", beer and wine turn sour if they are not properly kept. This is due to oxidation of ethanol to acetic acid. The reaction for the process is:

$$CH_3CH_2OH + O_2 \rightarrow CH_3COOH + H_2O$$

Next, continue introducing different oxidation products of alcohols. Inform them that oxidation of a primary alcohol first yields aldehyde, and then the aldehyde oxidizes to give a carboxylic acid. First, let the students write the general equation for the oxidation of primary alcohols and suggest oxidation products of some primary alcohols. Then introduce them to the general structural formula of aldehydes, their functional group and how they are named. Give students a chance to write the structures and names of some aldehydes from their molecular formulas.

Have the students recall the general structural formula of secondary alcohols. Then ask them to predict the oxidation products of these alcohols. After their attempts, tell them that oxidation of secondary alcohols yields ketones. Write the structures of some secondary alcohols on the blackboard and let the students predict the ketones resulting from oxidation of these alcohols. Next, tell them students how ketones are named in the IUPAC system. Write names of some ketones on the board and let the students write their structures.

After that, have the students recall the general structural formula of tertiary alcohols. Inform the students that ketones and tertiary alcohols are generally resistant to oxidation. However, they can oxidize under drastic conditions to give mixtures of carboxylic acids.

Give them some examples and introduce how carboxylic acids are named in the IUPAC system.

After completing oxidation of alcohols, let the students perform Experiment 1.8 in groups and present their observation and analysis to the class.

You can cross-check their presentations with the following pieces of information, which are answers to the questions raised in the observation and analysis part of the experiment.

1. A Pleasant smell is produced. This is due to the formation of an ester.
2. The equation for the formation of an ester in this experiment is:

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Ethanol}}{HO - CH_2 - CH_3} \xrightarrow{H^+} \underset{\text{Ethyl ethanoate}}{CH_3COOCH_2CH_3} + H_2O$$

3. Concentrated sulphuric acid serves as a dehydrating agent. It absorbs the water formed during the reaction so that the ester cannot hydrolyze to give the original acid and alcohol.

After the experiment, you can harmonize the concepts suggested by students with what they are expected to know by introducing the general equation for esterification reactions and giving some examples. Before you conclude this part, tell them how to name esters using the IUPAC system. Let them practice writing structures of simple esters from their names.

To conclude chemical properties of alcohols, introduce the products that can be formed by dehydration of alcohols and by the reaction of alcohols with hydrogen halides. Write the formulas of the reactants on the board and let the students complete the equation and name the products individually.

Finally, students should discuss Activity 1.31 for a few minutes and members of some groups should make presentations to the class. This activity is suggested to see whether or not students are able to identify the structures and functional groups of aldehydes, ketones, carboxylic acids and esters.

Assessment

You should assess each student's work throughout the section. Using your students' performance list, record how every student participates during discussions, presentations and explanations. Using questions from the suggested exercises or your own, give class works and home works. Check their exercise books and evaluate how the students perform in answering the questions. You can also give them test on the section.

Additional Questions

*1. What uses of ethane -1, 2,- diol and propane -1, 2, 3 triol do you know?

2. Monohydric alcohols are classified as primary, secondary and tertiary. But, quaternary alcohol doesn't exist. Why?
3. Do alcohols exhibit isomerism? If so, support your answer with examples.

*4. What products can be formed by the oxidation of 1 – pentanol and 3 – pentanol?

5. Which alkene should be hydrated in the presence of an acid catalyst to form 2 – Butanol?

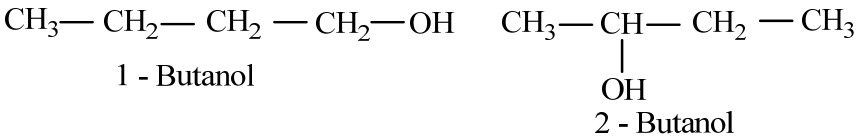
*6. Which alcohol can be prepared by hdyrolyzing n – propyl butanoate with KOH?

7. The molecular formula; C_3H_6O represents either an aldehyde or a ketone.
   a) Write the structural formulas of the aldehyde and the ketone that can be represented by the formula C_3H_6O and name them.
   b) Which alcohols should oxidize to give the aldehyde and the ketone, respectively.
   c) Write chemical equations that show the oxidation of the alcohols to form the aldehyde and the ketone.

8. Which alcohol and carboxylic acid must react to produce n – butyl propanoate?

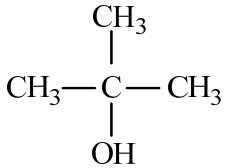
Answers to Additional Questions

1. Ethane – 1, 2 – diol is used as antifreeze, and propane – 1, 2, 3 – triol (glycerol) is used in cosmetics.
2. This is because a quaternary carbon atom is bonded to four other carbon atoms so that it cannot form additional bonds with the –OH group.
3. Yes they do. They show position isomerism as well as chain isomerism. For example, some isomers of C_4H_9OH are the following:

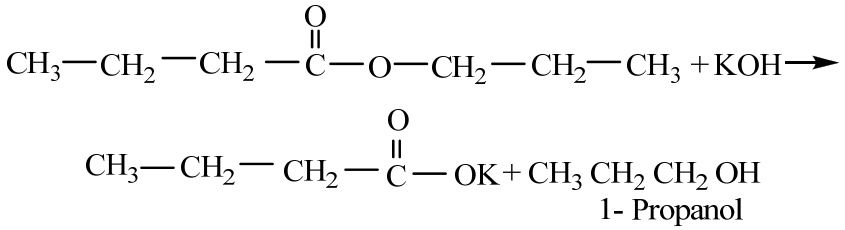


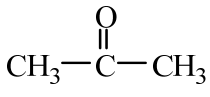
1 - Butanol

2 - Butanol

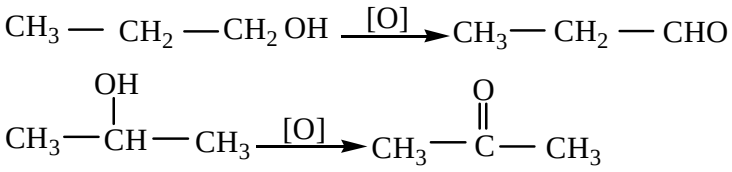


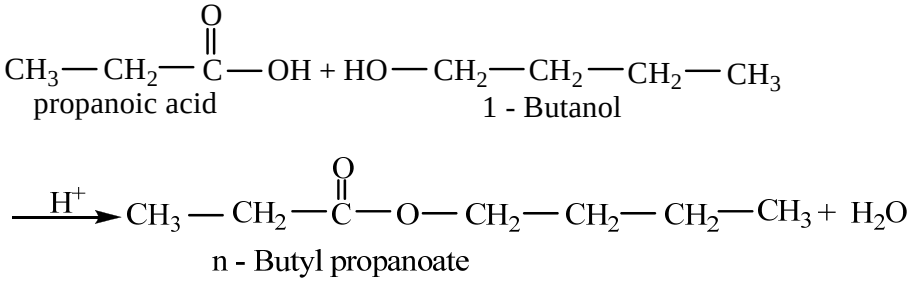
2 - Methyl - 2 - propanol

4. 1 – Pentanol may produce either pentanal or pentanoic acid on oxidation, while oxidation of 3 – pentanol gives 3 – pentanone.
5. 2 – Butene
6. 

7. a. $CH_3\,CH_2\,CHO$ (Propanal)  (Propanone)

   b. 1 – Proanol should oxidize to give propanal, and 2 – propanol should be oxidized to give propanone.

   c. 

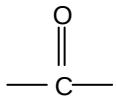
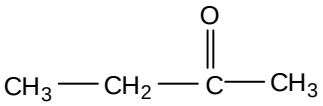
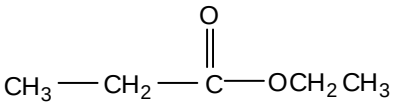
8. 

Answers to Exercise 1.14

1.	a)	monohydric	b) dihydric	c) trihydric
2.	a)	primary	b) secondary	c) tertiary

Answers to Exercise 1.15

1. The hydroxyl (-OH) group.
2. The number of the OH group they contain.

3. C_nH_{2n+1} OH
4. a, d, e primary
   c, f secondary
   b - tertiary.
5. a) 2 - Ethyl - 5 - methyl - 1 - hexanol.
   b) 2,2,4,4 – Tetramethyl - 3 -hexanol.
6. The presence of hydrogen bonding.
7. a) $CH_3OH + NaI$
   b) $CH_3CH_2COOK + CH_3CH_2OH$.
8. — CHO
9. 
10. — al and — one.
11. — COOH group.
12. a) CH_3CH_2COOH Or CH_3CH_2CHO if [O] is mild oxidizing agent
    b) 
    c) 

1.7 Industrial and Agricultural applications of organic Compounds

Period Allotted 2

Competencies

After completing the section, students will be able to:

- discuss the uses of organic compounds in the manufacture of beverages;
- discuss the uses of organic compounds in the manufacture of pharmaceuticals;

- discuss the uses of organic compounds in the manufacture of soaps and detergents;
- discuss the uses of organic compounds in the manufacture of dry cleaning agents;
- discuss the uses of organic compounds in the manufacture of fuels;
- conduct an experiment to prepare soap from naturally existing esters;
- discuss the uses of organic chemicals in the manufacture of pesticides and herbicides;
- discuss the importance and manufacture of urea.

Forward Planning

Read the section thoroughly and make appropriate preparation. Make a plan that shows the contents and activities you will treat during each period. One experiment is suggested in this section. Prepare the necessary chemicals and apparatuses required for Experiment 1. 9. Carry out the experiment beforehand. Plan how to organize students in groups to perform the experiment.

Teaching Aids

Refer to the students' text for the apparatus and chemicals required to perform Experiment 1.9.

Subject Matter Presentation

Use group discussion, experiment and question and answer methodologies to teach contents of this subtopic.

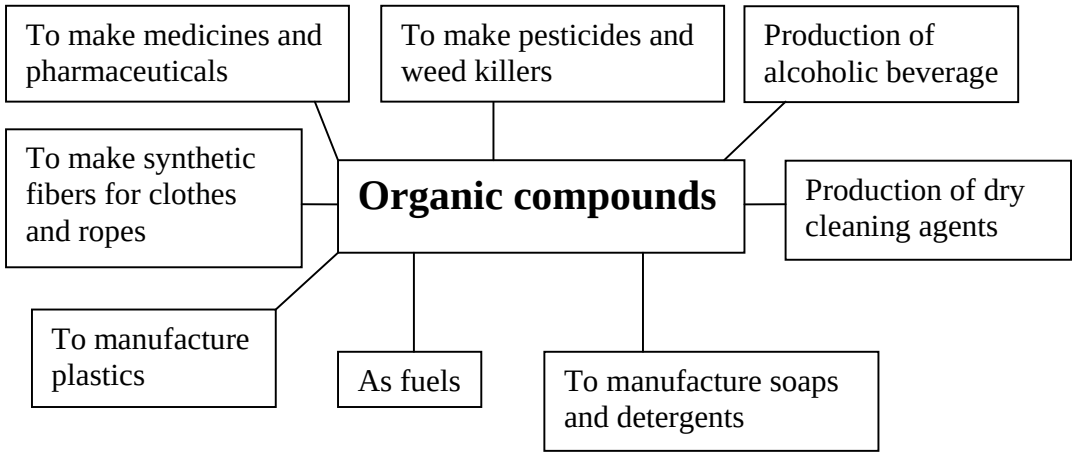
After introducing the topic for the section and making students ready for the teaching – learning process, let them discuss Activity 1.32 for some minutes in groups. After completing the discussions, encourage students from different groups to present their opinions to the class. Based on the concepts suggested by the students, harmonize their views and ideas with actual concepts they are supposed to know. In doing so, give them information about the major applications of organic chemicals. This should include the use of organic chemicals in the production of **alcoholic beverages** such as beer, wine and liquour; **pharmaceuticals** such as analgesics, antiseptics, sedatives, disinfectants and others; **dry cleaning** agents like tetrachloroethylene and tetra chloromethane. Let them also know that organic compounds can be used as fuels and in making soaps and detergents. In dealing with soaps and detergents, students should get information about: what soaps and detergents are, the raw materials used in their production, differences

between hard and soft soaps and what saponification is. Besides this, students should perform Experiment 1.9 under your supervision. Give them guidance and assistance whenever they are in need. After they complete the experiment, they should write a report in groups on their observations. Then let students from some groups make presentations to the class. For the points in the observation and analysis part of the experiment, you can use the following information.

a) Ethanol is used in this experiment to dissolve oil or fat and make hydrolysis occur easily.

b) Sodium chloride solution is added to reduce the solubility of soap and separate it out from the solution.

Conclude this section by giving them information on the agricultural applications of organic compounds in the production of pesticides, herbicides and fertilizers like urea. Finally, ask them to create a spider diagram that shows the uses and applications of organic compounds. You can use the following as a sample.



Assessment

You should assess each student's work throughout the section. Using your students' performance list, monitor how every student participates in discussions and during explanations. Ask oral questions. Give class work and homework and correct their work. Evaluate whether the suggested competencies for the section are achieved or not.

Additional Questions

1. What applications of organic compounds do you know other than those mentioned in your textbook?

Answers to Additional Questions

1. Organic compounds are also used in the manufacture of dyes, plastics, synthetic fibers for clothes and ropes, synthetic fat like margarine, artificial sweeteners, food-flavouring substances, explosives and as fuels (hydrocarbons).

Answers to Review Questions on Unit 1

1. a) 2 - Bromo - 3, 6 - dimethyl octane

   b) 4, 4, 5 - Trimethyl hept - 2 -yne.

   c) 5 - Bromo – 4,5 - dimethyl hept - 2 - ene

   d) 2 - Bromo - 3 - ethyl – 2,4 - dimethyl pentane.

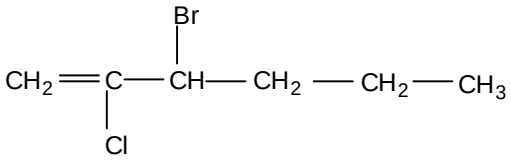
   e) 5 – Chloro - 2, 4, 4 – trimethyl - 2 - hexene

   f) 5 - Chloro - 3, 4 - dimethyl hex - 2 - ene.

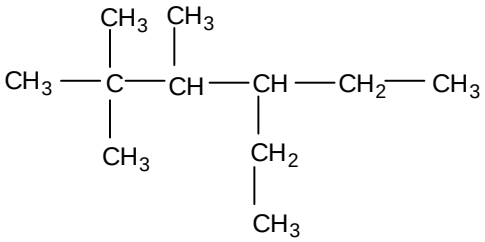
   g) 3, 3, 4, 4 - Tetramethyl - 2 - hexanol

   h) 3, 4 - Dimethyl - 1 - hexanol.

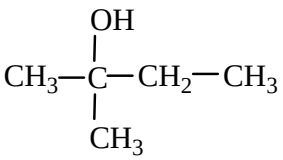
2. a)



   b)



   c)



3. a) $CH_3 — CH_3$

   b) $Na_2 CO_3 + CH_4$

   c) $CH_3\,CH_2\,CH_2\,CH_3 + 2NaBr$

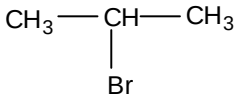
   d) $CH_3 — C \equiv CH + 2KBr + 2H_2O$

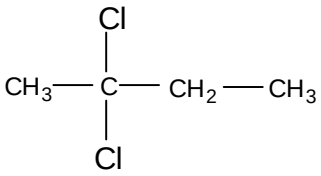
e) $CH_3 — CH = CH_2 + H_2O$

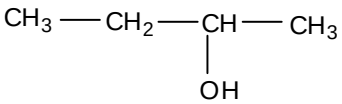
f) $CH_3\ CH_2\ CH_2OH + KCl$

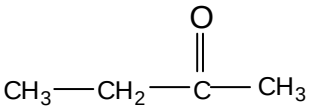
g) $HC \equiv C — CH_2 — CH_3 + NaBr$

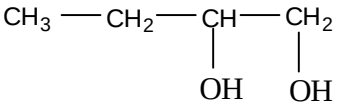
h) $CH_3COOK + CH_3CH_2OH$

4. a) 

b) 

c) 

d) 

e) 

f) $CH_3 — CH_2 — CHO$ – if [O] is mild oxidizing agent.

g) $CH_3 — CH_2 — CH_2COO\ CH_2\ CH_2\ CH_3$

h) $C_6H_5\ Cl + HCl$

5. C 6. B 7. A

8. D 9. C 10. D

11. B 12. C 13. A

14. D 15. B 16. C

17 D 18. C 19. D

20. D 21. B 22. B

23. A

Part III

a) False b) True c) False d) False

e) True f) False g) True h) False

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Unit 2 Important Inorganic Compounds

Unit Overview

Total Period Allotted 21

This unit begins by introducing the basis for the classification of chemical compounds as organic and inorganic. The main emphasis of the unit is to treat inorganic compounds. It introduces different classes of inorganic compounds such as oxides, acids, bases and salts.

The first section of the unit gives emphasis to oxides, their classification as acidic, basic amphoteric, neutral, and peroxides. It also presents definitions, chemical properties and differences among the different classes of oxides.

The second section of the unit introduces different definitions of acids, their classification as monoprotic and polyprotic, their general properties, strong and weak acids, concentrated and dilute acids, ways of handling acids, their preparation and common uses of some acids.

The next section deals with bases: their definition, general properties, precautions for handling them, the relationship between P^{H} and P^{OH}, preparation and uses of some bases. The last section deals with salts, their classification, preparation, uses of some important salts and properties. At the end, it gives information about plant nutrients, fertilizers, pesticides and weed killers.

To teach the contents in the unit, gapped lecture, group discussion, experiment and inquiry are the recommended methodologies.

Unit Outcomes

After completing this unit, 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, Brønsted-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 conclusions, applying concepts, relating cause and effect and problem solving.

Main Contents

2.1 Introduction

Period Allotted 1

Competencies

After completing this section, students will be able to:

- define inorganic compounds;
- name inorganic compounds;
- realize the different ways of classifying compounds on the basis of their composition and/or their chemistry;
- classify inorganic compounds as oxides, acids, bases and salts.

Forward Planning

Read the contents of the section thoroughly, and make the necessary preparation and plan how your students will actively participate in the teaching-learning process. Plan how to organize students in different groups and manage them during discussions.

Teaching Aids

A chart showing the two classes of chemical compounds and their differences can be used.

Subject Matter Presentation

We advise that you use mainly group discussion and a mini-lecture as methods for this section.

Use Activity 2.1 to start the lesson. The activity is designed to help students develop skills in classifying compounds as organic and inorganic and also discover some differences between these classes or compounds.

After introducing the topic of the section, let the students discuss Activity 2.1 for a few minutes in groups. During their discussion, check how every student participates, in the discussion. Give them guidance and the assistance they want from you. When they complete the discussion, invite students from two different groups to make presentations on points they discussed.

Next, build your mini-lecture. Consider the suggestions of the students and harmonize what they said with what you want them to know. Among the samples of compounds in the laboratory, ethanol, benzene, formaldehyde (methanol) sodium acetate, acetic acid, and etc are classified as organic compounds. The compounds such as the acids HNO_3, HCl, H_2SO_4 and salts like Na_2CO_3, $K_2Cr_2O_7$, NaCl etc are inorganic compounds.

You can also mention oxides of metals as inorganic compounds. Introduce students to the fact that the classification of compounds is mainly based on their sources. Inorganic compounds are compounds that come from mineral constituents of the earth or are found in non-living things. Organic compounds are those compounds that originate from animals and plants as well as compounds of carbon synthesized artificially. Then explain the basis for the classification of inorganic compounds.

Introduce the classification based on their composition or their chemistry. They may also be classified based on the metal, nonmetal or group they contain. Finally, explain that compounds formed by most of the known elements are inorganic, and that the field of chemistry that is concerned with the study of these compounds is inorganic chemistry. Inform students that, at this level, we classify inorganic compounds as

oxides, acids, bases and salts. Throughout your explanation, ask oral questions so that students can participate in the teaching-learning process.

Assessment

Assess each student's work throughout the section. Observe how each student is working during discussion and explanation. Give Exercise 2.1 as class work or home work. Check their work, record their results in your students' performance list, and evaluate how many of the students achieved the minimum requirement level.

Additional Questions

*1. Compounds of carbon, such as carbonates, hydrogen carbonates, cyanides and cyanates, are classified as inorganic instead of organic. Explain why.

2. At present, it is becoming very difficult to make a clear boundary between organic and inorganic compounds. What do you think is the reason for this?

Answers to Additional Questions

1. This is because the properties of these compounds of carbon are more similar to those of inorganic compounds than those of organic compounds.
2. Because of the synthesis of many organic compounds containing metals such as organometallic compounds.

Answers to Exercise 2.1

1. NaCl, KNO_3, $CaCO_3$, KOH, HCl, H_2SO_4, H_2O_2, Al_2O_3 etc.

2. Inorganic chemistry

2.2 Oxides

Period Allotted 3

Competencies

After completing this section, students will be able to:

- define oxides;
- classify oxides as acidic, basic, amphoteric, neutral and peroxides;
- define acidic oxides and give examples;
- explain the chemical properties of acidic oxides;
- define basic oxides and give examples;
- explain the chemical properties of basic oxides;

- conduct experiment to distinguish acidic oxides from basic oxides;
- compare and contrast acidic and basic oxides;
- define amphoteric oxides and give examples;
- explain the chemical properties of amphoteric oxides;
- discuss the salt forming nature of acidic, basic and amphoteric oxides;
- define neutral oxides and give examples;
- define peroxides and give some examples;
- explain the chemical properties of peroxides;
- conduct an experiment to distinguish peroxides from other oxides.

Forward Planning

Read the contents of this section thoroughly and design a plan of your own that shows which contents and activities you will treat during each period, and when students should conduct the suggested experiments. Three experiments are suggested in the section. Arrange the necessary chemicals and apparatuses required to perform the experiments. Carry out the experiments beforehand. If your laboratory is well-equipped, plan how students could perform the experiments by themselves in groups. You need also to plan how to follow up when students discuss the suggested activities in the section and perform the experiments. Also plan how to implement the suggested methodologies for each topic in the section.

Teaching Aids

Refer to the students' text for the apparatus and chemicals required to conduct Experiments 2.1, 2.2 and 2.3.

Subject Matter Presentation

Apply group discussion and question and answer methodologies for teaching contents in this subtopic.

First, introduce the topic of the section. Then continue your mini - lecutre by asking students to define what oxides are. After their responses, present the appropriate definition as binary compounds of oxygen and any other element (metal, nonmetal or metalloid).

Give them a few examples and let students suggest more examples of oxides. You can use Exercise 2.2 as class work for students to identify whether a given compound is an

oxide or not. Check their work. Inform students about the different classes of oxides, such as acidic, basic, amphoteric, peroxides and neutral oxides.

Acidic Oxides

After introducing types of oxides, continue with Activity 2.2. This activity enables students to discover what acidic oxides are and their reaction with bases. Let the students discuss Activity 2.2 for a few minutes.

When students discuss the activity, notice how every student participates in each group. Whenever necessary, give assistance and guidance to groups that are in need of it. When the time you allotted for the discussion is over, encourage students from different groups to present their opinions to their classmates. Appreciate the attempts made by the students in presenting their opinions. In relation to the activity, you can ask questions about the number of elements composing the given oxides, whether the elements carbon, nitrogen, phosphorus and sulfur are metals, nonmetals and metalloids. Emphasize that these elements are nonmetals, and that the oxides are oxides of nonmetals. You can generalize that acidic oxides are oxides of nonmetals and that they are formed by the combination of oxygen and nonmetals. Also introduce that acidic oxides dissolve in water and form acids. Tell them that acidic oxides are also named **acid anhydrides**. Give as many examples of acidic oxides as possible.

After that, continue dealing with properties of acidic oxides such as their reaction with water to form acids and their reaction with basic oxides to form salt. In explaining their reaction with bases, you can use the concept in Activity 2.2. Introduce that CO_2 is an acidic oxide. Limewater is an aqueous solution of calcium hydroxide, $Ca(OH)_2$, and it is a base. When CO_2 passes through a clear solution of lime water, the solution turns milky. This is due to the reaction of CO_2 with $Ca(OH)_2$, to form calcium carbonate, $CaCO_3$, which turns the solution white. The equation for the reaction is:

$$CO_2(g) + Ca(OH)_2(aq) \rightarrow CaCO_3(s) + H_2O(l)$$

Let the students practice writing chemical equations for the reactions of acidic oxides. After completing acidic oxides, proceed to treat basic oxides and amphoteric oxides.

Basic and Amphoteric Oxides

Use group discussion and experiment as the major methodologies to teach this topic and also use a mini-lecture when necessary.

First, ask the students to describe what basic oxides are and then provide the right definition by correcting them. Introduce them what basic anhydrides are. Tell them that

basic oxides can be soluble or insoluble in water. Inform them that the term alkali refers to soluble bases.

Let students discuss in groups for a few minutes to predict the products for the reactions between basic oxides and a) water b) acidic oxides c) acids as examples. When they complete the discussion, have some groups present their conclusions to the class. Then harmonize the concepts suggested by the students with the facts. Let the students practice writing a complete chemical equation for the reactions of basic oxides. You can give them Exercise 2.4, question 1 as class work or home work.

Let students perform Experiment 2.1 in groups after you complete basic oxides. They should write laboratory reports in groups and submit them to you. You can use the following note to evaluate their reports. From this experiment, the students are expected to realize that oxides can be prepared by the reaction of metals and nonmetals with oxygen. The answers to the questions that are raised in the observation and analysis part of the experiment are the following:

a) $S + O_2 \rightarrow SO_2$

$2Mg + O_2 \rightarrow 2MgO$

$2Ca + O_2 \rightarrow 2CaO$

b) When water is added to these oxides, SO_2 forms H_2SO_3, and MgO or CaO form $Mg(OH)_2$ or $Ca(OH)_2$.

c) Universal indicator turns yellow-orange in a solution of SO_2 and blue-purple in a solution of $Mg(OH)_2$, and blue litmus turns red in a solution of SO_2 and red litmus blue in a solution of $Mg(OH)_2$.

d) The color change occurred because a solution of SO_2 is acidic and that of MgO is basic.

After you complete basic oxides and Experiment 2.1, continue by introducing amphoteric oxides. Before you deal with the details, let students discuss Activity 2.3 in groups for some minutes. The activity enables them to discover and realize the change in properties of oxides of period III elements from basic to ampotheric and then to acidic. After their discussion, encourage one or two students from different groups to present their opinions and conclusions to their classmates. Following their responses, continue to harmonize the concepts suggested by students with the actual truth. Use the following table to show the variation in properties of oxides of Period 3 elements.

Element	**Na Mg**	**Al**	**Si**	**P S Cl**
Nature of the element	Metals		Metalloid	Non metals
Nature of oxide	Basic Na_2O and MgO	Amphoteric Al_2O_3	Acidic SiO_2 P_4O_{10} SO_2 Cl_2O_7	

From this table, you can show that the behavior of oxides change from basic to amphoteric and then to acidic as we go from left to right along a given period. Finally, explain the properties of amphoteric oxides. Have the students write balanced chemical equations related to chemical properties of amphoteric oxides. Have the students perform Experiment 2.2 in groups and present their findings to the class. After the presentation, inform them that Al_2O_3 dissolves in solutions of both NaOH and HCl and also reacts with them. This shows that Al_2O_3 is amphoteric. For the questions raised in the observation and analysis part of the experiment, use the following note.

1. Al_2O_3 reacts with both HCl and NaOH
2. The presence of chemical reaction between Al_2O_3 and HCl as well as Al_2O_3 and NaOH
3. $Al_2O_3(s) + 6HCl(aq) \rightarrow 2AlCl_3 + 3H_2O(l)$

   $Al_2O_3(s) + 2NaOH(aq) \rightarrow 2NaAlO_2(aq) + H_2O(l)$

Neutral Oxides and Peroxides

To teach the lesson for this topic, we suggest that use experiment and group discussion as main methodologies. You can use a mini-lecture only when harmonizing concepts.

After you complete the contents on basic and amphoteric oxides, continue by presenting concepts on neutral oxides and peroxides.

First, let the students discuss in groups for a few minutes and

a) distinguish the conceptual difference when the term “neutral” is used to describe the nature of substances and when used to describe a material in terms of electrical charge.

b) define neutral oxides and give examples.

After the discussion, let students from two different groups present their opinions to the class. In harmonizing the concepts suggested by the students, tell them that the term “neutral” in the context of this section, is used to describe oxides that are neither acidic

nor basic. The term is also used to describe substances that are neither negative nor positive. Give some examples of neutral oxides and then proceed to peroxides.

Before explaining the facts about peroxides, proceed to Activity 2.4. The activity is designed to help students realize some practical applications of peroxides in real life and also to enable them to discover how peroxides differ from the other oxides.

Let the students discuss Activity 2.4 for a few minutes and present their opinions to the class. Then, harmonize the concepts suggested by students with the actual facts by introducing that peroxides are oxides containing the peroxide link (-O-O-). Have the students notice that oxygen has an oxidation state of -1. Discuss their oxidizing properties and reactions with dilute acids to release hydrogen peroxide and the bleaching capacity of hydrogen peroxide. Based on the activity, inform students that hydrogen peroxide can be used to decolourize hair, and that it can be obtained by reacting peroxides like Na_2O_2 and CaO_2 with water.

Have the students perform Experiment 2.3 under your supervision. Have them write a report and present it to the class. Inform your students that, upon addition of Na_2O_2 or BaO_2 in the third beaker, the brown color of iodine appears first due to the oxidation of I^- to I_2 and then turns blue upon addition of starch.

The equation for the change is:

$$2KI\,(aq) + 2H_2SO_4(aq) + Na_2O_2(aq) \longrightarrow K_2SO_4(aq) + Na_2SO_4(aq) + I_2(aq) + 2H_2O.$$

Assessment

Assess the students' work throughout the section. Record how each student is doing on your students' performance list. You may make a record of the students' participation in discussions, during explanations, in performing experiments, in presentations, and in doing class and homework. From your records of what students have done; see how many of them achieved the suggested competencies for the section. Encourage students working above the minimum requirement level and give them additional work.

Assist students working below the minimum requirement level either by arranging extra lesson time or giving them additional activities.

Additional Questions

1. List metallic oxides you know that are acidic in nature.
2. What types of oxides (acidic, basic, neutral or amphoteric) do the metalloids such as boron, silicon and arsenic form? Support your answer by giving examples.

3. The peroxides like Na_2O_2 and K_2O_2 react with water. What products do they form in their reactions?

*4. Identify the unknown oxides, A, B and C, as acidic, basic or amphoteirc, based on the following experimental results.

Oxide	Color of litmus in solution of the oxide		Reaction with an acid	Reaction with a base
	Blue litmus	Red litmus		
A	Red	Red	No	Yes
B	Blue	Red	Yes	Yes
C	Blue	Blue	Yes	No

Answers to Additional Questions

1. CrO_3, Mn_2O_7, etc.
2. The metalloids boron, silicon and arsenic form acidic oxides with the formula B_2O_3, SiO_2 and As_2O_5
3. They produce hydrogen peroxide and bases as follows:
   $Na_2O_2 + 2H_2O \rightarrow 2\,NaOH + H_2O_2$
   $K_2O_2 + 2H_2O \rightarrow 2KOH + H_2O_2$
4. A is acidic, B is amphoteric and C is basic.

Answers to Exercises 2.2

a, c, d, e, f - are oxides

Answers to Exercise 2.3

1. P_4O_{10}, NO_2, N_2O_3, N_2O_5, SO_2, etc.

2. a) $P_4O_6 + 6H_2O \longrightarrow 4H_3PO_3$

   b) $SO_3 + H_2O \longrightarrow H_2SO_4$

   c) $CaO + CO_2 \longrightarrow CaCO_3$

   d) $Ca(OH)_2 + SO_3 \longrightarrow CaSO_4 + H_2O$

   e) $2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$

Answers to Exercise 2.4

1.

a) $K_2O + H_2O \longrightarrow 2KOH$

b) $MgO + H_2O \longrightarrow Mg(OH)_2$

c) $Na_2O + CO_2 \longrightarrow Na_2CO_3$

d) $Li_2O + SO_2 \longrightarrow Li_2SO_3$

e) $BaO + H_2SO_4 \longrightarrow BaSO_4 + H_2O$

f) $CuO + 2HCl \longrightarrow CuCl_2 + H_2O$

2. c, d, and h are acidic and the rest are basic.

Answers to Exercise 2.5

a) $ZnO + 2HCl \longrightarrow ZnCl_2 + H_2O$
$PbO + 2HCl \longrightarrow PbCl_2 + H_2O$

b) $ZnO + 2NaOH \longrightarrow Na_2ZnO_2 + H_2O$
$PbO + 2NaOH \longrightarrow Na_2PbO_2 + H_2O$

c) $ZnO + 2HNO_3 \longrightarrow Zn(NO_3)_2 + H_2O$
$PbO + 2HNO_3 \longrightarrow Pb(NO_3)_2 + H_2O$

d) $ZnO + 2KOH \longrightarrow K_2ZnO_2 + H_2O$
$PbO + 2KOH \longrightarrow K_2PbO_2 + H_2O$

Answers to Exercise 2.6

1. a, e, g, o - basic oxides
c, f, p - acidic oxides
d, i, l - amphoteric oxides
b, h, k - neutral oxides
j, m, n - peroxides

2. a) $6BaO + P_4O_{10} \longrightarrow 2Ba_3(PO_4)_2$

b) $SrO + SO_3 \longrightarrow SrSO_4$

c) $CO_2 + 2KOH \longrightarrow K_2CO_3 + H_2O$

d) $3ZnO + 2H_3PO_4 \longrightarrow Zn_3(PO_4)_2 + 3H_2O$

e) $Al_2O_3 + 6HNO_3 \longrightarrow 2Al(NO_3)_3 + 3H_2O$

f) $CaO + 2HCl \longrightarrow CaCl_2 + H_2O$

g) $PbO + 2NaOH \longrightarrow Na_2PbO_2 + H_2O$

3. a) N_2O_5 or NO_2 b) CO_2 c) SO_3 d) SO_2 e) P_4O_{10} f) P_4O_6
4. a) BaO b) SrO c) MgO d) Li_2O e) K_2O f) Cs_2O
5. In possessing the peroxide link and also containing oxygen in the oxidation state of -1.
6. Using indicators.

2.3 ACIDS

Period Allotted 7

Competencies

After completing this section, students will be able to:

- define acids in terms of Arrhenius, Brønsted-Lowry and Lewis;
- give examples of acids based on Arrhenius, Brønsted- Lowry and Lewis concepts;
- classify acids as monoprotic and polyprotic based on the numbers of ionizable hydrogen atoms;
- group acids as binary and ternary based on the number of elements they contain;
- explain the general properties of acids;
- 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;
- use the necessary precautions while working with acids;
- define pH and 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 indicator or pH meter;

- calculate the pH of a given acidic solution;
- calculate the hydrogen ion concentration from the given information;
- perform activities to investigate some physical properties of acids;
- perform activities to investigate some chemical properties of acids;
- explain the direct combination of elements, the reaction of acidic oxides with water, formation of volatile acids from non volatile acids as the three methods of preparation of acids;
- conduct simple experiment to prepare acids in a laboratory;
- describe the uses of three common laboratory acids.

Forward Planning

Read the contents of this section thoroughly ahead of time to be familiar with its basic concepts. Set a plan of your own that shows the contents and activities you are going to treat during each period so that the entire section will be covered within seven periods. There are seven experiments suggested in the section. Make the necessary arrangement of chemicals and apparatuses required to perform the experiments. Carry out the experiments beforehand. Prepare a plan on when and how the students will conduct the experiments in groups.

Teaching Aids

Refer to the student's text for the necessary chemicals and apparatus required to conduct Experiments 2.4, 2.5, 2.6, 2.7, 2.8, 2.9 and 2.10.

Subject Matter Presentation

Definitions of Acids

Use group discussion and question and answer methodologies to teach the contents in this topic.

The section starts with Activity 2.5. It helps students to develop more concepts on acids and discover which acids and bases they encounter in everyday life.

Introduce the topic of the section. Have the students to discuss Activity 2.5 for a few minutes in groups. During their discussion, strictly follow how every student in each group takes part in the discussions. You are also expected to guide them and give assistance whenever they are in need. After they complete their discussion, let two students from different groups present what they discussed in their groups to their classmates. After their presentations use a mini - lecture, to harmonize their ideas with

concepts they are expected to know. Introduce them to acids that we encounter in our daily lives. This can include acetic acid, citric acid, lactic acid etc. The bases that we encounter in our daily lives include soaps and detergents that we use daily and tooth paste. Tell them also that *injera*, cheese and fruits like lemon and organs are sour. Then continue with the Arrhenius definition of an acid in relation to the concept in Activity 2.5. Acids release a hydronium ion, H_3O^+, in aqueous solution. This polyatomic ion is formed when an H^+ ion reacts with water.

$$H^+(aq) + H_2O(l) \longrightarrow H_3O^+(aq)$$

Explain that Arrhenius acids are those capable of releasing hydronium iona in aqueous solutions such as HCl, HNO_3, H_2SO_4, HI, HBr, and HF. Before concluding your explanation, let students get information about the limitations of Arrhenius definition. Continue by introducing the students to the Brønsted-Lowry definition of an acid.

Before you deal with the details, let the students discuss in groups the following questions for a few minutes.

1. Is it possible to say that the hydrogen ion, H^+, is a proton? Why? (The hydrogen atom is represented by ${}^1_1H$)
2. Consider the following chemical equation

   $$NH_3(aq) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$$

   a) What species is donated by H_2O as it changes from H_2O to OH^- in the above reaction?

   b) In the reaction given by the above equation, H_2O is a Brønsted-Lowry acid. What is an acid according to the Brønsted Lowry concept?

After they complete the discussions, let two students from different groups present their opinions to the class. Then, harmonize their suggestions with the facts they are supposed to know. Tell them that H^+ is a proton. It is a hydrogen ion that can be formed when a hydrogen atom loses its electron. You can show them that by drawing the structures of a hydrogen atom and ion for comparison. In case of the second question, tell them that as H_2O changes to OH^-, it donated H^+ (a proton) to NH_3. Thus H_2O is an acid. So, an acid is a proton donor according to the Brønsted-Lowery concept.

Be sure that the students noticed that the Brønsted-Lowry concept is wider than that of Arrhenius. Let them get further information that all Arrhenius acids are also Brønsted-Lowry acids. But, the reverse is not true. This is because Brønsted-Lowry acid includes substances that can donate protons in gaseous state or in nonaqueous solutions. Have the

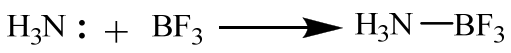
students identify Brønsted-Lowry acids from a given chemical equation that represents an acid - base reaction. Give them some questions as class work.

After the students understand what Brønsted-Lowry acids are, then continue by presenting the Lewis concept of acids. Before you deal with the details, let the students discuss the following points in groups for a few minutes, and have some groups present their opinions to the class.

a) What is a coordinate covalent bond?

b) What precondition should be fulfilled for two atoms to form a coordinate covalent bond between them?

c) Consider the following equation:



If BF_3 in the reaction given by the above equation is an acid, what is an acid according to the Lewis concept?

After the presentations, harmonize the concepts suggested by the students with the facts. In doing so, remind them of the definition of the coordinate covalent bond. Tell them that for two atoms to form a coordinate covalent bond between them, one of the atoms must have a lone pair of electrons and the other must have an unfilled shell or a vacant orbital. In relation to the reaction, tell them that BF_3 is a Lewis acid since it is an electron pair acceptor. Then, give them the appropriate definition of a Lewis acid. Support your explanation with some examples and equations. Based on the chemical equations, ask the students to indentify the Lewis acids.

Classification of Acids

Make sure that the students understand the three definitions of acids, and then continue with their classification. We advise you to start introducing the contents by using Activity 2.6. The activity is suggested to help students discover one of the basis for the classification of acids. Have the students discuss Activity 2.6 for a few minutes in groups. Then have one or two students from different groups present their views. Then harmonize their ideas with the facts they are supposed to know. Tell them that H_3PO_4 has three ionizable hydrogen atoms, and hence it is triprotic. Although, the number of hydrogen atoms in CH_3COOH is four, only one of them is ionizable and hence it is monoprotic. Now introduce that acids can be classified, based on the number of ionizable hydrogen atoms they possess per molecule, as monoprotic, diprotic and triprotic. Before you conclude introducing monoprotic and polyprotic acids, use Activity 2.7 to help students understand that not all compounds containing hydrogen are acids. Have the students discuss Activity 2.7 in groups for a few minutes and present

their opinions to the class. Then tell them that even though NH_3 contains three hydrogen atoms, it doesn't release these hydrogen atoms and is not a triprotic acid. Rather, it is a base.

Write the chemical formulas for HF, HCl, H_2S in one group, and write those for HNO_3, H_2SO_4 and $HClO_3$ in another group. Tell them that HF, HCl and H_2S are binary acids, while HNO_3, H_2SO_4 and $HClO_3$ are ternary acids. Have the students discuss this in groups for a few minutes s they can discover the basis for the classification of acids as binary and ternary. Then have one or two groups present their opinions to the class.

Inform them that acids can also be classified, based on the number of elements forming the acid, as binary and ternary acids. Give examples of each case.

General Properties of Acids

To deal with the contents of this topic, we advise you to apply experiment, group discussion and question and answer methodologies.

Evaluate whether or not students are able to identify monorotic and polyprotic acids as well as binary and ternary acids. Then, start teaching the lesson by using Activity 2.8 which is designed to help students discover the taste of acids. Have them discuss Activity 2.8, in groups and then have one or two students present their opinions to the class. Tell them that lemon and orange juice taste sour because citric acid is present in the juice. Next, present the general properties of acids. This should include their taste, effect on indicators, reactions with active metals, carbonates and hydrogen carbonates, sulphites and bases. While dealing with properties of acids, use experiment as your major methodology. So, students should perform Experiments 2.4-2.7. When they conduct Experiment 2.4 to see the effect of acids on indicators, have the students write laboratory reports in groups on their observations and present to the class.

Make sure that the students' experimental results agree with the following facts:

Indicator	Color of indicator in			
	Lemon juice	Dilute HCl	Dilute HNO_3	Dilute H_2SO_4
Phenolphthalein	Colourless	Colourless	Colorless	Colorless
litmus	Red	Red	Red	Red
methyl red	Red	Red	Red	Red
universal indicator	Orange - red	red	Red	Red

In relation to the reactions of acids with active metals, have the students perform Experiment 2.5 under your supervision. Have them produce laboratory reports in

groups. Then have students from two different groups present their observations. Check whether or not the following points are mentioned in their reports.

- When acids are added to the provided metals in each test tube, formation of bubbles shows that a gas is released.
- When a burning splint is brought close to the mouth of the test tube, a "popping" sound is heard. This proves that the gas is hydrogen.
- The reaction of powdered magnesium with HCl and H_2SO_4 is the most violent.

After completing the experiment and presentation, you can continue by explaining reactions of acids and carbonates. Let students discover the products that result from reactions of acids and carobnates by performing Experiment 2.6 in groups. Then have them and write group reports and make presentations to the class. In relation to this experiment, make sure that their reports on observation and analysis include the following points.

- The formation of bubbles indicates the release of a gas.
- The change in the color of damp blue litmus to red when it is held close to the mouth of the test tube proves the gas to be acidic.
- When the gas is passed through lime water, the clear solution turns milky, and this proves the gas to be carbon dioxide.

Following Experiment 2.6 and the students' presentations on their findings, tell them that the reactions of acids with sulphites produce SO_2, salt and water. Write some chemical equations and have the students complete and balance the equations in relation to reactions of sulphites and acids. Then proceed to reactions of acids with bases and basic oxides. To observe this property of acids, have students perform Experiment 2.7 in groups, write laboratory reports and submit them to you. Collect the reports and correct them.

Use the following note to check the reports of the students on their observations.

- NaOH is added one drop at a time, so we will not add more base than required to neutralize the acid.
- The products formed in step 4 are NaCl and H_2O, in step 5, $CaCl_2$ and H_2O.
- When we dip blue litmus in the solutions immediately after the mixing in step – 5, red litmus turns blue, indicating the presence of excess base.
- The blue litmus remains blue, and the red stays red in procedures 4 and 5 when neutralization is complete.

Strength of Acids, Dilute and Concentrated Acids

You are advised to use group discussion and question and answer methodologies for this part.

We suggest that you start teaching the lesson by using Activity 2.9. The activity is suggested believing that students can discover the effect of acids on specific materials and can learn the precautions to be taken in chemical laboratories. Therefore, have the students discuss Activity 2.9 in groups for a few minutes. Encourage some of them to present their opinions to the class. After the presentations, tell them that citric acid has no effect on the cloth but nitric acid attacks and may even damage the cloth. Therefore, nitric acid is a strong acid and citric acid is a weak acid. However, it is not possible to categorize acids as strong and weak based on their effects on other materials. Thus, you need to introduce degree of ionization as the basis for classifying acids as strong and weak. Inform students that strong acids ionize completely in aqueous solution, while weak acids ionize only slightly.

You can use the acids mentioned in the activity as examples. They should also know that acids are corrosive and that it is not advisable to taste any laboratory acid.

Before you start introducing concentrated and dilute acids, give the students a chance to discover what concentrated and dilute acids are on their own. Have them discuss Activity 2.10 in groups for a few minutes and have two or more students from different groups present their ideas to the class. Following their presentations, harmonize the ideas suggested by students with facts which you want them to know. In the suggested activity, a solution containing 95% H_2O and the rest HCl is a dilute solution. In a car battery, if the electrolyte used is 35% H_2SO_4, then 65% of it is water. It is a dilute solution compared to concentrated sulphuric acid, which is 98% H_2SO_4 by mass. Then students that "concentrated" and "dilute" are terms used to describe the relative amount of an acid present in a given quantity of acid solution. Be sure that the students understand that concentration can be expressed in terms of number of moles per litre or molarity (M). Give them some examples of how to calculate the molarity of an acid solution. Let them also practice how to calculate the molarity of an acid solution by solving some problems.

Be sure that the students understand that acids conduct electricity in aqueous solutions. This is because they ionize to positive and negative ions. The conduction of electricity through acid solutions depends on the concentration of ions. Since strong acids produce ions to a greater extent, they transmit electricity better than a solution of equal concentrations of weak acids. To prove this practically, have the students perform

Experiment 2.8 in groups under your supervision. They should write laboratory reports and present them to the class. Make sure that students have discovered that solutions of 1.0 M HCl and 1.0 M HNO_3 produce a bright light, while those of 1.0 M CH_3COOH produce a dim light. This result shows that HCl and HNO_3 are strong acids, while CH_3COOH is a weak acid. Following Experiment 2.8, introduce the precautions for handling acids.

p^H and p^H Scale

We advise you to apply experiment and question and answer methodologies to this subtopic.

After you check whether the students are able to differentiate strong and weak acids, and dilute and concentrated acids, present the pH and pH scales. Solve some problems to show how the pH of a solution can be calculated from a given concentration of H^+ or the reverse. Let students practice calculating pH or concentration of H^+ independently. You can use Exercise 2.7 for this purpose as class work or home work.

Next have the students determine the pH of the given substances in Experiment 2.9. This will help students develop skills in determining whether a substance is an acid or not, from its pH value. After they complete the experiment, have one or two groups present their findings. The result they obtained should prove that the given substances are all acidic. This is because the pH values determined by the experiment are all less than 7.

Preparation of Acids

We advise you to use group discussion, experiment and question and answer methodologies for this sub topic.

Check whether the students understand how to calculate pH from a given $[H^+]$, or the reverse, and can identify a solution as acidic or basic from its pH value. Then present the preparation of acids. First, let the students discuss in groups for a few minutes and suggest how they can prepare the following acids:

a) H_2SO_4 and HNO_3

b) HCl and HBr

Let one or two groups present their opinions to the class. After the presentations, introduce the three methods and then conduct Experiment 2.10. In relation to the experiment, check whether or not the students have included the following points in their group reports. The white precipitate formed upon mixing $Ba(ClO_2)_2$ solution with dilute H_2SO_4 is $BaSO_4$. The equation for the reaction is:

$$Ba(ClO_2)_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2HClO_2(aq)$$

The final solution is acidic due to the formation of chlorous acid.
You can start teaching the lesson on the uses of some important acids with Activity 2.11. The activity is designed to help students discover the uses of common acids in daily life and also to realize the implication of high consumption of sulphuric acid by a country. So, let the students discuss Activity 2.11 in groups and present their views. In harmonizing their views with reality, tell them about the presence of citric acid in citrus fruits used as food, the use of vinegar, the use of dilute solutions of ethanoic acid as food flavoring substances, lactic acid in cheese, carbonic acid in carbonated beverages and hydrochloric acid in gastric juice that helps digestion.

Let them also know that high consumption of sulphuric acid indicates the economic growth of a country since it is the leading industrial chemical used in the production of a wide variety of substances. Then, introduce them to the uses of HCl, HNO_3 and H_2SO_4.

Assessment

Assess the students' work throughout the section. Check how every student does during discussions, explanations, class work and homework. Evaluate whether or not most of the students have achieved the competencies suggested for the section. Appreciate students working above the minimum requirement level and give them extra work. Assist those working below the minimum requirement level by arranging additional lesson time or giving them additional exercises on points they didn't understand.

Additional Questions

*1. Classify the following acids as strong or weak.

a) HI b) H_2SO_4 c) H_2CO_3 d) HNO_2

e) H_3PO_4 f) HNO_3 g) HCOOH h) H_2S

2. Gastrite patients are advised to take tablets or suspensions of weak bases such as magnesium hydroxide or aluminium hydroxide. Which reaction of acids enables them get relief upon taking the weak base?

3. The acids of phosphorus, H_3PO_4, H_3PO_3 and H_3PO_2, are triprotic, diprotic and monoprotic acids, respectively. What is the reason for this?

*4. The compounds BF_3, $AlCl_3$, and PCl_5 are acids, according to the Lewis concept, but not according to Arrhenius and Bronsted – Lowry. Why?

*5. Two reagent bottles, labeled A and B, are filled with solutions prepared by dissolving 49g H_2SO_4 in 250 mL solution and 122.5 g of the acid per litre solution, respectively.

a) What is the molarity of solution A and B, respectively?

b) When you compare the two solutions which one is

i) more concentrated?

ii) more dilute? (molar mass of: H_2SO_4 = 98 g/mol)

6. The pH of an acid solution is 2.8. What is the hydrogen-ion concentration in the solution?

*7. Aqueous solution of HCl is a good conductor of electricity. What is the reason for its electrical conductivity?

Answers to Additional Questions

1. a, b and f are strong acids.
   c, d, e, g and h are weak acids.
2. Neutralization reaction.
3. H_3PO_4, H_3PO_3 and H_3PO_2 contain three, two and one ionizable hydrogen, respectively.
4. They neither release H^+ in aqueous solutions nor donate or accept H^+.
5. a) 2M and 1.25M, respectively.
   b) i. solution in A

   ii. solution in B
6. 1. 6×10^{-3} M
7. This is due to complete dissociation of HCl to H^+ and Cl^- ions in aqueous solution.

Answers to Exercise 2.7

1. $[H^+] = 1.0 \times 10^{-8}$ mol/L
2. $\frac{[H^+]_A}{[H^+]_B} = \frac{10^{-2}}{10^{-6}}$

   $\Rightarrow [H^+]_A = 10^4 \times [H^+]_B$

Answers to Exercise 2.8

1. All are Arrhenius acids, except d and f.
2. a) CH_3COOH b) HCN

   c) HF d) $HClO_4$
3. a) $AlCl_3$ b) BF_3 C. $SiCl_4$ d) PF_5
4. Monoprotic acids: a, d, e, f, g, h, i.

   Diprotic acids: b, c, j, k

   Triprotic acids: l

Binary acids: d, e, k

Ternary acids: a, b, c, f, g, h, i, j, l

Strong acids: a, b, e, h

Weak acids: c, d, f, g, i, j, k, l

5. Using indicators

6. Their degree of ionization (dissociation)

7. a) 2.3 b) 2.523 c) 5.7

8. a) 10^{-4}M b) 1.0 x 10^{-2}M c) 1.0 x 10^{-5} M

9. 0.075 moles

2.4 Bases

Period Allotted 5

Competencies

After completing this section, students will be able to:

- define bases in terms of the concepts of Arrhenius, Brønsted-Lowry and Lewis;
- give examples of bases based on the Arrhenius, Brønsted-Lowry and Lewis concepts;
- explain the general properties of bases;
- define strong and weak bases;
- distinguish between strong and weak alkalis (soluble bases);
- define concentrated and dilute alkalis;
- distinguish between concentrated and dilute alkalis (soluble bases);
- use necessary precautions while working with bases;
- 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 given information;
- conduct activities to investigate some chemical properties of bases;

- 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;
- conduct simple experiments to prepare bases in a laboratory;
- describe the uses of the three common laboratory bases (NaOH, $Ca(OH)_2$ and NH_3).

Forward Planning

Read the contents of this section thoroughly. Prepare a plan in relation to the content and activities you are going to deal with during each period so that all content in the section will be covered within five periods. Set questions on points which you intend to teach during each period and use them when you are harmonizing concepts or during stabilization. Design procedures on how to make the teaching – learning process more successful and to manage the students in their interaction.

There are two experiments (2.11 and 2.12) suggested in this section. Prepare the chemicals and apparatus required to conduct the experiments and plan when and how to conduct them. Carry out the experiments beforehand.

Teaching Aids

Refer to the students' text for the chemicals and apparatuses required to conduct Experiments 2.11 and 2.12.

Subject Matter Presentation

Definitions of Bases

Implement group discussion and question and answer methodologies to teach this topic. Introduce the topic of the section. The section starts with Activity 2.12. The activity is suggested to help students discover the taste of bases and understand the agricultural application of bases. Let the students discuss Activity 2.12 in groups. Encourage students from some groups to present their views on points they discussed to the class. After their presentations, continue the lesson on bases. First, tell them why we study bases and introduce a few uses of bases. For example, you can tell them that farmers add limestone to their soil to remove soil acidity.

Then, continue with the definitions of bases. Before dealing with the details, ask the students to tell you what Arrhenius acids are. After they respond to your questions, ask them again if they can state the Arrhenius definition of bases. Next, define bases according to the Arrhenius concept. Arrhenius bases include hydroxides of alkali metals

and lower members of alkaline earth metals. Examples of Arrhenius bases are LiOH, NaOH, KOH, $Ca(OH)_2$, $Ba(OH)_2$ etc.

Next, ask the students to state the Brønsted-lowery definition of acids. After they answer your question, tell them that Brønsted-Lowery bases are opposite to Brønsted-Lowery acids. Write some chemical equations related to Brønsted-Lowry acid-base reactions, and let the students identify Brønsted-Lowry acids and bases. Check how every student is doing.

Finally, tell them that not all Brønsted-Lowry bases are Arrhenius bases, but that all Arrhenius bases possess a hydroxide ion, which is a Brønsted-Lowery base. Again, let the students recall the Lewis definition of acids. Then define Lewis bases as electron-pair donors. Inform them that Brønsted-Lowery bases are also Lewis bases. However, Lewis bases includes substances capable of forming a coordinate bond by donating an electron pair with species other than H^+. Inform them that Lewis concept accepts H^+ as one kind of acid only. Let the students get a clear idea of the Lewis definition of bases by discussing Activity 2.13 for a few minutes in groups. After completing the discussion, let some groups explain their views to the class. Then harmonize their ideas with the facts by informing them that NH_3 in the first and F^- in the second are Lewis bases, while H^+ in the first and BF_3 in the second equation are Lewis acids.

General Properties of Bases

Group discussion and question and answer methodologies can be implemented in this subtopic.

Make sure that students have understand the three definitions of bases and then proceed to the general properties of bases. The first statement in activity 2.12 is suggested in order to introduce the bitter taste of bases. Let them know that soap also tastes bitter, since it forms a basic solution. Before, you continue with other properties of bases, use Activity 2.14, which is suggested to help students discover what they feel when touching bases. So, let students discuss Activity 2.14 in groups and have one or two students present their opinions to the class. After the presentations, tell them that a solution of washing soda in water is basic. When one washes his hands with the solution, it gives a soapy feel. So bases feel soapy to the touch.

Let the students discuss the following points in groups for a few minutes and some groups present their opinions to the class.

a) What is the effect of soluble bases on the colour of litmus, phenolphthalein, methyl red and universal indicator?

b) Which ion do soluble bases release in aqueous solution?

c) What products do they form when bases react with acids and acidic oxides?

d) Why do aqueous solutions of soluble bases conduct electricity?

After the presentations, harmonize the concepts suggested by the students with the facts. Build a mini-lecture and introduce the effect of bases on indicators, the ion released by soluble bases in aqueous solution, their capacity to neutralize acids and acidic oxides and their ability to conduct electricity. Let them practice writing chemical equations on the reactions of bases.

Strong, Weak, Dilute and Concentrated Bases

We advise that, before you continue introducing the strength of bases, you implement Activity 2.15. The activity helps students to realize the conceptual differences between the terms concentrated, dilute, strong and weak bases. So, let them discuss Activity 2.15 for a few minutes in groups and present their opinions to the class. Then ask them to recall the basis for the classification of acids as strong and weak. Tell them that the classification of bases as weak and strong is also based on their degree of dissociation or ionization. Give examples of strong bases, such as LiOH, NaOH, KOH, $Ba(OH)_2$, and weak bases. Emphasize that a strong base is not the same as a concentrated base. A solution of a strong base can be either concentrated or dilute, and the same is true for a solution of a weak base like NH_3, $Mg(OH)_2$, etc. Again, let the students recall what "concentrated" and "dilute" mean. Let them know that the concentration of bases is expressed in terms of the number of moles of the base per liter of solution, or molarity. Solve some problems to show them how to calculate the molarity of a basic solution. Help students to practice calculating molarity of basic solutions by giving them additonal questions. Following this, tell the students about the precautions to be taken in handling bases and then continue on to present pOH.

pOH

We advise you to use group discussion, question and answer, and experiment as methodologies for this subtopic.

Start teaching the lesson on pOH by using Activity 2.16. The activity enables students to realize the presence of H^+ and OH^- in water in equal amounts and also to discover the effect of increasing $[OH^-]$ on the contration of H^+.

Before you deal with the details about p^{OH}, have the students discuss Activity 2.16 for a few minutes in groups and present their conclusions to the class. To harmonize their ideas with the actual concepts, tell them that water can behave as an acid and a base, and that it can behave as a proton donor as well as proton acceptor. However, it contains the same concentration of H^+ and OH^-. After that, ask the students to recall the

definition of pH and then let them define pOH. Introduce them to the mathematical expression of pOH.

$$pOH = -\log[OH^-]$$

Derive the relationship between pH and pOH. Inform them about the relationship as

$pH + pOH = p^{kw}$ or $pH + pOH = 14$ at 25°C.

Then, proceed by explaining how to use this relationship to calculate the $[H^+]$, pOH and pH from given concentrations of OH^- and values of K_w by solving some examples. Have the students practice calculating $[H^+]$, $[OH^-]$, pH and pOH from given concentrations of acids or bases. From the expression $[H^+]\ [OH] = 1.0 \times 10^{-14}\ mol^2/l^2$, help them to realize that an increase in $[OH^-]$ in a solution is accompanied by a decrease in $[H^+]$.

When you are quite sure that students have understod how to calculate pH, pOH, $[H^+]$ or $[OH^-]$ from given information, continue with Experiment 2.11. Make the necessary arrangement for students to perform it in groups.

After they complete the experiment, have them write laboratory reports on their observations and present them to the class.

Their observations and analyses should include the following points.

- Bases like NaOH and KOH melt when heated.
- Bases like $Ca(OH)_2$ decompose on heating to form an oxide and water. The equation for the decomposition of $Ca(OH)_2$ is

$$Ca(OH)_2 \xrightarrow{heat} CaO + H_2O$$

- The formation of water is proved by using cobalt chloride paper, which turns pink in the presence of water.

- When the solution obtained after neutralization is allowed to evaporate, white crystals of KNO_3, salt will remain on the watch glass.

Preparation of Bases

It is advisable to use mainly experiments and a mini-lecture to teach concepts in this lesson.

Start teaching this section by using Activity 2.17. The activity helps students realize that there are many salts other than NaCl, to discover where salt deposits are found in Ethiopia and also know that salts can be colored compounds.

When you are dealing with the methods for the preparation of bases, use experiment as the major methodology. Have students to perform Experiment 2.12 in groups to discover and understand the methods. Cut a small piece of sodium for the experiment or have students cut under your supervision. After the students complete the experiment, let them write laboratory reports on their observations in groups and present them to the class. Following their presentation, harmonize their ideas with those they are expected to know. From the experiment, make sure they have discovered that bases can be prepared by the reaction of active metals and water, metal oxides with water and by double-displacement reaction. The answers to the questions in the observation and analysis part of the experiment are:

1. The gas given off while performing procedure 1 is hydrogen

   $$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

   The solution obtained in this procedure turns red litmus blue and methyl orange yellow, and it is basic.

2. In the second procedure, when CaO or MgO dissolves in water, the resulting solution is basic and turns red litmus blue.

When a solution of K_2SO_4 or Na_2SO_4 is added to a $Ba(OH)_2$ solution, there is formation of a white precipitate, which is barium sulfate. The final solution contains either KOH or NaOH, depending on the type of sulfate used and turns red litmus to blue. If Na_2SO_4 and $Ba(OH)_2$ are used for the experiment, the reaction is as follows:

$$Na_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow BaSO_4(s) + 2NaOH(aq)$$

Finally, introduce the uses of some important bases, such as NaOH, KOH, $Ca(OH)_2$ and ammonia solution.

After you conclude this section, have the students do the reading assignment, either in groups or individually, and then either submit their work for correction or present them to the class, as per your decision.

Assessment

Assess the work of each student throughout the section. You can do so by making a record in your students' performance list. To make a record, see how every student participates in discussions, in presenting the conclusions of the group after discussions, in answering questions during explanations, in answering questions given as class work and homework, and in performing experiments. You can also use quizzes or tests. From the records you have, decide whether most of the students have achieved the minimum requirement level. Appreciate students working above the minimum requirement level

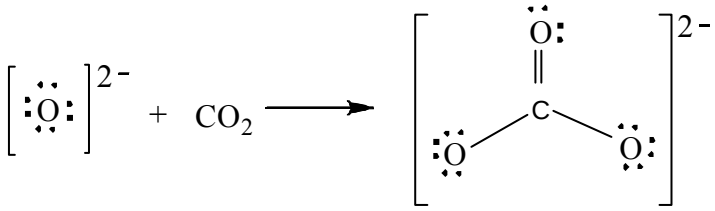
and give them additional exercises. Arrange make-up classes or give more exercises for students working below the minimum level.

Additional Questions

*1. All Bronsted – Lowry bases are not Arrhenius bases. Why?

*2. All Bronsted – Lowry bases are Lewis bases but, all Lewis bases are not Bronsted – Lowry bases. Why?

3. Identify the Lewis acid and Lewis base in each of the following reactions:

a) 

b) $CO_2 + H_2O \longrightarrow H_2CO_3$

c) $Co^{3+} + 6NH_3 \longrightarrow Co(NH_3)_6^{3+}$

*4. Decide whether solutions having the following pH values are acidic or basic.

a) 2.6 b) 1.0 c) 13 d) 4 e) 9

*5. Are solutions with the following pOH values acidic or basic?

a) 1.5 b) 10 c) 5 d) 8 e) 3.0

*6. Consider the following reactions:

i) $HS^- + OH^- \rightleftharpoons S^{2-} + H_2O$

ii) $HS^- + HBr \rightleftharpoons H_2S + Br^-$

a) Identify the Bronsted – Lowry acid and base in both reactions.

b) Which substance behaves as proton donor in one reaction and as a proton acceptors in the other?

c) What do we call species that behave as proton donors as well as proton acceptor?

*7. What is the pOH, pH and $[H^+]$ of a solution whose hydroxide ion concentration is

a) 2.0×10^{-4}M b) 1.0×10^{-8}M c) 4.0×10^{-3}M

8. How many grams of NaOH are contained, per liter, of solutions that have the following concentrations? (Molar mass: NaOH = 40 g/mol)

   a) 2.5M b) 1.25M c) 3.2M

Answers to Additional Questions

1. Because Brønsted- Lowry bases include all substances that can accept H^+ even if they do not release OH^- in aqueous solutions.
2. This is because Lewis bases include molecules and ions that can form coordinate covalent bonds using their lone pair, with H^+ and other species.
3. a) The Lewis base is O^{2-}, and CO_2 is a Lewis acid.
   b) CO_2 is the Lewis acid, and H_2O is the Lewis base.
   c) CO^{3+} is the Lewis acid, and NH_3 is the Lewis base.
4. a, b and d are acidic
5. a, c, e are basic
6. a. i. HS^- is acid and OH^- is a base
   ii. HS^- is a base and HBr is an acid.
   b. HS^-
   c. Amphiprotic or simply amphoteric
7. a) pOH = 3.7, pH = 10.3, $[H^+] = 5.0 \times 10^{-11}$ M
   b) pOH = 8, pH = 6, $[H^+] = 1.0 \times 10^{-6}$ M
   c) pOH = 2.4, pH = 11.6, $[H^+] = 2.5 \times 10^{-12}$ M
8. a) 100g b) 50g c) 128 g

Answers to Exercise 2.9

1. $\left[OH^-\right] = 3.33 \times 10^{-10}\,M$
2. $pOH = 1.4,\ pH = 12.6$

Answers to Exercise 2.10

1.

Acid	Base
a. HCOOH	CN^-
b. H_2S	OH^-

2.

Base	Acid
a. Cl^-	$AlCl_3$
b. NH_3	H^+

3. a. 2 M b. 2 M

4. a. pOH = 2.34, $[H^+] = 2.3 \times 10^{-12}$ mol/L, pH = 11.66.
   b. pOH = 5.6, $[H^+] = 4.0 \times 10^{-9}$ mol/L, pH = 8.4.
5. a) pH increases b) $[H^+]$ decreases c) pOH decreases
6. 0. 143 mole NaOH
7. 0.25 M

2.5 Salts

Period Allotted 5

Competencies

After completing this section, students will be able to:

- define salts;
- give examples of salts;
- classify salts as acidic, normal and basic salts;
- explain the direct combination of elements, the reaction of acids with bases and the reaction of acids with metals as methods of salt preparation;
- conduct simple experiment to prepare a salt by neutralization;
- list some important salts and discuss their uses;
- explain the properties of salts;
- describe the chemical tests of some salts by conducting activities;
- mention the essential nutrients of plants;
- describe the functions of nitrogen, phosphorus, and potassium in plant growth;
- define fertilizers;
- list some common fertilizers;
- explain the importance of fertilizers;
- list some common inorganic compounds that are used as pesticides and herbicides.

Forward Planning

Read the contents in this section thoroughly. Set a plan for the contents and activities that you need to deal with during each period so that the whole content of the section can be covered within five periods. In addition, there are seven experiments in this section, Experiments 2.13 – 2.19. Arrange all the chemicals and apparatuses required to

conduct the experiments. Prepare a schedule for conducting and how to organizing the students in groups for laboratory work. Carry out all the experiments before you allow students to conduct the experiments.

Subject Matter Presentation

Definition and Classification of Salts

Group discussion and question and answer methods are suggested for teaching this lesson.

Introduce the topics of the section and prepare for the teaching – learning process. Let the students discuss in groups Activity 2.17 for a few minutes. After they complete their discussions, invite some groups to present their ideas. During their presentation, write the salts they know on the board. Let them also suggest properties of salts they know such as solubility in water, colour etc. After their presentations, you can add a few examples of salts like NaCl, $CaCO_3$, Na_2SO_4, KNO_3, $CaSO_4$, $(NH_4)_2$ HPO_4 $MgCl_2$ etc. Inform them that most salts are found in nature while some are manufactured industrially. For example, large deposits of NaCl and sufficient amounts KNO_3, Mg CO_3 are found in the Dalol Depression, Afar region. NaCl is also found in the Somali region around Elkere. Sodium chloride for various consumptions in Ethiopia is obtained by evaporation of salt water from Afdera Lake located in the Afar region. $CaCO_3$, limestone is found in western Showa, near Ghuder at a place called Senkelle. Tell them also that most salts are white in colour, but that salts of transition metals are coloured. A few examples are hydrated copper sulphate, $CuSO_4 \bullet 5H_2O$ (blue), potassium dichromate, $K_2Cr_2O_7$ (yellow) and potassium permanganate, $KMnO_4$ (dark violet). Write the formulas of some salts on the board. Ask students to define salts. After their responses, introduce the definition of salts.

You can start introducing the classification of salts by using Activity 2.18. This activity will help students to differentiate an acid salt, basic salt and normal salt. Therefore, let the students discuss this activity in groups for a few minutes. Encourage two students from different groups to present what they discussed to the class. Following their presentations, explain the three classes of salts **acidic, normal** and **basic salts**.

To harmonize their ideas with the actual concepts, write the formulas Na_2SO_4, $NaHSO_4$ and H_2SO_4 on the blackboard. Ask them in what manner the formulas of the salts differ from the acid. Based on their responses, tell them that when all ionizable hydrogen atoms of an acid are completely replaced by a metal or ammonium ion, the resulting salt is normal salt. If the ionizable hydrogen atoms are partly replaced by a metal ion or ammonium ion, the salt that can be obtained is an acid salt. Write the formulas $ZnCl_2$,

$Zn(OH)Cl$ and $Zn(OH)_2$ on the board and proceed in the same manner as above to define basic salt.

Write the formulas of some salts and let students classify the salts as acidic, basic and normal. After checking how students are doing their work, continue dealing with the preparation of salts.

Preparation of Salts

Group discussion, experiment and question and answer methodologies are suggested to deal with contents of this lesson.

Start teaching the lesson on this part by using Activity 2.19. The activity is designed to help students discover methods for the preparation of salts on their own. So, have students suggest some methods of preparation after they discuss Activity 2.19. Following their responses, tell them that NaCl can be prepared by reacting Na and Cl_2, Na_2O and HCl or NaOH and HCl. Then, introduce the methods used in salt preparation. Have the students write balanced chemical equations for each method of preparation. Inform students that not every method can be used to prepare every salt.

Let students perform Experiment 2.13 in groups to see one method of preparation of salts. After completing the experiment, students from two groups should make presentations. Check whether each presentation is in accordance with the following observation: During this experiment, on heating the mixture of CuO and H_2SO_4, there is a color change from dark brown to a somewhat blue color. This is due to the formation of copper sulfate in the reaction. The equation for the reaction is:

$$CuO + H_2SO_4 \rightarrow CuSO_4 + H_2O$$

After performing the experiment, you can start introducing the uses of some important salts by using Activity 2.20. The activity is aimed at helping students realize the importance of salts in medicine. Have the students discuss this activity and ask some groups to share their ideas with the class. Next, harmonize their opinions with the actual concepts and inform students that oral rehydration salt, ORS, contains glucose, sodium chloride, trisodium citrate and potassium chloride. This is the composition of ORS available in pharmacies. Inform them that homemade ORS can be prepared by mixing sugar, common salt (NaCl) and lemon juice in water.

Following this, introduce the uses of some important salts, such as NaCl, NH_4NO_3, $CuSO_4$, $FeCl_3$, and KNO_3. Then continue by explaining properties of salts.

Properties of Salts

We advise you to use gapped lecture to teach this lesson. When dealing with the properties of salts, first introduce the group of salts that are soluble in water. Also inform them about the exceptions among the groups. Define these terms: hygroscopic, deliquescent and efflorescent. Give examples of deliquescent, hydroscopic and efflorescent salts. Explain why solutions of soluble salts conduct electricity. Then compare thermal stability of carbonates. Ask students to suggest carbonates that undergo decomposition reaction when heated. Tell them that carbonates of sodium and potassium do not decompose easily. In addition, nitrates of sodium and potassium decompose by heat to give nitrites and oxygen gas, while those of other metals produce metal oxide, nitrogen dioxide and oxygen.

Write the chemical formulas of the reactants on the board, and have students to complete and balance the chemical equations related to decomposition of salts by heat. After completing the content on properties of salts, continue by presenting chemical tests of some ions in salts.

Chemical Tests of Some Ions in Salts

It is advisable to use experiment as a methodology while dealing with this subtopic.

We advise you to start teaching this lesson by using Activity 2.21. The activity enables students to know why fireworks give different colours and realize how flame colours can be used to identify metals present in salts. Let the students discuss Activity 2.21 in groups for a few minutes. Encourage students from different groups to explain their ideas to the class.

After that, give them some information on fireworks (sparks used on holiday celebrations). These fireworks produce different colors on explosion because the compounds used in their production contain different metals. For example, those containing strontium compounds produce a crimson flame color, sodium compounds orange-yellow, copper compound blue-green etc. So chemists use flame tests and other chemical tests to know the presence of certain substances (metals). Have students conduct Experiment 2.14 in groups. While performing the experiment, they should discover that certain metals produce a characteristic flame color peculiar to them. When they carry out this experiment, make sure that they obtained the following results:

The following flame colors are observed while heating the salts containing Li^{+}, Na^{+}, K^{+}, Ca^{2+}, Sr^{+2} and Ba^{2+}.

Metal ion in the salt	Color of flame produced
lithium	crimson
sodium	yellow
potassium	purple (violet)
calcium	orange-red
strontium	crimson
barium	green

Regarding Experiment 2.15, make sure that the students obtained the following results.

1 The formation of a blue precipitate which dissolves in excess ammonia to form a deep blue solution indicates the presence of Cu^{2+} ions. The blue precipitate is $Cu(OH)_2$, which dissolves in excess ammonia to form copper (II) tetra amine, $Cu(NH_3)_4^{2+}$

2 The formation of a pale-green precipitate in the second test tube indicates the presence of Fe^{2+} ions.

$$Fe^{2+}(aq) + 2OH^-(aq) \rightarrow Fe(OH)_2(s)$$

Pale-green

3 The formation of a pale-brown precipitate in the third tube confirms the presence of Fe^{3+} ions:

$$Fe^{3+}(aq) + 3OH^-(aq) \rightarrow Fe(OH)_3(s)$$

Pale-brown

The observations for Experiment 2.16 are:

1 After the addition of $AgNO_3$ in the presence of HNO_3

i The formation of white precipitate in the first test tube indicates the presence of chloride ions. The white precipitate is AgCl.

ii The formation of yellow precipitate in the second test tube proves the presence of bromide ions and the precipitate is AgBr.

iii The formation of yellowish-green precipitates confirms the presence of iodide ions and the precipitate is AgI.

HNO_3 is used in this experiment to prevent unwanted precipitation by the reaction of Ag^+ and other ions.

2 If ammonia solution is added to each test tube, the precipitate in the first (AgCl) will dissolve, the precipitate in the second (AgBr) will dissolve partly, while the precipitate in the third (AgI) will not dissolve.

In performing Experiment 2.17, the following observation should be made by students.

Formation of white precipitate ($BaSO_4$) indicates the presence of sulfate ions in the solution. It is formed by the reaction of Ba^{2+} and SO_4^{2-}.

$$Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$$

Some drops of dilute HCl are added to the solution to be tested to avoid confusion. That is, ions like CO_3^{2-} can form a precipitate with Ba^{2+}. However, HCl dissolves compounds like $BaCO_3$ but not $BaSO_4$.

While conducting Experiment 2.18, students will get the following result:

When dilute HCl is added to the solution of Na_2CO_3 and $NaHCO_3$, there is an evolution of carbon dioxide gas, which turns limewater milky. This is due to the formation of $CaCO_3$.

$$Ca(OH)_2(aq) + CO_2(aq) \rightarrow CaCO_3(s) + H_2O(l)$$

Upon addition of calcium chloride solution, solutions of carbonates form a white precipitate of $CaCO_3$.

$$Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$$

Solutions of hydrogen carbonates do not form precipitate upon the addition of $CaCl_2$ solution.

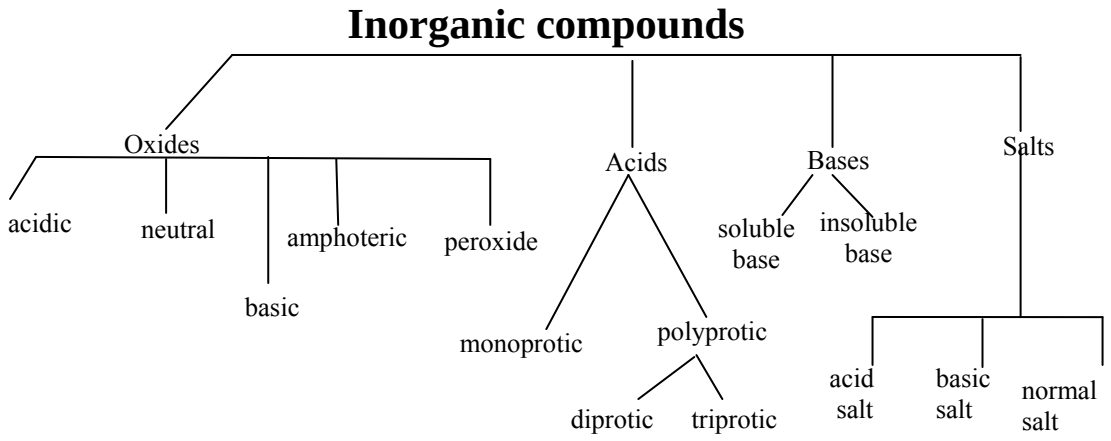
In testing for nitrates in Experiment 2.19, students will get the following results:

When concentrated sulphuric acid is poured down the side of the test tube, the acid sinks to the bottom, and a brown ring is formed where the two layers meet. The formula of the substance that forms the brown ring is $FeSO_4 \cdot NO$.

As a summary of important inorganic compounds, list the following words on the blackboard and have students construct a concept map for the classification of inorganic compounds, using the given words.

- Monoprotic acid
- Base
- Amphoteric oxide
- Salt
- Triprotic aicd
- Inorganic compounds
- Acidic oxide
- Basic salt
- Soluble base
- Neutral oxide
- Polyprotic acid
- Peroxide
- Acid salt
- Basic oxide
- Acid
- Normal salt
- Oxide
- Insoluble base
- Diprotic acid

The concept map has the following form.



Plant Nutrients

It is advisable to teach this part using group discussion and inquiry as your methodologies. After completing the experiments on chemical tests of some ions in salts, continue by teaching the lesson on plant nutrients. We advise you to start the lesson by using Activity 2.22. This activity will help students identify salts that are used as fertilizers, realize the form in which plants absorb nutrient elements and discover the effects of eating food materials grown using synthetic fertilizers. First, have the students discuss the activity in groups and explain what they discussed to the rest of the class. After that, suggest your own view; you may conclude that DAP and urea are common fertilizers used in Ethiopia. DAP is an inorganic salt, while urea is an organic compound. Also, tell them about the presence of many inorganic salts that are used as fertilizers, such as KCl, KNO_3, $(NH_4)_2SO_4$, NH_4NO_3 and $Ca(H_2PO_4)_2$. In relation to the

second question in Activity 2.22, tell them that although nitrogen is abundant in air, it is not in the form that plants can use. Also tell them that eating organically grown food materials is better than eating food grown using synthetic fertilizers. This is because food materials grown using synthetic fertilizers may cause cancer through long-term use.

Present the elements required for the growth of plants called essential nutrients. Then, have them discuss Activity 2.23 and discover the micronutrients and macronutrients required for the growth of wheat, maize and rice.

Then, introduce **macronutrients** and **micronutrients** and the elements classified in the two categories. Ask students to describe the importance and role of **nitrogen, phosphorus** and **potassium** in plant growth. Have students define fertilizers. List some common fertilizers and explain their importance. Introduce that fertilizers can be natural products or artificial chemicals. Define complete fertilizers and NPK. Finally, list some inorganic chemicals that are used as pesticides and herbicides.

Assessment

You may assess each student's work throughout the section by supervising how he or she is doing in all activities of the teaching - learning process, by correcting their class work and homework and by recording everything about the students in the performance list. From your records, see whether the suggested competencies for this section are achieved by most of the students. As you did in the previous sections, appreciate students working above the minimum requirement level and give them additional exercises. For students working below the minimum requirement level, assist them with what you think is important to enable them catch up with the rest of the class.

Additional Questions

1. What type of salt (acidic, basic or normal) will be formed if one mole of H_3PO_4 is allowed to react with

   a) 1 mole of NaOH? b) 2 moles of NaOH? c) 3 moles of NaOH?

2. Write the balanced chemical equation for each of the reactions (a to c) in question 1.
3. If a salt releases a reddish – brown gas with a disagreable smell that turns moist blue litmus red up on heating,

   a) Which anion is most likely present in the salt?

   b) Which gas is liberate by heating the salt?

4. What symptom do plants show when they grow on nitrogen-deficient soil?

*5. How can you prepare

a) calcium hydroxide b) calcium nitrate from calcium carbonate?

*6. The formula of DAP (used as a fertilizer) is $(NH_4)_2 HPO_4$.

a) Is DAP an acid, basic or normal salt?

b) Which acid and base should be used to produce this fertilizer?

c) Write the balanced chemical equation for the reaction that yields DAP.

*7. Which elements are considered to be primary mineral nutrients?

Answers to Additional Questions

1. a. Acidic b. Acidic c. Normal salt
2. a. $H_3PO_4 + NaOH \rightarrow NaH_2PO_4 + H_2O$

   b. $H_3PO_4 + 2NaOH \rightarrow Na_2HPO_4 + 2H_2O$

   c. $H_2PO_4 + 3NaOH \rightarrow Na_3PO_4 + 3H_2O$

3. (a) Nitrate, NO_3^- ion

   (b) Nitrogen dioxide

4. Their leaves turn yellow.
5. (a) First decomposing calcium carbonate by heat and then dissolving calcium oxide in water.

   (b) By reacting calcium carbonate with nitric acid.

6. a. Acid salt

   b. Ammonia and phosphoric acid

   c. $2NH_3 + H_3PO_4 \rightarrow (NH_4)_2HPO_4$

7. Nitrogen, phosphorus and potassium

Answers to Exercise 2.11

1. a) KOH and H_2SO_4 c) $Mg(OH)_2$ and HBr

   b) $Ca(OH)_2$ and HNO_3 d) $Ba(OH)_2$ and HI

2. See the students' text, pages 140 and 141.
3. Soluble: a, c, e , g, h

   Insoluble: b, d, f

4. Because they release positive and negative ions

5. Carbonates of group IA, Na_2CO_3 and K_2CO_3
6. Nitrates of sodium and potassium
7. a) $AgNO_3$ solution

   b) NaOH solution

   c) $BaCl_2$ or $Ba(NO_3)_2$ solution
8. Na_2CO_3

Answers to Exercise 2.12

1. Refer to the students' text, page 153.
2. Plants absorb nitrogen in the form of NO_3^-, phosphorus as $H_2PO_4^-$ and HPO_4^{2-} (in small amounts), and potassium as K^+.

Answers to Exercise 2.13

1. Synthetic fertilizers: a and c

   Organic fertilizer: b
2. No, because for acidic soil, we cannot use a fertilizer that increases its acidity. The same is also true for basic soil.

Answers to Review Exercise on unit 2

Part I

1. Acidic	2. Alkalis	3. Salt	4. React
5. Litmus	6. Soluble	7. Ammonia	8. Hydroxide
9. Acids	10. Salt		

Part II A

1. E	2. D	3. B	4. C	5. A

Part II B

6. E	7. A	8. B	9. F	10. D

Part III

11. C	12. A	13. B	14. A	15. B
16. C	17. D	18. C	19. C	20. A

Part IV

21. a. $ZnO + 2HCl \rightarrow ZnCl_2 + H_2O$

    b. $ZnO + 2NaOH \rightarrow Na_2ZnO_2 + H_2O$

22. a. $CaO + 2HCl \rightarrow CaCl_2 + H_2O$

    b. To neutralize the acid in the soil

23. a. To increase soil productivity and get more product

    b. Nitrogen, phosphorus and potassium

    c. By mixing the aqueous ammonia and sulphuric acid and allowing the water to evaporate

    d. Ammonium hydroxide + Nitric acid $\rightarrow$ Ammonium nitrate + water

24. a) Ammonia and sulphuric acid

    b) Potassium hydroxide and phosphoric acid

    c) See 23d.

25. No, because there are many compounds, such as hydrocarbons have contain hydrogen but are not acids. In the same manner, compounds containing the OH group are not bases, such as alcohols and carboxylic acids.

26. a) NaOH $\rightarrow$ Arrhenius base

    b) $H_2O \rightarrow$ Brønsted-Lowery/Lewis base.

    c) $NH_3 \rightarrow$ Brønsted-Lowery/Lewis base.

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Unit 3 Electrochemistry

Unit Overview

Total Period Allotted 10

Most of the content in this unit are not familiar to the students even though they know some of the concepts and have encountered the practical application of products of electrochemistry. So, it is important to support the teaching-learning process in this unit with practical activities or experiments.

The unit consists of five sections. The emphasis of the first section is on the definition of electrochemistry, electrochemical processes, how and where interconversion of electric energy chemical energy or chemical energy to electrical energy occurs. It also introduces to the importance of electrochemistry. The second section emphasizes electrical conductivity. It introduces why metals and electrolytes transmit electricity. It also presents information on types of electrolytes and how to distinguish them experimentally. The third section emphasizes electrolysis. It includes definition of electrolysis, introduces components of an electrolytic cell and how to predict the products that form at the electrodes during electrolysis. It also defines **half – cell reaction** and **cell reaction**. The fourth section deals with galvanic (voltaic) cells. It defines galvanic cells, types of galvanic cells and tells how they produce electricity. It also explains how to construct simple Galvanic cells. The last section of the unit emphasize the industrial applications of electrolysis. This includes the production of chemicals, production of metals and nonmetals, purification of metals and electroplating.

To teach the concepts in this unit, gapped lecture, inquiry, group discussion, experiment and visual-based learning are the suggested methodologies.

Unit Outcomes

After Completing this Unit, 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, nonmetals 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.

Main Contents

3.1 Introduction

Period Allotted 1

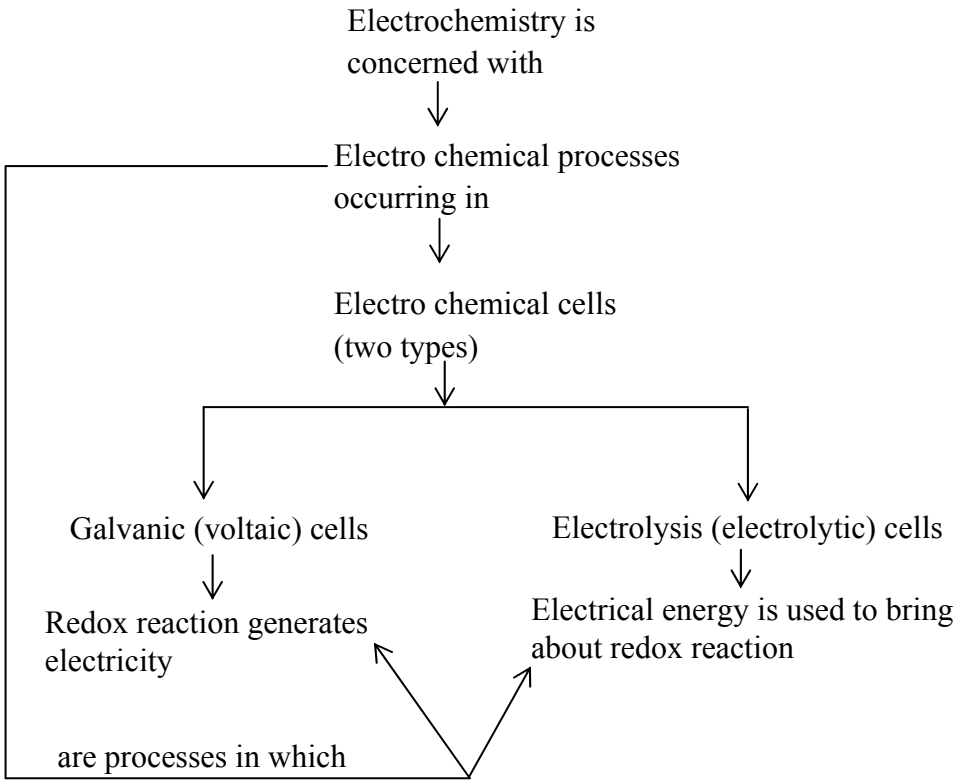
Competencies

After completing this subunit, students will be able to:

- explain electrochemistry.

Forward planning

Read the contents in this section and make the necessary preparation. You can prepare a chart like the following as a teaching aid to help students understand concepts presented in this section.



We suggest that you tell the students to bring old dry cells to the class one day before the period in which you intend to teach this section.

Teaching Aids

Chart showing definition of electrochemistry and classification of electrochemical processes.

Subject Matter Presentation

For teaching this lesson, we suggest that gapped lecture and group discussion are the suggested methodologies to implement. We suggest that you better start teaching the lesson by letting students discuss what they feel about the following terms in groups.

a. electrochemistry by splitting the word into **electro** and **chemistry**

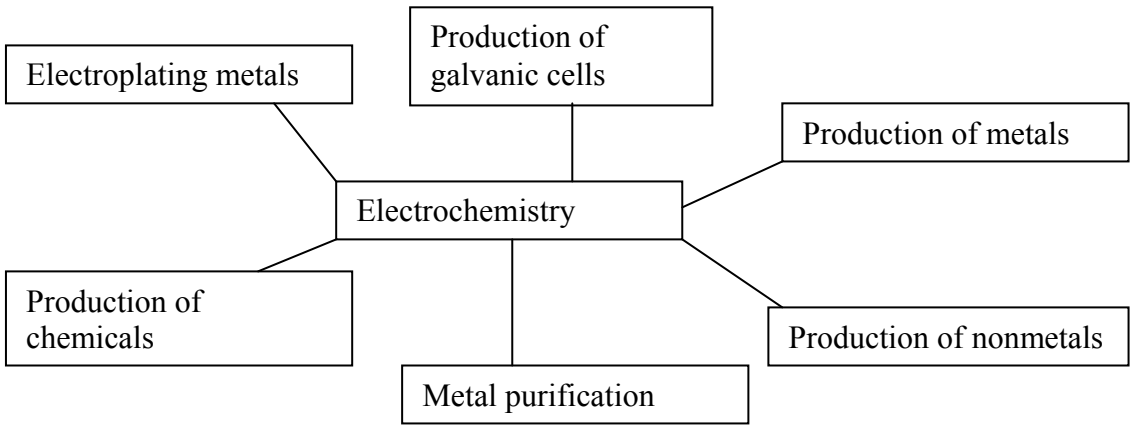
b. electrochemical cells, by splitting it into **electro** and **chemical cell**.

After the discussions, have some groups present their opinions to the class. Then continue by harmonizing concepts suggested by students with the actual concept.

First define electrochemistry as a field of chemistry dealing with the interconversion of chemical and electrical energy. Introduce the interconversion of chemical energy to

electrical energy, or the reverse, as it takes place in electrochemical cells. Define electrochemical cells. Inform students about their classifications as voltaic and electrolytic cells. Tell the students that electrolytic cells convert electrical energy to chemical energy. Ask them some questions about the points you explained and then continue with Activity 3.1. The activity is designed to help students discover the components of dry cells, what energy they produce and why they produce this energy. So, let them discuss this activity in groups for a few minutes and then have some groups present their opinions to the class. After the presentations, continue by harmonizing concepts. Then, tell them that voltaic cells contain chemicals packed together. As a result of the reaction taking place in the cells, they generate electricity.

In relation to Activity 3.1, tell them that dry cells are galvanic cells. When we peel off the external cover, we get a zinc cup filled with a white paste-like matter, a black substance and a black rod at the center. The reaction that takes place between the chemicals packed together generates electricity. Give them an independent work to write out a spider diagram about the applications of electrochemistry in real life. The diagram looks like the following.



Assessment

You can assess how every student is working on this section by asking oral questions, giving class work and checking their works. Make sure that the suggested competencies are achieved by the learners. For students working below the minimum requirement level, give additional exercises on points that are not clear to them.

Additional Questions

*1. What do we call those devices that convert electrical energy to chemical energy or chemical to electrical energy?

*2. List materials are you know that products of electrochemistry.

Answers to Additional questions

1. Electrochemical cells
2. Sample answers: dry cell, watch battery, plated trophy medals etc.

3.2 Electrical Conductivity

Period Allotted 2

Competencies

After completing the subunit, students will be able to:

- define electrical conductivity;
- explain metallic conductivity;
- explain electrolytic conductivity;
- distinguish between metallic and electrolytic conduction;
- distinguish between weak and strong electrolytes;
- use conductivity apparatus to test conductivity of substances.

Forward Planning

Read this section, plan how to manage the students during their discussions and how to make students enjoy the teaching-learning process. You can give project 3.1 to students before you start dealing with electrical conductivity so that they can use it in activity 3.2. Plan where to get materials for Activity 3.2.

Teaching Aids

Refer to the students' text for materials required to conduct Experiment 3.1. Prepare diagrams showing metal conductor and conduction through graphite.

Subject Matter Presentation

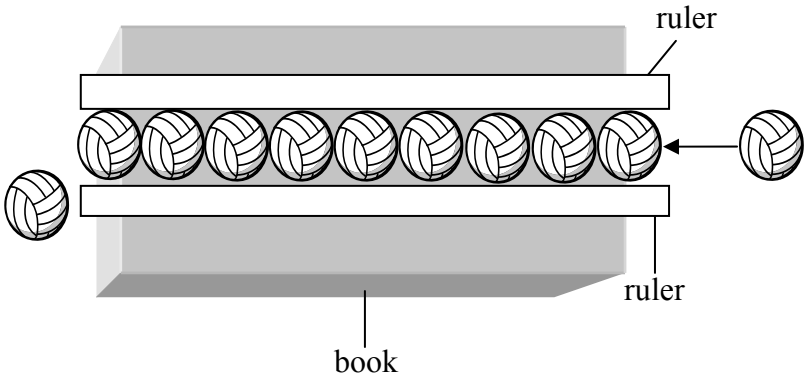
To teach this section, you can use visual-based active learning group discussion and experiment as methodologies.

We advise you to start teaching this section by asking students to define what electrical conductivity is. After their responses, give them the appropriate definition. Describe the conductivity apparatus and its basic components. Introduce metallic and electrolytic conductivity as the two types of electrical conductivity. Then continue with Activity 3.2. The purpose of the activity is to help students develop skills in identifying conductors and nonconductors practically, using a conductivity apparatus. During the

activity they will learn have about the anomalies of some materials like graphite in their conduction of electricity.

So, have students do Activity 3.2 for a few minutes in groups. Then, have some groups present their ideas to the class. After their presentations, make sure that they can identify conductors and nonconductors. Their classification should include an iron bar, zinc metal, coins and a spoon as conductors. On the other hand, sodium chloride crystal, a rubber stopper, rubber bands, stone, glass, dry wood, a pencil, chalk and solid sulphur are nonconductors. From this, it can be noted that metallic substances are conductors of electricity. Then, introduce the structure of metals as the arrangement of positive metal ions in a sea of mobile electrons or delocalized electrons. These **delocalized valence** electrons are **able to move and are responsible for metallic conductivity**. Emphasize that the charge carriers in metallic conduction are the electrons. Introduce that graphite is a nonmetal but conducts electricity, and explain why it is a conductor.

For students to understand metallic conductivity, you can use this visual-based active learning method. Provide them with as many spherical balls of equal size as possible and have them do the following activity in groups. First let one student from each group place his/her chemistry textbook on the desk. Then let him/her place two rulers on the book parallel and close to each other and pack the balls between the rulers as shown below.



After they have done so, let them try to add one ball carefully at one end. What happens to the ball at the other end? Let them add another ball. From the above analogy, ask them to suggest

a) What the balls packed between the rulers represent.

b) What the newly added ball means.

After their suggestions, tell them that the balls packed between the rulers represent delocalized electrons in metals and the newly added balls represent electrons entering the metal from the electric current source.

Then continue by presenting **electrolytic conductivity**. To teach this concept, we suggest that you use experiment as your method. Before you deal with the details, have the students perform Experiment 3.1 in groups and write laboratory reports. Collect the laboratory reports and correct them. Make sure that their reports show that:

- The bulb glows with bright light when solutions of table salt, copper sulfate, hydrochloric acid, sodium hydroxide, and molten lead bromide are used as electrolytes.
- Solutions of acetic acid and ammonia solution produce dim light.
- Sugar solution and distilled water don't cause the bulb to glow.

Besides this, check that they classified:

- Table salt, copper sulfate hydrochloric acid, sodium hydroxide and fused lead bromide as strong conductors,
- Solutions of acetic acid and ammonia as weak conductors.
- Sugar solution and distilled water as nonconductors.

Harmonize what they observed in the experiment with the truth. Define electrolytes, describe the differences between strong and weak electrolytes and give examples. Tell the students why electrolytes transmit electricity in aqueous solution or in a molten state.

Tell them what determines the extent of conductivity in an electrolyte solution, based on the experiment. Finally, be sure that the students realize that solutions of strong electrolytes transmit electricity better than the same concentration of weak electrolytes.

Assessment

You can assess how every student is doing by asking oral questions, giving class work and homework. Check their work, and supervise how they are doing during discussions and conducting experiments.

Additional Questions

*1. What components does a conductivity apparatus possess?

*2. When it is used repeatedly, how can a metal remain a conductor once its free electrons have been displaced at the other end by the electricity entering the metal from the source?

3. Suppose you are passing electricity through a molten electrolyte. What will happen to the conduction of electricity through the electrolyte as time goes on? Why?

*4. Why do solutions of strong electrolytes conduct electricity better than solutions of weak electrolytes of the same concentration?

Answers to Additional questions

1. Electric wires, electrode, A D. C source or dry cells, a switch and a light bulb.
2. The free electron will be replaced by the electrons entering the metal from the source.
3. Decreases, because the cations and anions will change to their atomic and molecular state (neutral).
4. Solutions of strong electrolytes dissociate completely into their ionic state and are better conductors of electricity, while weak electrolytes dissociate to their ionic state to a little extent.

Answers to Exercise 3.1

1. i) Metallic conductivity is caused by the flow of free electrons, while electrolytic conductivity is caused by the movement of ions.

   ii) Electrolytes are substances that conduct electricity, either in solution or in a molten state, while nonelectrolytes do not.

2. Because NaCl and $CaCl_2$ dissociate into ions in molten state or in solution. But in solid state, the ions are held at fixed positions and cannot move.

3. Because they ionize to a greater extent.

3.3 Electrolysis

Period Allotted 2

Competencies

After completing this section, students will be able to:

- define the term electrolysis;
- define the terms electrode, anode, cathode, electrolyte, anion and cation;
- describe electrolytic cell;

- draw labelled diagram of an electrolytic cell;
- define the terms half-cell 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.

Forward Planning

Read this section thoroughly. Prepare a diagram that shows the different parts of an electrolytic cell and assemble the materials required to conduct Experiment 3.2.

Teaching Aids

- Diagram of an electrolytic cell.
- Materials suggested in the students' text for performing Experiment 3.2.

Subject Matter Presentation

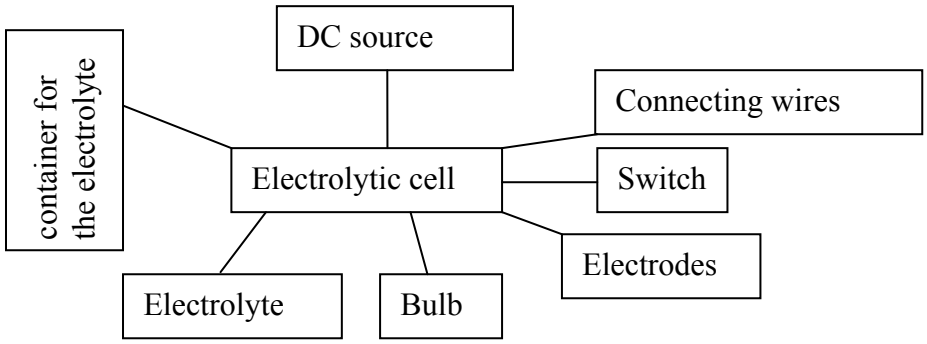
The methodologies suggested for teaching this section are question and answer, visual-based learning and experiment.

This subtopic starts with Activity 3.3. The activity helps students to identify electrodes as anode and cathode, based on their connection to the terminals of the battery. It also enables them relate the name cations and anions to the names of the electrodes. So, have the students discuss Activity 3.3 for a few minutes and then ask some students from different groups to present their views to the class. During the presentations, take note on the views of students. Use the note for harmonizing concepts. Again let students discuss the following points in groups for a few minutes and some groups present their opinions to the class.

1. The word **electro** may refer to electricity and the word **lysis** means to **split apart**. What do you think electrolysis is?
2. During electrolysis of copper sulphate solution using copper electrodes, the copper anode dissolves. When the same solution is electrolyzed using graphite electrodes, nothing will happen to the electrodes. If the copper electrode is active, while graphite is the inert electrode, what does active and inert electrode mean?

After the presentations, continue by harmonizing their ideas with the facts. Start with the definition of electrolysis as a process that brings about chemical changes, using an electric current. Let students be aware of the fact that this process is carried out in an electrolytic cell, and that this cell converts electrical energy to chemical energy.

Introduce them to the components of an electrolytic cell as a direct current source, connecting wire, electrodes, electrolyte and the container for the electrolyte, using a diagram. Define the terms electrode, anode, cathode, anions and cations. Emphasize that the anode and cathode are the electrodes attached to the positive and negative terminals of the direct current source, respectively. Have the students draw an electrolytic cell and label its different parts. To make sure that the students are familiar with an electrolytic cell, have them draw a spider diagram in groups to show the different parts of an electrolytic cell. Use the following diagram for comparison.



Next, explain that, during electrolysis, anions move towards the anode, lose electrons at the anode and form atoms that may combine to form molecules. At the same time, cations migrate towards the cathode and gain electrons at the cathode to form atoms. The names anion and cation are given to negative and positive ions due to their movement towards the anode and cathode, respectively. Emphasize that oxidation occurs at the anode, reduction occurs at the cathode. After introducing these basic concepts, have students perform Experiment 3.2, write laboratory reports and present them to the class. Make sure that their presentation includes the following points.

i) The bulb doesn't glow when the salt is in the solid state. But, it glows when lead bromide is fused due to its ionization. The reaction for its ionization is:

$$PbBr_2 \longrightarrow Pb^{2+} + 2Br^-$$

Thus, fused lead bromide conducts electricity due to the migration of Pb^{2+} and Br^- ions to the cathode and anode, respectively. During electrolysis, each lead ion gains two electrons at the cathode. On the other hand, Br^- ions lose one electron each, forming bromine atoms which combine with one another to form bromine molecules. The reactions occurring at the electrodes and the overall cell reactions are:

Cathode reaction: $Pb^{2+} + 2e \longrightarrow Pb$ (Reduction)

Anode reaction: $2Br^- \longrightarrow Br_2 + 2e$ (Oxidation)

Cell reaction: $PbBr_2 \xrightarrow{\text{electrolysis}} Pb + Br_2$ (Redox reaction)

So, Pb deposits at the cathode and Br_2 is liberated at the anode. After the presentations, have students practice writing half-cell reactions and cell reactions for the electrolysis of fused $MgCl_2$ and fused KBr. Finally, inform students that, during the process of electrolysis in an electrolytic cell, electrons flow from the anode to the cathode in the external circuit. In the electrolyte solution, there is only movement of ions. Even though there is electron transfer at the surface of the electrode, there is no direct flow of electrons from the cathode to the anode through the electrolyte solution.

Assessment

Assess each student's work throughout the section. Have the students write anode, cathode and cell reactions. Have them describe the different parts of an electrolyte cell.

Additional Questions

*1. What is the difference between active and inert electrodes?

*2. Explain the differences between half – reaction and cell reaction.

*3. Why do we refer to the reaction taking place at the anode and cathode as oxidation and reduction, respectively?

4. Which of the following views are true for the electrolysis of fused electrolytes? For those which you think are wrong, explain why?

* a) The number of electrons lost at the anode by negative ions is the same as the number of electrons gained at the cathode by the positive ions.

b) The mass of the substance liberated at the anode is equal to that of the substance produced at the cathode.

c) The number of positive ions reduced at the cathode is always the same as the number of ions oxidized at the anode.

*d) Electricity flows through the molten electrolyte from the cathode to the anode.

*5. Why do the anions move to the anode, and cations to the cathode, during electrolysis?

Answers to Additional questions

1. Active electrodes involve themselves in the redox reaction but inert electrodes don't react with the electrolyte.
2. Half reaction is one of the reactions occurring at the electrode. It is either oxidation or reduction. But, cell reaction is the combination of the two electrode reactions.
3. Because, at the anode, losing of electrons is the event, and at the cathode it is gaining of electrons.
4. a) True
   b) False. This is because the masses of the substances produced at the cathode and anode depend on the relative atomic mass and the charge of the ion. For

example, if 193,000 C of electricity is passed through molten $CaCl_2$, 40 g calcium is liberated at the cathode and 71 g chlorine at the anode.

c) False. The number may not be exactly equal because the number depends on the ionic charge. For example, during electrolysis of fused $CaCl_2$, for every Ca^{2+} reduced at the cathode, two Cl^- ions will be oxidized at the anode.

d) False. The lost electrons at the anode passes to the cathode and to gained by the cations. There is no current flow through the electrolyte from cathode to anode.

5. Anions are negatively charged ions, attracted to the positive electrode (anode). Cations are positively charged ions, attracted to negatively charged electrode (cathode).

Answers to Exercise 3.2

a) I^- and Cl^-

b) K^+ and Na^+

c) For fused KI:

Anode reaction: $2I^- \rightarrow I_2 + 2e$

Cathode reaction: $2K^+ + 2e \rightarrow 2K$

Cell reaction: $2KI \xrightarrow{\text{electrolysis}} 2K + I_2$

For fused NaCl:

Anode reaction: $2Cl^- \longrightarrow Cl_2 + 2e$

Cathode reaction: $2Na^+ + 2e \longrightarrow 2Na$

Cell reaction: $2NaCl \xrightarrow{\text{electrolysis}} 2Na + Cl_2$

During electrolysis of fused KI, potassium is produced at the cathode and iodine at the anode, while in the electrolysis of NaCl, sodium is produced at the cathode and chlorine at the anode.

3.4 Galvanic Cells (Voltaic Cells)

Period Allotted 3

Competencies

After completing this section, students will be able to:

- construct simple galvanic cell using strips of zinc, copper, $ZnSO_4$ and $CuSO_4$ solutions;
- mention different types of voltaic cells;

- describe how voltaic cells can be used to make commercially useful batteries;
- distinguish between voltaic cell and electrolytic cell;
- describe voltaic cells.

Forward Planning

Read this section. Accordingly, make the necessary preparations for how to manage students during discussion and when they construct simple galvanic cells. You also need to plan how to give assistance to the different groups and check how they are doing.

Teaching Aids

- Diagrams of Leclanche cell and lead – storage battery
- Materials suggested in the student's text for performing Experiment 3.3
- Old car battery (if available)

Subject Matter Presentation

For this section, you can use visual-based learning, group discussion and experiment as methodologies.

Before you deal with the contents of this section, give some examples of galvanic cells and ask the students: what materials are present in the cells, what they produce and how they produce. This section begins with an activity. Activity 3.4 gives a general overview for the discussion of galvanic (voltaic) cells. The activity probes students and helps to get their prior experience pertaining to galvanic cells.

Have the students discuss Activity 3.4 for a few minutes and them present their views to the class. After some groups present their suggestions, appreciate the ideas suggested by students and harmonize their ideas with the actual concepts they are supposed to know.

Emphasize that galvanic cells are electrochemical cells that generate electricity. Galvanic cells are energy-converting devices and convert chemical energy to electrical energy. After the expiry dates written on them, galvanic cells fail to produce the expected amount of electrical energy even if the cell is not in use. This is because the reaction between the chemicals can proceed by itself. Then, proceed by introducing the types of galvanic cells as **primary** and **secondary voltaic cells.** Emphasize that, even though there are a few other Galvanic cells, these two types are important at this level. In relation to primary and secondary cells, let students discuss the following points in groups for a few minutes and then present their opinions to the class. Cells like the ordinary Leclanche cell and cells used in electronic wrist watches are primary, while the

cells used in mobile telephones, some video cameras and car batteries are secondary cells. What is the basis for this classification? After the presentations, continue introducing students to the primary cells as cells that are not rechargeable. This is because the original reactants (chemicals) cannot be recovered by recharging. The reactions in these cells are not reversible. Let the students notice that early voltaic cells consisted of metal rods suspended in an electrolyte solution. Thus, they are sometimes referred to as **wet** cells. Give **Daniel's cell** as an example of a wet cell.

You can support your teaching by letting students perform Experiment 3.3. They construct a simple galvanic cell, using strips of zinc, copper, $ZnSO_4$ and $CuSO_4$ solutions. Then they, check for the presence of current flow, using a sensitive voltmeter. Have the students make simple galvanic cells by inserting pieces of different metals in a lemon or tomato and attaching one piece of metal to the positive end and the other metal to the negative end of the voltmeter by means of a wire to check for the presence of current flow. Have them repeat this experiment, using different metals and identify which pair of metals produces greater current. Following the experiment, students should write a laboratory report and submit them for correction. Collect the laboratory reports and correct them. Check that the observation and analysis in the reports coincides with the following points:

A. For the cell in procedure 1

1 There are chemical reactions at both electrodes.

2 Electron flow is from the zinc to the copper strip in the external circuit.

3 Zinc is the anode and copper the cathode.

4 Oxidation occurs at the zinc electrode and reduction at the copper electrode.

5 Anode reaction: $Zn \longrightarrow Zn^{+2} + 2e$

Cathode reaction: $Cu^{2+} + 2e \longrightarrow Cu$

Cell reaction: $Zn + Cu^{2+} \longrightarrow Zn^{+2} + Cu$

B. For the cell in procedure 2

1. Yes, there is deflection.

2. Magnesium produces the greatest and iron the least, when coupled with copper electrode.

Yes there is. The more reactive the metal is, the greater the voltage produced.

After the experiment, introduce the practical problems of using wet cells and why explain dry cells were developed. Use the **Leclanche cell** as a very good example of dry cells. Have students draw a diagram of a Leclanche cell and label its parts. Remind students of what they discussed in Activity 3.4: that Galvanic cells also possess anode and cathode.

Give more examples of primary cells and continue your teaching by describing secondary cells. Tell the students that secondary cells (batteries) are rechargeable, that the reaction occurring at the electrodes when the battery is in operation (generating electricity) can be reversed on recharging and so that the original reactants can be recovered. Use a car battery (lead storage battery) as an example of a secondary cell (battery). Tell them the materials used as anode, cathode, electrolyte, anode reaction, cathode reaction, cell reaction when discharging and recharging. Inform students that lead storage battery is a wet cell, since it uses dilute sulphuric acid as electrolyte. Show them different parts of car battery. Tell them also about dry secondary batteries such as Ni-Cd cell and batteries used in mobile telephones. Here give emphasize that primary cells can be thrown away after use, while secondary cells can be used repeatedly by recharging. Before you conclude, have the students distinguish between voltaic cells and electrolytic cells by discussing Activity 3.5 and presenting their ideas to the class. Students should realize that an anode is negative and a cathode is positive in voltaic cells, which is the opposite to electrolytic cells. Although the anode is negative and cathode is positive in galvanic cells, and the reverse is true in electrolytic cells, oxidation occurs at the anode and reduction occurs at the cathode in both electrochemical cells. You can use the following table to compare and contrast voltaic and electrolytic cells.

Voltaic Cell	Electrolytic Cell
⇒ The reaction is spontaneous redox ⇒ Chemical reaction generates electricity ⇒ Converts chemical energy to electrical energy ⇒ Anode is negative ⇒ Cathode is positive	⇒ The reaction is a nonspontaneous redox ⇒ Electrical energy brings about chemical change. ⇒ Convert electrical energy to electrical energy. ⇒ Anode is positive. ⇒ Cathode is negative.

Assessment

You can assess how every student is doing by asking oral questions, giving class work and homework. Check their work, supervise how they are doing during discussions and conducting experiments. For students working below the minimum requirement level, give additional exercises on points that are not clear to them.

Additional Questions

*1. What is the basis for the classification of galvanic cells as primary and secondary?

2. In constructing simple galvanic cells why is it important to use two different metals as electrodes? How can cells, made in this way produce electricity? Explain.

3. In lead – acid (lead storage) batteries, the battery cannot be recharged indefinitely. Explain why.

*4. Why are some voltaic cells called dry cells, even though their chemistry involves water?

*5. Given a voltaic cell consisting of a gold electrode in a gold nitrate solution in one half – cell, and a zinc electrode in a zinc nitrate solution in another half – cell, and connected by a salt bridge. The electrode reactions when a wire is connected to both electrodes are:

$$Au^{+3} + 3e \longrightarrow Au$$

$$Zn \longrightarrow Zn^{+2} + 2e$$

a) Identify the metal that serves as anode and cathode.

b) Which electrode is negative and which one is positive?

c) Write the balanced chemical equation for the cell reaction.

d) What is the direction of electron flow in the external circuit?

Answers to Additional questions

1. Primary cells are those cells that are not rechargeable once they stop providing electricity, we throw them away. But secondary cells can be recharged and used repeatedly.
2. Because one of them will oxidize and the other will be reduced (difference in tendency of losing electrons). Electricity is produced because electrons will transfer from the metal which loses electrons more readily than to the other metal which has little tendency to lose electrons through the wire.

3. The concentration of the acid decreases over time.
4. Because they contain the electrolyte in the form of a paste.
5. a) Zn – anode, Au – cathode
   b) The gold electrode is positive and the zinc electrode is negative.
   c) $2(Au^{3+} + 3e^- \rightarrow Au) \rightarrow 2Au^{3+} + 6e^- \rightarrow 2Au$

      $3(Zn \rightarrow 2n^{2+} + 2e^-) \rightarrow 3Zn \rightarrow 3Zn^{2+} + 6e^-$

      Cell reaction: $2Au^{3+} + 3Zn \rightarrow 2Au + 3Zn^{2+}$

   d) from Zn to Au

Answers to Exercise 3.3

1. Zn is anode, and Cu is cathode. The anode is negative, and the cathode is positive.
2. See the text.
3. In an electrolytic cell, electricity is required for the redox reaction to occur. In galvanic (voltalic) cells, the reaction between the chemicals packed together proceeds without any external aid. Hence it is spontaneous.

Answers to Exercise 3.4

1. Primary galvanic cells are not rechargeable, but secondary cells can be recharged.
2. Lead is anode and PbO_2 is cathode; dilute sulphuric acid is the electrolyte.
3. The concentration of sulphuric acid decreases:
4. $Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \rightarrow 2PbSO_4(s) + 2H_2O(l)$

3.5 Industrial Applications of Electrolysis

Period Allotted 2

Competencies

After completing this section, students will be able to:

- describe selected industrial applications of electrolysis;
- explain how electrolysis is used for purification of metals;

Forward Planning

Read the contents of this section thoroughly and prepare for the teaching learning process. Prepare diagrams to teach the production of aluminum and purification of

copper. Prepare copper metal, copper sulfate solution, any article (nail or spoon) and dry cells to demonstrate what electroplating is.

Teaching Aids

- Diagrams showing the production of aluminum and purification of copper.
- Copper metal, $CuSO_4$ solution, a nail or spoon, and dry cells.

Subject Matter Presentation

The methodologies suggested to teach this section are visual-based learning, problem solving and group discussion.

The section starts with an activity. The aim of Activity 3.6 is to relate the industrial application of electrolysis with students' day-to-day lives and to help them realize the consequence of using impure copper for the transmission of electric current.

Let students discuss Activity 3.6 in groups. After their discussion, encourage some students from different groups to present their opinions to the class. Appreciate the students for their attempts and harmonize their ideas with the facts they should know, as follows. If impure copper is used for the transmission of electricity, the impurity will result in power wastage. This is because the impurities reduce the capacity of copper to transmit electricity and also change electricity to heat energy. Houseware cooking utensils are electroplated in order to prevent corrosion and poisoning of the food being cooked. In order to overcome these problems, electrolysis contributes its share. Then, inform students about the industrial applications of electrolysis. Before you deal with the details, ask the students if they can suggest some industrial applications of electrolysis. First, explain the application of electrolysis in the production of chemicals. Use the electrolysis of a concentrated solution of sodium chloride or brine as an illustrative example. Show the electrode reaction and the overall cell reaction, using chemical equations. Mention that, during electrolysis of brine, the chemical sodium hydroxide forms in the solution and the nonmetals chlorine and hydrogen will be liberated at the anode and cathode, respectively. Then, proceed to introduce the production of aluminium from molten aluminium oxide, Al_2O_3, mixed with a small amount of cryolite, Na_3AlF_6, as an example how electrolysis is used in the production of metals. Let the students attempt to write the equations for the electrode and cell reactions. You can give them a hint by writing the equation for the ionization of Al_2O_3. Check whether the students have done well or not.

Continue to introduce the application of electrolysis in the **purification of metals**.

Teaching this part requires applying the problem-solving method, since it presents how one can obtain a pure metal from an impure one.

Before you deal with the details, let students discuss Activity 3.7 in groups for a few minutes. The purpose of the activity is to help students consolidate their knowledge in writing half-reactions and cell reactions for processes that involve electrolysis. After the discussion, let two students from different groups present their views to the class. Then, to harmonize the concepts suggested by the students with the facts they are expected to know, inform them that in purifying metals by electrolysis, the impure metal should be used as anode, the pure sheet of the metal as cathode and a solution containing ions of the metal to be purified as an electrolyte. Take purification of copper by electrolysis as a specific example. Here you should tell them that copper atoms from the anode oxidize to copper ions and enter into the solution, while the cathode reduces copper ions from the solution and pure copper deposits on the surface of the cathode. Write equations to show the oxidation and reduction half-reactions. Add the two half-reactions. Then show them that the reactants and products cancel out so that there is no overall reaction. However, the process is not a waste of time and energy. The net effect is that the impure copper oxidizes at the anode and deposits at the cathode after reduction. Inform students that the anode decreases and the cathode increases in size. Let students also know that this method of metal purification is called **electrorefining**. Ask students what procedure they should follow if they are given a task of purifying silver or gold by this method.

At the end of this section, you are expected to deal with electroplating. An activity is suggested for the subtopic. The purpose of this activity is to help students realize that electric energy is important for carrying out electroplating. So, have them discuss Activity 3.8 in groups for a few minutes and then have some groups present their opinions to the class. After this, tell them that, when the zinc electrode is dipped in copper sulphate solution, part of the electrode in the solution will be covered by a layer of copper metal. This is due to the reduction of copper ions by zinc atoms from the electrode, as follows.

$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{+2}(aq) + Cu(s)$$

So, this process is not electroplating, because electroplating requires the use of electricity. Then continue with the details on electroplating.

First, define what electroplating is and then introduce students to the procedures to be followed. Emphasize that coat the surface of one metal with another metal, the plating metal should be made the anode, the material to be plated (whose surface is to be coated or covered) should be made the cathode and the electrolyte should contain ions of the plating metal. Use producing a silver-plated copper medal as an example. In order to ensure that they have understood the concept of electroplating, ask students how they could produce a gold-plated spoon or an iron nail coated with copper by electrolysis.

Finally, inform students of the purpose of electroplating to prevent corrosion and for decorating articles.

Assessment

You can assess how every student is doing by asking oral questions, giving class work and homework. Check their work, supervise how they are doing during discussions and conducting experiments. Make a record of their performances. Don't forget to appreciate students working above the minimum requirement level. For students working below the minimum requirement level, give additional exercises to assist them.

Additional Questions

1. List metals, nonmetals and compounds whose production involves the process of electrolysis.
2. An impure copper contains iron, zinc, nickel, platinum, gold and silver as impurities. During purification of this copper by electrolysis:
   a) Which of the metals oxidize along with copper and will go in to the solution?
   b) Which of the metals remain unaffected and fall away from the anode as sludge?
   c) Among ions of the oxidized metals, copper ions pass through the solution, gain two electrons each and deposit at the cathode. Why do ions of other metals remain in solution? Explain.
3. Can the process of electroplating be carried out only in the presence of electricity?
4. When large current is used in the process of electroplating, the surface of the plated material is rough. What do you think is the reason for this?
5. If you want to produce gold-plated coins, how can you accomplish this task?

Answers to Additional questions

1. Sample answer: Sodium, aluminum, chlorine, Oxygen; Sodium hydroxide
2. a) Zinc, iron and nickel
   b) Platinum, gold and silver
   c) Because a higher voltage of electricity is required to reduce ions of Ni^{2+} and Fe^{2+}, compared to Cu^{2+}.
3. Yes
4. The amount of the plated substance is directly related to the amount of electricity delivered. So large amounts of electricity produce large amounts of the plating

metal at a time, which deposit on the surface irregularly, making the surface rough.

5. Using gold as anode, the coin as cathode and an electrolyte containing gold ions.

Answers to Review Exercise on unit 3

Part I

1. D	2. C	3. B	4. D	5. A
6. C	7. A	8. A	9. B	10. C
11. B	12. D	13. C	14. A	15. C
16. D	17. B	18. C	19. D	

Part II

20. Metallic conductivity

21. a) Copper b) Silver c) Copper d) Silver

e) $Cu(s) + 2Ag^{+}(aq) \longrightarrow Cu^{2+}(aq) + 2Ag(s)$

22. Electrodes

23. Cathode, anode, anode, cathode

24. Electroplating

Part III

25. Refer to the text.

26. In solid state, their ions are held at fixed positions and cannot move. In solution, their ions separate and become mobile.

27. a) Ca^{+2} and Cl^{-}

b) Anode reaction: $2Cl^{-} \longrightarrow Cl_2 + 2e^{-}$

Cathode reaction: $Ca^{+2} + 2e \longrightarrow Ca$

28. Refer to the text on page 173 – 174.

29. Student A should use impure silver as anode, pure silver as cathode and $AgNO_3$ solution as electrolyte.

Student B should use gold as anode, the medal as cathode and solution containing gold ions (Au^{+3}) as electrolyte.

30. See the students' text.

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Unit 4 Chemistry in Industry and Environmental Pollution

Unit Overview **Total Period Allotted 25**

This unit mainly emphasizes on introducing students to the applications of chemistry in industry. It gives information that all chemical manufacturing processes involve chemical reactions.

The first section of the unit (4.1) deals with the general characteristics of chemical industries. It explains that all chemical industries use naturally available materials or materials obtained after processing natural resources as starting materials in their manufacturing activities.

The second section, 4.2, introduces the definition of natural resources and their classification as **renewable** and **non-renewable**. It also presents examples of renewable and non-renewable natural resources. The third section (4.3) is a broader section and gives emphasis to the occurrences, methods of extraction and chemical properties of some metals and non-metals. The elements to be considered in this section are: aluminium, iron, copper, nitrogen, phosphorus, oxygen, sulfur and chlorine. The following section (4.4) deals with some chemical industries in Ethiopia. It gives emphasis to glass, ceramics, cement, sugar, paper and pulp, tannery and food processing and preservation. The last section (4.5) of the unit gives emphasis to environmental pollution. Since pollution is the major problem of the globe at present, this section will introduce types of pollution, pollutants of air, water and land, the harm the pollutants can cause and methods of reducing these pollution problems.

Dear colleague, from experience of teaching, it is observed that teaching this unit using lecture method is boring and cumbersome to students. So, different teaching methods are suggested for each section and sub-topic. The major methodologies suggested for this unit are peer teaching, gapped lecture, inquiry and group discussion.

Unit Outcomes

After completing this unit, 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, sulfur 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;
- demostrate scientific inquiry skills: observing, classifying, communicating, asking questions, applying concepts and problem solving.

Main contents

4.1 Introduction

Period Allotted 1

Competencies

After completing this section, students will be able to:

- list general characteristics of chemical industries.

Forward Planning

Read the contents of this section thoroughly. Plan how to manage students when they discuss activities and make presentations. Decide which groups should make presentations.

Teaching Aid

- Prepare a chart that shows a list of some chemical industries, what they use as raw materials and what they produce.

Subject Matter Presentation

The suggested methodologies for this section are peer teaching, group discussion and visual based learning. This section starts with Activity 4.1. The activity helps students to visualize the way of life in the pre-industry society. They can remember what they learned in other subjects to recite and write the products of chemical industry and starting materials they use. This activity helps them to acquire prior knowledge about chemical industry.

You better treat this section by allowing students to make presentations on the contents of the section. So, give them a home work to make preparation on the section in groups before the period in which you deal with it. All groups in each section need to make preparation on the section. Tell them the points on which they should lay emphasis. This may include, definition of a chemical industry, the general characteristics of chemical industries, their opinions on points in Activity 4.1 and negative impacts of chemical industries they know. During the period in which you treat the section, let students from two different groups make presentations to the rest of the class turn by turn. After each group completes the presentation, give chance to other students to ask the groups some questions, and also give the opportunity to the groups to answer questions raised by other members of the class. Then, harmonize the ideas of the students with those which they are supposed to know. Inform them that much of our life at present relies on the materials produced by chemical industries. Define chemical industry as an institution involved in the manufacturing of chemical substances such as soaps and detergents, beverages, sodium hydroxide, textiles, pharmaceuticals, fertilizers, pesticides, herbicides, acids, bases, cement, paper and pulp, metals and non-metals etc. Introduce to students that all chemical industries use naturally available raw materials while others use raw materials produced by other industries.

Let students realize that chemical processes (reactions) and physical processes in some cases are involved in converting the raw materials into the desired products. Chemical reactions are mostly carried out in special corrosion resistant chambers. Inform students

that chemical industries use different methods of purifying the materials they produce and also have quality control laboratories to check whether or not their products meet the desired specification. Inform them that chemical industries also consume large amounts of energy in their manufacturing processes. They can cause environmental pollution unless they treat the waste products coming out of the manufacturing process, before they discharge them to the surroundings.

Assessment

Assess each student's work throughout the section. You can do so either by giving class work or homework and checking the work of every student. Also record the effort that has been made by each group during presentation. Collect the written documents prepared by other groups who didn't involve in presentation. Check their works and make a record. See their achievements and make sure that the competencies suggested for the section are achieved or not.

Additional Questions

1. List down general characteristics of chemical industries other than those mentioned in your text book.

Answers to Additional Questions

1. Sample answer: They use relatively large quantities of water. Unless controlled, they release to the environment wastes in the form of gas (smoke), liquid or solid.

4.2 Natural Resources and Industry

Period Allotted 1

Competencies

After completing this section, students will be able to:

- define natural resources;
- list natural resources;
- classify natural resources as renewable and non- renewable;
- define chemical industry as a firm that involves the taking of raw materials from the environment and turning them into usable products by chemical means;
- describe the application of minerals in industry.

Forward Planning

You need to plan when to give this section as a home work for students to make preparation in groups for presentation. Decide which groups of students should make presentations during the period. Make the necessary arrangement on how to manage students and initiate them to be active participants.

Teaching Aids

- A chart that shows the classification of natural resources with examples.

Subject Matter Presentation

Use peer teaching and group discussion methodologies for this section. This section begins with an activity. Activity 4.2 is designed to help students get more information about natural resources and relate concepts with their biology and geography courses.

Students are expected to have some ideas about natural resources from what they have learned in their biology or geography courses. So, it is advisable if you implement peer-teaching methodology for this part. Give them a home work to make preparation on the section in groups before the period you plan to deal with it. Let all groups in each section make preparation. Give them information about the points they should emphasize on. This may include: definition of natural resources and examples, classification of natural resources with examples, importance of natural resources for industry, the application of minerals in industry and other points mentioned in Activity 4.2. During the period, let students from different groups make presentations to the rest of the class. It is better if groups other than those involved in section 4.1 take part in this section. After the presentation of each group, give chances for other students to ask the group members some questions related to the points in the presentation. Let students among the group members answer the questions raised by their classmates. To harmonize concepts suggested by the students in their presentation, define natural resources as materials available in nature for peoples to utilize. Examples are metal ores, soil, trees, air, food crops, crude oil, natural gas, coal, wool, cotton etc. Inform them about the basis for the classification of natural resources as **renewable** and **non - renewable.** Inform students that renewable resources can be replenished (replaced) by natural processes while non-renewable resources cannot be replenished. For example, fossil fuels include petroleum, natural gas and coal. If these substances are completely used up, they cannot be renewed. Even their formation in the earth's crust requires several millions of years. Write a list of natural resources on the black board and let students classify them as renewable and non-renewable. After giving correction to the works of students, continue introducing the importance of natural resources for industry. Lay emphasis on the fact that chemical

industries use natural resources as starting materials (raw materials) and convert them into usable products by chemical means. Inform them that some industries may not use natural resources as raw materials directly but materials produced by other industries. At the end of this section, explain the application that they use of minerals in industries. For example, crude oil is fractionally distilled to give different petroleum products that are used as a fuel or to produce various petrochemicals. Air can be used as starting material for the production of O_2, N_2 and argon. Rocks such as limestone can be used in the manufacture of building materials like cement, lime and in the extraction of iron. Minerals such as metal ores are used to manufacture metals. For example, sodium chloride is used to manufacture sodium metal, sodium hydroxide and chlorine.

Assessment

Evaluate the work of every student throughout the section. Make the necessary follow up during presentation. You can evaluate the performances of the groups involved in the presentations based on how they managed to deal with the contents in accordance with the suggested competencies for the section. For the groups who didn't get the chance to make presentations, collect the written documents they prepared and check whether they have done well or not. Record their performances in your students' performance list. Give class works or home works. Check the work of every student, record the performance and make sure that the suggested competencies for the section are achieved. Appreciate students working above the minimum requirement level and encourage them to continue working hard. Assist students working below the minimum requirement level by arranging additional lesson time.

Additional Questions

*1. What natural resources are available in your locality that can be used as raw materials for any industrial manufacturing activity? Classify these natural resources as renewable and non – renewable.

*2. What materials can be manufactured by industries from the natural resources available in your locality?

Answers to Additional Questions

1. Answers may vary: Accept the answers which are suitable for the environment you are living in.
2. Answers may vary: Accept all answers suitable for the area where you live.

Answers to Exercise 4.1

a) Non-renewable

b) Non-renewable

c) Renewable

d) Renewable

e) Renewable

4.3 Production of Some Important Metals and Non – metals

Period Allotted 12

Competencies

After completing this section students will be able to:

- outline the extraction of aluminium by the Hall process;
- describe the main physical and chemical properties of aluminium;
- describe the uses of aluminium;
- outline the extraction of iron by the blast furnace;
- briefly describe conversion of pig iron to steel;
- describe wrought iron;
- describe the main chemical properties of iron;
- describe the uses of iron;
- outline the extraction of copper;
- describe the main chemical properties of copper;
- describe the uses of copper;
- outline the production of nitrogen;
- describe the main chemical properties of nitrogen;
- outline the production of phosphorus;
- describe the main chemical properties of phosphorus;
- outline the production of oxygen;
- describe the main chemical properties of oxygen;
- outline the production of sulphur;
- describe the main chemical properties of sulphur;

- outline the production of chlorine;
- describe the chemical properties of chlorine.

Forward Planning

Read the contents of the section thoroughly. Prepare a plan that shows the contents you treat during each period so that you can cover the contents of this section within twelve periods. Besides this, you need also to plan on how to budget your time for students to discuss in groups, make presentations, harmonizing and other activities during each period. Prepare diagrams that assist you to explain extraction of aluminium by Hall process, iron in a blast furnace and the Frasch process for the extraction of sulphur. Decide when to give project work 4.1 as well as how students should form groups to perform the project work. You better give them the project work a week before the period in which you intend to deal with iron.

Teaching Aids

- Diagram of Hall cell
- Diagram of blast furnace (model of blast furnace)
- Diagram showing the purification of copper.
- Diagram showing the Frasch process for the extraction of sulphur.

Subject Matter Presentation

Aluminum

Methodologies suggested for teaching this section are group discussion, visual-based learning and gapped lecture.

This section starts with an activity. Activity 4.3 helps students identify the applications of aluminum in the electric world. Generally, it shows high electrical conductivity of aluminum.

You can start teaching this section by allowing students discuss Activity 4.3 for some time in groups and present their views to the class. After they have done so, give them appropriate information about the activity as follows. Steel-Cored aluminium cables are used for conducting high voltage electricity because aluminium is good conductor. The steel core gives strength to the wire. Many materials made of aluminium such as cooking utensils are also used at home. It is also used for making water tanks, food packaging cans and wrappers. Then proceed to introduce the students that aluminium is the third most abundant element in the earth's crust next to oxygen and silicon and is the most abundant metal. Naturally, aluminium exists only in the form of compounds such as

bauxite ($Al_2O_3 \cdot 2H_2O$), **orthoclase** ($KAlSi_3O_8$), **bery** ($Be_3Al_2Si_6O_{18}$), **cryolite** (Na_3AlF_6) and **corundum** (Al_2O_3). Mention bauxite as the principal ore from which aluminium is extracted. Let them know that bauxite is purified in a series of steps such as heating with NaOH solution, treatment with an acid to precipitate $Al(OH)_3$, filtration and then heating $Al(OH)_3$ to get Al_2O_3 emphasizing the purpose of each step. Then inform them that aluminium is extracted by electrolysis of aluminium oxide mixed with cryolite by the **Hall process**. Here tell them about the role of cryolite. After introducing the occurrence of aluminium and the steps followed to obtain aluminium oxide from bauxite, let students discuss Activity 4.4 in groups for a few minutes. Following their discussion, give the opportunity for some groups to present their conclusions to the rest of the class.

In this section, students from groups other than those involved in section 4.1 and 4.2 should take part in the presentations. Next, harmonize concepts presented by the students with the facts they are expected to know. First, write the inonization equation for Al_2O_3 in the molten state:

$$2Al_2O_3 \longrightarrow 4Al^{3+} + 6O^{2-}$$

During electrolysis, Al^{3+} move to the cathode, gain three electrons each and become aluminium atom which is collected at the cathode. O^{-2} move to the anode, lose two electrons each and become oxygen atom which in turn combine to form oxygen molecule.

Anode reaction: $6O^{2-} \longrightarrow 3O_2 + 12e$ (Oxidation – half reaction)

Cathode reaction: $4Al^{3+} + 12e \longrightarrow 4Al$ (Reduction – half reaction)

Cell reaction: $2Al_2O_3(l) \xrightarrow{\text{Electrolysis}} 4Al(l) + 3O_2(g)$

After that, proceed to introduce some important physical properties of aluminium and its chemical properties. In treating chemical properties of aluminium, mention that aluminium forms a protective oxide layer (film) on its surface. The thin film of oxide can be removed with mercury (II) chloride solution to make aluminium react with oxygen readily. Aluminium also reacts with dilute acids to form salts, burns in chlorine gas to form $AlCl_3$ and also reacts with NaOH. Finally, explain the uses of aluminium. Let students write research to discover aluminium - made materials and other points given in research and writing part. Allow some students to present their findings to the class and give them a reading assignment on Iron.

Iron

The methodologies suggested to teach this part are visual-based active learning, gapped lecture and group discussion.

After completing the main points on aluminium, continue dealing with iron. Start the lesson using Activity 4.5. The purpose of this activity is to enable students to relate Iron and steel so that prior experience of students will be known. Let students discuss the activity for a few minutes and let some students from different groups present their opinions to the class. Then, let certain groups present what they have prepared from the reading assignment on iron to the class. In the mean time, give chances to other groups to ask questions to make the class more interactive. Next to their presentations, introduce to them that iron is the cheapest metal because of its abundance and simpler method of extraction. Let them also know an alloy as a mixture of two or more metals or metals and non – metals. Stainless steel is an alloy containing iron, nickel, chromium and little amount of carbon. Then, introduce that iron is the 4^{th} most abundant element and the second metal in abundance in the earth's crust. Mention the naturally occurring mineral ores of iron. Let them know the extraction of iron in a blast furnace, the raw materials used (iron ore, limestone, coke and hot air), the purpose of limestone and the reactions taking place in the furnace, formation of slag and how the slag separates from the molten iron. Give them an activity on the main points you introduced and check their works. Then, proceed to deal with the conversion of pig iron to steel and the methods employed in the process.

Then, continue treating physical and chemical properties of iron. This should include its reaction with dilute acids, hydrogen chloride gas, chlorine, formation of rust and conditions for rusting. Inform students that iron is capable of reducing ions of less reactive metals from solutions of their salts. Let them complete and balance the equation for the reactions of iron. Finally, introduce to them some important uses of iron in the form of pig iron, as wrought iron and in the manufacture of alloys such as stainless steel. At the end of the lesson on iron, let students discuss Activity 4.6 in groups and present their views to the class. Following the presentations, tell them that steel can be used to make spoons, forks, knives, chains, chisels and other materials.

To implement the problem-solving methodology in this topic, have the students prepare samples of protected iron bar (rods) that will not rust even when used during the rainy seasons. They can prepare the samples using any one of the methods applied during the unit to protect iron from corrosion. Then have some students show the class the sample they prepared.

Copper

You can use gapped lecture and group discussion to teach the lesson on this part.

Before you deal with the details on copper, start the lesson using Activity 4.2. The activity will help students remember and consolidate what they learnt in unit 3.

Let students discuss the activity for a few minutes. Then, encourage some students from different groups to make presentations about the points they discussed. After the presentations, using gapped lecture continue introducing the occurrence, method of extraction and purification of copper. Relate what the students suggested from their discussion on the purification of copper with the actual concept. Tell them also that zinc doesn't deposit on the cathode in the refining process of copper since it requires higher voltage to reduce than copper. Give them a short activity to see how students are following your presentation. Then, proceed to introduce them to the chemical properties of copper and its uses. In case of its uses, try to relate what the students suggested after discussing Activity 4.7 with the actual uses. This may include the use of copper to produce electric cables, alloys that are used to make coins, medals, hard tops and other articles.

Nitrogen

To teach the contents in this part, use gapped lecture, and group discussion methodologies.

After completing the contents on metals, continue with important nonmetals. First, treat the contents on nitrogen. Use Activity 4.8 to start the lesson. This activity is aimed at assisting students remember the structure of nitrogen as it has direct impact on its chemical property and the form of nitrogen absorbed by plants. So, let students discuss Activity 4.8 in groups for a few minutes. Allow some students from different groups to present their opinions.

After their presentations, inform them that nitrogen is a diatomic element having the structure $:N \equiv N:$. The two atoms form a triple bond between them to complete their octet. Let them also know that plants absorb nitrogen in the form of nitrate ion, NO_3^-.

Introduce to the students how nitrogen occurs in nature, its abundance as 80% by volume of air and also its presence in the form of compounds as nitrate minerals and in animals and plants as constituent of proteins. Let them know how nitrogen is manufactured industrially by fractional distillation of liquid air starting from purification of air to make it free from dust, CO_2 and water vapor. You better give students an activity to ensure that they realized the concepts you explained.

After introducing some of its physical properties, continue with chemical properties of nitrogen. This should include that nitrogen is inert at room temperature, its reactivity increases when heated and reacts with metals in group IA and IIA to form nitrides, with oxygen NO and NO_2. Inform students that nitrogen also forms other oxides such as N_2O and N_2O_5 even though it is not by direct combination of nitrogen and oxygen. Let

students also know that nitrogen combines directly with hydrogen in the Haber process to form ammonia. During your explanation, encourage students to write chemical equations for the reactions before you complete and balance them. At the end of your explanation, inform students about some uses of nitrogen and ammonia.

Phosphorus

After completing the content on nitrogen, proceed to deal with phosphorus. It is advisable to use group discussion and question and answer methodologies. Start the lesson using Activity 4.9. Let the students discuss the activity and make presentation.

The purpose of this activity is to show the analogy of the light produced by phosphorus (phosphorescence) and light produced in glowing warm due to protein (bioluminescence).

Before dealing with the details, after the presentation, tell students that one of the properties of white phosphorus is glowing in the dark. Glow worm also produces light as white phosphorus does. However, the emission of light by glow worm is because of a process called bioluminescence. Bioluminescence is a kind of chemical reaction which involves the oxidation of protein by a certain enzyme in an organism which results in the emission of light. Then, proceed in treating the occurrence of phosphorus. Inform students that phosphorus doesn't exist in elemental state and that it is found in nature only in the form of compounds: principally as rock phosphate, $Ca_3(PO_4)_2$ and also in living things. Then, acquaint them with the extraction of phosphorus by the reduction of rock phosphate with coke (carbon) in presence of silica at very high temperature in an electric furnace.

Inform students that phosphorus, P_4 obtained in the process is in the gaseous state and allowed to condense, collected and stored under water as a solid. Introduce to them that the phosphorus obtained during extraction is white phosphorus. The element exhibits two common allotropes: white and red phosphorus. Ask them to describe white and red phosphorus. After their responses, tell them that white phosphorus is a white waxy-looking substance, very poisonous, unstable and consists of P_4 molecules while red phosphorus is relatively stable, and consists of P_4 molecules linked together to form a polymer. White phosphorus is stored under water while red phosphorus is not. Let students also get information about the preparation of red phosphorus by heating white phosphorus to 250^0_C in absence of air.

To discover some physical properties of white and red phosphorus, let students discuss Activity 4.10 for some time and let students from some groups make presentations. Then inform them about the following properties.

White phosphorus	Red phosphorus
- Extremely poisonous - Soluble in carbon disulfide, CS_2 - White waxy solid - Density 1.8 g/cm^3 - Boils at 287^{o}C - Glows in the dark	- Relatively non – toxic compared to the white form. - Not appreciably soluble in CS_2 - Dark red powder. - Density 2.16 g/cm^3 - Sublimes at 416 ^{o}C - Doesn't glow in the dark.

Continue introducing chemical properties of phosphorus. Encourage the students to write the complete chemical equations for the reactions of phosphorus. This should include the reaction of phosphorus with limited supply of oxygen to form P_4O_6 or P_2O_3 and P_4O_{10} or P_2O_5 when reacted with excess oxygen. Besides this, inform them that the reaction of phosphorus with excess and limited amount of chlorine yields PCl_5 and PCl_3, respectively. At the end, let students get some information about the uses of phosphorus.

Oxygen

Start the lesson on this part with the suggested activity. The aim of Activity 4.11 is to show the link between chemistry and biology and to get prior knowledge of students on the use of oxygen in real life. After giving a brief summary on phosphorus, continue introducing concepts on oxygen using group discussion and inquiry as your methods of teaching. First, let students discuss Activity 4.11 for a few minutes and then present their views to the class. After their presentations, harmonize concepts. Let them know that glucose and carbon dioxide are the products formed in photosynthesis and respiration respectively. The chemical reaction for photosynthesis and respiration are the following:

$$6CO_2 + 6H_2O \xrightarrow{\text{Sun light}} C_6H_{12}O_6 + 6O_2 \text{ (photosynthesis)}$$

$$C_6H_{12}O_6 + 6O_2 \longrightarrow 6CO_2 + 6H_2O + \text{Energy (Respiration)}$$

Oxygen is used in hospitals to treat patients that have difficulty in breathing. Astronauts breathe in space either wearing masks lined with potassium super oxide, KO_2 which produces oxygen when reacted with water that is released during respiration or using bottled oxygen. When you deal with the details on oxygen, introduce the presence of oxygen in elemental state constituting about 20% by volume of the atmospheric air and 46.6% by mass of the earth's crust in the form of compounds. In dealing with the production of oxygen, emphasize that its production follows the same procedure as the production of nitrogen. It is obtained by fractional distillation of liquefied air. While

treating chemical properties of oxygen, introduce that it is relatively uncreative. However, it forms oxides with many of the elements. It combines with metals and non-metals to form basic and acidic oxides respectively. It is also required for combustion of substances. Before concluding your explanation on oxygen, let students know some physical properties of oxygen such as its state at room temperature, density, solubility in water, color etc and its uses.

Sulphur

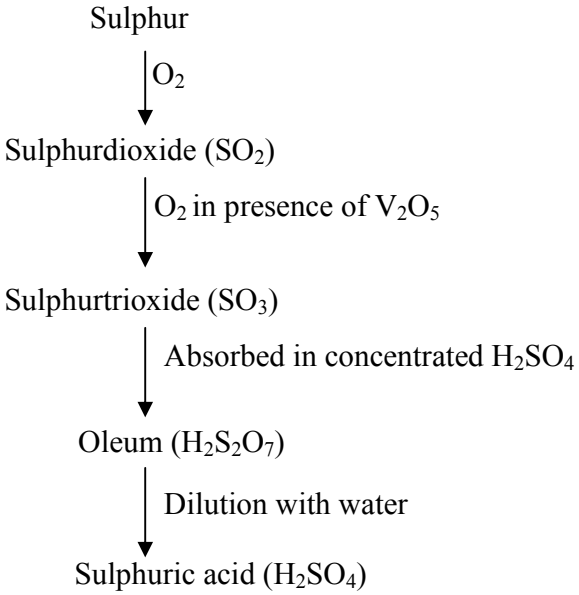
Give a brief summary on oxygen and then continue dealing with the contents on sulphur.

You can use visual based active learning, group discussion and gapped lecture methodologies to teach the contents in this lesson.

Allow the students to discuss in groups Activity 4.12 and present their opinions to the class. After their suggestions, implement gapped lecture method and continue introducing the occurrence of sulphur in elemental state and in the form of compounds. After introducing the occurrence of sulphur, let the students know that sulphur is extracted from underground deposits by the **Frasch Process**. Following the extraction, introduce rhombic and monoclinic sulphur as allotropes of sulphur consisting of S_8 molecules. You can give a short activity on the points you treated to ensure that students are following the lesson accordingly or not.

Continue with your gapped lecture and inform students that about one - half of the sulphur needed by industries is obtained from waste products of other industrial processes such as removal of H_2S from refining of natural gas and crude oil and removal of SO_2 from roasting metal sulphide ores. The use of sulphur compounds produced by other industries reduces the demand for natural resource and also reduces atmospheric pollution and acid rain.

Let the students recall some physical properties of sulphur and continue dealing with chemical properties of sulphur. Encourage students to write the chemical equations showing the chemical properties on their own. This should include the reaction of sulfur with metals when heated to form sulphides, with oxygen to form SO_2 and SO_3. Finally, inform students that sulphur is the raw material from which sulphuric acid is manufactured by the **contact process**. Show the steps involved in contact process of sulphuric acid production. Conclude the lesson by giving information about the properties and uses of sulphuric acid. Finally, let the students write a flow chart to show the steps for the production of sulphuric acid. The chart should look like the following:



Chlorine

Check whether or not students have realized the main concepts on sulphur, continue with the contents on chlorine. You better use gapped lecture, group discussion and independent work as your methods of teaching. Start the lesson with the suggested activity. Activity 4.13 is used here to enable students get perception about real events about chlorine and misconceptions related with the events. It also helps to connect the lesson with real life and get their prior knowledge about the element. So, let students discuss this activity for a few minutes in groups and let some of them present their views. After this, tell them that the water turns white not because of chlorine, but due to pressure and that chlorine is used in water purification to kill bacteria. After that, introduce the occurrence of chlorine. Tell them that it is the most abundant among the halogens and doesn't exist free in nature. Then, let them know the extraction of chlorine by the electrolysis of concentrated solution of sodium chloride (brine). Discuss the anode and cathode reactions and other products that can be obtained during the process and also inform them that NaOH and Cl_2 must be kept apart to avoid their reaction.

Before you continue on the physical properties of chlorine, let students discuss Activity 4.14 in groups and present their opinions. Then, inform them that the smell of tap water is due to chlorine. Introduce some of its physical properties and continue dealing with the chemical properties. Inform them that chlorine is a powerful oxidizing agent. It reacts with heated metals to form chlorides, with hydrogen to form hydrogen chloride, displaces less reactive halide ions (Br^- and I^-) from solutions of their compounds, dissolves in water to give acidic solution and its ability to bleach coloured materials. Give them an

activity to write chemical equations independently on chemical properties of chlorine. Before concluding your explanation, let students get information about some important uses of chlorine.

Assessment

Assess each student's work throughout the section; see how every student involves in group discussions and presentations. Give class works and home works. Evaluate the performances of students by correcting their exercise books. Check that most of the students have achieved the minimum requirement level. Encourage the students working above the minimum requirement level. Arrange the necessary assistance for students working below the minimum requirement level. Give them additional exercises.

Additional Questions

1. Bauxite is an important raw material. It is a hydrated oxide of a certain metal. The metal is extracted by electrolysis.

   *a) Which metal is extracted from bauxite?

   *b) The compound cryolite is also used in the extraction process. Why is this?

   c) What are the electrodes used in the electrolysis made of?

   d) *i. At which electrode is the metal obtained?

   *ii. Write an equation for the reaction that takes place at this electrode.

   e) *i. What product is released at the other electrode?

   ii. This product reacts with the electrode itself. What problem does that cause?

   f) Mention three uses of the metal obtained from bauxite.

2. During the extraction of iron in the blast furnace:

   *i. explain how calcium carbonate helps in the removal of impurities using chemical equations.

   *ii. name the waste gases released from the furnace.

   iii. explain why the slag and the waste gases are both useful.

*3. Explain why iron is converted into steel.

4. What does the term roasting sulphide ore mean?

*5. Which metal turns green due to the formation of Verdigris?

6. Explain how red phosphorus can be prepared from the white form?

*7. Explain why nitrous oxide, N_2O is named laughing gas?

8. What is the major use of the nitrogen compound manufactured by the Haber process?

*9. What are the steps involved in contact process of sulphuric acid production?

*10. What catalyst is used in contact process?

11. Explain how chlorine is manufactured industrially.

12. Explain why concentrated sulphuric acid:

    a) turns blue copper (II) sulphate white

    b) chars sugar

    c) is used to dry acidic gases

*13. Decide whether each of the following descriptions fits oxygen, sulphur or chlorine:

    a) Quite soluble in water.

    b) Forms acid in water.

    c) Solid at room temperature.

    d) Reacts with metals to form oxides.

    e) Exists in more than one solid form.

    f) Removes color from dyes, when damp.

    g) Burns in air with a blue flame.

    h) Reacts with hydrogen to form water.

    i) A poisonous gas.

    j) Is added to rubber to make it hard.

    k) Relights a glowing splint.

    l) Is colorless.

    m) Forms a gaseous oxide when burnt which causes acid rain.

Answers to Additional Questions

1. a) Aluminum

   b) To reduce the meeting point from 2045℃ to 1000℃.

   c) graphite electrodes.

   d) i. cathode

ii. $4Al^{3+}(\ell) + 12e^- \rightarrow 4Al(\ell)$

e) i. oxygen

ii. It oxidizes the graphite electrode to carbon dioxide and the size of the electrode decreases through time.

f) Sample answers: for utensils, electricity and construction

2. i) $CaCO_3(s) \xrightarrow{\text{heat}} CaO(s) + CO_2(g)$

$CaO + SiO_2 \rightarrow CaSiO_3$

ii) CO, CO_2, NO_2

iii) the slag is used mostly for the manufacture of cement.

CO_2 is used for reduction of C to carbon monoxide. Reduction of iron oxides to metallic iron by carbon monoxide.

3. Because the iron recovered from the blast furnace is hard and brittle.

4. Heating the sulphide in oxygen to give sulphur dioxide.

5. Copper

6. By heating white phosphorus to 250℃ in absence of air as red phosphorous is the polymer of white phosphorous.

7. Because it gives a sense of laugh when inhaled.

8. To make fertilizer.

9. See page 210 in the text book, steps 1 – 4

10. V_2O_5

11. Chlorine is produced industrially by the electrolysis of a concentrated aqueous solution of sodium chloride. The cell reaction is
$2NaCl(aq) + 2H_2O(\ell) \rightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$

12. a) because it absorbs water from the copper (II) sulphate.

b) Because it dehydrates sugar and converts it to carbon.

c) Since it absorbs water

13.

a) Cl	d) O	g) S	j) S	m) S
b) Cl	e) S	h) O	k) O	
c) S	f) Cl	i) Cl	L) O	

Answers to Exercise 4.2

1. See the text on page 192, 195, 196 and 202.
2. Aluminium and Copper are only purified by electrochemical process after extraction.
3. All the metals remain stable in dry air. Aluminium remains stable in moisture, iron forms a reddish brown rust, $Fe_2O_3 \bullet nH_2O$ on its surface. Copper forms a greenish layer of basic copper carbonate ($Cu(OH)_2 \bullet CuCO_3$) on its surface. Al and Fe are affected by acidic solutions but copper is not affected by most acid solution with the exceptions of dilute and concentrated HNO_3, and hot and concentrated H_2SO_4.
4. See the text on page 198
5. See the text on page 194, 201 and 204.

Answers to Exercise 4.3

1. Nitrogen from air, phosphorus from rock phosphate ($Ca_3(PO_4)_2$), oxygen from air, sulphur from under groups deposit and chlorine from NaCl.
2. Nitrogen and oxygen fractional distillation of liquid air, chlorine by electrolysis.
3. Nitrogen forms NO and NO_2, phosphorus forms P_4O_6 and P_4O_{10} and sulphur forms SO_2 when heated
4. $Cl_2 + H_2O \longrightarrow HOCl + HCl$

4. 4 Some Industries in Ethiopia

Period Allotted 6

Competencies

After completing this section, students will be able to:

- define industry;
- list some industries in Ethiopia;
- describe the general characteristics of industries;
- outline the important steps in ceramics production;
- mention some uses of ceramics;
- outline the important steps in cement production;

- outline the important steps in sugar production;
- outline the important steps in pulp and paper production;
- explain how tanning is carried out;
- describe the application of chemical preservation of skin and hides;
- mention some uses of skin and hides;
- explain the process of food packing and preservation;
- present a report in a class after visiting a nearby food factory.

Forward Planning

Read the contents of this section thoroughly and plan how to cover the contents within six periods. Your plan may include the contents and activities you should treat during each period, the time to give project work 4.2 for students as an assignment. Also work out a plan on: how much time you need to allot for students to discuss activities, make presentations, harmonizing concepts, stabilization and evaluation during each period.

Subject Matter Presentation

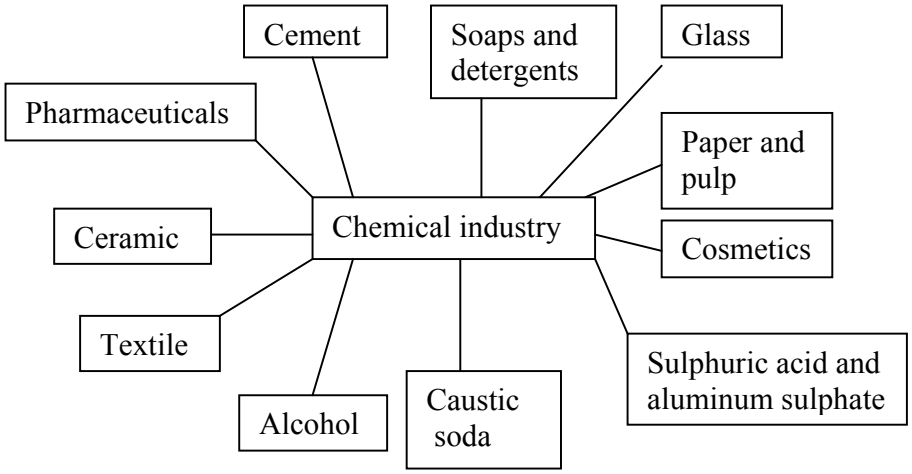
To teach the contents in this part, you better use inquiry, brain storming and group discussion as methods of teaching.

You can start teaching this section, using Activity 4.15. The purpose of this activity is to enable students to get a general overview about industry, their general characteristics and the number of the industries in Ethiopia a student can list. This will help you to know the prior knowledge and experience of your students. So, let students discuss Activity 4.15 in groups for a few minutes. After completing their discussion, let students from different groups present their ideas to the rest of the class. Following the presentations, continue harmonizing concepts suggested by students with the facts they are expected to know. When you do so, begin with the definition of an industry as an institution involved in the production of materials of desirable quality that satisfy social needs. This includes industries that manufacture cement, soaps and detergents, pharmaceuticals, plastic products, alcohols, beverages etc. After defining an industry, list some industries in Ethiopia.

Serial No	Industry	Product	Location
1	Mesobo Cement Factory	Cement	Tigray
2	Muger Cement Factory	Cement	Muger (western shewa)
3	Dire Dawa Cement Factory	Cement	Dire Dawa
4	Derba Midroc Cement Factory	Cement	Northern Shewa
5	Nifas Silk Paint Factory	Paint	A.A
6	Dil Paint Factory	Paint	A.A
7	Tseday Paint Factory	Paint	A.A
8	Repi Soap and Detergent Factory	Soap and detergent	A.A
9	Gulele Soap Factory	Soap	A.A
10	Nazreth Soap Factory	Soap	Nazreth (Adama)
11	Fincha Sugar Factory	Sugar	Fincha
12	Metehara Sugar Factory	Sugar	Metahara
13	Wonji Sugar Factory	Sugar	Wonji
14	Matador Addis Goma Factory	Tyres	A.A
15	Saint George Brewery	Beer	A.A
16	Bedelle Brewery	Beer	Bedelle
17	Meta Brewery	Beer	Sebeta
18	Harar Brewery	Beer	Harar
19	Dashen Brewery	Beer	Gondar
20	Awash Tannery	Processed leather	A.A
21	Mojo Tannery	Processed leather	Mojo
22	Addis Foam and Plastic Factory	Plastic	A.A
23	Ethio Plastic	Plastic	A.A
24	Adamitulu Pesticide Factory	Pesticides	Adamitulu
25	Caustic Soda Factory	Caustic soda	Ziway

26	Tabor Ceramic Factory	Ceramics	Hawassa
27	Sulfuric Acid and Aluminum sulphate Factory	Sulphuric acid and aluminium sulphate	Awash Melkassa
28	Ethio Gas and Carts	Plastic arts and CO_2	A.A
29	Chora Gas and Chemical Products	Oxygen, acetylene, shoe polish, floor wax	A.A
30	Addis Glass Factory	Glass	A.A
31	Nas Foods Factory	Biscuits	A.A
32	Arbaminch Textile Factory	Textile	Arbamich
33	Almeda Textile Factory	Textile	Tigray (Adowa)

There are many other industries that are not mentioned here; particularly those involved in the production of soft drinks, foods, pharmaceuticals and other products. You can give the students an activity to write spider diagram showing materials produced by chemical industries in Ethiopia.



After listing some industries in Ethiopia, revise the general characteristics of industries. You can apply brain storming as your methodology. Let the students write about the characteristics of industries in groups. Then, ask then to suggest what they know, record what they suggested on the blackboard and then tell them the truth. This should include that industries:

- use materials available in nature as raw materials for the production process.
- involve mostly chemical processes to transform the raw materials to the desired products.
- use large amounts of energy in their manufacturing process.
- control the quality of their products and check their products in quality control laboratories whether they satisfy the desired specifications or not. Mention also some other characteristics of industries.

Glass

To teach the contents on glass, you better use peer teaching methodology.

In order to make the teaching – learning process simpler, let students do project 4.2. Give them the chance to do it in groups two or three days before the period during which you treat the topic. In addition to the points suggested in the project, let them also discover types of glasses and raw materials used in their production. You can allow some groups to make presentations and let others submit their project work for correction. During the presentations, let other groups ask questions and let the group presenting the lesson answer the questions. After the presentations, you better summarize the main points. Inform students that it is possible to recycle glass. Glasses of different colors can be produced using various substances. Most common glasses are mixtures of two or more silicates. The ordinary glass used for making window pans, bottles, and dishes is called **soda lime glass**. It is a mixture of sodium silicate and calcium silicates with excess silica. It is made by heating together silica sand, sodium carbonate or sodium sulphate and calcium carbonate. Let students also know quartz glass and borosilicate glass and how they are made. Before you conclude the lesson on glass, let the students know the steps in glass production.

You can also inform them about the substances that can be added to impart different colors to glass during manufacturing. Mention the following.

Substance added	**Color of glass**
Cobalt (II) oxide	Deep blue
Ferrous compounds	Green
Cadmium sulfide	Yellow
Chromium (III) oxide)	Orange
Cupric oxide	Green
Sulfur	Amber

Ceramics

Give a short summary on glass and on steps in glass production and proceed to deal with concepts on ceramics. First, let the students discuss in groups Activity 4.16 for a few minutes and let some groups present their conclusions to the rest of the class. In harmonizing their ideas with the truth, let students know that pottery is one form of ceramic. Let them also know about the presence of ceramic industry in Ethiopia. For example, mention Tabor Ceramic Factory located in the town of Hawassa. Then, introduce what ceramic is by using samples of ceramic materials.

Mention some typical examples of traditional ceramics. Introduce the raw materials used for the production of ceramics. Then, continue on the steps involved in ceramics production. List some ceramic products such as cups and saucers, plates, dishes, floor and wall tiles, bath room structures and others.

Cement

It is better to use inquiry and group discussion as teaching methods.
The construction industry is growing at a faster rate in Ethiopia. For this reason, the production of cement is vital. Activity 4.17 enables students to discover how the number of cement factories is increasing in Ethiopia and also realize that industries are established around the areas where the raw materials are found. So, let the students discuss Activity 4.17 in groups and explain their views to their friends in class. After they do so, introduce the presence of some cement factories in Ethiopia. These factories are located in rural areas closer to places where they get raw materials. Then, ask students to suggest if they know the raw materials used to produce cement. After their responses, introduce the raw materials for cement production and the steps followed in the process. Let students discuss the uses of cement. Finally, let students do project 4.3.

Sugar

After completing the contents on cement production, continue on manufacturing of sugar. You better use inquiry and group discussion as teaching methods for this part. The topic starts with an activity. The activity is suggested to assists students discover the raw materials used in sugar production. So, you can start by letting students discuss Activity 4.18 in groups, and letting some groups present their views to the class. To harmonize the concepts of students with the fact, introduce the raw materials used for sugar production. These are sugarcane and sugar beet. However, inform students that more than 60% of the world's sugar is produced from sugarcane. In Ethiopia, sugar is produced from sugarcane. Then introduce the steps followed during the manufacturing process. As much as possible, explain the purpose of each step so that students can realize the basic steps in sugar production.

Paper and Pulp

Revise the main points on sugar production and continue introducing concepts on paper and pulp. Use inquiry and group discussion to teach the contents.

The topic begins with an activity. The purpose of Activity 4.19 is to inculcate in the minds of the students, the idea that wasting of paper is equivalent to cutting trees. It also helps them realize the importance of proper management of paper. In the mean time, you will get interest from student side to continue your lesson (teaching). So, let students discuss Activity 4.19 for some time in groups and let one or two groups present their ideas to the class. Then, introduce that paper can be recycled. So, recycling reduces cutting trees for paper production. Also, inform them that the quality of paper depends on the method used for its production. Give emphasis that wood pulp can be manufactured from soft woods and hard woods. Mention some examples of soft and hard woods. Inform students about the composition of wood as lignin, cellulose, oils and resins. The production of wood pulp involves separating cellulose from other components.

Inform them about the roles of the individual steps involved in paper production. Especially, give emphasis to pulping. Mention the types of pulping as mechanical and chemical pulping. Let students be informed that there are two main types of chemical pulping. In both chemical methods of pulp production, the pulp is recovered by filtration. Then, the pulp recovered by filtration is bleached using strong oxidizing agents (bleaching agents) such as chlorine, chlorine oxide, ozone, and hydrogen peroxides.

Tanning

After you complete the contents on paper and pulp, continue with tanning. Use inquiry and group discussion to teach the contents. Start the lesson with the suggested activity. The purpose of Activity 4.20 is to show the reality of leather products of Ethiopia. Most of us do not prefer using the products of our country because of the prejudice we have against local products. This activity will show the reality and helps the teacher to get students experience on this issue.

Let the students discuss Activity 4.20 in groups and let some groups present their opinions to the class. Following their presentations, continue harmonizing their opinion with the reality. Inform students that leather products are replaced by synthetic products because is relatively expensive. Let them also know that most people prefer to buy imported leather products rather than those produced in Ethiopia. This is because imported leather products have beautiful appearance.

Then, introduce the steps followed in tanning. Let them also know the processes and purposes of each step. Revise the main points on tanning and continue with the contents on food processing and preservation.

Food Processing and Preservation

You better use inquiry and group discussion as methodology in teaching this topic.

Let the students first discuss Activity 4.21 in groups and let some groups present their opinion to the class. Following their presentation, harmonize concepts. Tell them that keeping food at cool place hinders the growth of micro organisms which spoil food. After that, let them discuss Activity 4.22 in groups for a few minutes and let some groups present their opinions. Here, you can apply brain storming method and record the ideas suggested by each group on the board. In harmonizing concepts, inform students that the traditional method of food preservation includes salting, pickling, sugaring, smoking, drying and canning. Explain how each method preserves food. Use the following information on the traditional methods of food preservation.

a. **Salting**: Salting or curing draws out moisture from meat through Osmosis.

b. **Pickling**: Pickling is a method of preserving food in an edible liquid that inhibits growth or kills bacteria and other micro - organisms. Typical pickling agents include brine, vinegar, alcohol, vegetable oil etc.

c. **Sugaring:** Sugar is used to preserve fruit, either in syrup (with fruits such as apples, pears and peaches) or in crystallized forms where preserved food is cooked in sugar.

d. **Smoking**: Smoking is the process of flavouring, cooking or preserving food by exposing it to the smoke from burning or smoldering plant (wood).

e. **Drying**: Drying is one of the oldest methods of food preservation. It reduces water activity sufficiently and prevents bacterial growth. This method is used to preserve meat (to make "Quanta") and cereal grains such as wheat, maize, oats, barley, rice and others.

f. **Canning**: Canning involves cooking food, sealing it in sterile cans or jars, and boiling the contents to kill or weaken any remaining bacteria in the form of sterilization.

In harmonizing the ideas suggested by the students during presentation, let them know that among the processes explained in traditional context, salting, smoking and drying are used in Ethiopia. After introducing the traditional methods, inform them about the modern methods of food preservation which include freezing, freeze drying and vacuum packing. Among the modern methods, freezing is widely used in Ethiopia.

After completing the topic, organize a trip for students to visit a nearby factory involved in food production. After the visit, let them write reports on how the factory works, what methods it uses in its production and preservation, the type of food it produces, and the raw materials it uses for the production.

Assessment

You need to asses every student's work throughout the section. You can evaluate the work of each student by recording his/her involvement in

- discussion
- presentation
- answering questions raised during presentation or harmonizing
- doing class work or home work
- participation
- answering questions given as quiz.

Based on your record, check whether the suggested competencies are achieved or not. Encourage those working above the minimum requirement level and give assistance to those working below the minimum requirement level by arranging extra lesson time.

Answers to Exercise 4.4

1. Glass is a mixture of two or more silicates such as $CaSiO_3$ and Na_2SiO_3. While cement is a mixture of calcium silicate, Ca SiO_3 and calcium aluminate, Ca Al_2O_4 and also contains magnesium oxide and iron (III) oxide.
2. See the text on page 215
3. i) Decomposition of limestone

   $$CaCO_3(s) \xrightarrow{heat} CaO(s) + CO_2(g)$$

   ii) Reaction of calcium oxide with aluminium oxide and silica.

   $$CaO + Al_2O_3 \longrightarrow Ca\ Al_2\ O_4$$

   $$CaO + SiO_2 \longrightarrow CaSiO_3$$
4. See the text page 219
5. See the text page 221
6. See the second step in leather production page 223
7. Freezing, freeze – drying and vacuum – packing.

4.5 Environmental Pollution

Period Allotted 5

Competencies

After completing this section, students will be able to:

- define pollution;
- list the three types of pollution;
- list the names of common air pollutants;
- describe the effects of air pollutants;
- describe some of the main methods used to reduce air pollution;
- describe the different types of industrial water pollutants;
- explain some of the factors involved in water pollution and their effects;
- describe some of the methods used to reduce water pollution;
- explain some of the factors involved in land pollution;
- describe some of the main methods used to reduce land pollution;
- carry out a project on the effects(s) of an industry on environment.

Forward Planning

Since pollution problem is becoming a global issue, teaching the contents on environmental pollution requires much emphasis. This is because the problem affects the lives of every one of us directly or indirectly. So the teacher is expected to acquaint students with the causes of pollution, their effects and methods of reducing pollution. To get more information, you better search for books, magazines and other reference materials. With the help of the concepts in the teachers guide and other reference materials on current issues, you can make a very good presentation on pollution.

So, this section needs to be treated with a very great concern and emphasis. To create awareness among students, it is advisable if students discover pollution problems themselves and be part of the solution. Here, the teacher is advised to plan how to organize a peer teaching method. You better plan when to give a home work for different groups of students to make preparation on air pollution, water pollution and land pollution. Since this section needs to be covered within five periods, let group 1 make preparation on Activity 4.23, Activity 4.24 and the introduction part; group 2 on air pollutants, their effects and methods of reducing air pollution; group 3 on water pollution and methods of reducing water pollution and group 4 on land pollution and methods of reducing land pollution. Besides this, if your school is located in a small town or a rural

area, prepare the necessary arrangements for students to contact experts from agriculture and rural development offices to give them some information about pollution problems that fertilizers, pesticides and weed killers can cause. If your school is in a town where there are some industries, let the students form a group and carry out the suggested project work in this section. All students should take part in this project work. The project work should be given at least one week before the period during which they present their investigation to the class. You should prepare transportation facilities, letters from the school to the industries that request their willingness to cooperate with the students to carry out their investigation. Also plan how to give assistance to students during their discussion and while doing this project work. You also need to make a plan on how to allot the duration of time for students to discuss activities, present their opinions to the class, presentation of the group who made preparation on a given topic, and for harmonizing concepts.

Teaching Aids

- Reference materials available in the school library containing contents related to pollution.

Subject Matter Presentation

This section should be treated with full participation of students. The main duties of the teacher are to create a conducive atmosphere for the teaching - learning process, motivating students to be active participants and harmonizing the basic concepts suggested by the students with the concepts they are expected to know.

Air Pollution

You better use peer teaching, problem solving, and group discussion methodologies. To begin dealing with this section, let students discuss Activity 4.23 in groups for a few minutes and let students from one or two groups present their opinion to the class. Again, let them discuss Activity 4.24 in groups for a few minutes and let some groups present their opinion. Jot down the points suggested by the students related to the activities and use them when you harmonize concepts. In this section, teaching the contents involves problem solving methodology. Students involve in identifying the causes of pollution, their effects and suggest solution to the problem in their environment.

Next, let the first group who has made preparation on Activity 4.23, 4.24 and introductory part of the section, explain what they have prepared to the class. After they completed the presentation, continue harmonizing concepts. First, define the terms: pollution and pollutants and continue on Activity 4.23. Introduce to the students that the Copenhagen international climate change summit was held in 2002 E.C. An African

delegation led by Prime Minister Meles Zenawi of Ethiopia had taken part in the summit. The solution put forward by the Prime Minsiter to the problem was accepted by the participants of the summit and was a promising one to Africa. In the summit, Ethiopia has been given respect by other nations. The major issue of the summit was to discuss the effects of climate change and to devise ways to overcome the problem. Besides this, the summit also discussed how African countries and other developing nations can get aids (donations of money) as compensation from developed nations. This is because developed nations are responsible for global warming and for climate change since carbon dioxide released by their heavy industries is the main cause for the problem. After that, tell them if there is any activity in your area that has been done to create awareness about air pollution and global warming. In relation to Activity 4.24, list down the human activities which contribute to air pollution and how they do so in your environment. In addition, point out the solution and contribution of the learners to overcome the problems.

In the following period, let students discuss Activity 4.25 in groups for a few minutes and let one group present the idea of the group to the class. Jot down the suggested points by the group so that you can use them when you harmonize concepts. Then, let the second group of students (Group 2) make a presentation on air pollutants, their harmful effects and methods of reducing air pollution. You can ask students some questions about the effects of each type of air pollutant in between the presentation in order to make the presentation more interactive. Let the students also ask the group some questions. It is better if different members of the group involve in presentation and answering questions. After the group introduces air pollutants and their effects, ask the listeners to suggest methods of reducing air pollution.

Following their responses, let the presenters continue to introduce the methods of reducing air pollution. When the presentation is over, continue to stabilize concepts. You can do so by asking students to tell you the substances responsible for air pollution, their effects and how to reduce their harmful effects. You can use the following note to inform methods of reducing air pollution.

Methods of Reducing Air Pollution

1. Removal of sulphur dioxide from gaseous fuels (*flue-gas desulphurization*) or using low-sulphur fuels.
2. Using furnaces and internal combustion engines operating at low temperatures to avoid the combing of N_2 and O_2 and reduce the amount of the oxides of nitrogen produced and released into the atmosphere.

3 Using catalytic converters fitted to car exhausts to convert unburnt hydrocarbons into CO_2 and water, carbon monoxide to carbon dioxide and the oxides of nitrogen to N_2 and O_2.
4 Increasing the air-to-fuel ratio for complete combustion of fuels.
5 Using a spray of water to wash out particles from the waste gases.
6 Passing waste gases through filters.
7 Banning the use of CFCs as aerosol propellant gases and replacing them with less harmful alternatives.
8 Reducing the use of lead paints and using lead-free fuels
9 Reducing CO_2 emission to the atmosphere from the combustion of fossil fuels like petroleum and mineral coal, and using alternative energy sources such as hydroelectric power sources and nuclear energy.

Finally, for students to gain more knowledge, let them do the suggested research and writing part on this topic.

Water Pollution

After revising the main points on air pollution, you can continue on water pollution. Peer teaching and group discussion can be used as methodology. First, let the students discuss Activity 4.26 in groups for a few minutes and let two students from different groups present their opinion to the rest of the class. Take note on the points suggested by the groups to use them during harmonizing concepts. After that, let the third group make presentation on water pollution. In between the presentation, you better ask questions related to the topic to facilitate the teaching - learning process. At the end, you better revise the main points mentioned during presentation and others which are very important. In the process of stabilization, mention the causes of water pollution, their effects and methods of reducing the problem. Finally, let students prepare a water conservation plan project (4.4) and submit it to you and then check how they managed the project work.

Land Pollution

In order to deal with the contents in this part, peer teaching, investigation and group discussion are the recommended methodologies. Investigation is suggested as a method to assist students discover the effect of an industry on the environment.

To start the lesson on this topic, let all students discuss Activity 4.27 in groups for a few minutes and let two students from different groups present their opinion to the rest of the class. Take note on the points suggested by the groups. Then, let the fourth group who has made preparation on land pollution produce presentation to the class. Try to make the teaching learning process more interactive by asking students some guiding questions

between the presentations, whenever you think it is important, especially, on the points of Activity 4.28.

After the presentation is over, harmonize the concepts suggested by the students with those they are expected to know. Use the following note on the methods of reducing land pollution.

Method of Reducing Land Pollution:

1 Burning solid waste like paper and wood.
2 Recycling plastics and other materials such as glass, aluminium and tin cans.
3 Reducing the use of non-biodegradable plastics.
4 Converting potentially dangerous chemical wastes into harmless substances, by combustion or by other chemical means.
5 Using the waste products of one industry as raw materials in another industry. For example, SO_2 formed from the roasting of sulphide ores during the manufacture of metals can be used in the production of sulphuric acid. Similarly, the slag formed during the extraction of iron or copper can be used in the production of cement and glass.
6 Using biodegradable plastics for packaging.

Before you complete this section, let two other groups make presentations on their investigation about the effects of an industry on the environment. Following their presentations, give time for the rest of the class to conduct discussion on their presentation. At the end, give your own conclusion in relation to students presentations and points mentioned in their investigation.

Assessment

You can assess each student's work throughout the section by recording how each student is doing in his/her daily activity.

You can make a record in relation to

- Participation of students in discussion.
- Participation of students in presentation.
- Participation of students in answering questions.
- How they performed class works and home works.
- The results they achieved in a quiz or test .

  From all these records, make sure that the suggested competencies for this section are achieved by all students.

Answer to Exercise 4.5

1. See the text on page 226, 227
2. See the notes on the method included in this guide.

Answers to Review Exercise on unit 4

Part I

1. a) blast b) heamatite c) coke d) air e) reduces f) oxide

Part I I

2. D	3. C	4. A	5. D	6. C	7. B
8. B	9. C	10. D	11. A	12. D	13. D
14. D	15. C	16. B	17. C	18. D	19. C
20. B	21. C	22. C	23. A	24. B	25. D

Part III

26. C 27. D 28. F 29. A 30. E 31. B

Part IV

See the text for this part

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Federal Democratic Republic of Ethiopia

Ministry of Education

Chemistry

Minimum Learning Competencies and Syllabus

Grade 10

MINIMUM LEARNING COMPETENCIES (MLCs)

No	Area of Competencies	Minimum Learning Competencies (MLCs)
1	**CHEMICAL REACTIONS**	• Explain what an Electro chemistry is • Define electrical conductivity and differentiate electrolytic conductivity from metallic conductivity • Define terms like Electrolysis, Electrode, Cathode, anode, Anion, Cation, Electrolyte, non-electrolyte, strong electrolyte and weak electrolyte, half reaction and cell reaction • Confirm by performing simple experiments on metallic and electrolytic conductivity • Describe electro chemical cell • Draw labeled diagram of electrolytic cell and represent electrode reactions by ionic half-reactions for fused electrolytes • Perform an activity to show electrolysis of molten electrolytes • Explain voltaic cell • Explain the difference between voltaic cell and electrolytic cell • Describe the difference types of voltaic cell • Describe how voltaic cells can be used to make commercially useful batteries • Describe selected industrial applications of electrolysis
2	**CLASSIFICATION IN CHEMISTRY**	• Classify inorganic compounds in to oxides, acids, bases and salts • Define oxides and classify them in to acidic oxides, basic oxides, neutral oxides, Amphoteric oxides and peroxides • Define acidic oxides, give examples and explain their properties and methods of preparation • Define Amphoteric oxides, give examples and explain their properties • Define neutral oxides, give examples and explain their properties. • Define acids and bases in terms of Arrhenius, Bronsted-Lowry and Lewis and give examples. • Classify acids and bases on the number of ionizable (replaceable) hydrogen ion (H^+) and based on the number of elements they are composed of. • Explain the general properties of acids and bases • Distinguish between Strong and weak acids; concentrated and diluted acids • Distinguish between Strong and weak bases; concentrated and diluted bases • Use the necessary precautions while working with acids and bases • Define PH and POH, describe the PH scale and identify a given PH labeled solution as acidic, basic or neutral • Show the mathematical relationship between PH and POH

		• Calculate the PH, POH, H^+ ion concentration, OH^- ion concentration of a solution when the necessary variables are given. • Perform an activity to determine the PH of some common substances using universal indicator or PH meter • Explain methods of preparing acids and bases and describe the uses of the three common laboratory acids and the three common laboratory bases • Conduct simple experiment to prepare acids and bases in the laboratory • Define salts and give examples • Classify salts as acidic, basic, and normal salts • Explain properties of salts • Explain methods of preparing salts • List some important salts and explain their uses • Describe the chemical tests for some salts (Sulfates, chlorides, nitrates, and carbonates) • List essential nutrients elements • Describe the functions of nitrogen, phosphorus and potassium • Define fertilizers and describe their importance • List some common inorganic compounds that are used as pesticides
3	**ORGANIC CHEMISTRY**	• Narrate the historical development of organic chemistry • Classify organic compounds • Define the term functional group • Define homologous series and state its characteristics • Define the terms hydrocarbons, structural formula, condensed structural formula and cis-trans isomerism • Write the general formulas for alkanes, alkenes and alkynes • Write the molecular formula, condensed structural formula and names of the first ten members of alkanes, alkenes and alkynes • Give the IUPAC names for branched alkanes, branched alkenes, branched alkynes, cyclo alkanes and cyclo alkenes • Write the possible structural isomers of the alkanes- C_4H_{10}, C_5H_{12} and the alkenes- C_4H_8 and C_5H_{10} • Write cis-trans isomers for the given alkenes • Explain the physical and chemical properties of alkanes, alkenes alkynes homologous series • Explain why alkenes and alkynes undergo addition reaction but not substitution reaction • Describe the laboratory and industrial preparation of methane, ethane and ethyne • Prepare methane, ethane ethyne in a laboratory • Performa a project on the production of biogas from cow dung • Define aromatic hydrocarbons • Draw and explain the structure of benzene

		• Describe the main physical properties and chemical reactions of benzene • Carry out test tube reactions of benzene with a. $KMnO_4$ b. Br_2/CCl_4 c. Conc. H_2SO_4 • List the natural sources of hydrocarbons and tell their formation • Explain the fractional distillation of petroleum, discuss fractionally distilled petroleum products and their uses • Tell the composition of coal • Explain destructive distillation of coal • Classify alcohols based on the number of hydroxyl (OH^-) groups • Classify monohydric alcohols in to primary, secondary and tertiary alcohols, write the general formula of monohydric alcohols and give some examples from each of them • Write the molecular formulas and names of the first six members of monohydric alcohols • Give the IUPAC names for given alcohols • Describe the physical properties of alcohols • Explain the industrial and laboratory preparation of ethanol • Explain the general methods of preparation of alcohols • Performa an activity of preparing locally distilled alcohol (Katikalla) • Explain the chemical reactions of alcohols such as oxidation, reaction with active metals, esterification and dehydration • Write the general structural formulas of aldehydes, Ketones, carboxylic acids and esters and give the structures and names of common members each group • Discuss the uses of organic compounds in the manufacture of industrial products like beverages, pharmaceuticals, fuels, soaps and detergents and dry cleaning agents • Discuss the uses of organic compounds in the manufacture of agricultural products like pesticides, herbicides and urea • Conduct an experiment to prepare soap from naturally existing ester(fats or oils)
4	**CHEMISTRY AND INDUSTRY**	• Define and classify natural resources • Explain the importance of natural resources in the manufacturing of industrial products • Describe the chemical properties and extraction methods of aluminum, iron and copper • Describe the chemical properties and industrial production of nitrogen, phosphorus, sulfur and chlorine • Mention the important steps in the production of glass, ceramics, Cement, Sugar, Paper and pulp and tanneries • Describe different methods of food processing and preservation • Explain how different industrial by products pollute air, water and land.

Introduction

Students need an understanding of chemistry to fully appreciate the complexity and interactions present in their world. Chemistry deals with composition, properties and transformation of substances. The study of chemistry should help the students to increase their analytical and perceptive capabilities and provide opportunity to explore vocations in the field of chemistry. It also provides students with the knowledge and skills in chemistry and technology and enables them to solve problems and make decisions in everyday life based on scientific attitudes and noble values.

To achieve the above mentioned purpose and to cop up with the current demands of chemical knowledge for technological, agricultural and industrial development chemistry curriculum has to be updated all through the grade levels.

The chemistry curriculum for grades 9 and 10 are then revised based on the new curriculum framework of Ethiopian schools taking into consideration the assessment made in March 2008 in selected secondary schools of the country, international experiences and the current situations of our country.

Feedback of the assessment made it clear that the secondary school curriculum also has a problem of content overload, content difficulty inappropriate to the grade levels, giving less emphasis to active learning methods, limitations in integrating agriculture and technology and unnecessary repetitions. The curriculum revision then addressed these problems basically.

The revision also considered international standards. In this regard chemistry curriculum of different countries including India, Malaysia, Singapore, England, Ghana, and Uganda were taken as references. The international consultant has also contributed in keeping standards by sharing experiences and involving in the revision processes.

Consideration of the above mentioned major points led to some restructuring of the units of grade 9 and 10. In grade 9, the titles Chemical Symbols, Formulas and Equations and chemical Reaction are collectively given under the unit Chemical Reaction and stoichiometry. Similarly, Hydrocarbons and Oxygen Derivative Hydrocarbons are given in grade 10 as Introduction to Organic Chemistry and some parts of the oxygen derivative hydrocarbons are taken to grade 12. In the unit of Electrolysis of grade 10 Electrolysis of aqueous solutions and their quantitative aspects are also taken to grade 12. To solve the problems of content overload, chemistry of only three selected metals (Al, Fe, and Cu) is treated in grade 10. Besides, some agricultural and industrial applications are integrated in the units.

The format of the syllabus is different from the traditionally used format. There are only three columns of competency, content and suggested activities respectively in the syllabus below which comes the assessment row.

In the assessment the minimum learning competencies for students working at the minimum requirement level are listed to evaluate their performances. The statement **"minimum requirement level"** should not mislead and should be understood as the **"standard level"**. Students working at the standard level are expected to achieve the competencies set for the grade level successfully. Teachers should give special considerations for those who are working above and below the standard levels by encouraging the ones that work above the standard and by giving

extra attention for those who work below the standard. Enrichment activities should be designed and provided through optional exercises, supplementary exercises, etc, for those who work above and remedial activities should be designed and provided through tutorial, peer tutorial, group work, etc, for those who work below.

Assessment is done through continuous process; however, specific assessment techniques are selected in order to collect information about how well students are achieving the competencies. The assessment techniques used at any particular time depends on what facility with the knowledge, skill, or process the teacher wants the student to demonstrate. The appropriateness of the techniques therefore results on the content, the instructional strategies used, the level of development of the students and what is to be assessed. The environment and culture of the students must also be considered.

Various assessment techniques are listed below. The techniques listed are meant to serve only for reference, since the teacher exercises professional judgement in determining which techniques suit the particular purpose of assessment.

Correlating Instruction, Evaluation, and Science Goals

Instructional Strategies	Some Important Active Learning Methods for Science	Some Corresponding Assessment Techniques
Direct	• Demonstrations	• Group/Individual (Peer/Self): Performance Assessments • Short-Answer Quizzes & Tests
Indirect	• Concept Mapping/Formation/ Attainment • Inquiry • Problem Solving	• Individual/Group: Presentations • Oral Assessments • Performance Assessments • Written Assignments
Experiential	• Conducting Experiments • Field Observations & Trips • Model Building • Simulations	• Group/Individual: Performance Assessments • Written Assignments • Peer/Self: Oral Assessments • Technical Skills
Independent Study	• Reports • Homework • Research Projects	• Performance Assessments • Portfolios • Presentations • Quizzes • Written Assignments
Interactive	• Brainstorming • Co-operative Learning Groups • Discussion • Laboratory Groups	• Group/Peer: Oral Assessments • Written Assignments

For the better implementation of the curriculum material the chemistry syllabus of each grade level is accompanied by materials such as flowchart, minimum learning competencies, student textbook, teachers guide, practical activities manual and student workbook.

This syllabus for grades 9 and 10 were revised by 13 teachers and national and international education experts.

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Allotment of Periods
for Units and Sub-units of Chemistry
Grades 10

10	**Unit 1: Introduction to Organic Chemistry**	1.1 Introduction 1.2 Saturated hydrocarbons - alkanes 1.3 Unsaturated hydrocarbons – alkenes and alkynes 1.4 Aromatic hydrocarbons-benzene 1.5 Natural sources of hydrocarbons 1.6 Alcohols 1.7 Industrial and agricultural applications of organic compounds	1 9 9 2 2 9 2	34
	Unit 2: Important Inorganic Compounds	2.1 Introduction 2.2 Oxides 2.3 Acids 2.4 Bases 2.5 Salts	1 3 7 5 5	21
	Unit 3: Electro Chemistry	3.1 Introduction 3.2 Electrical conductivity 3.3 Electrolysis 3.4 Galvanic cells (voltaic cells) 3.5 Industrial applications of electrolysis	1 2 2 3 2	10
	Unit 4: Chemistry in Industry and Environmental Pollution	4.1 Introduction 4.2 Natural resources and industry 4.3 Production of some important metals and non metals 4.4 Some industries in Ethiopia 4.5 Environmental pollution	1 1 12 6 5	25

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.

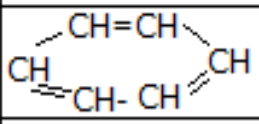
Competencies	***Contents***	***Suggested Activities***
Students will be able to:	***1. Introduction to organic chemistry***	Students should appreciate that chemicals found in and derived from living things, both animals and plants, were once thought to contain a life force, the 'force vitals', which was absent in chemicals obtained from the ground.
	1.1 Introduction *(1 period)*	
• Narrate the historical development of organic chemistry.	• History of organic chemistry	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.
	• Classification of organic	Students should understand that organic compounds

<table>
<tr><th>Competencies</th><th>Contents</th><th>Suggested Activities</th></tr>
<tr><td>• Classify organic compounds

• Define the term functional group

• Define hydrocarbon</td><td>compounds

1.2 Saturated hydrocarbons (alkanes)</td><td>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.

<table>
<tr><td>Alkanes</td><td>R-CH₂-CH₃</td></tr>
<tr><td>Alkenes</td><td>R-CH=CH₂</td></tr>
<tr><td>Alkynes</td><td>R-CH≡CH</td></tr>
<tr><td>Aromatics</td><td>  </td></tr>
<tr><td>Alcohols</td><td>R-OH</td></tr>
<tr><td>Aldehydes</td><td>  </td></tr>
<tr><td>Ketones</td><td>  </td></tr>
<tr><td>Carboxylic acids</td><td>  </td></tr>
<tr><td>Esters</td><td>  </td></tr>
</table>

Students should understand that the term hydrocarbon is used to describe organic chemicals that contain hydrogen and carbon only.

• Compounds that contain only carbon-carbon single</td></tr>
</table>

Competencies	***Contents***	***Suggested Activities***
• Define saturated hydrocarbon	*(9 periods)*	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 • Write the first ten members of alkanes homologous series • Write the molecular formulas of alkanes from the given numbers of carbon atom	• 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}. 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.
• Explain the physical properties of alkanes		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
• Write the structural formulas of the first ten alkanes • Apply IUPAC rules to name straight and branched chain alkanes.	• Physical properties	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.

Competencies	*Contents*	*Suggested Activities*
	• Nomenclature	

Prefix	**Number of carbon atoms**	**Prefix**	**Number of carbon atoms**
Meth	1	hex	6
Eth	2	hept	7
Prop	3	oct	8
But	4	non	9
Pent	5	dec	10

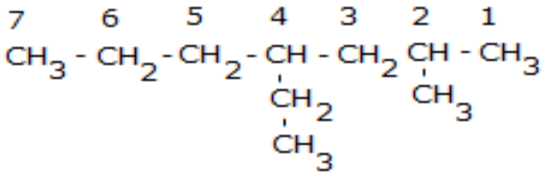
Students should use the suffix 'ane' to generate the names of the first ten alkanes e.g. meth + ane = methane, eth + ane= ethane, etc.

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

Students should work through an example with the help of the teacher.

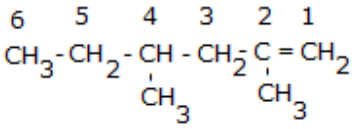


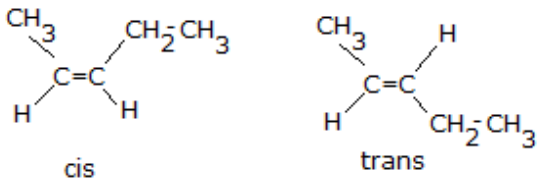
- The longest carbon chain contains 7 carbon atoms therefore it is a heptane
- The carbon chain is numbered from right to left to

Competencies	***Contents***	***Suggested Activities***
• 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}. • Describe the general methods for preparation of alkanes in a	• Isomerism • Preparation	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 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. C-C-C-C C-C(-C)-C 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. 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

Competencies	*Contents*	*Suggested Activities*
laboratory • Prepare methane in a laboratory by decarboxylation method • Carryout a project work to produce biogas from cow dung • Explain the chemical properties of alkanes	• Chemical properties	$2R\text{-}Br + 2Na \rightarrow R\text{-}R + 2NaBr$ • 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. 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 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.
• Define unsaturated hydrocarbons • Define alkenes • Write the general formula of alkenes • Write the molecular formula first nine homologous series of alkenes	**1.3 Unsaturated hydrocarbons – alkenes and alkynes** *(9 periods)* • 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

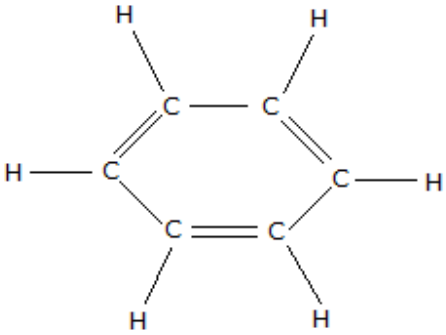
Competencies	***Contents***	***Suggested Activities***
• Define alkynes • Write the general formula of alkynes • Write the molecular formula first nine homologous series of alkynes • Write the molecular formulas of alkenes and alkynes from the given number of carbon atoms		nine alkenes in the series. 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 alkynes	• 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.
• 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.

Competencies	***Contents***	***Suggested Activities***
		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	• Isomerism	Students should appreciate that isomers of C_5H_{10} exist because the carbon-carbon double bond can be in two

Competencies	***Contents***	***Suggested Activities***
C_5H_{10} • Define geometric (cis-trans) isomerism • Give examples of molecules that show geometric isomerism • Construct models that show cis-trans isomerism • Describe the general method for preparation of alkenes in a laboratory • Prepare ethylene in a laboratory by dehydration of ethanol	• Preparation	different positions, giving pent-1-ene and pent-2-ene. 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}  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. 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. $R\text{-}CH_2\text{-}CH_2\text{-}OH \rightarrow R\text{-}CH{=}CH_2 + H_2O$

Competencies	***Contents***	***Suggested Activities***
• Describe the general method for preparation of alkynes in a laboratory. • Prepare acetylene in a laboratory by the reaction of CaC_2 with water. • Test for unsaturation of ethylene and ethyne		• 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. 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. $CaC_2 + 2H_2O \rightarrow HC{\equiv}CH + Ca(OH)_2$ 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.
• Explain chemical properties of alkenes	• Chemical properties	• $R\text{-}CH{=}CH_2 + Br_2 \rightarrow R\text{-}CHBr\text{-}CH_2Br$ • $R\text{-}C{\equiv}CH + 2Br_2 \rightarrow R\text{-}CBr_2\text{-}CHBr_2$ 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

Competencies	*Contents*	*Suggested Activities*
		$R\text{-}CH{=}CH_2 + HX \rightarrow R\text{-}CH_2\text{-}CH_2X$ • 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. $R\text{-}CH{=}CH_2 \rightarrow R\text{-}CHOH\text{-}CH_2OH$
• Explain chemical properties of alkynes.		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.
• Explain the uses of ethylene and acetylene.	• Uses of ethylene and acetylene.	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
• Compare and contrast the properties of ethane, ethene and ethyne		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
• Define the term aromatic	**1.4 Aromatic hydrocarbons - benzene** *(2*	Students should understand that the term aromatic is used to describe compounds which contain benzene rings or similar structures.

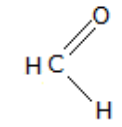
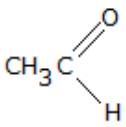
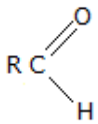
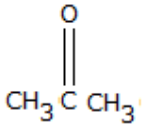
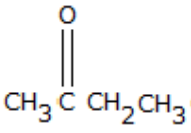
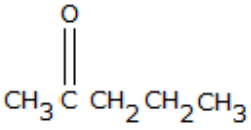
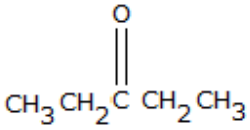
Competencies	***Contents***	***Suggested Activities***
hydrocarbon • Draw the structure of benzene	*periods)* • Structure	Students should consider the structure of benzene, C_6H_6.  Students should be shown the different diagrams used to show the structure of benzene. At first glance students may assume 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	• 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.

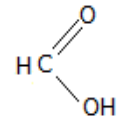
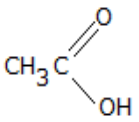
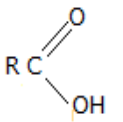
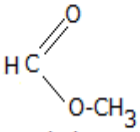
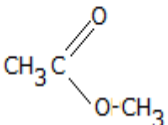
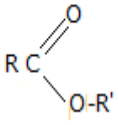
Competencies	*Contents*	*Suggested Activities*
H_2SO_4		Benzene: • Does not undergo addition reactions like an alkene • Undergoes substitution reactions Students should conclude that there is something about the aromatic structure what makes aromatic compounds more stable and less reactive than might be first thought.
	1.5 Natural sources of Hydrocarbons *(2 periods)*	Students should be able to list the major natural sources of hydrocarbons- natural gas, crude oil and coal.
• List the major natural sources of hydrocarbons • Describe natural gas	• Natural gas	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	• 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

Competencies	***Contents***	***Suggested Activities***
• Mention products of fractional distillation of crude oil • Discuss the uses of petroleum products		• 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 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.
• Define alcohols • Tell the functional group of alcohols. • Classify alcohols based on the number of hydroxyl (OH^-)groups.	**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

Competencies	***Contents***	***Suggested Activities***
• 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. • 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 • Classify alcohols based on the number of hydroxyl (-OH) groups	• Classifications of monohydric alcohols	• 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 $C_nH_{2n+1}OH$ 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.
• 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

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 • Explain the chemical reactions of alcohols such as oxidation, reaction with	• Preparation • Chemical properties	• 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) 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-Cl + NaOH → R-OH + NaCl • Hydrolysis of esters by heating with potassium hydroxide solution R-COO-R' + KOH → R-COOK + R'-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. 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

Competencies	*Contents*	*Suggested Activities*
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 • Write the general structural formula of ketones • Write the molecular formulas and		$R\text{-}CH_2\text{-}OH + [O] \rightarrow R\text{-}COH$ • 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. • Secondary alcohols are oxidised to form ketones $R\text{-}CHOH\text{-}R' + [O] \rightarrow R\text{-}CO\text{-}R'$ Ketones are named on the basis of the number of carbon atoms present and the suffix 'anone'.  propanone  butanone  general formula of a ketone 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.  pentan-2-one  pentan-3-one

Competencies	*Contents*	*Suggested Activities*
names of simple ketones • Write the general structural formula of carboxylic acids • Write the molecular formulas and names of simple carboxylic acids • Write the general structural formula of esters • Write the molecular formulas and names of simple esters		(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.  methanoic acid  ethanoic acid  general formula of a carboxylic acid 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

Competencies	*Contents*	*Suggested Activities*
		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 - disinfectants e.g. Dettol
• Discuss the uses of organic compounds in the manufacture of soaps and detergents. • Discuss the uses of organic compounds in the manufacture of dry-cleaning agents. • Discuss the uses of organic	- Soaps and detergents - Dry cleaning - Fuels	• Soaps and detergents - sodium and potassium salts of long-chain carboxylic acids - sodium laurylsulphate • Dry cleaning - tertrachloromethane and others • Fuels - alkanes e.g. natural gas, gasoline, paraffin - ethanol - bio fuels

Competencies	***Contents***	***Suggested Activities***
compounds in the manufacture of fuels • Conduct an experiment to prepare soap from naturally existing esters (fats or oils) • Discuss the uses of organic compounds in the manufacture of pesticides and herbicides. • Discuss the importance and manufacture of urea	• Agricultural application -Pesticides - Herbicides - urea	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. 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 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).

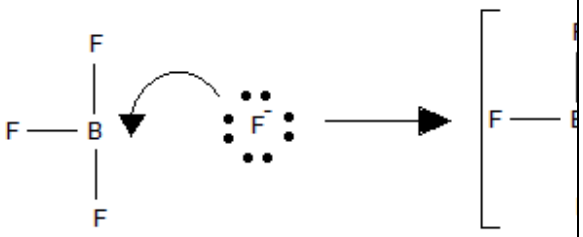
Demonstrate scientific inquiry skills: observing, classifying, comparing and contrasting, inferring, predicting, communicating, measuring, asking questions, interpreting data, drawing conclusion, applying concepts, relating cause and effect and problem solving

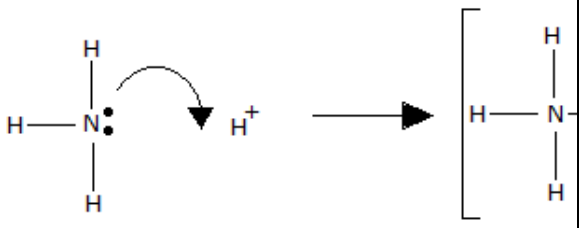
Competencies	***Contents***	***Suggested Activities***
Students will be able to: • Define inorganic compounds • Classify inorganic compounds as oxides, acids, bases and salts	***2. Important inorganic compounds*** **2.1. Introduction** *(1 period)*	Students should understand that the term 'inorganic' 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. 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 • Define acidic oxides • Give examples of acidic	**2.2. Oxides** *(3 periods)* • Acidic oxides	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. 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

Competencies	***Contents***	***Suggested Activities***
oxides • Explain the chemical properties of acidic oxides		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

Competencies	***Contents***	***Suggested Activities***
• 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.
• 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	• 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.

Competencies	*Contents*	*Suggested Activities*
properties of peroxides		$2Na(s) + O_2(g) \rightarrow Na_2O_2(s)$ 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.
• Distinguish peroxides from other oxides by conducting an experiment		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	• Definitions of acids - Arrhenius	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. 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

Competencies	***Contents***	***Suggested Activities***
concepts	- Brønsted-Lowry - Lewis	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. 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. 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

Competencies	*Contents*	*Suggested Activities*
		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: $HCl(aq) \rightleftharpoons H^+(aq) + Cl^-(aq)$ $H_2SO_4(aq) \rightleftharpoons 2H^+(aq) + SO_4^{2-}(aq)$
• Classify acids as	• Classification of acids	Students should use the term 'monoprotic' to describe hydrochloric acid since it has only one

Competencies	***Contents***	***Suggested Activities***
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		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	• 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:

Competencies	***Contents***	***Suggested Activities***
between strong and concentrated acids • Describe the conceptual difference between weak and dilute acids • Use the necessary precautions while working with acids • 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	• Concentrated and diluted acids • Precautions in handling acids • pH	$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$ 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. 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. 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 • Diluting any acid that gets onto clothes • Using a bellows to pipette acid 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

Competencies	***Contents***	***Suggested Activities***
universal indicators or pH meter • Calculate the pH of a given acidic solution • Calculate the concentration of hydrogen ion from the given information • Perform activities to investigate some physical properties of acids • Perform activities to investigate some chemical properties of acids • Explain the		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 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 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

Competencies	*Contents*	*Suggested Activities*
direct combination of elements, the reaction of acidic oxides with water and formation of volatile acids from non volatile acids as the three methods of preparation of acids • Conduct simple experiment to prepare acids in laboratory • Describe the uses of the three common laboratory acids.	• Preparation of acids • Common uses of HCl, HNO_3, H_2SO_4	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). • 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. 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
• Define bases in terms of the	**2.4. Bases** *(5 periods)* • Definition of bases	Students should already be aware how the

Competencies	***Contents***	***Suggested Activities***
concepts of Arrhenius, Brønsted-Lowry and Lewis • Give examples of bases based on Arrhenius, Brønsted-Lowry and Lewis concepts	- Arrhenius - Brønsted-Lowry - Lewis	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. • 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
• Define strong and weak 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:

Competencies	***Contents***	***Suggested Activities***
• Distinguish between strong and weak alkalis(soluble bases) • Define concentrated and dilute alkalis • Distinguish between concentrated and dilute alkalis(soluble bases) • Use the necessary precautions while working with bases	• Concentrated and dilute bases • Precautions in handling bases	$NaOH \rightarrow Na^+ + OH^-$ 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. 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. 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	• POH - 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

Competencies	***Contents***	***Suggested Activities***
• 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		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: • 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	• 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.

Competencies	*Contents*	*Suggested Activities*
basic oxides with water and double displacement reactions as the three methods of preparation of bases • Conduct simple experiments to prepare bases in laboratory		• Double displacement reactions in which the products of the reaction are a soluble base and an insoluble salt e.g. $K_2SO_4(aq) + Ba(OH)_2(aq) \rightarrow 2\ KOH(aq) + BaSO_4(s)$ 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
• Define salts • Give examples of salts	**2.5. Salts** *(5 periods)*	Students should recall that a salt is produced when an acid is neutralised by a base: acid + base = salt + water 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

Competencies	***Contents***	***Suggested Activities***
• 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	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. 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
• Explain the properties of salts	• 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

Competencies	***Contents***	***Suggested Activities***
• Describe the chemical tests of some salts by conducting activities		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
• Define fertilizers • List some common	- 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.

Competencies	***Contents***	***Suggested Activities***
fertilizers • Explain the importance of fertilizers • List some common inorganic compounds that are used as pesticides	- Pesticides	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 ($CO(NH_2)_2$. 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.

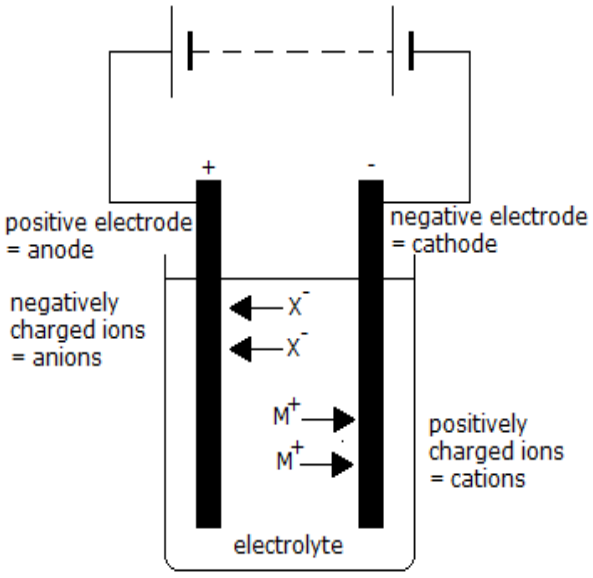
Unit 3: Electrochemistry *(10 periods)*

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	**3.2 Electrical conductivity** *(2 periods)*	Students should understand that both metals and aqueous solutions conduct electricity but that the process is different in each case.
• Explain metallic conductivity	• Metallic conductivity	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	• Electrolytic conductivity	Students should be aware that in electrolytic conductivity: • The electrolyte contains ions

Competencies	***Contents***	***Suggested Activities***
• Distinguish between metallic conduction and electrolytic conduction • Distinguish between strong and weak electrolytes • Use conductivity apparatus to test conductivity of substances		• 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 This could be done using a simple circuit composed of three cells and a lamp.
• 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	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.

Competencies	*Contents*	*Suggested Activities*
		 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 • Cathode
• Define the terms half-reaction and cell reaction		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

Competencies	***Contents***	***Suggested Activities***
• 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		• 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 • Mention different types of voltaic cells	**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. 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

Competencies	*Contents*	*Suggested Activities*
• Describe how voltaic cells can be used to make commercially useful batteries. • Distinguish between voltaic cell and an electrolytic cell • Describe voltaic cell		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

Competencies	***Contents***	***Suggested Activities***
		• Purification of metals • Electroplating 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.

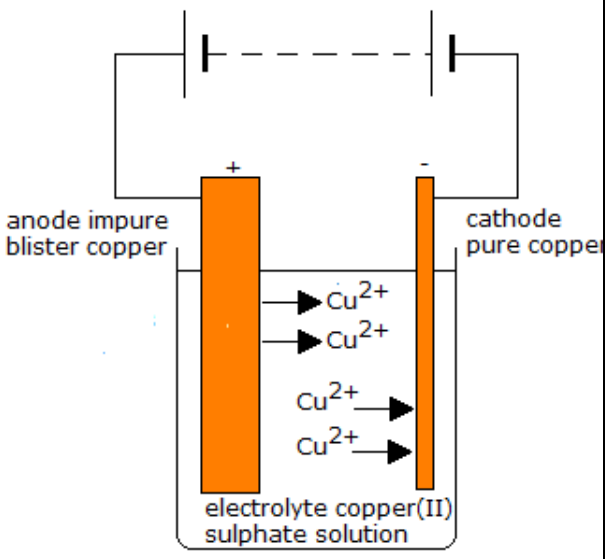
Competencies	***Contents***	***Suggested Activities***
Students will be able to: • List general characteristics of chemical industries • Define natural resources • List natural resources	**4. Chemistry in Industry and Environmental Pollution.** **4.1 Introduction** *(1 period)* **4.2 Natural resources 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

Competencies	*Contents*	*Suggested Activities*
• Classify natural resources as renewable and non-renewable • 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	• 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 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
• Outline the extraction of aluminium by the Hall process	**4.3 Production of some important metals and non-metals** **Aluminium** *(12 periods)* - 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:

Competencies	***Contents***	***Suggested Activities***
• Describe the main physical and chemical properties of aluminium	- chemical properties	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 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. $4Al(s) + 3O_2(g) \rightarrow 2Al_2O_3(s)$ • 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 $2Al(s) + 2NaOH(aq) + 6H_2O(l) \rightarrow 2NaAl(OH)_4(aq) + 3H_2(g)$
• Describe the uses of aluminium	- Uses	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

Competencies	***Contents***	***Suggested Activities***
• Outline the extraction of iron by the blast furnace	• **Iron** - Extraction	• The manufacture of household utensils • Window frames and roofing sheets • Packing material the food industry 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.

Competencies	***Contents***	***Suggested Activities***
• 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. • 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
• Describe the main chemical properties of copper	- Chemical properties	Students should know about the chemical properties of copper. These should include:

Competencies	*Contents*	*Suggested Activities*
		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
• 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

Competencies	*Contents*	*Suggested Activities*
	•**Phosphorous** - Production	combine to form ammonia $N_2(g) + 2H_2(g) \rightarrow 2NH_3(g)$
• Outline the production of phosphorous		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
	- Chemical properties	Students should recall the physical properties of phosphorus.
• Describe the main chemical 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 • $P_4(s) + 10Cl_2(g) \rightarrow 4PCl_5(s)$
	• **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.
• Outline the production of oxygen		
	- Chemical	

Competencies	*Contents*	*Suggested Activities*
• Describe the main chemical properties of oxygen	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
• Describe the main chemical properties of sulphur	- Chemical properties	Students should recall the physical properties of sulphur 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

Competencies	*Contents*	*Suggested Activities*
• Outline the production of chlorine • Describe the chemical properties of chlorine	• **Chlorine** - Production - Chemical properties	• Sulphur is the raw product from which sulphuric acid is made: $S(s) + O_2(g) \rightarrow SO_2(g)$ $2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$ $H_2SO_4(l) + SO_3(g) \rightarrow H_2S_2O_7(l)$ $H_2S_2O_7(l) + H_2O(l) \rightarrow 2H_2SO_4(l)$ 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 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 $Cl_2(g) + 2Br^-(aq) \rightarrow 2Cl^-(aq) + Br_2(aq)$

Competencies	*Contents*	*Suggested Activities*
		• 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	**4.4 Some industries in Ethiopia** *(6 periods)*	Students should define industry and understand the general characteristics of industries. Students Could list some common industries in Ethiopia.
• Describe the general characteristics of industries.	• Introduction	Students should be able to give a brief description of the manufacture of glass including:
• Outline the important steps in glass production	• Glass	• 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
• 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

Competencies	***Contents***	***Suggested Activities***
		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
• Explain how tanning is carried out • Describe the application of chemical preservation 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

Competencies	***Contents***	***Suggested Activities***
• Mention some uses of skin and hide		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*
		Students should define pollution
• Define pollution • List the three types of pollution	**4.5 Environmental Pollution** *(5 periods)* • Introduction	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

Competencies	***Contents***	***Suggested Activities***
		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 • 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	- 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

Competencies	***Contents***	***Suggested Activities***
pollutants • Explain some of the factors involved in water pollution and their effects. • Describe some of the main methods used to reduce water pollution • Explain some of the factors involved in land pollution • Describe some of the main methods used to reduce land	- Methods of reducing water pollution • Land pollution - Factors involving in land pollution	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 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 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 Students should be able to discuss methods used to reduce land pollution. These could include:

Competencies	***Contents***	***Suggested Activities***
pollution • Carry out a project on the effects(s) of an industry on environment	- Methods of reducing land pollution	• 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 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.