CHEMISTRY

TEACHER'S GUIDE

GRADE 8

Authors, Editors and Reviewers:

Amare Legesse(B.Sc.)

Kefyalew Ketema(B.Sc.)

Teketel Yohannes(Prof)

Evaluators:

Mulugeta Mesfin(B.Ed.)

Getahun Tadesse(B.Ed.)

Mekbib Belete(B.Sc.)

FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA

MINISTRY OF EDUCATION

Published E.C. 2006 by the Federal Democratic Republic of Ethiopia, Ministry of Education, under the General Education Quality Improvement Project (GEQIP) supported by IDA Credit No. 4535-ET, the Fast Track Initiative Catalytic Fund and the Governments of Finland, Italy, Netherlands and the United Kingdom.

The Ministry of Education wishes to thank the many individuals, groups and other bodies involved-directly and indirectly-in publishing this textbook and the accompanying teacher guide.

Developed and Printed by

STAR EDUCATIONAL BOOKS DISTRIBUTORS Pvt. Ltd.

24/4800, Bharat Ram Road, Daryaganj,

New Delhi – 110002, INDIA

and

ASTER NEGA PUBLISHING ENTERPRISE

P.O. Box 21073

ADDIS ABABA, ETHIOPIA

Under GEQIP Contract No. ET-MoE/GEQIP/IDA/ICB/G07/09-F

ISBN 978-99944-2-288-3

Table of contents

GENERAL INFORMATION TO THE TEACHER

The students' text of chemistry grade eight is prepared in such a manner that teachers can implement active learning methodology in 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, and develop skills in performing experiments and solving problems. So, the teacher 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. Forming Groups

You need to organize different groups in each section you are going to teach during your first contact with the students. You may assist students to form groups based on their seats, roll numbers 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.

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 on 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. Given 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 student's textbook. 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.

7. Supplementary 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 (*) only for students working above the minimum requirement level, while students working below the minimum requirement level can attempt other questions. 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. Fast learners can do all the suggested questions.

8. Giving Note

You are not expected to write notes on the black 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 teacher's guide, but not in the students' text. However, you can write short notes related to the main points as you harmonize concepts. Tell them the main points they should emphasize, in taking notes from the text. Also tell them to jot down only 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 exercises 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 8 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 includes:

- 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.

10.1 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.

10.2 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.

10.3 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.

10.4 Presentation

This is an activity where students present a topic in front of their classmates. This can be done individually or as a group.

10.5 Demonstration

This is a method where the teacher shows the students how something is done.

10.6 Experiments

It usually involves a very specific and controlled method of procedures, where results are usually recorded.

10.7 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.

10.8 Question and Answer (Inquiry)

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

10.9 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.

10.10 Visual-based Active Learning

This method helps students learn using real object models, pictures, drawings and charts.

10.11 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.

10.12 Library Research

The library research report provides an opportunity for students to work independently and to improve their research and writing skills. Writing a research report will give students an opportunity to use a variety of up-to-date sources such as reference texts, newspapers, and popular and scientific magazines.

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

i. http://www.ntlf.com/html/lib/bib/91-9dig.htm

ii. http:ctl.byu.edu/active-learning-techniques/

iii. http:pdfcast.org/pdf/strategies-to-incorporate-active-learning-into-online-teaching

iv. 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 perform 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.

UNIT 1 CLASSIFICATION OF COMPOUNDS

Total Periods allotted: 17 periods

Unit Overview

This unit is divided into three subunits. The first subunit tries to introduce the classification of compounds as organic and inorganic. In addition, it defines organic chemistry and inorganic chemistry.

The second subunit discusses organic compounds. The simplest types of organic compounds are hydrocarbons. It only puts much emphasis to the following three major types of hydrocarbons: alkanes, alkenes and alkynes. Even though the chemistry of these hydrocarbons is very vast, it focuses on the formulas and names of the first ten alkanes, alkenes and alkynes. Some of the uses of hydrocarbons such as methane, propane, butane, octane, decane, ethene, propene, and ethyne are discussed. Moreover, the importance of some oxygen containing derivatives of hydrocarbons such as ethanol, ethanoic acid and formalin are also explained.

The third subunit describes inorganic compounds. First, it presents classification of inorganic compounds. Next, it presents the definitions, properties, preparations and uses of oxides, acids, bases and salts. In this section, some experiments are also designed to be conducted to show the properties and preparations of oxides, acids and bases.

In these days, the methods of teaching are shifted from traditional lecture method, which puts little emphasis on students' participation in teaching-learning process, to active learning methods. The key concept in active learning is that *knowledge* is not transferred; information is transferred but *knowledge is created* when a student thinks about the information. Hence, in active learning, you should provide your students with opportunities to do some work based on the ideas you have given them or from what they already know. Therefore, active learning methods such as group discussion, gapped lecture, experiment, demonstration, role play, brainstorming, independent work, drama, spider diagram, flash light cards, matching activities and other appropriate methods can be used.

Unit Outcomes

After completing this unit, students will be able to:

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

Main Contents

1.1 INTRODUCTION

Periods Allotted: 1 period

Competencies

After completing this section, students will be able to:

- *tell that compounds are classified as organic and inorganic;*
- *define organic chemistry as the study of carbon containing compounds; and*
- *define inorganic chemistry as the study of non-carbon containing compounds.*

Forward Planning

Dear teacher, since students will learn using active learning methods, it is advisable to plan group formations. In addition, prior reading about classification of compounds from the student textbook or reference books is worthwhile.

Teaching Aids

Common salt (sodium chloride) and sugar (sucrose)

Subject Matter Presentation

For this subunit, brainstorming, group discussion, gapped lecture and presentation can be used as active learning methods.

You can start this topic by grouping students and letting them discuss the **start-up activity**. The start-up activity helps them to brainstorm about the classification of matter which they learned in grade 7 chemistry. In addition, it would let them think about the physical methods that help us to classify substances based on physical and chemical properties. You can facilitate their discussion by clarifying misconceptions (if any). Some students may not be active in group discussions due to various reasons. It would, therefore, be better to identify these students and encourage them to participate in their respective groups. After their discussion, allow them to share their ideas with other group members. Then, harmonize their discussion by providing the following answers.

1. Compounds are a class of pure substances formed when two or more elements combine chemically. There are different ways of classifying compounds. One of these classifications is based on their composition and chemical properties. Generally, compounds are classified in to two broad classes as organic and inorganic compounds.
2. Both ethanol and water are colourless liquids. They can easily be distinguished by their odour. Water is odourless but ethanol has distinct odour. They can also be distinguished by their taste. Water is tasteless but ethanol has sharp taste. We can also identify them by determining their boiling points. At 1 atm, water boils at 100^oC and ethanol boils at 78^oC.
3. Elements are pure substances that cannot be broken down into smaller substances under an ordinary condition. Each element is made of similar atoms. When two or more elements combine in a chemical reaction, they form compounds. Mixtures are formed when two or more pure substances are combined physically in any proportions.

You can use gapped lecture to discuss the historical classifications of compounds as organic and inorganic. To illustrate organic and inorganic compounds, you can use familiar examples like common salt (sodium chloride) for inorganic compounds and sugar (sucrose) for organic compounds. In addition, help the students to emphasize on the modern definition of organic chemistry and inorganic chemistry. Then, encourage them to answer **Exercise 1.1** as a classwork.

Assessment

You assess each student's work continuously throughout the subunit. This can be done by preparing a performance sheet and recording the performance of every student. You can make records based on the student's performance in discussing the start-up activity, presenting their views after discussion and answering the questions in **Exercise 1.1**.

By observing their performances from the record, provide them with feedback to improve students' learning (formative assessment). In addition, you can use self assessment and peer assessment methods to enhance students' performance. Appreciate students why are working above the minimum requirement and encourage them to continue working hard. For low achievers, identify their learning difficulties and help them to achieve the minimum required level for this subunit.

Additional Questions

Gifted students should answer all the questions. However, questions indicated by asterisks are for students working above the minimum requirement. You can use this convention throughout this Teachers Guide.

*1. Classify each of the following compounds as organic or inorganic.

a.	Glucose	d.	Carbon dioxide	g.	Citric acid
b.	Sodium hydrogen carbonate	e.	Marble	h.	Copper oxide
c.	Acetic acid	f.	Magnesium sulphate		

2. What was the significance of the synthesis of urea by Friedrick Wöhler?

Answers to Additional Questions

1.	a.	Organic	d.	Inorganic	g.	Organic
	b.	Inorganic	e.	Inorganic	h.	Inorganic
	c.	Organic	f.	Inorganic		

2. Before synthesis of urea by Friedrick Wöhler, no one has successfully prepared organic compounds from inorganic substances. As a result, chemists believed that organic compounds could only be synthesized by living organisms. They thought that plants had vital force or 'vis vitalis' that would enable them to synthesize organic compounds. This thought precluded the synthesis of organic compounds in the laboratory. After the synthesis of urea, many organic compounds have been synthesized and the idea of the vital force theory was refuted.

Answers to Exercise 1.1

1.

a.	Inorganic	c.	Organic	e.	Organic	g.	Organic
b.	Organic	d.	Inorganic	f.	inorganic	h.	Inorganic

2. a. Inorganic Chemistry b. Organic Chemistry
   c. Organic Chemistry d. Organic Chemistry

1.2 ORGANIC COMPOUNDS

Periods Allotted: 4 periods

Competencies

After completing this section, students will be able to:

- *write the general formula of alkanes, alkenes and alkynes;*
- *write the specific chemical formulas of the first ten members of alkanes, alkenes and alkynes;*
- *name the first ten members of alkanes, alkenes and alkynes; and*
- *list some common uses of organic compounds.*

Forward Planning

Prior reading about the formula and naming of hydrocarbons as well as the uses of organic compounds is very useful. This subunit also contains a significant number of activities. Hence it is advisable to refer to the answers of these activities from this teacher's guide; you also need to make a plan that shows the topic and activity you are going to deal with during each period. Your plan should be prepared in a manner that enables you complete the contents in this section with in four periods. Moreover, you need to prepare a chart that shows the classification of hydrocarbons. You may also need a lighter to explain the importance of gaseous hydrocarbons.

Teaching Aids

Lighter and a chart that shows the classification of hydrocarbons.

Subject Matter Presentation

1.2.1 Formula of Hydrocarbons

For this subtopic, gapped lecture, group discussion, presentation, and independent work can be used as active learning methods.

You can start teaching this topic with **Activity 1.1.** This activity lets them to draw their attention to the topic under discussion. Thus, let them do the activity in groups for some minutes. Facilitate group discussions by clarifying ideas that are not clear to them. When they complete, give chance to some group representatives to present the answers to the class. Next, harmonize ideas by telling to them the following information.

1. Hydrocarbons are compounds of carbon and hydrogen. Therefore, they are classified as organic compounds.
2. Carbon and hydrogen are the two elements which are constituents of hydrocarbon.
3. The name hydrocarbon was derived from the names of two elements which are hydrogen and carbon.

The chart you prepared can be used to illustrate the classification of hydrocarbons.

Inform to them the general formula of alkanes. Use gapped lecture to introduce to students what homologous series, homologues and alkanes are. Give them **Exercise 1.2** as class work and check their work. After that, help the students to know about alkenes and give them **Exercise 1.3** as class work. Finally, let the students distinguish alkynes from alkenes and alkanes. After they do so, you may give them **Exercise 1.4** as homework.

1.2.2 Nomenclature (Naming) of Hydrocarbons

For this subtopic, it is better to use gapped lecture, group discussion and presentation as active learning methods.

Start teaching the contents in this topic using **Activity 1.2.** This activity helps them to understand the purpose of naming hydrocarbons and guess how one can give name to hydrocarbons. Then let them form groups and do **Activity 1.2**. Facilitate group discussions by clarifying questions raised during their discussion. After the discussion, encourage them to present their answers to the class. Harmonize their discussions by providing answers for **Activity 1.2.**

1. We give specific name to a hydrocarbon using a prefix that shows the number of carbon atoms it contains and a suffix to show the group it belongs to.
2. The names of hydrocarbons are given systematically. This means that we have to follow certain rules developed by chemists.

After harmonizing concepts on **Activity 1.2**, you can briefly introduce to students the prefixes used to indicate the number of carbon atoms in the names of alkanes, alkenes, and alkynes as well as their corresponding suffixes. Let them do **Exercise 1.5** as class

work independently. After each student completes the Table, invite some students to come forward and, write their answers and complete each of the six columns of the Table drawn on the board. Next, let other students discuss on the answers given.

1.2.3 Importance of Organic Compounds

For this subtopic, brainstorming, gapped lecture, group discussion, and project work can be used as active learning methods.

You can begin this subtopic by letting students do **Activity 1.3** to brainstorm the uses of organic compounds from their daily experience. This activity is designed to help students search some organic compounds which are useful in their area. Facilitate group discussions by clarifying questions raised during their discussion and harmonize their discussions by providing answers for **Activity 1.3.**

1. The students could mention useful organic compounds such as:
   - margarine used as food and vinegar used to flavour salad;
   - nylon and polysters used as synthetic fibers;
   - polyvinyl chloride (PVC) and polyethylene used as plastic bottles, bags, cups, plates, shoes, pipes, etc.
   - fertilizers and pesticides used in agriculture;
   - pain killers and antibiotics used as medicines;
   - dyes;
   - cow dung used us a fuel for cooking and as a fertilizer;
   - soaps and detergents used for cleaning purposes.
2. Synthetic organic compounds have made life more comfortable for human beings. They are used for making clothes (synthetic fibers), fuels, cosmetics, plastics, synthetic rubber, dye stuffs, pesticides, pharmaceuticals, refrigerants, photographic chemicals, synthetic flavours and others.

After that, continue to introduce to students the importance of methane, propane and butane, octane, decane, ethene and propene, and ethyne. Then, proceed to deal with the importance of other organic compounds. First, tell to them the uses of ethanol and then, let them do **Activity 1.4**. This activity helps them to think about the negative effects of drinking alcohol. Facilitate group discussions by clarifying vague concepts. After discussing the activity, let some groups present their ideas to the rest of the class. Following the presentations, tell to students the following suggested answers.

There are a variety of negative effects that are associated with the consumption of

alcohol. While the negative effects can either be long term or short term, all of them start with the first drink of alcohol. Negative effects may not become apparent immediately, but as time goes on, the adverse effects of alcohol will become more and more noticeable. Negative effects of too much alcohol intake by a person may include poor economy, family instability, loss of appetite, physical weakness and even lead to death.

Finally, tell to them the uses of ethanoic acid and formalin. After that, you may give **Exercise 1.6** as a homework.

Assessment

You can assess students' performance based on your record about each students' performance in discussing from **Activity 1.1 to 1.4**, presenting their views after discussion, and answering the question in **Exercise 1.2 to 1.6.**

By observing their performances from the record, provide them with feedback to improve students' learning. Appreciate students working above the minimum required level and encourage them to continue working hard. For low achievers, identify their learning difficulties and help them to achieve the minimum required level for this subunit.

Additional Questions

1. What are hydrocarbons? Give examples,

* 2. Classify each of the following compounds as alkane, alkene or alkyne.

a. $C_{11}H_{24}$ b. $C_{12}H_{24}$ c. $C_{26}H_{50}$

3. Write the formula of each of the following compounds.

a. An alkane containing four-carbon atoms.

b. An alkane containing twenty-hydrogen atoms.

* c. An alkyne containing eleven-carbon atoms.

* d. An alkene containing twenty six-hydrogen atoms.

* e. An alkane containing fourteen-carbon atoms.

* f. An alkyne containing twenty four-hydrogen atoms.

Answers to Additional Questions

1. As their names indicate, hydrocarbons are compounds that contain carbon and

hydrogen only. For example, alkanes, alkenes and alkynes are hydrocarbons.

2 a. Alkane b. Alkene c. Alkyne

3. a. C_4H_{10} b. C_9H_{20} c. $C_{11}H_{20}$

d. $C_{13}H_{26}$ e. $C_{14}H_{30}$ f. $C_{13}H_{24}$

Answers to Exercise1.2

1. The formula of alkanes containing three, five, seven and nine carbon atoms are C_3H_8, C_5H_{12}, C_7H_{16} and C_9H_{20}, respectively.

2. If CH_2 is subtracted from C_6H_{14}, it becomes C_5H_{12}. Similarly, if CH_2 is added to C_6H_{14}, it becomes C_7H_{16}. Therefore, C_5H_{12} and C_7H_{16} are the homologues that come before and after C_6H_{14}.

Answers to Exercise1.3

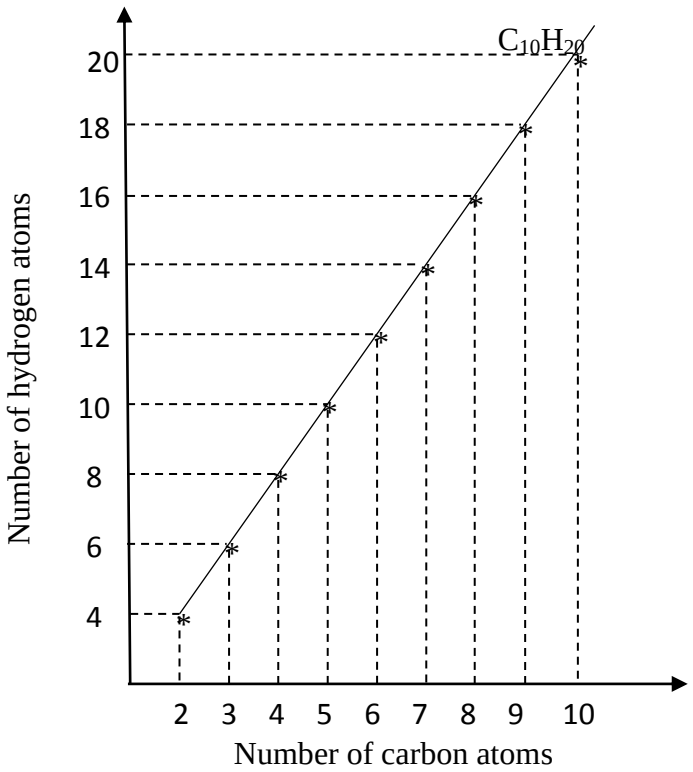
1. Alkanes have two hydrogen atoms more than the corresponding alkenes.

2. The formula of alkenes containing four, six, eight and ten carbon atoms, respectively, are: C_4H_8, C_6H_{12}, C_8H_{16} and $C_{10}H_{20}$.

3. The formula of alkenes is C_nH_{2n}. Prepare the following table discussing with students.

C	2	3	4	5	6	7	8	9	10
H	4	6	8	10	12	14	16	18	20

Using the data in the above table, label the y-axis with the number of hydrogen atoms and the x-axis with the number of carbon atoms as follows. Then guide students to predict the formula of the alkene that has 10 carbon atoms.



The formula of the alkene having 10 carbon atoms from the x and y axis can be predicted as $C_{10}H_{20}$.

Answers to Exercise1.4

1. The formulas of the first nine alkynes are listed in the Table below.

Number of Carbon atoms	***Formula***
1	No alkyne with one carbon atom
2	C_2H_2
3	C_3H_4
4	C_4H_6
5	C_5H_8
6	C_6H_{10}
7	C_7H_{12}
8	C_8H_{14}
9	C_9H_{16}
10	$C_{10}H_{18}$

2. The formulas of an alkane, alkene and alkyne containing nine carbon atoms, respectively, are C_9H_{20}, C_9H_{18} and C_9H_{16}. The number of hydrogen atoms in C_9H_{20} exceeds the number of hydrogen in C_9H_{18} by two. Similarly, the number of hydrogen atoms in C_9H_{18} exceeds the number of hydrogen in C_9H_{16} by two.

Answers to Exercise 1.5

1. a. Butane: C_4H_{10}, Butene: C_4H_8, Butyne: C_4H_6

   b. Hexane: C_6H_{14}, Hexene: C_6H_{12}, Hexyne: C_6H_{10}

2. The students may fill in the Table as shown below.

Carbon atoms	Formula of alkane	Name of Alkane	Formula of alkene	Name of Alkene	Formula of alkyne	Name of Alkyne
1	CH_4	Methane	-	-	-	-
2	C_2H_6	Ethane	C_2H_4	Ethene	C_2H_2	Ethyne
3	C_3H_8	Propane	C_3H_6	Propene	C_3H_4	Propyne
4	C_4H_{10}	Butane	C_4H_8	Butene	C_4H_6	Butyne
5	C_5H_{12}	Pentane	C_5H_{10}	Pentene	C_5H_8	Pentyne
6	C_6H_{14}	Hexane	C_6H_{12}	Hexene	C_6H_{10}	Hexyne
7	C_7H_{16}	Heptane	C_7H_{14}	Heptene	C_7H_{12}	Heptyne
8	C_8H_{18}	Octane	C_8H_{16}	Octene	C_8H_{14}	Octyne
9	C_9H_{20}	Nonane	C_9H_{18}	Nonene	C_9H_{16}	Nonyne
10	$C_{10}H_{22}$	Decane	$C_{10}H_{20}$	Decene	$C_{10}H_{18}$	Decyne

Answers to Exercise 1.6

Part III Short Answers

1. a. C_5H_{10} b. C_7H_{16} c. C_6H_{10}
   d. C_8H_{16} e. C_9H_{20}

2. a. Alkene b. Alkane c. Alkyne d. Alkane

3. a. C_8H_{18}, Octane b. C_7H_{16}, Heptane c. C_9H_{18}, Nonene
   d. C_8H_{16}, Octene e. C_8H_{14}, Octyne f. C_7H_{12}, Heptyne
4. a. Propane and butane b. Octane
   c. Decane d. Ethene and propene
   e. Ethyne f. Ethanol or ethyl alcohol
   g. Formalin h. Acetic acid.

1.3 INORGANIC COMPOUNDS

Periods allotted: 12 periods

Competencies

After completing this subunit, students will be able to:

- *tell that inorganic compounds are classified into oxides, acids, bases and salts;*
- *define oxides;*
- *classify oxides into metallic and non-metallic oxides;*
- *give examples of metallic and non-metallic oxides;*
- *define acidic oxide and basic oxide;*
- *give examples of acidic and basic oxides;*
- *describe the properties of acidic oxides and basic oxides;*
- *explain the preparation of acidic oxides and basic oxides;*
- *prepare sulphur dioxide in the laboratory by burning sulphur in air;*
- *use moist blue litmus paper to test the acidic nature of sulphur dioxide;*
- *prepare magnesium oxide in the laboratory by burning magnesium ribbon in air;*
- *use red litmus paper to test the basicity of magnesium oxide in water solution;*
- *define acid as a substance that releases hydrogen ions in water solution;*
- *give common examples of acids;*

- *define pH as the measure of acidity or alkalinity of a solution;*
- *describe pH scale;*
- *explain preparation of acids by direct combination of elements and reaction of acidic oxide with water;*
- *describe the properties of acids;*
- *conduct experiments on the properties of acids;*
- *list some common uses of hydrochloric acid, nitric acid and sulphuric acid;*
- *define base as a substance that neutralises an acid;*
- *define an alkali as a substance that releases hydroxide ions in aqueous solution;*
- *give some common examples of bases;*
- *prepare bases by the reaction of metals with water and basic oxides with water;*
- *describe the properties of alkalis;*
- *investigate properties of bases experimentally;*
- *list some common uses of sodium hydroxide, magnesium hydroxide and calcium hydroxide;*
- *define dilute and concentrated acid and base;*
- *describe concentrated acidic and alkaline solutions;*
- *describe dilute acidic and alkaline solutions;*
- *explain the safety precautions while working with acids and bases;*
- *give some common examples of salts;*
- *name some common salts;*
- *define salts as compounds that are composed of the positive ions of a base and the negative ions of an acid;*
- *tell that salts are classified as binary and ternary;*
- *define binary salts;*
- *define ternary salts;*
- *give examples of binary and ternary salts;*
- *explain direct elemental combination and neutralization reactions as methods of salt preparation; and*
- *list some uses of common salts.*

Forward Planning

Read the contents on classification of inorganic compounds, properties, preparation and uses of oxides, acids, bases and salts from the student's text, reference books and other resources to fully understand the subject matter of the lesson. Make a plan of your own on how to manage students during discussion, presentation and assessment. In your plan show the time allotted for each activity you are going to perform during every period while you are dealing with this section. Prepare ahead the necessary teaching and learning materials for this topic. Prepare yourself on the activities and Exercises before the class.

Teaching Aids

- Periodic table
- Some labelled packs of foods and drinks
- Refer the student text to prepare the necessary chemicals and apparatus required to perform **Experiments 1.1** – **1.10**.
- Chart of safety precautions in working with acids and bases

Subject Matter Presentation

You are advised to use discussion, lecture, inquiry, demonstration and experiment (practical method) as your teaching methods for this subunit. Use these methods in a way that promotes active learning. Encourage your students to participate in the teaching-learning process.

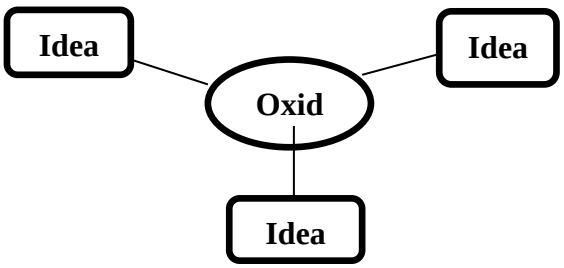
After introducing the topic of the section, let the students discuss **Activity 1.5** in groups for a few minutes. Then invite some of the groups to present their ideas to the class. After their presentations, harmonize concepts using the following information. **Activity 1.5** is designed for students to be aware of the existing inorganic compounds and the elements they contain in the foods and drinks they take. Display the containers of some labelled packed foods and drinks for students in a class. Here you can use the periodic table as teaching aid to indicate the elements that are contained in the compounds used to make the food.

The foodstuffs and drinks we take, may contain salts or neutral substances. Hence the labels on the containers of foodstuffs and drinks indicate their compositions.

Next, introduce to students that the classification of inorganic compounds into groups (Oxides, Acids, Bases and Salts) is based on their composition and properties.

1.3.1 Oxides

Here you can start the lesson by implementing the **spider diagram** active learning strategy as a **start - up activity**. Students should write down a word "oxide" at the center of their Exercise book and circle it. They can then write down any ideas connected to *oxide* and join them to the central word (Oxide) with lines. When they complete their work, write the word oxide at the center of the blackboard yourself, and record the ideas they suggest.



After their responses, tell them what oxide means and then ask them to define the term "binary". After appreciating the attempts of your students, give the appropriate answer to your questions.

Next to the above start-up activity on oxides, have students discuss **Activity 1.6** in groups for a few minutes. When they complete, invite some of the groups to present their ideas to the class. After their presentations, harmonize concepts using the following information.

Activity 1.6 is designed to help students easily identify the constituents of oxides. It also helps students to classify oxides as metallic oxides and non-metallic oxides.

1. a. Carbon dioxide, CO_2: C and O
   b. Magnesium oxide, MgO: Mg and O
   c. Calcium oxide, CaO: Ca and O
   d. Sulphur dioxide, SO_2: S and O
   e. Sodium oxide, Na_2O: Na and O
2. Oxygen is common to all compounds.
3. Metallic oxide and non-metallic oxide because metallic oxides consist of metals and oxygen whereas non-metallic oxides consist of non-metals and oxygen.
4. The oxides MgO, CaO and Na_2O are classified as metallic oxides, and CO_2 and SO_2 are non-metallic oxides.

   To check whether or not students have understood the definition of an oxide, let them do **Exercise 1.7** as classwork. In addition to that, inform to students the oxides considered as basic oxides

Types of oxides

Continue teaching the lesson by asking students how they can group oxides. After their attempts, tell them the appropriate answer. Give the definitions of metallic oxides and non-metallic oxides using some examples. In addition to that, inform to students the oxides considered as basic oxides or basic anhydrides and those considered as acidic oxides or acid anhydrides. Give them **Exercise 1.8** as a classwork.

Properties of oxides

Start the lesson by asking students whether or not they can suggest another method for the classification of oxide. After appreciating their attempts, tell them that classification of oxides is possible based on the nature of the solution they form in water. Next, define acidic oxides and basic oxides. Give examples of chemical reactions of acidic oxides with water and basic oxides with water. In addition to the reactions of basic and acidic oxides with water, make students be familiar with the reactions of basic oxides with acids, and reactions of acidic oxides with bases.

Finally give them **Exercise 1.9** as a homework.

Preparation of Oxides

Continue teaching the lesson by introducing the two common methods of preparing oxides. These are:

1) direct synthesis - direct combination of elements with oxygen.

2) indirect methods - thermal decomposition of some compounds

After you introduce the methods, give the students more time to discuss **Activity 1.7** in groups and present their answers to the class. **Activity 1.7** is designed to enable students to give more examples on the preparation of oxides by direct synthesis. After their presentation, give the answer as follows.

Oxides of nitrogen: NO is called nitric oxide. Nitric oxide is a by-product of combustion of hydrocarbons in automobile engines and fossil fuel in power plants. It is also produced naturally during the electrical discharges of lightning in thunderstorms by direct combination of Nitrogen and Oxygen. When exposed to oxygen, NO is converted into nitrogen dioxide, NO_2.

$N_2 + O_2 \rightarrow 2NO$ (Only when there is high electric discharge)

$2NO + O_2 \rightarrow 2NO_2$

Sodium reacts with O_2 to form Na_2O in a limited amount of oxygen. Notice that mixed oxides (Na_2O and Na_2O_2) are usually formed during the reaction of sodium with oxygen.

$$4Na(s) + O_2(g) \rightarrow 2\ Na_2O(s)$$

After harmonizing concepts on the activity, demonstrate **Experiment 1.1.** During the demonstration, tell them to watch carefully and record their observations. When you complete the demonstration, tell the students to write a laboratory report in groups and then let one or two group representatives present about the experiment to the rest of the class. Make sure that their presentations coincide with the following.

a. Sulphur burns with a blue flame to form sulphurdixoide. The gas changes moist blue litmus red.

b. The equation for the reaction is:

$$S + O_2 \rightarrow SO_2$$

c. Sulphur dioxide is an acidic oxide.

After that, continue to demonstrate **Experiment 1.2.** The experiment enables them to develop skills how they can prepare basic oxides and identify their properties. Tell them to watch carefully and record their observations. When the demonstration is complete, allow them to write a laboratory report in groups and submit it to you for correction. When you check their laboratory reports, make sure that they respond to the questions in the observation and analysis part as follows:

1. Magnesium burns with a bright white flame forming a white powder.
2. The equation for the reaction is:

$$2Mg + O_2 \rightarrow 2MgO$$

3. The solution feels slippery or soapy
4. Red litmus turns blue.
5. The solution of magnesium oxide is basic.

$$MgO + H_2O \rightarrow Mg(OH)_2$$

After the experiment, continue teaching about preparation of oxides by thermal decomposition of hydroxides, carbonates and nitrates. Support your mini-lecture with examples.

Finally, you can give them **Activity 1.8** and **Exercise 1.10** as a homework.

You can use the following information for **Activity 1.8**

1. a. $Cu(OH)_2 \xrightarrow{heat} CuO + H_2O$

   b. $CuCO_3 \xrightarrow{heat} CuO + CO_2$

   c. $2Cu(NO_3)_2 \xrightarrow{heat} 2CuO + 4NO_2 + O_2$

1.3.2 Acids

Give a short summary on the preparation of oxides and continue to introduce your students to the second group of inorganic compounds, acids. Bring sample of fruits such as orange, lemon, tomato, grape fruit, and vinegar to the classroom for **Activity 1.9**. It is designed for students to understand the prominent property of acids which is common to all. Then, have the students discuss **Activity 1.9** in groups for a few minutes. Next, invite some of the groups to present their ideas to the class. After their presentations, harmonize concepts with the following fact.

All acids taste sour. Most fruits like orange, lemon, tomato, grape and vinegar taste sour because they contain acids. The acid found in orange and lemon is citric acid and the acid found in vinegar is acetic acid.

Caution: *Students should not taste any substance to check the acidity or basicity unless you tell them to do so.*

Next, tell them the origin of the word 'acid' and ask them if they can suggest the names of some more acids. After their feedback, inform to them the following.

Citric acid (lemon and orange), carbonic acid (soft drinks and mineral water), lactic acid (milk), butyric acid (butter), boric acid (in some foods), amino acids (protein), tartaric acid (baking powder), tannic acid (tea), and fatty acids (fat) are some examples of acids.

Then, continue with **Activity 1.10.** This activity is suggested to assist students know the three most common laboratory acid. Have them discuss **Activity 1.10** in groups for a few minutes. When they complete, give the chance to two group representatives to present the names of the acids to their classmates. After the presentations, tell them that hydrochloric acid, nitric acid and sulphuric acid are the three common laboratory acids.

Next, explain acids in terms of their properties to release H^+ ions when they are mixed with water. Describe the three common laboratory acids: Nitric acid, HNO_3, Hydrochloric acid, HCl, and Sulphuric acid, H_2SO_4. Tell them also the less common acids: Citric acid, Vinegar, Carbonic acid, Methanoic acid and Benzoic acid.

The pH Scale

Begin to teach this topic, by asking students whether or not all acids are equal in strength. If they differ in strength, how could we know their relative strength? After you get feedback, appreciate their responses and tell them that pH is one of the methods to express the relative strengths of acids and bases.

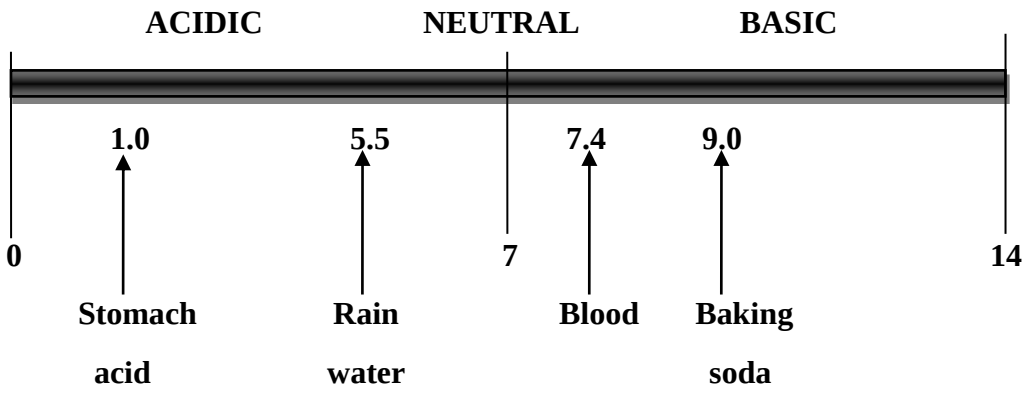
After that, define pH. Introduce to them the pH range and the pH value of acidic, basic and a neutral solution. Then, continue with **Activity 1.11.** This activity is designed for students to research the pH levels of some substances. Here, you have to guide the students how to conduct the research. So, have them discuss the activity for a few minutes in groups. When they complete the discussion, encourage two students from different groups to present their finding to their classmates.

Use the following table to harmonize concepts suggested by students with the fact.

	pH	Example
ACIDS	0	HCl (1.0 M)
	1	Stomach Acid
	2	Lemon Juice
	3	Vinegar
	4	Soda, wine
	5	Rainwater
	6	Milk
NEUTRAL	7	Pure Water
BASES	8	Egg Whites
	9	Baking Soda
	10	Anti-Acid, Detergent
	11	Ammonia
	12	Mineral Lime, $Ca(OH)_2$
	13	Bleach
	14	Caustic soda, NaOH (1.0 M)

1. pH of lemon juice = 2, liquid detergents = 10, solution of antacid =10, vitamin C = 2-3 and water = 7

2.



Preparation of Acids

After giving a short summary on the previous lesson, introduce students to the two methods of acid preparation. After that, continue to deal with the details on how to prepare acids by direct combination of elements. Support your mini-lecture with chemical equations. Next, proceed to **Activity 1.12.** The activity is designed to assist students to gain skills in writing equations and enable them suggest the type of acid that can be obtained. So, have them discuss this activity for a few minutes in groups. When they complete the discussion, invite two students from different groups to present their opinion to the class. After the presentations, harmonize concepts as follows.

$H_2(g) + F_2(g) \rightarrow 2HF(g)$

$HF(g) + H_2O(l) \rightarrow HF(aq)$, Hydrofluoric acid

$H_2(g) + Br_2(g) \rightarrow 2HBr(g)$

$HBr(g) + H_2O(l) \rightarrow HBr(aq)$, Hydrobromic acid

$H_2(g) + S(g) \rightarrow H_2S(g)$

$H_2S(g) + H_2O(l) \rightarrow H_2S(aq)$, Hydrosulphuric acid

Then, continue with the second method of acid preparation. Before you deal with the details, ask them what they recall about the product that can be obtained from the reaction of an acidic oxide and water. Give chance to two students to respond. After their response, remind them that the reactions of acidic oxides with water produce acids. Inform to them that this reaction is used as the second method of acid preparation. Give them some examples and proceed to **Activity 1.13.** This activity is designed to help students practice writing chemical equations and develop skills to identify the oxide that should react with water to produce a particular acid. So, have them discuss in groups for a few minutes. After that, let two group representatives present their opinion to the class.

Following the presentations, harmonize concepts as follows. Sulphuric acid is prepared by the reaction of sulphur trioxide (SO_3) with water. The equation for the reaction is

$$SO_3(s) + H_2O(l) \rightarrow H_2SO_4(aq)$$

Finally, give them **Exercise 1.11** as a homework.

Next, proceed to deal with properties of acids. First, introduce to students the definition of acid-base indicators and common indicators used in school laboratories. Then, allow them to do **Experiment 1.3** in groups. When they complete, let them write laboratory report in groups and submit them to you for correction. Make sure that their reports in the observation and analysis part include the following points.

Acid	**Colour of indicator in the acid solution**		
	Litmus	**Phenolphthalein**	**Methyl arrange**
Dilute HCl	Red	Colourless	Red
Dilute H_2SO_4	Red	Colourless	Red

After **Experiment 1.3**, which is supposed to be conducted by students, continue with **Activity 1.14.** The activity is designed to enable students realize that locally available materials can be used as indicators. Let them discuss **Activity 1.14** in groups for a few minutes. Encourage two students from different groups to present their findings to the class. Following the presentations, harmonize concepts by telling them that the lemon juice is an acid and the tea is an indicator. That is why its colour changes from brown to light yellow.

After harmonizing concepts on **Activity 1.14**, proceed to deal with reaction of acids with metals. Write the general word equation and give some examples. Then, continue with **Experiment 1.4.** Allow the students to do the experiments on their own in groups under your supervision. Make them write laboratory reports in groups and some groups present their conclusions to the rest of the class. Make sure that their presentations coincide with the following points.

1. Zinc is cleaned with steel wool until it is shiny to remove any coating that hinders its reaction with HCl.
2. The metal begins to react with the acid.
3. The formation of bubbles.
4. It is colourless.
5. A popping sound is produced.
6. $Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

Next, continue with **Activity 1.15.** This activity is suggested to enable students develop their experience in writing chemical equations and predict reaction products when acids combine with metals. So have the students discuss the activity for a few minutes in groups.

After the discussion, invite some students from different groups to present their work to the rest of the class. Following the presentation, harmonize concepts using the following information.

1. a. $Mg(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2(g)$
   b. $2Al(s) + 6HCl(aq) \rightarrow 2AlCl_3(aq) + 3H_2(g)$
   c. $Fe(s) + 2HCl(aq) \rightarrow FeCl_2(aq) + H_2(g)$
2. a. $Zn(s) + H_2SO_4(aq) \rightarrow ZnSO_4(aq) + H_2(g)$
   b. $Mg(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + H_2(g)$
   c. $2Al(s) + 3H_2SO_4(aq) \rightarrow Al_2(SO_4)_3(s) + 3H_2(g)$
   d. $Fe(s) + H_2SO_4 \rightarrow FeSO_4(aq) + H_2(g)$

Then, continue to deal with the reactions of acids with carbonates and hydrogen carbonates. Write the general word equation for the reaction and give specific examples. After that, continue with **Experiment 1.5.** This experiment is suggested to assist students develop skills in performing experiments and observe the reactions practically on their own. So, have the students do the experiment in groups. Provide them the materials required for the experiment and assist them whenever they are in need. Tell them to take care since they are working with acids.

When they complete the experiment, let them write laboratory reports and submit the for correction. Check that they answered the questions in the observation and analysis part of the experiment as follows.

a. Yes, there is

b. The formation of bubbles indicate that a gas is released from the reaction mixture.

c. The lime water turn milky. This is due to the reaction of calcium hydroxide with carbon dioxide to form calcium carbonate.

d. I. $CaCO_3(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + CO_2(g) + H_2O(l)$
   II. $2NaHCO_3(s) + H_2SO_4(aq) \rightarrow Na_2SO_4(aq) + 2CO_2(g) + 2H_2O(l)$
   III. $Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$

Next, treat neutralizing effect of acids on bases. Write the word equation for the general reaction and give them specific examples. Then, continue with **Experiment 1.6.** This experiment is designed to help students discover the fact about naturalization reaction on their own.

So, let them do it in groups, write laboratory report and present their findings to the rest of the class. Make sure that concepts in the presentations coincides with the following

a. The solution becomes pink when phonolphtahlum is added to it.

b. The colour disappears as a result of complete neutralization.

c. Actually it should not. However, the presence of a single drop of excess acid may affect the colour of blue litmus and change it to red.

d. $2NaOH\ (aq) + H_2SO_4\ (aq) \longrightarrow Na_2SO_4\ (aq) + 2H_2O\,\ell$

After harmonizing concepts on **Experiment 1.6**, continue with **Activity 1.16.** This activity is designed to help students explore the uses of the common acid. So, let them do this activity in groups. You should give them this activity two or three days before you intend to present the lesson. Tell them to prepare the table on a chart paper using markers for the presentation. After they did the activity, invite two or three students from different groups to make a five minutes presentation using the chart they prepared. Following the presentations, harmonize concepts using the note given below.

Name	**Formula**	**Uses**
Hydrochloric acid	HCl	- for pickling metals. - to prepare drugs, dyes, paints, photographic chemicals. - to remove excess mortar from bricks.
Nitric acid	HNO_3	- to produce nitrate fertilizers, nylon, plastics and organic dyes. - to manufacture explosives. - picking stainless – steel. - etching metals.
Sulphuric acid	H_2SO_4	- to produce fertilizers, synthetic fibres, paper, plastics, dyes, explosives paints, drugs, car batteries, etc. - for cleaning corroded metal surfaces. - in the production of phosphoric acid.

Finally, give them **Exercise 1.12** as homework.

1.3.3 Bases

To begin to teach the contents in this subtopic, start with **Activity 1.17.** This activity is suggested to help students realize some properties of bases using the materials they can get from their locality. So, have them discuss this activity for a few minutes in groups. When they complete, let two students from different groups present their opinion to the rest of the class. After the presentations, harmonize concepts using the following information.

Aqueous solution of ash is basic. That is why it tastes bitter and also feels slippery to touch. After harmonizing concepts, define what a base and an alkali is. Give them some examples. After that, proceed to deal with **Activity 1.18.** This activity is designed to help students to increase their level of knowledge on bases. Thus, have them discuss the activity for a few minutes in groups. When they complete, encourage some students from different groups to present their findings to the rest of the class.

After the presentations, harmonize concepts as follows:

a. Students can suggest different metal oxides such as calcium oxide (CaO), magnesium oxide (MgO), copper (II) oxide (CuO), barium oxide (BaO), sodium oxide (Na_2O), potassium oxide (K_2O), etc.

b. They can suggest different hydroxides such as Magnesium hydroxide ($Mg(OH)_2$), sodium hydroxide (NaOH), potassium hydroxide (KOH), etc.

Next, continue with the preparation of bases. Write the general word equations for the preparation of bases by the reactions of active metals with water and metal oxides with water. Write the formulas of the reactants on the board and let students complete the equations on their own. Then, check how they are doing and give them corrections. After that, demonstrate **Experiments 1.7.** Tell students to watch carefully during the demonstration and record their observations. When you complete the demonstration, let the students write laboratory reports about their observation in groups and students from some groups present their opinion to the class. After that, harmonize concepts suggested by students with the fact as follows:

a. Calcium burns with a brick – red flame colour. The equation for the reaction is:

$$2Ca + O_2 \rightarrow 2CaO$$

b. When the calcium oxide formed dissolves in water, it changes to calcium hydroxide.

$$CaO + H_2O \rightarrow Ca(OH)_2$$

c. When red litmus paper is introduced into calcium hydroxide solution, the red colour turns blue. This shows that aqueous solution of calcium hydroxide is basic in nature.

After harmonizing the views suggested by the students with the fact, continue dealing with the properties of bases. First, treat the effect of a base on an acid – base indicator. Here it is advisable for you to allow students to perform **Experiment 1.8** on their own in groups. You need only to provide them the necessary materials for the experiment. You should also follow how every group is doing according to the suggested procedure. Help the groups who need assistance. When they complete the experiment, let them write a laboratory report on their observation in groups and present to the rest of the class. Following the presentations, harmonize the concepts suggested by the students with the fact using the information given below.

a. The colour of ammonia solution, phenolphthalein and methyl orange are colourless, colourless and orange respectively.

b. Red litmus turns blue, blue litmus remains unchanged, phenolphthalein turns pink, and methyl orange remains orange (yellow)

c. Solutions of bases change the colour of indicators.

Then continue dealing with the neutralizing effect of bases on acids. First, ask them to define what neutralization is and again ask them to suggest the reaction products of acids and bases. After they respond, write the general word equation for the reaction of an acid and a bases on the blackboard. After that, write two word equation representing acid-base reactions and then let them write the balanced formula equations. Next, allow them perform **Experiment 1.9** in groups. They should do it under your supervision. Provide them with the materials required for the experiment. Assist them whenever they are in need. When they complete the experiment, tell them to write a laboratory report. Invite two students form different groups to present their findings to the rest of the class.

After the presentations, harmonize concepts using the following information.

a. The solution stays colourless

b. Because of complete neutralization of the acid with the base.

c. It doesn't affect the colour of either blue litmus or red litmus papers. However, addition of a single drop of excess base can cause colour change of red litmus paper to blue.

d. The equation for the reaction is:

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$

Next, continue with the uses of sodium hydroxide, magnesium hydroxide and calcium hydroxide. Give them **Activity 1.19** to do it in groups as homework at least two days before the period you planned to deal with it. **Activity 1.19** is designed to help students develop skills to explore the uses of common bases on their own. Tell them to prepare the complete table on a chart paper using markers.

After they did the activity, encourage two or three students from different groups to make a five minutes presentation using the chart they prepared. Then harmonize the concepts presented by the students with the actual uses of the bases given in the following table.

Name of the Base	Common Name	Formula	Uses
Sodium hydroxide	Lye or caustic soda	NaOH	- oven cleaner, for soap and detergent production, - to manufacture paper and pulp, textiles, dyes, cosmetics, pharmaceuticals and in petroleum refining.
Magnesium hydroxide	Milk of magnesia (in suspension form)	$Mg(OH)_2$	- As stomach antiacid to neutralize acids (HCl).
Calcium hydroxide	Lime water (in solution form) or slaked lime	$Ca(OH)_2$	- to make mortar - to neutralize soil acidity - to remove temporary hardness of water. - to manufacture bleaching powder. - to test carbon dioxide gas.

After that, give them **Exercise 1.13** as a homework and proceed to deal with dilute and concentrated acids and bases. Frist, ask the students to explain what dilute and concentrated mean. After you get response from the students, tell them what the terms dilute and concentrated refer to. Make sure that they have understood the two terms clearly and then continue to deal with the safety precautions while working with both acids and bases. You better use question and answer methods during your explanation on the safety precautions. When you complete the explanation, give them **Exercise 1.14** as a homework.

1.3.4 Salts

To teach the contents in this sub-section, you better use question and answer, group discussion, experiment and gapped lecture as methods of teaching.

You can start the lesson by asking students oral question to tell you what salt is. After you get feedback from two students, continue with **Activity 1.20.** This activity is designed to help students realize that salts us important groups of compounds used in our daily lives. So, have them discuss this activity for a few minutes in groups. After they complete the discussion, let two or three students share their findings to the rest of the class. Following their presentations, harmonize concepts using the following note.

a. Sodium chloride is the salt used to prepare our foods.

b. Sodium hydrogen carbonate is used to make baking powder.

c. Calcium carbonate is the constituent of limestone and marble.

a. they can mention the salts like ammonium phosphate, potassium nitrate, ammonium sulphate, ammonium chloride, calcium hydrogen phosphate, etc.

b. potassium nitrate is used to make gun powder.

Then continue to explain about salt. Give emphasis that the term ‘salt’ doesn’t refer only to the salt that we use to prepare our food which is commonly known as **table salt**.

Mention that salts are used for various purposes such as raw materials for the industrial production of different substances such as fertilizers, building materials, etc. Besides this, help them to recall what they have learned about neutralization reaction. Mention that these reactions result in the formation of salts.

After giving a short explanation on what salts are, continue to deal with naming salts. Introduce to students that group names of salts are related to the names of the acids from which they are derived. Mention some examples from **Table 1.2** given in the student text. Then proceed to deal with **Activity 1.21.** This activity is designed to assist students realize how they can get group names of salts. Have the students discuss this activity in groups for a few minutes. When they complete the discussion, encourage one student to

share his/her group's opinion to the rest of the class. Next, harmonize concepts by telling them the group names of salts derived from hydrochloric acid, nitric acid and sulphuric acid are chlorides, nitrates and sulphates, respectively.

After that, continue to deal with the way how we can get the name of a specific salt. Mention that the first word in the name of the salt is derived from the name of the base, and the second word from the name of the acid. Give two or three examples. Before you name the salt yourself, let the students attempt to name it. Here, you need to write only the name of the base and the name of the acid from which the salt is derived in the following manner.

$$\text{Name of Acid} + \text{Name of base} \rightarrow \text{name of salt} + \text{water}$$

From the equation, allow them to suggest the name of the salt. If they are not able to name the salt correctly, tell them the correct name.

You are also expected to help students how they can identify the acid and the base combinations that form a specific salt from the name of that salt. Give some examples for the students encouraging them to attempt first on their own.

When you complete this task, ask students if they can define salt in relation to positive and negative ions. After their attempts, tell them that a salt is a compound containing a positive ion derived from a base and a negative ion derived from an acid. At the end, give them **Exercise 1.15** and **1.16** as a homework.

Note for the teacher

1. In case of naming salts of binary acids like hydrochloric acid, hydrobromic acid, hydrochloric acid, hydrosulphuric acid, etc, you need to drop the prefix 'hdyro' and change the ending '– ic acid' to '-ide'-. Thus, the second word in the name of the salt becomes; chloride, bromide, iodide, sulphide, etc.
2. In case of naming salts derived from ternary or oxy acids such as nitric acid, chloric acid, etc. change the ending '- ic acid ' to '-ate' to get the words, nitrate, chlorate, etc.
3. To name salts derived from the acids such as sulphuric acid and phosphoric acid, modify the main word in the name to end in '-ate' to get the words sulphate and phosphate.

Make sure that students have realized the concepts on salts and how to name them and continue to deal with the classification of salts. Introduce to students the basis for the classification of salts as binary and ternary, and give them **Exercise 1.17** as a classwork

and check their work.

After that, proceed to deal with the preparation of salts. First, treat the preparation of salts by direct combination of metals and non-metals. Mention that this method is used only to make binary salts and it cannot be used to prepare ternary salts. Then, continue to introduce to students how salts are prepared by neutralization reaction. Write the general word equations for the neutralization reactions of basic oxides and metal hydroxides with acids. Let students write some equations for reactions that involve metallic oxides and acids as well as metal hydroxides and acids.

Check how students are doing. Then, continue with **Activity 1.22.** This activity is designed to help students gain more knowledge in identifying the metal oxide or metal hydroxide and the acid that should react to form a specific salt. So, have the students discuss this activity in groups for a few minutes and some group representatives share their findings to the rest of the class. Next, harmonize concepts as follows; you can ask them to write the balanced equations for the preparation of each salt while harmonizing

a. Calcium sulphate can be prepared by the reaction of sulphuric acid with calcium oxide or calcium hydroxide.

$$CaO + H_2SO_4 \longrightarrow CaSO_4 + H_2O$$

$$Ca(OH)_2 + H_2SO_4 \longrightarrow CaSO_4 + 2H_2O$$

b. Magnesium nitrate is prepared by reacting nitric acid with magnesium oxide or magnesium hydroxide.

$$MgO + 2HNO_3 \longrightarrow Mg(NO_3)_2 + H_2O$$

$$Mg(OH)_2 + 2HNO_3 \longrightarrow Mg(NO_3)_2 + 2H_2O$$

c. Aluminium chloride is prepared by reacting either aluminium oxide or aluminium hydroxide with hydrochloric acid.

$$Al_2O_3 + 6HCl \longrightarrow 2AlCl_3 + 3H_2O$$

$$Al(OH)_3 + 3HCl \longrightarrow 2AlCl_3 + 3H_2O$$

d. Potassium nitrate is prepared by reacting either potassium oxide or potassium hydroxide with nitric acid.

$$K_2O + 2HNO_3 \longrightarrow 2KNO_3 + H_2O$$

$$KOH + HNO_3 \longrightarrow KNO_3 + H_2O$$

After harmonizing concepts, demonstrate **Experiment 1.10.** Before the demonstration, prepare solutions of equal concentration of hydrochloric acid and sodium hydroxide for the second part of the experiment. When you demonstrate the first and the second part

of the experiment, students should watch what is going on in each part and record their observations. After the demonstrations, they should write a laboratory report in groups on each part and submit it for you. While correcting the reports, make sure that the following points are included in the observation and analysis part of the experiment.

For part I of the experiment

a. Copper (II) oxide is dark – brown powder.

b. The solution turns blue due to the reaction of the oxide with the acid.

c. The colour of the crystal is blue and the crystal is copper sulphate.

d. The equation for the reaction is:

$$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$$

For part II of the experiment

a. The colour of red litmus is changed to blue indicating that the solution is still basic.

b. 15 mL of hydrochloric acid if the acid and the base have the same concentration.

c. When the neutralization reaction is complete, and the solution obtained after mixing the acid and the base is neutral.

d. White crystal and the compound is sodium chloride.

e. The equation for the reaction is:

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$

Before you conclude this section, give **Activity 1.23** as a group work for the students to do it. You should tell them to do the activity two or three days before the period you intend to treat the activity. The activity is suggested to help students to develop skills in achieving a certain knowledge on their own. You can tell them to prepare the complete table on a chart paper using markers for use during presentation. During the period at which you deal with this part, let some students from different groups produce a three-minutes presentation to their classmates. After that, you need to harmonize the ideas suggested by the students with the fact, using the following table.

Name of the salt	Formula of the salt	Name of acid and base that form the salt	Important uses
Sodium Chloride	NaCl	Sodium hydroxide and hydrochloric acid	- to prepare food - in the manufacturing of sodium, sodium hydroxide and chlorine - to make sodium hydrogen carbonate
Calcium carbonate	$CaCO_3$	Calcium hydroxide and carbonic acid	- in the extraction of iron - as building material in the form of limestone and marble - in the manufacture of glass - to produce calcium oxide (quick lime) and calcium hydroxide.
Sodium bicarbonate (hydrogen carbonate)	$NaHCO_3$	Sodium hydroxide and carbonic acid	- to make baking powder. - in fire extinguishers
Potassium nitrate	KNO_3	Potassium hydroxide and nitric acid	- as a fertilizer - to make gun powder
Diammonium phosphate (DAP)	$(NH_4)_2 HPO_4$	Ammonium hydroxide and phosphoric acid	- as a fertilizer

Assessment

Assess each student's work throughout section 1.3. Your assessment of each student's work can be based on the record you have related to his/her involvement in:

- group discussion on activities 1.5 – 1.22.
- presentation after discussion on Activities 1.5 – 1.22.
- performing **Experiment 1.1** – **1.10**
- presentation after **Experiment 1.1**, **1.4**, **1.6**, **1.7**, **1.8** and **1.9**.
- writing laboratory reports on **Experiments 1.2, 1.3, 1.5** and **1.10**
- answering questions during mini – lecture or harmonizing

- doing classwork and homework accordingly
- answering questions given as quiz or test.

Based on your record, check whether or not the suggested competencies are achieved. In case of students who are working above the minimum requirement level, appreciate their achievements and give them additional work. For those who are working below the minimum requirement level, arrange additional lesson time or give them additional Exercises so that they can catch up with the rest of the class.

Additional Questions

1. Classify each of the following as acidic oxide and basic oxide.

   a. Li_2O c. MgO e. P_2O_5

   b. SO_2 d. Na_2O f. N_2O_3

2. Write the acid anhydrides of the following acids.

   a. H_2CO_3 b. HNO_2 c. H_2SO_3

3. Complete and balance the following equations.

   a. $MgCO_3 \xrightarrow{heat}$ b. $Fe(NO_3)_2 \xrightarrow{heat}$ c. $Ca(OH)_2 \xrightarrow{heat}$

4. Identify incorrect statements and give reason for your answer.

   a. Acids taste bitter b. Acids have a pH value less than 7

   c. Bases feel soapy d. Bases change blue litmus to red.

   e. Acidic oxides are also called acid anhydrides.

   f. Potassium chloride is a normal salt.

Answer to Additional questions

1. Acidic oxide: SO_2, P_2O_5, N_2O_3

   Basic oxide: Li_2O, MgO, Na_2O

2. a. CO_2 b. N_2O_3 c. SO_2

3. a. $MgO + CO_2$ b. $2FeO + 4NO_2 + O_2$ c. $CaO + H_2O$

4. ‘a’ and ‘d’ are Incorrect, because acids taste sour and bases change red litmus to blue.

Answers to Exercise 1.7

Compounds a, c, d and f are binary compounds; also c, d and f are oxides.

Answers to Exercise 1.8

1. A. Magnesium oxide
   B. Zinc oxide
   C. Ferric oxide or Iron (III) oxide
   D. Lithium oxide
2. Basic oxides: a, c

   Acidic Oxide: d,

   b is not acidic or basic oxide.

Answers to Exercise 1.9

1. Basic oxides: a and c

   Acidic oxides: b and d

2. A is an acidic oxide. The name of this particular oxide is tefra phosphorus hexoxide (P_4O_6)

   B is basic oxide such as calcium oxide (CaO) and magnesium oxide (MgO)

3. a and b are basic oxides which produces bases in water solution.

   c and d are acidic oxides which produces acids in water solution.

4. Oxides of metals form basic solution when dissolved in water, their reactions with acids produce salt and water. Oxides of non-metals form acids when dissolved in water and they react with bases to form salt and water.

5. a, b and d are acidic oxides, c and e are basic oxides.

6. a. N_2O_5, NO_2
   b. Na_2O
   c. K_2O
   d. SO_3
   e. CO_2

Answers to Exercise 1.10

1. Thermal decomposition of metal nitrates produce a metal oxide (basic oxide), nitrogen dioxide (an acidic oxide) and oxygen. Thermal decomposition of carbonates yield metal oxide (basic oxide) and carbon dioxide (an acidic oxide).

2. An acidic oxide produces an acid when combined with water. It is a non-metallic oxide like sulphur dioxide.

   A basic oxide produces a base when combined with water. It is a metallic oxide like copper oxide.

   Nitrogen dioxide is an acidic oxide and Lithium oxide is a basic oxide.

Answers to Exercise 1.11

1. a. hydrochloric acid b. nitric acid c. sulphuric acid
2. a. pH < 7 b. pH = 7 c. c and d pH > 7
3. a. $SO_2(g) + H_2O(l) \rightarrow H_2SO_3$
   b. $CO_2(g) + H_2O(l) \rightarrow H_2CO_3$ (carbonic acid)
   c. $P_2O_3(g) + 3H_2O(l) \rightarrow 2H_3PO_3$(phosphorous acid)

Answers to Exercise 1.12

1. a. Red b. Red c. Colourless
2. Hydrogen ion
3. Hydrochloric acid, Hydrobromic acid and Hydrofluoric acid (use equations given as answers to **Activity 1.12**)
4. Hydrochloric acid
5. Nitric acid
6. Sulphuric acid
7. In the production of sulphate and phosphate fertilizers.

Answers to Exercise 1.13

1. a. By the reaction of potassium metal or potassium oxide with water.
   b. By the reaction of calcium metal or calcium oxide with water.
   c. By the reaction of magnesium oxide and water.
2. Bases have bitter taste, feel soapy to touch, neutralize bases and affect the colours of indicators.
3. Using indicators
4. Potassium hydroxide, KOH
5. Sodium hydroxide, NaOH
6. Calcium hydroxide, $Ca(OH)_2$
7. Magnesium hydroxide, $Mg(OH)_2$

Answers to Exercise 1.14

1. A concentrated base contains relatively large amount of a base while a dilute base contains a little amount of a base in a given volume of solution.

2. a. washing the eyes with plenty of water and then seek medical treatment.
   b. drinking 1.2% solution of acetic acid or lemon juice.

Answers to Exercise 1.15

1. a. Barium sulphate + water
   b. Calcium nitrate + water
   c. Potassium chloride + water
   d. Sodium iodide + water
2. a. Sodium hydroxide and sulphuric acid
   b. Potassium hydroxide and nitric acid
   c. Calcium hydroxide and sulphuric acid
   d. Lithium hydroxide and hydrochloric acid
   e. Magnesium hydroxide and hydrochloric acid

Answers to Exercise 1.16

	Positive ion	**Negative ion**
a.	Sodium hydroxide,	Nitric acid
b.	Calcium hydroxide,	Hydrochloric acid
c.	Barium hydroxide,	Hydrochloric acid
d.	Potassium hydroxide,	Sulphuric acid
e.	Ammonium hydroxide,	Nitric acid
f.	Copper hydroxide,	Sulphuric acid

Answers to Exercise 1.17

a.	Binary, $AlCl_3$	d.	Binary, CaI_2	h.	Ternary, $CaSO_4$
b.	Ternary, $CuSO_4$	e.	Binary, KCl	i.	Ternary, $Pb(NO_3)_2$
c.	Ternary, $Ba(NO_3)_2$	f.	Binary, CaS		

Answers to the Review Exercises on Unit 1

I. Matching

1. C	2. G	3. F	4. D	5. E	6. A	7. B

II. Multiple Choices

8. C	9. B	10. C	11. D	12. A	13. C	14. A
15. D	16. C	17. B	18. A	19. B	20. C	21. D
22. D	23. C	24. B	25. A			

III. Short Answers

26. a. Butane b. Heptene c. Ethyne

27. a. C_4H_{10} b. C_3H_6 c. C_6H_{10}

28. a. Phosphoric acid, H_3PO_4 and potassium hydroxide, KOH
    b. Ssulphuric acid, H_2SO_4 and sodium hydroxide, NaOH
    c. Hydrobromic acid, HBr and calcium hydroxide, $Ca(OH)_2$
    d. Hydrochloric acid (HCl) and Copper(II) hydroxide ($Cu(OH)_2$).

29. Sodium chloride, NaCl

30. Calcium carbonate $CaCO_3$

31. Potassium nitrate, KNO_3

References

Darrell D. Ebbing, Steven D. Gammon, ***General Chemistry***, 6th edition, 1999, Houghton Mifflin Company, New York.

Donald A. McQuarrie, Peter A. Rock, ***General Chemistry***, 1984, W.H. Freeman, New York.

Jean B. Umland, Jon M. Bellema, ***General Chemistry***, 3rd edition, 1999, Brooks/Cole, Pacific Grove.

John, C. K. and Paul, M. T. ***Chemistry and Chemical Reactivity***, 5th edition). 2003, USA: Thomson Learning Inc.

Kenneth W. Whitten, Raymond E.Davis, M. Larry Peck, George G. Stanley, ***General Chemistry***, 7th edition, 2004, Brooks/Cole, Belmont.

Martin S. Silberberg, **Chemistry, the molecular Nature of Matter and Change**, 4th edition, 2006, Mc Graw Hill, New York.

Ralph H. Petrucci, William S. Harwood, ***General Chemistry – Principles and Modern Application,*** 6th edition, 1993, Macmillan, New York.

Raymond Chang, ***Chemistry***, 3rd edition, 1988, Random House, New York.

Stephen, H. S. ***Organic and Biological Chemistry***, 2nd edition, 2001, USA: Houghton Mifflin Company.

Steven S. Zumdahl, ***Chemical Principles***, 3rd edition, 1992, D.C. Health and Company, Toronto.

Theodore L. Brown, H. Eugene LeMay, Jr. and Bruce E. Burten, ***Chemistry – the Central Science***, 8th edition, 2000, Prentice Hall, New Jersey.

Zumdahl, A. S., ***Chemistry***, 5th edition, 2000, USA: Houghton Mifflin Company.

WEBSITES

1. http://chemistry.about.com/od/lecturenoteslabs/a/Alkanes.htm
2. http://en.wikibooks.org/wiki/Organic_Chemistry/Alkanes

3. http://www.mhhe.com/physsci/chemistry/carey/student/olc/ch02alkane.html
4. http://www.cliffsnotes.com/study_guide/Alkanes-Halogenation.topicArticleId-22667,articleId-22607.html
5. http://www.chemguide.co.uk/organicprops/alkanes/background.html
6. http://en.wikipedia.org/wiki/Alkene
7. http://www.chemguide.co.uk/organicprops/alkenemenu.html
8. http://www.chemguide.co.uk/organicprops/alkenes/background.html
9. http://www.elmhurst.edu/~chm/vchembook/503alkenes.html
10. http://research.cm.utexas.edu/nbauld/teach/alkenes1.html
11. http://en.wikipedia.org/wiki/Alkyne
12. http://www.ucc.ie/academic/chem/dolchem/html/dict/alkynes.html
13. http://www.chem.ucalgary.ca/courses/351/Carey5th/Ch09/ch9-1.html
14. http://www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/addyne1.htm
15. http://en.wikipedia.org/wiki/Oxide
16. http://www.rod.beavon.clara.net/oxides.htm
17. http://www.answers.com/topic/oxide
18. http://www.britannica.com/EBchecked/topic/436674/oxide
19. http://en.wikipedia.org/wiki/Acid
20. http://www.elmhurst.edu/~chm/vchembook/181acids.html
21. http://www.shodor.org/unchem/basic/ab/
22. http://www.bbc.co.uk/schools/ks3bitesize/science/chemical_material_behaviour/acids_bases_metals/revise1.shtml
23. http://www.streetdirectory.com/travel_guide/27207/medical_conditions/four_major_negative_effects_of_alcohol.html

UNIT 2 SOME IMPORTANT METALS

Total periods allotted: 12

Unit Overview

This unit is divided into eight subunits. The first subunit discusses about the general properties of metals. The second subunit discusses about sodium and potassium. The occurrence important ores and uses of sodium and potassium are the main issues discussed here. It only puts much emphasis to the common uses and main ores. The third subunit is about magnesium and calcium. The students should have clear idea about the occurrence, common ores and uses of these metals.

The fourth subunit is totally devoted to aluminum. Like the previous metals, much emphasis is given to the occurrence, important ores and uses. The fifth subunit is about the common metal that exhibits a wide range of application in every sector of the economy starting from prehistory till now. This metal is Iron. Its occurrence, important ores and uses need to be thoroughly discussed.

Copper and silver have been known since ancient times. The sixth unit discusses about the occurrence, important ores and uses of these metals. Then what come are occurrence, important ores and uses of the precious metals gold, platinum and tantalum in subunit seven. Finally, alloys, the main advantages of alloying and their importance is discussed in subunit eight.

In these days, the methods of teaching are shifted from traditional lecture method, which puts little emphasis on students' participation in teaching-learning process, to active learning methods. The key concept in active learning is that *knowledge* is not transferred; information is transferred but *knowledge is created* when a student thinks about the information. Hence, in active learning, you should provide your students with opportunities to do some work based on the ideas you have given them or from what they already know. Therefore, active learning methods such as group discussion, gapped lecture, experiment, demonstration, role play, brainstorming, independent work, drama, spider diagram, flash cards, matching activities and other appropriated methods can be used. These techniques could obviously help students to have a better mind setup and strive for active learning method.

Unit Outcomes

After completing this unit, students will be able to:

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

Main Contents

2.1 GENERAL PROPERTIES OF METALS

Periods Allotted: 1 period

Competencies

After completing this section, students will be able to:

- *mention general properties of metals;*
- *investigate general properties of metals practically; and*
- *present a report of your project work on the properties of fe, ag, and au after visiting the works of black smiths and goldsmiths.*

Forward Planning

Dear teacher, since students will learn using active learning methods, it is advisable to plan group formations. In addition, prior reading about some common properties of

common metals from any literature of chemistry is very important. Because it reduces burden and makes the students' participation active.

Teaching Aids

Some available metals in the vicinity and periodic table.

Subject Matter Presentation

For this subunit, brainstorming, group discussion and presentation can be used as active learning methods.

You can start this topic by grouping students and letting them discuss the **start-up activity**. The start-up activity helps them to brainstorm about the place of some elements in the periodic table and related properties. In addition, it would let them think about the physical and chemical properties of these elements. You can facilitate their discussion by clarifying misconceptions (if any). Some students may not be active in group discussions due to various reasons. It would, therefore, be better to identify these students and encourage them to participate in their respective groups. After their discussion, allow them to share their ideas with other group members. Then, harmonize their discussion by providing the following answers.

In the boxes which contain numbers 1, 3, and 11 (the alkali metals) students are supposed to write letter 'A', in the boxes contained by numbers: 2, 10, and 18 (noble gases) letter 'N' and letter 'P' in the box which is occupied by number 9 (the most active non-metal is fluorine). Finally, put letter 'C' in the boxes contained by the numbers 4 and 12 (the alkaline earth metals with a valence of 2 form a compound with the general formula CP_2 with fluorine which is one of the halogen family) .

You can use gapped lecture to discuss the general properties of metals. To illustrate the properties of metals you can collect different metals and explain the common properties. **Activity 2.1** is anticipated to help you know prior knowledge of students on the general properties and uses of metals. Then, guide the students to perform **Experiment 2.1** watchfully. Students should be in a position to identify that metals are conductors of electricity and non-metals except carbon in the form of graphite are non-conductors. Metals are lustrous while non-metals are not and make students identify metals from non-metals by their physical appearance.

The very high malleability and ductility of metals such as silver and gold could be understood clearly by students if the practically see it by visiting the nearby goldsmiths and blacksmiths – **Project 2.1.**

Assessment

You assess each student's work continuously throughout the subunit. This can be done by preparing a performance sheet and recording the performance of every student. You can make records based on students' performance in discussing the start-up activity, presenting their views after discussion and answering the questions in **Exercise 2.1.**

By observing their performances from the record, provide them with feedback to improve students' learning (formative assessment). In addition, you can use self-assessment and peer assessment methods to enhance students' performance. Appreciate students working above the minimum required level and encourage them to continue working hard. For low achievers, identify their learning difficulties and help them to achieve the minimum required level for this subunit.

Additional Questions

Gifted students should answer all the questions. However, questions indicated by asterisks are for low achievers. You can use this convention throughout this Teachers Guide.

*1. Classify the following elements as metal and non-metal.

a. Phosphorous	d. Calcium	g. Copper
b. Carbon	e. Sulphur	h. Nitrogen
c. Tungsten	f. Magnesium	i. Sodium

2. Which metals are the most malleable and ductile?

3. Which metal is widely used in household electric system?

*4. Are there metals which are found in the liquid state at room temperature?

Answers to Additional Questions

1. a, b, e, and h are non-metals. c, d, f g, and i are metals
2. the coinage metals silver and gold
3. copper
4. So far one metal (mercury) is known to be liquid at room temperature.

Answers to Exercise 2.1

1. Metals except mercury are solid under ordinary conditions. Non-metals can be obtained in the three states of matter. Metals are shiny while non-metals are dull. Metals are conductors of electricity while non-metals are not. Most metals are hard, malleable and ductile whereas non-metals are brittle. Metals produce a high pitch sound when struck – resonant (sonorous) but non-metals are not.
2. Tungsten
3. Mercury
4. Gold, silver and copper

2.2 SODIUM AND POTASSIUM

Periods Allotted: 2 periods

Competencies

After completing this section, students will be able to:

- *explain the occurrence of sodium and potassium;*
- *list common ores of sodium and potassium; and*
- *discuss the uses of sodium and potassium.*

Forward Planning

Prior reading about the physical properties of sodium and potassium like that it is soft solid which can be scratched by a finger nail though it is very harmful to do so, tarnishes in air and loses it metallic luster.

Sodium and potassium are the most active metals that they can't be found in nature in the free state. Students should read about the most common compounds of sodium and potassium and the uses of these metals.

Teaching Aids

Sodium metal usually stored in a liquid paraffin and periodic table of the elements.

Subject Matter Presentation

For this subtopic, gapped lecture, group discussion, presentation, and independent work can be used as active learning methods. Here, draw the attention of the students towards the occurrence, important ores and uses of sodium and potassium in their metallic forms and compounds of sodium and potassium. Explain why sodium is stored in liquid hydrocarbon.

Activity 2.2 is intended to create awareness regarding the very nature of the two most active metals which can't be obtained native in nature, and potassium is one of the main plant nutrients and absorbed by plants in the form of potassium ion (K^+). Besides, people in ancient times could not isolate these active metals from their compounds. Notice that the least active metals like gold and silver were easy to extract because they are obtained freely in nature. The alkali metals are the strongest reducing agents known; therefore, they can't be prepared by chemical reduction of their oxides. The principal compounds from which sodium and potassium metals are extracted are NaCl and KCl. Thanks for Sir Humphrey Davy who first isolated sodium from molten sodium chloride and potassium from molten potassium chloride.

Inform the students to read independently the common ores and general methods of extracting sodium and potassium metals from literatures of chemistry. Give them **Activity 2.3** as homework. This activity helps the students to go through the uses of

sodium and potassium compounds. For example sodium chloride is used as a food preservative and additive in food which has medicinal value, sodium hydroxide in soap making and other industrial processes, sodium carbonate and sodium sulphate in glass factories, potassium nitrate and potassium chlorate in gun powders (explosives), potassium manganite (VII) as medicine and drying agent.

Soluble salts of potassium are used as fertilizers. Fertilizers must be soluble so as to furnish the plant with the cation or anion required for its growth. All salts of potassium are soluble.

Similarly, help the students to discuss on **Exercise 2.2** as a classwork. Finally, harmonize the points of discussion.

Additional Questions

1. What is the most important information you should know about potassium phosphate and sodium phosphate?
2. Who should not take potassium phosphate and sodium phosphate?
3. Who discovered sodium and potassium?
4. Why is sodium and potassium so important?
5. Why are sodium and potassium stored in liquid paraffin's?

Answers to Additional Questions

1. Do not take antacids containing aluminum, calcium, or magnesium while taking potassium phosphate and sodium phosphate, except under the supervision of your doctor. Antiacids may decrease phosphate absorption.
2. One cannot take potassium phosphate and sodium phosphate if he/she has *high levels of potassium in his/her body, high levels of phosphorous in his/her body, infected phosphate stones, or Severe kidney disease.*

   Before taking potassium phosphate and sodium phosphate, one should tell to his/her doctor that he/she has *a bowel obstruction, heart disease, high blood pressure, kidney disease, liver disease or cirrhosis, swelling or water retention, high levels of sodium in your body, low levels of calcium in your body, pancreatitis, or Rickets.*

   One may not be able to take potassium phosphate and sodium phosphate, or may require a lower dose or special monitoring if he/she has any of the conditions listed above.

3. Sir Humphrey Davy
4. Because potassium-rich foods, including fruits and vegetables, have long been recommended as a dietary defense against heart disease and other chronic illnesses.

"If you have too much sodium and too little potassium, it's not as good as than either one on its own," said researchers, who have led efforts to get the public to eat less salt.

Potassium may neutralize the heart-damaging effects of salt. Sodium increases the risk of high blood pressure, a major cause of heart disease and stroke. Salt – or sodium chloride – is the main source of sodium for most people.

The research found people who ate a lot of salt and very little potassium were more than twice as likely to die from a heart attack as those who ate about equal amounts of both nutrients. Such a dietary imbalance posed a greater risk than simply eating too much salt, according to the researchers. Exactly how potassium and salt interact is not understood, and no one believes that simply taking a potassium pill will protect someone against the dangers of a high-salt diet. What health officials have been saying for years is "eat a lot of fresh fruits, vegetables and other potassium-rich foods, and eat less salty, processed foods."

Health officials say no one should eat more than 2,300 milligrams of sodium a day, equal to about a teaspoon of salt. Certain people, such as those with high blood pressure, should eat even less.

5. **Sodium** and **potassium** are stored in **liquid hydrocarbons** because pure sodium and potassium are very reactive; they will react with the air in oxygen. Paraffin will not react with sodium and potassium.

   If you want a more chemical, in-depth answer, sodium and potassium exist as relatively stable ions. Hydrocarbons are typically nonpolar covalent compounds. Therefore, sodium and potassium will not react with them.

Answers to Exercise 2.2

1. Sodium
2. Rock salt, Chile salt peter, sodium sulphate, potassium nitrate, potash, borax, etc.
3. Because alkali metals such as sodium and potassium react with oxygen in the atmosphere.
4. They are used to reduce metals like platinum from their ores

- An alloy of sodium and potassium is used as a coolant in some nuclear reactors
- Metallic sodium is crucial in the manufacturing of organic compounds. A chemical heat transfer unit often uses alloys of sodium.

5. Sodium and chlorine. Huge deposits of rock salt are found in Tigray and Afar regional states.

2.3 MAGNESIUM AND CALCIUM

Periods Allotted: 2 periods

Competencies

After completing this section, students will be able to:

- *explain the occurrence of magnesium and calcium;*
- *list common ores of magnesium and calcium; and*
- *discuss the uses of magnesium and calcium.*

Forward Planning

One of the most important principles of good teaching is the need for planning. Far from compromising spontaneity, planning provides a structure and context for teacher and students, as well as a framework for reflection and evaluation.

We have seen that one of the advantages of group discussions is that it provides opportunities for in-depth discussion, reflection and consolidation of learning. Group discussion is also costly in terms of time and physical resources, so it is important to maximize the learning that can be achieved by forward planning and appropriate structuring of activities. Take enough time to prepare for the class. Read the contents on occurrence, important ores and uses of calcium and magnesium and the compounds of these metals. Get ready on the activities and exercises before you enter to the class.

Teaching Aids

Magnesium ribbon, chalk, marble, cement and periodic table of the elements.

Subject Matter Presentation

To start the discussion on occurrence, important ores and uses of the alkaline earth metals magnesium and calcium, give **Activity 2.4** for the students as a classwork and let them relate this activity with **Activity 2.2** number 2 and discuss in group. **Experiment 2.2** assists students to understand the effect of magnesium and calcium on soil. It appears that brief explanation about liming is very important to start the discussion on the observation and analysis of the experiment. The following points may help to harmonize the general idea:

All soils contain calcium ions (Ca^{2+}) and magnesium (Mg^{2+}) cations (positively charged ions). The amount and relative proportion usually reflect the soil's parent materials. Ca and Mg are plant-essential nutrients. The presence of these metals in the soil decrease soil acidity. Soil acidity has a negative impact on fertility, biological activity and plant productivity.

Soil pH influences nutrient availability. In strongly acid soils calcium and magnesium are depleted due to leaching.

Prevention is better than cure!

As acidity is a slow process and the correction of acidity by liming is also slow where possible soils need to be limed before acidity is having an effect.

Inform students that magnesium burns with an intense white light at high temperature. You can show them by burning a piece of magnesium ribbon and discuss accordingly the uses of magnesium in flares and fireworks.

Activity 2.5 is designed to help students easily identify the uses of some calcium and magnesium compounds. Let them research on the uses of the selected compounds and metallic elements Ca and Mg. When they complete, invite some of the students to present their ideas to the class. After their presentations, harmonize concepts using the following information:

- Magnesium oxide is used for making furnace lining. Discuss the heat resisting ability of the oxide of magnesium and this is the reason why it is used for this special purpose.
- Magnesium hydroxide, magnesium chloride, magnesium sulphate and magnesium citrate have medicinal applications.
- Calcium hydroxide or calcium oxide may be used to decrease soil acidity.
- What's the difference between "cement," "concrete" and "mortar?" Powdered limestone is mixed with powdered clay and heated in a rotary kiln to produce cement. Cement is a fine gray powder which is used to make mortar and concrete. Often, the terms "cement," "concrete" and "mortar" are used almost interchangeably by the layman in conversations about cement mixing. However, the terms refer to substances that have three different purposes:

Cement mixing therefore, properly speaking, refers to using cement in the mixing of mortar or concrete.

Mortar is made by mixing cement with lime, sand and water. Mortar is used in between bricks or stones for wall building, or as a covering surface for walls.

Concrete is made by mixing cement with sand, water and rock pieces. The rock pieces (called aggregate) may be of various sizes. Concrete sets like stone, and is widely used as a building material. Concrete can be reinforced with steel rods or cables, making the material stronger.

- Calcium metal is used as a deoxidizer in the steel industry, i.e. it is used to remove oxygen from a molten metal. It is also used to remove sulphur compounds from crude oil. In both cases calcium is acting as a reducing agent.

Next to the above activity let the students discuss on **Exercise 2.3** for some time and facilitate their activities.

Assessment

You can assess students' performance based on your record about each student's performance in discussing from **Activity 2.4 to 2.5**, presenting their views after discussion, and answering the question in **Exercise 2.3.**

In addition, you can assess their performance by letting them reflect their reports for **Experiment 2.2**. By observing their performances from the record, provide them with a feedback to improve students' learning. Appreciate students working above the minimum required level and encourage them to continue working hard. For low achievers, identify their learning difficulties and help them to achieve the minimum required level for this subunit.

Additional Questions

1. *What is calcium carbonate and magnesium hydroxide used for?*
2. *What is the most important information you should know about calcium carbonate and magnesium hydroxide?*

Answers to Additional Questions

1. The combination of calcium carbonate and magnesium hydroxide is used as an antacid to relieve indigestion, upset stomach, and heartburn. Calcium carbonate and magnesium hydroxide may also be used for purposes not listed in this medication guide.
2. You should not use this medication if you have ever had an allergic reaction to an antacid. Ask a doctor or pharmacist before taking this medicine if you have kidney disease. Avoid taking other medications at the same time you take an antacid. Some antacids can make it harder for your body to absorb certain drugs, making them less effective.

Answers to Exercise 2.3

1. The main raw materials used in the cement manufacturing process are limestone, and clay. The main material, limestone, is usually mined on site while the other minor materials may be mined either on site or in nearby quarries.
2. The reason why the metal surface tarnishes when magnesium is left in moist air for several hours is because of the reaction of magnesium with air forming magnesium oxide.
3. Brilliant white

4.

a. Calcium carbonate, $CaCO_3$, the alkaline earth metal is Ca.
b. Calcium hydroxide, $Ca(OH)_2$, the alkaline earth metal is Ca.
c. Calcium oxide, CaO, the alkaline earth metal is Ca.
d. Calcium sulphate dihydrate, $CaSO_4.2H_2O$, the alkaline earth metal is Ca.
e. Magnesium sulphate, $MgSO_4$, the alkaline earth metal is Mg.

2.4 ALUMINUM

Periods Allotted: 1 period

Competencies

After completing this section, students will be able to:

- *explain the occurrence of aluminum;*
- *list common ores of aluminum; and*
- *discuss the uses of aluminum.*

Forward Planning

There are four fundamental questions a teacher should ask himself when planning a teaching period.

1. Who am I teaching? The number of learners and their study level or stage in training.
2. What am I teaching? The topic or subject, the type of expected learning (knowledge, skills, and behaviors).
3. How will I teach it? Teaching and learning methods, length of time available, location of teaching session, access to students, internet resources, etc. What do the learners know already?
4. How will I know if the students understand? Informal and formal assessments, questioning techniques, feedback from students. What are the learners going on to next?

What do the learners want to know or be able to do as a result of your teaching? And how will I find this out? How will I build in flexibility to address unforeseen learning needs?

Bearing this in mind, manipulate a technique of teaching which avoids boring approach of the subject because as you already know there are terms which are repeated in every section like occurrence, important ores, and uses.

Teaching Aids

Aluminum foil and periodic table.

Subject matter presentation

For this section, gapped lecture, group discussion, presentation, and independent work can be used as active learning methods.

You can use gapped lecture to discuss the occurrence, important ores and uses of aluminum. Then let them do A**ctivity 2.6** and present their answers to the class. Facilitate group discussions by clarifying vague ideas to them. This activity lets them to draw their attention to the topic under discussion. Harmonize their discussions by providing the following answer.

The method of extraction of gold was simple as compared to aluminum. Even these days aluminum is extracted using the process of electrolysis which needs electric energy but gold is mined from natural deposits. Therefore the production of aluminum was not as simple as gold and aluminum was expensive. The possible reason why aluminum was not in a position to be isolated until the early nineteenth century is that aluminum is a relatively reactive metal, meaning that it easily bonds with other elements to form a compound. For this reason, it is seldom found in nature as pure aluminum. Recent methods of extraction such as electrolysis have enabled reactive metals, such as aluminum, to be separated from its ore to its pure form. In summary, Al wasn't discovered till much later due to its reactivity and difficulty to extract.

Danish chemist Hans Christian Orsted first produced aluminum in 1825 by reacting aluminum chloride with potassium amalgam. Therefore, Orsted is considered to be the discoverer of aluminum.

Finally, let students perform **Activity 2.7** and **Exercise 2.4** at home or elsewhere referring to any material which is thought to be helpful for their further knowledge. Then facilitate the discussion by forwarding the following ideas.

Reduction of metal oxides with aluminum powder in which a huge amount of heat is liberated is called **thermite** process.

Thermite process is very useful for the welding of broken metal parts. When Aluminum powder reacts with iron oxide, a large amount of heat is released and about a temperature of 3500 ^{0}C is attained which is enough to weld broken metallic parts.

$$2Al + Fe_2O_3 \rightarrow Al_2O_3 + 2Fe + heat$$

Discuss some known facts about aluminum like:

- The biggest producers of aluminum metal are Australia, Brazil, Canada, Norway, Russia and the United States.
- Many years ago, aluminum was considered more precious than gold.
- Aluminum is very reactive and is never found uncombined in nature.

- Aluminum is easily recyclable. It requires much less energy to recycle aluminum than it does to extract it in the first place!
- Recycled aluminum has the same physical properties as aluminum.
- While Americans still use the spelling aluminum (the original name given to the element), most countries have now adopted the modified spelling aluminium.

Assessment

After completing each part of the lesson, ask short answer questions. Observe whether the lesson objective is achieved or not. Evaluate students' understanding of what they read from different references of chemistry and their textbook.

Assess each student's work to determine whether the students have achieved the minimum required level or not. Students working at the minimum required level will be able to:

- Discuss the common ores of aluminum and the main ore from which aluminum is extracted. Besides, aluminum is the first most abundant metal in the earth's crust. Students usually confuse the first most abundant element and the first most abundant metal. They have to be clear with it.
- Compare and contrast the method of isolation of the metals in Groups 1 and 2 with aluminum and discuss the difficulties encountered during the isolation of aluminum as compared to sodium, potassium, magnesium and calcium.
- Discuss the common uses of aluminum and the main reasons why aluminum is used for miscellaneous applications.

In order to execute the above requirement level, you may use different instruments of assessment such as classworks, homeworks, assignments, quizzes or tests.

Answers to Exercise 2.4

1. It is used for window frames, door knobs and to make utensils in the kitchen. There are various things that are made out of it at home, like the utensils and foils in which food is packed. It can even be used as a wrinkle remover from clothes; some of the uses also include home decor items like railings, grills, curtain bars as well as artifacts made from aluminum. It is used in making indoor and outdoor furniture, refrigerators, saucepans, kettles, etc.

2. High voltage overhead power lines must satisfy many simultaneous requirements: minimum electrical resistance (to reduce losses), safe clearance above the ground, sufficient strength for the applied loads, and practical cost for the hundredths or thousands of km typically installed. A wide variety of cable specifications are available to meet the demands for different current carrying capacity in many different climates and types of terrain. Long-distance overhead conductors use

aluminum in preference to copper - the lower electrical conductivity being more than compensated by the lower density and cost. Therefore, high electrical conductivity, high ductility, light weight (Aluminum weighs about one third of copper, nickel, brass, and steel. Its specific gravity is 2.7. So the aluminum cables are very light weight, hence suitable for long distance cabling. They are also useful in overhead cabling), high resistance to corrosion, high strength (the high strength of aluminum prevent it from creeping even under high load. However, on overhead transmission lines it is sometimes strengthened with steel) are the most common characteristics of aluminum to be used as electric cables.

3. The principal ore of aluminum is bauxite ($Al_2O_3.2H_2O$).

4. Aluminum forms a protective oxide layer which inhibits further reaction with water and oxygen. An oxide film can be grown on certain metals like aluminum and the thickness of this layer and its properties vary greatly depending on the metal, with only the aluminum and tantalum films being of substantial commercial and technological importance. Aluminum is unique among these metals in that, this oxide coating has diverse and important applications including architectural finishes, prevention of *corrosion* of automobile and aerospace structures, and electrical insulation.

5. a. corrosion resistance

b. Corrosion resistance, light, shining, malleable and ductile.

6. a. Al and O b. Al, Si and O c. Na, F, and Al

7. Aluminum could react with acidic foods to produce hydrogen; the metal would become eroded. In a basic medium containing sodium hydroxide (oven cleaner), aluminum reacts and again the metal become pitted.

2.5 IRON

Periods allotted: 1 period

Competencies

After completing this section, students will be able to:

- *explain the occurrence of iron;*
- *list common ores of iron; and*
- *discuss the uses of iron.*

Forward Planning

Prior reading about the occurrence, important ores and uses of iron is very useful. This section also contains two activities and one exercise which comprise six questions. Hence it is advisable to refer to the answers of these activities and exercises from this

Teachers Guide. Moreover, you need to refer to any available literatures of chemistry to have a prior knowledge about iron, because as you know iron is the metal which people start to use in ancient times. The adoption of this metal during the Iron Age often coincided with the changes in society regarding economic activities (agricultural) and social engagements at that moment.

Teaching Aids

Iron nails, knives, forks, spoons, periodic table, etc.

Subject Matter Presentation

Start the discussion on occurrence, important ores and uses of iron by briefing the students in the introduction minutes. Then give **Activity 2.8** for the students as a classwork and let them discuss in groups and present the group's opinion by their group representatives. The following points may help to harmonize the general idea:

Iron's use by humans dates back about 5000 years. It is the second most abundant metal element in the earth's crust and is primarily used to produce steel, one of the most important structural materials in the world.

The prevalence of one material does not signify that longer known materials were abandoned. Flint continued to be used for the fashioning of simple, every-day tools, though not for making weapons, with ever growing infrequency until Roman times. The use of copper and bronze, even if employed ever more rarely for the fashioning of tools and weaponry, grew during the subsequent ages.

A blacksmith makes many kinds of tools and other objects out of iron. He heats the metal in the forge to make it soft, and then hammers it on an anvil to shape it. The first metal used was Iron. Iron was found to be more easily available and cheaper to produce. Its properties were more useful and desirable than other metals. Iron is still used today but is nearly always alloyed with carbon to make steel, the steel can then be mixed or alloyed with other metals such as nickel to make steels with special properties.

Activity 2.9 is designed to help students easily identify the uses of iron. Let them research on the uses of iron. When they complete, invite some of the students to present their ideas to the class. After their presentations, harmonize concepts using the following information:

Students should be aware that iron is most frequently used as an alloy known as steel which is much stronger than pure iron. Iron in the form of steel can be used to make bicycle frames, tin cans, girders (ferro), car bodies, large structures, cutting tools, chisels, razor blades, drill bits, springs, cutlery, kitchen sinks, surgical instruments, edge of high speed cutting tools, etc.

Finally, let the students discuss on **Exercise 2.5** and harmonize their responses with the concepts discussed in the text.

Assessment

Check whether all the students actively participate during the discussions. Do not forget to record students' performance in the performance list you prepared as you evaluate every activity of the students.

Students working at the minimum required level will be able to:

- Explain the occurrence, important ores and uses of iron.
- List some common ores of iron.
- Tell why iron has been known and used since ancient times. They should be able to deduce that it is easier to isolate iron from its ores than metals discussed in the previous sections.

Answers to Exercise 2.5

1. The most important ores of iron are: Heamatite (Fe_2O_3), Limonite ($Fe_2O_3.H_2O$), Magnetite (Fe_3O_4), Iron pyrite (FeS_2) and Siderite ($FeCO_3$).
2. An ore is a mineral or mixture of minerals from which economically feasible metals are extracted (isolated).
3. Iron is the cheapest and most important of all metals - important in the sense that iron is overwhelmingly the most commonly used metal, accounting for 95 percent of worldwide metal production. Iron is used to manufacture steel and other alloys important in construction and manufacturing - building (bridge , highway , rail road , etc.) , transportation (car , train , boats , plane , etc.) , tools (knife , machines , etc.) Iron is also vital in the functioning of living organisms, transporting oxygen in blood via the hemoglobin molecule.

Iron catalysts are used in the Haber-Bosch Process to produce ammonia. Most automobiles, machine tools, building parts and machine parts are made out of iron.

Stainless steel is a very common type of steel. Steel is made by combining iron with other metals. Stainless steel is used in building parts, cooking pots and pans, cutlery and surgical equipment. It is also used in aircraft and automobiles.

4. a. Fe and O b. Fe and O c. Fe, C, and O

2.6 COPPER AND SILVER

Periods Allotted: 1period

Competencies

After completing this section, students will be able to:

- *explain the occurrence of copper and silver;*
- *list common ores of copper and silver; and*
- *list the uses of copper and silver.*

Forward Planning

Take ample preparation time to have a broad knowledge of copper and silver. Bear in mind that the main contents incorporated here in this unit in general are how the metals are obtained in the earth's crust, the common compounds of the metals and their uses. Although we have not specifically considered the method of extraction in the text, try to work on them by using information from this unit or principles discussed elsewhere. Get prepared so that you will be able to create a better teaching-learning atmosphere.

Teaching Aids

Copper wire used as a household electric cable and silver ring, and a periodic table.

Subject Matter Presentation

After introducing the topic, let students act upon **Activity 2.10** which might enable the power of students' minds understand the nature of copper and silver. They have to come to compromise that these two metals unlike the metals discussed in the previous sections can be obtained freely in nature. You can use the problem-solving method, which helps to identify in advance areas of difficulty by thinking of questions which will help students in the following topics. The suggested answers for **Activity 2.10** are given below:

Copper, silver, gold and platinum are the four most unreactive metals. This means that they do not form compounds and can exist as simple lumps of the metal in the rock. They can be found **native.** These are easy to extract since they can be mined. Also, you can even find pieces of gold in streams. More reactive metals are not found in lumps and must be extracted from the rocks in which they occur.

After the students present their opinions, continue your discussion important ores of copper and silver.

Finally, bring the attention of students to **Activity 2.11**which is intended to be used to discuss on the uses of copper and silver. The possible answer for this activity is that

- Copper is used to pipe water supplies. The metal is also used in refrigerators and air conditioning systems.
- Computer heat sinks are made out of copper as copper is able to absorb a high amount of heat.
- Some copper is added to fungicides and nutritional supplements.
- As a good conductor of electricity, copper is used in copper wire, electromagnets and electrical relays and switches.
- Copper is a great water-proof roofing material. It has been used for this purpose since ancient times.
- Some structures, such as the Statue of Liberty, are made with copper.

- Copper is sometimes combined with nickel to make a corrosion resistant material that is used in shipbuilding.
- Copper is used in lightning rods. These attract lightning and cause the electrical current to be dispersed rather than striking, and possibly destroying, a more important structure.
- Copper is often used to color glass. It is also one component of ceramic glaze.
- Many musical instruments, particularly brass instruments, are made out of copper.

The demand for silver comes primarily from three areas; industrial uses, jewelry and silverware, and photography. These industries represent 95 percent of annual silver consumption. Silver's superior properties make it a highly desirable industrial component. Silver's artistic beauty and status make it one of the most romantic and sought after precious metals.

Due to its status as a precious metal, ranked second only to gold, silver is often used to award second place. The most famous silver award is the second place Olympic Silver Medal. Silver also symbolizes honor, bravery, and accomplishment, which is why many military organizations, employers, clubs, and associations use silver or silver-colored awards to honour individuals for their contributions.

Photography had been one of the primary industrial uses of silver until the recent rise of digital media. Traditional film photography relies on the light sensitivity of silver halide crystals present in film. When the film is exposed to light, the silver-halide crystals change to record a latent image that can be developed into a photograph. The accuracy of this process makes it useful for non-digital consumer photography, film, and X-rays.

Silver is sometimes used as a conductor. It is an even better conductor than gold and at a lower price is sometimes used for this purpose. However, it is still more expensive than copper, so this isn't a widespread use.

One widespread use of silver is in dentistry. Silver can be mixed at room temperature to create an alloy that is then used to fill cavities.

Assessment

You are required to assess students' active involvement in each of the activities. Do not forget appreciating students who are working above the minimum required level. Give **Exercise 2.6** as homework to assess whether the students have achieved the minimum required level. Let them exchange opinions with each other and assess themselves. Students may enjoy correcting themselves from your answers which are supposed to be coming from you.

Answers to Exercise 2.6

1. Cuprite (Cu_2O), Malachite ($CuCO_3.Cu(OH)_2$), Chalcocite (Cu_2S), Chalcopyrites ($CuFeS_2$) and Covelline (CuS).
2. Much of the newer overhead cables are made of aluminum with steel reinforcing it for strength purposes. Aluminum is much cheap and much lighter (density), thus it is cheaper to use aluminum rather than copper for high voltage transmission, and copper has a lower resistance which means more electricity can get through the wire/ cable, which means more electricity, can get around the world quicker. Most people should use copper because it has a lower resistance where aluminum has a bit of a high resistance not too much but a bit so that is why we use copper not aluminum. Copper wires allow electric current to flow without much loss of energy. This is why copper wires are used in main cables in houses and underground electric systems (although overhead cables tend to be aluminum because it is less dense). However, where size rather than weight is important, copper is the best choice. Thick copper strip is used for lightning conductors on tall buildings like church spires. The cable has to be thick so that it can carry a large current without melting.
3. Because of its durability, resistant to corrosion, malleability and ductility, copper is used in making electrical wiring for residential and commercial purposes and in plumbing. Because of its good thermal conductivity copper is used to make cookware.

   Silver is used mainly in making jewelry, coins, decorative arts, electronic components, etc.
4. Basic copper carbonate is composed of Cu, C, H and O. The chemical formula is $CuCO_3.Cu(OH)_2$ or written as $Cu_2CO_3(OH)_2$
5. The common ore of silver is argentite (Ag_2S)

2.7 GOLD, PLATINUM AND TANTALUM

Periods Allotted: 2 periods

Competencies

After completing this section, students will be able to:

- *explain the occurrence of gold, platinum and tantalum;*
- *list common ores of gold, platinum and tantalum; and*
- *list the uses of gold, platinum and tantalum.*

Forward Planning

A teaching instruction is a supplement to the training that the teacher receives in the method that is used for instruction. Any guide will assure that the teacher appropriately applies the principles and techniques learned in the training as he or she is teaching the

lessons. You can choose one or two from several different methods in designing your teaching plan. For teaching instructions to be useful, the notes should be simple with each lesson following the same pattern. In your plan set appropriate time for students to do the activities and exercises given in the section. You are anticipated to help the students in forming groups during group discussions to clarify the questions in the activities and exercises where required and to facilitate their discussions among group members.

Teaching Aids

Gold ring, bracelet, or necklace.

Subject Matter Presentation

Start the discussion on occurrence, important ores and uses of gold, platinum and tantalum by giving detailed explanation for the students in the discussion minutes. Gold's use by humans dates back to ancient times. Very little attention was paid to paltinum as it was neither prized nor used in the same way as gold. A goldsmith makes many kinds of jewelry and other objects out of gold.

Finally, let the students discuss on **Exercise 2.5** and harmonize their responses with the concepts discussed in the text. Create awareness that gold and platinum are found native in nature. Investigate the opinion of the students about the reactivity of these precious metals. Among these three metals tantalum is the recently discovered one – in about 200 years ago from now. Explain the main ores and uses of these three metals.

Assessment

Check whether all the students actively participate during the discussion gathering. Do not forget to record students' performance in the performance list you prepared as you evaluate every activity of the students.

Students working at the minimum required level will be able to:

- Explain the occurrence, important ores and uses of gold, platinum and tantalum.
- List some common ores of gold, tantalum and platinum.

Review why gold has been known and used since ancient times. They should be able to deduce that it is easier to isolate gold from its ores than metals discussed in the previous sections.

Answers to Exercise 2.7

1. Gold is very low in the reactivity series of metals (the reactivity series of metals is based on the reaction of the metal with oxygen, moisture and acids). This makes it poorly electropositive. This means that it does not prefer to exist as positive ions by losing electrons but prefers its neutral atomic state. This explains why one can

find native gold, something which can never occur for highly electropositive metals like potassium.

2. Copper, gold and silver.

3. The only other common form of gold in ores is when the gold combines with tellurium and other metals. These minerals, like **calaverite**, are known as gold tellurides.

   Electrum can also be considered as one of the ores of gold.

   Sperrylite is the common ore of platinum

   Tantalite is the ore of tantalum

4. Gold is used in electrical wiring and jewelry.

Platinum is used in making jewelry, and most importantly as a catalyst.

Tantalum is used in making capacitors and surgical uses.

2.8 ALLOYS

Periods Allotted: 2 Periods

Competencies

After completing this section, students will be able to:

- *define the term alloy;*
- *give examples of some common alloys;*
- *describe the importance of alloying;*
- *identify the components of some common alloys;*
- *describe some of the common properties of alloys and*
- *explain the uses of some common alloys.*

Forward Planning

Set a lesson plan by dividing this section into separate lessons so as to complete within 2 periods. Reading about the topics included in this section and practicing the activities as well as the exercises in the students textbook and reference materials ahead of time is subtlety. If it appears to you that the materials contained in the students' textbook are inadequate, design a mechanism by which you can get more information.

Teaching Aids

Refer to the textbook and make the required teaching aids which may help for the better teaching-learning process. You can use for example brass, bronze, soldering iron, silver amalgam, and the like.

Subject Matter Presentation

For the delivery of the lesson in this section, gapped lecture and group discussions as well as concept mapping is active learning methodologies suggested. The section includes advantages of alloying metals and their uses. Ask students to define alloys – **Activity 2.12**. Then use some common alloys to introduce the idea of modifying the properties of a metal by mixing other elements most frequently metals. Discuss as much as possible the common alloys which we come across in our day-to-day activities. Exchange a few words why alloys were often used in ancient times. Take into consideration that people in ancient times had no means of separating the metal components. Finally, let the students discuss on **Activity 2.13** and **2.14**. Synchronization of the activities could include the following:

- The "karat" numbering system for gold is a 24-point scale used to express its purity or "fineness". For example, 24-karat gold is 24 parts gold and zero parts other metals; i.e., 100 percent pure gold. Meanwhile, 22-karat gold is 22 parts gold and two parts other metal while 14-karat gold is 14 parts gold and 10 parts filler. Therefore, 24-Carat gold is fine (99.9% Au), 18-Carat gold is 18 parts gold 6 parts another metal (forming an alloy), 12-Carat gold is 12 parts gold (12 parts another metal), and so forth.
- Pure gold (24 karat) is very soft and jewelry made of pure gold would soon wear away so other metals are usually added to harden the gold and making it suitable for making jewelry.
- Brass is an alloy made of copper and zinc. It is used to make ornaments musical instruments, statuary, nuts, and bolts.
- Bronze is an alloy of copper and tin. It is used in making general metal work, medals, coins and sculptures.
- Solder is an alloy of lead and tin. It is used for joining different metal parts (soldering).
- Stainless steel is an alloy of iron, carbon, chromium and nickel. It is used for making cutlery, tools and surgical instruments.
- Dentist amalgam is an alloy of mercury and silver. It is used for dental fillings.
- Duralumin is an alloy of aluminum, copper, magnesium and manganese. It is used for building of aircrafts, railways and ships.
- Type metal**,** alloy of lead, antimony, and tin used to make type characters for printing. By varying the proportions of the metals, the desired properties are produced for different kinds of typecasting and printing processes.

- Alloys can be of metal-metal and metal-nonmetal. Steel and phosphor-bronze are examples of metal-non-metal alloys. Phosphor-bronze is an alloy of phosphorous, copper and tin used for making the most rust resisting items, for example, ship propellers.

Assessment

After completing each part of the lesson, ask short answer questions. See whether the lesson objective has been achieved or not. Evaluate students' understanding from what they read and discuss in class. Evaluate if the minimum required level is achieved or not. Students working with the minimum requirement level will be able to:

- Discuss the advantage of mixing metals with metals and metals with nonmetals.
- Discuss the uses of some common alloys.
- Identify the components of some common alloys.

Answers to Review Exercises

Answers For Multiple Choice Part

1. d 2. b 3. b 4. d 5. d 6. b 7. d

For Short Answer Questions

8.

a. The molten metal that catches fire in chlorine gas and gives off white fumes is sodium.

b. The metal that forms two types of oxides and rusts in moisture is iron. The formulas of its oxides are: FeO; Fe_2O_3.

c. The metal used in hot water systems is copper, because it is a good conductor of heat and electricity.

d. The metal used in long distance cables wires is aluminum, because it is a light metal and a very good conductor of electricity.

e. The metal added to gold to harden it is copper.

9. Heamatite (Fe_2O_3), magnetite(Fe_3O_4), siderite($FeCO_3$) and iron pyrite(FeS_2).

10. a. Tantalum b. Magnesium c. Aluminum

REFERENCES

A.Atkinson, certificate chemistry, 3rd edition, 1974, Longman Group Ltd, Aylesbury, England.

Darell D. Ebbing, General chemistry, Houghton Mifflin company, Boston.

Davis, Gailey and Whitten, principles of chemistry 1984, CBS College publishing.

Graham C.Hill, John Holman, chemistry in context, second Edition, 1983, Butler and Tanner ltd London.

Henry Dorin, chemistry, the study of matter, fourth edition, 1992, prentice Hall, Inc. Massachusetts.

Henry Dorin, vitalized Chemistry, 7th edition, college Entrance Book company, 1970, New york.

James E. Brady and Gerard E.Humiston, General Chemistry, 3rd editon, 1982, Hohn Wiley and Sons. Inc. New york.

Jerome L. Rosenberg, college chemistry, 6th Edition, 1980, McGraw-Hill Book company, New york.

Raymond change, General chemistry, 1st edition, 1986, Random House, New york.

Raymond E.Davis, principles of chemistry 1984 Saunders college Publishing, Philadelphia, USA

UNIT 3 SOME IMPORTANT NON-METALS

Total period allotted: 10 periods

Unit Overview

This unit's general idea is about the general properties of non-metals and their compounds, the occurrence and uses of some common non-metals and their compounds. Even though non-metals are very few in number their uses are diverse.

Unit Outcomes

After completing this unit, students will be able to:

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

Main Contents

3.1 GENERAL PROPERTIES OF NON-METALS

Periods allotted: 2 periods

Competencies

After completing this section, students will be able to:

- *Mention the general properties of non-metals*

Forward Planning

Teachers should update themselves because they may forget the subject matter if they stop reading for a certain period of time. If one has to play the role of a model teacher, he/she has to discharge the following duties and responsibilities.

- Note what is contained in the textbook regarding the content you are intending to teach. If much is not there in the textbook, plan to use references. Thoroughly read and understand the content chosen for the daily lesson.
- You need to prepare the lessons based on the instructional method you have chosen in unit 2 since the technique of teaching seems similar.
- You need to decide which part of the lesson period needs much of your contribution.
- You need to train the students the advantages of group discussion and the technique of presentation by the group leader.
- Prepare a brief statement of the purpose and contents of the lesson and for what objective it is intended.
- Prepare examples on how to teach each part of a lesson, such as "How to teach the general properties of non-metals ". You are supposed to say that the terms and techniques of discussions are not different from the terms and techniques in unit 2.
- Prepare tests to give to the students at specific points in the course and evaluate their know-how.

Teaching Aids

Periodic table, some non-metals like carbon in the form of graphite, sulphur, and phosphorous.

Subject Matter Presentation

The **Start-up Activity** helps to start the discussion with non-metals. Non-metals can be obtained naturally in the form of monoatomic, diatomic and polyatomic forms. For example, oxygen exists in diatomic form and carbon in monoatomic form. Air is composed of mainly nitrogen and oxygen and some argon and carbon dioxide. The components of all these species are a non-metal. Oxygen the most important component of air is used for respiration.

You are advised to use discussion, lecture, and inquiry as your teaching methods for this section. Use these methods in a way that promotes active learning method. Encourage students to participate in the teaching-learning process. Discuss the vital needs of non-metals in human life and plants. The key components of food items are made of non-metals. Let students discuss **Activity 3.1** to support the discussion. Harmonize the answers of the students taking the following points into consideration.

1. Some non - metals and their uses are listed below

- Oxygen is used for breathing.
- Chlorine is used for purifying water.
- Phosphorous is used in crackers.
- Graphite is used as a good conductor of electricity.
- Nitrogen is used by plants.
- Graphite is used in making leads and electrodes
- Carbon is used as a fuel and its compounds are used for various purposes which are primarily hydrocarbons and also present in our body,
- Bromine is used in dyes and pesticides. In general non-metals are used as food, beverage, and clothing.

2. Where do plants get the carbohydrates, proteins, fats and vitamin they contain? The plants themselves make these nutrients. The process by which a plant makes sugar is called photosynthesis. To make sugar the plant uses water and carbon dioxide as raw materials and light energy from the sun. The process of photosynthesis takes place mainly in the green leaves of plants.

   Water is absorbed by the roots of the plant. The water moves along the stem and into the leaf along tubes called veins. During photosynthesis water is made to react with carbon dioxide. Sugar is produced as food and oxygen as waste product. The chemical process in word equation for photosynthesis is

   Carbon dioxide + water + light energy $\rightarrow$ sugar +oxygen

3. Not only do plants support humans, they support animals too. In a complicated sense we support the plants as well because they take in our carbon dioxide. Therefore, if there weren't any trees giving off oxygen, there would be no humans and if there is no humans no carbon dioxide for the plants. So having lots of plants around is good for people and animals — plants and trees make the oxygen that we need to breathe. *Without trees, there would be no life on Earth – at least, not one habitable by humans. It is as simple as that.* ***NO TREES, NO HUMANS****. It is worth repeating!!!* ***NO TREES, NO HUMANS.***

Finally, give **Exercise 3.1** as homework.

Assessment

You assess each student's work continuously throughout the section. This can be done by preparing a performance sheet and recording the performance of every student. You can make records based on students' performance in discussing the **Start-up Activity** and **Activity 3.1**, presenting their views after discussion and answering the questions in **Exercise 3.1.**

By observing their performances from the record, provide them with feedback to improve students' learning (formative assessment). In addition, you can use self assessment and peer assessment methods to enhance students' performance. Appreciate students who are working above the minimum required level and encourage them to continue working hard. For low achievers, identify their learning difficulties and help them to achieve the minimum requirement for this subunit.

Answers to Exercise 3.1

- Aluminum, oxygen, and silicon.
- Aluminum is the most active metal in the p-block and fluorine the most active non-metal.
- Carbon in the form of graphite and Iodine.

3.2 CARBON

Periods allotted: 1 period

Competencies

After completing this section, students will be able to:

- *Explain the occurrence of carbon*
- *Discuss the uses of elemental carbon*

Forward planning

Learning and teaching should meet the needs of the whole learner. To organize quality education the quality of teaching is very important. To support quality teaching one needs to have an excellent planning which harmonize plans by providing the kind of detail that allows you to plan work at individual or group levels to progress students' learning and teaching over a single period.

Quality time needs to be given to the planning process at all levels. Forward planning should focus on what the students will learn rather than on the content of what you will teach.

Teaching Aids

Graphite in a dry cell and carbon black (soot)

Subject matter presentation

Start the discussion on occurrence, important ores and uses of carbon by briefing the students in the introduction minutes. Assist students to recognize carbon as the basis of all life forms on the earth. Remind the students that carbon compounds are the basis of all organic compounds (Unit 1). Carbon exists in three solid forms at room temperature. Here you can discuss the idea of allotropy and the three allotropic forms of carbon. One of these allotropes is discovered lately. Its name is fullerenes. Talk about the properties of diamond including rigid structure, electrical insulator, and the hardest substance known. Prompt students to discuss the uses of diamond on the subject of its attractive appearance, hardness and good thermal conductivity. Correspondingly, let the students discuss on the uses of graphite related to its properties.

Assessment

After completing each lesson topic ask short-answer questions. Assess whether the lesson's objective has been achieved or not. Evaluate students understanding from what they read and discuss in class. Students working at the minimum requirement level should be able to discuss the occurrence and uses of carbon.

Answers to Exercise 3.2

1. Carbon black is an inorganic, synthetic black pigment produced by the partial burning of hydrocarbons, and the term is used to refer to any of several similar black pigments including pure carbon black and lamp black.
   The most common use of carbon black is as a pigment and reinforcing phase in automobile tires. Carbon black also helps conduct heat away from the tread and belt area of the tire, reducing thermal damage and increasing tire life. Carbon black particles are also employed in photocopier and laser printer toner.

2. Graphite can conduct electricity due to the vast electron delocalization within the carbon layers. These valence electrons are free to move, so are able to conduct electricity. However, the electricity is only conducted within the plane of the layers.

   Diamond is a carbon tetrahedral shape and so carbons are linked with each other and have not free electrons to move in plates like graphite could. That is also why graphite is a lubricant and diamond is a cutting abrasive. Therefore the main reason for their difference in electrical conductivity is the structure.

3. When you look at graphite and diamond, it is hard to imagine that they are identical chemically, for they are so different physically. Graphite is opaque and metallic- to earthy-looking, while diamonds are transparent and brilliant.

   Graphite conducts electricity but diamond does not.

   Graphite absorbs light and appears black in color but diamond disperses light and is shiny.

   Graphite is soft but diamond is hard. The hardness of minerals is compared using the **Mohs Hardness Scale**, a relative scale numbered 1 (softest) to 10 (hardest). Graphite is very soft and has a hardness of 1 to 2 on this scale. Diamonds are the hardest known natural substance and have a hardness of 10. No other naturally occurring substance has a hardness of 10. The crystal structure of graphite yields physical properties that permit the use of graphite as a lubricant and as pencil lead. The gem and industrial properties of diamond, physical properties that we cherish and exploit, are also a result of diamond's crystal structure.

4. Diamond, graphite and fullerenes.

3.3 NITROGEN

Periods allotted: 2 periods

Competencies

After completing this section, students will be able to:

- *explain the occurrence of nitrogen*
- *conduct an experiment to estimate the nitrogen content*
- *discuss the uses of elemental nitrogen*

Forward Planning

Establish what children already know - the repeating terms from Unit 2. These are terms like occurrence, important ores and uses. Be clear about the prevailing form of learning. Use all available expertise as teachers cannot solve every learning difficulty by themselves. When you set a plan to, divide this section into separate lessons so as to complete it in 2 periods.

Subject Matter Presentation

For teaching this lesson group discussion, brain storming and concept mapping are the active learning methodologies suggested. This section needs the awareness of students that nitrogen is the major component of air which is about $4/5^{th}$ of the air. They should also be aware that when substances are heated in air they react with oxygen far more than nitrogen because nitrogen is much less reactive than oxygen. The importance of nitrogen for plant growth is probably the reason why most fertilizers are composed of nitrogen. Plants absorb nitrogen in the form of nitrogenous compounds like nitrates and urea because atmospheric nitrogen is toxic to plants. Let the students discuss the nitrogen cycle. Finally, they should be mindful that nitrogen is there in proteins and is important in living organisms. After conducting **Experiment 3.1** and discussing on the observation and analysis part, let students research on **Activity 3.2** and **Activity 3.3.** These activities can be approached in the following way.

Plants that contribute to nitrogen fixation include the legume family such as, clovers, soybeans, alfalfa, and peanuts. They contain bacteria called ***Rhizobia*** within nodules in their root systems, producing nitrogen compounds that help the plant to grow and compete with other plants. When the plant dies, the fixed nitrogen is released; making it available to other plants and this helps to fertilize the soil. In many traditional and organic farming practices, fields are rotated through various types of crops, which usually includes one consisting mainly or entirely of clover or buckwheat non-legume family, which are often referred to as "**green manure**".

Bacteria are the microorganisms that are able to convert atmospheric nitrogen.

Naturally occurring organic fertilizers, such as animal manure, farm area added extras, food waste, peat, seaweed, and biosolids, must go through a controlled heat process before they can be used as high quality, biologically stable, and mature compost.

Advantage: Organic fertilizers have the advantage of avoiding certain problems associated with the regular heavy use of artificial fertilizers. Some of these are the necessity of reapplying artificial fertilizers regularly (and perhaps in increasing quantities) to maintain fertility and costs are lower for if fertilizer is locally available.

Depending upon the material, organic wastes can supply macronutrients (N, P, and K) and micronutrients to the soil for use by crops. These materials can replace part of or all synthetic fertilizers used in an operation. Adding organic matter to mineral soils can improve their physical properties (infiltration, water holding, structure, etc.) and chemical properties (Cation Exchange Capacity, fertility, etc.) Through agricultural utilization of organic wastes, producers can benefit (and possibly derive marketing potential) from materials that otherwise may be placed into landfills or present environmental pollution problems.

Although the density of nutrients in organic material is comparatively modest, they have many advantages. The majorities of nitrogen-supplying organic fertilizers contain insoluble nitrogen and act as a slow-release fertilizer. By their nature, organic fertilizers increase physical and biological nutrient storage mechanisms in soils, justifying risks of over-fertilization. Organic fertilizer nutrient content, solubility, and nutrient release rates are typically much lower than mineral (inorganic) fertilizers.

Disadvantage: Organic fertilizers have the following disadvantages:

- As a dilute source of nutrients when compared to inorganic fertilizers, transporting large amount of fertilizer incurs higher costs, especially with slurry and manure.
- The composition of organic fertilizers tends to be more complex and variable than a standardized inorganic product.
- *Improperly* processed organic fertilizers may contain **pathogens** from plant or animal matter that are harmful to humans or plants. However, proper **composting** should remove them.
- More labor is needed to compost organic fertilizer, increasing labor costs. Some of this cost is offset by reduced cash purchase.
- More applications of organic fertilizer are needed to apply sufficient nutrients to the soil.

Assessment

You assess each student's work continuously throughout the section. This can be done by preparing a performance sheet and recording the performance of every student. You can make records based on students' performance in discussing the **Activity 3.2** and **Activity 3.3**, presenting their views after discussion and answering the questions in **Exercise 3.3.**

By observing their performances from the record, provide them with feedback to improve students' learning. In addition, you can use self assessment and peer assessment methods to enhance students' performance. Appreciate students working above the minimum required level and encourage them to continue working hard. For low achievers, identify their learning difficulties and help them to achieve the minimum required level for this subunit.

Answers to Exercise 3.3

1. The actual breakthrough in nitrogen fixation came through the efforts of Fritz Haber. Haber worked out the reaction conditions for the combination of nitrogen and hydrogen to make ammonia.
   $N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$
2. All plants need nitrogen to make amino acids, proteins and DNA, but the nitrogen in the atmosphere is not in the form that they can use.
3. By nitrogen fixing microorganisms to nitrates and ammonium salts.

3.4 PHOSPHORUS

Periods Allotted: 1 Period

Competencies

After completing this section, students will be able to:

- *explain the occurrence of phosphorous.*
- *discuss the uses of elemental phosphorous.*

Forward Planning

Take enough time to prepare for the class. Read the contents of the section from the students' text, reference books and other resources to fully understand the subject matter of the lesson. Make a plan of your own on how to manage students during discussion, presentation and assessment. In your plan show the time allotted for each activity you are going to perform during the period in which you deal with this section. Ahead of time prepare the necessary teaching and learning materials for this topic. Prepare yourself on the activities and exercises before the class.

Teaching Aids

Phosphorous, phosphoric acid and DAP, Periodic table

Subject Matter Presentation

You are advised to use discussion, lecture, inquiry, and demonstration as your teaching methods for this subunit. Use these methods in a way that promotes active learning. Encourage your students to participate in the teaching-learning process. They should

have to appreciate the allotropic forms of phosphorous and the reason why white phosphorous is kept under water.

After introducing the topic of the section, let the students discuss **Activity 3.4** in groups for a few minutes. Then invite some of the groups to present their ideas to the class. After their presentations, harmonize concepts using the following information. **Activity 3.4** is designed for students to be aware of the occurrence and uses of phosphorous. Elemental phosphorous is used in the formation of phosphoric acid, in making incendiary bombs for military applications, in making matches, in making alloys such as phosphor bronze an alloy made of phosphorous, copper and tin. Then **Activity 3.5** can be approached as follows:

- Phosphoric acid is used for the production of phosphorous fertilizers, is a common additive for bottled solutions like soft drinks, as rust remover from metal surfaces.
- The oxides of phosphorous are used for drying gases and for removing water from solvents. P_4O_{10} is used to remove water from concentrated sulphuric acid, which itself is a strong dehydrating agent.
- Phosphine toxic gas and is used as a fumigant against rodents and insects. It is also used in the production of flame retardants.
- Sodium tripolyphosphate is used as a household cleaner and for water softening. These phosphates are important ingredients of commercial fertilizers.
- The soluble form of calcium phosphate which is calcium dihydrogen phosphate obtained by reacting insoluble calcium phosphate with sulphuric acid or phosphoric acid is used as a fertilizer
- Organophosphorous compounds are used to manufacture insecticides and herbicides.
- Phosphorous is essential for plant growth and it is one of the main nutrients of plants. A considerable amount of phosphorous is converted into acids and then to salts which are used as fertilizers.

Assessment

Assess each student's work throughout **Section 3.4**. Your assessment of each student's work can be based on the record you have related to his/her involvement in:

- group discussion and
- their presentation after discussing on **Activities 3.4 – 3.5.**

Answers to Exercise 3.4

1. White and red phosphorous.
2. White phosphorous.
3. White phosphorous
4. White phosphorus
5. P_4O_6 and P_4O_{10}.

3.5 OXYGEN

Total Periods Allotted: 1period

Competencies

After completing this section, students will be able to:

- *explain the occurrence of oxygen.*
- *discuss the uses of elemental oxygen.*

Forward Planning

Dear teacher, since students will learn much from active learning methods, it is advisable to plan group formations because the technique of teaching-learning process is almost similar. In addition, prior reading about some common properties and uses of oxygen from any literature of chemistry is very important. Because it reduces burden and makes the students' participation active the moment you facilitate the discussion.

Subject Matter Presentation

Start the discussion by explaining the present by volume of oxygen in air. About 21% by volume of air ($1/5^{th}$ of the air) is oxygen. Let students appreciate that oxygen is the active component of air. Check the understanding of students by asking the composition of nitrogen is air by volume and if nitrogen is reactive or not. Discuss in class that oxygen is the major component of water and that it can be obtained by electrolysis of water. Finally, discuss the uses of oxygen in supporting combustion; oxygen is used for respiration (life giving), for cutting and welding and as rocket fuel.

Assessment

You assess each student's work continuously throughout the section. This can be done by preparing a performance sheet and recording the performance of every student. You can make records based on students' performance in discussing **Exercise 3.5.**

By observing their performances from the record, provide them with feedback to improve students' learning. In addition, you can use self-assessment and peer

assessment methods to enhance students' performance. Appreciate students working above the minimum required level and encourage them to continue working hard. For low achievers, identify their learning difficulties and help them to achieve the minimum required level for this subunit.

Answers to Exercise 3.5

1. Oxygen
2. Oxygen is soluble in water and it is this soluble oxygen which enables aquatic animals' survival.
3. Oxygen obtained freely in nature as a component of air forming about 21% by volume. oxygen combines almost with all the elements and therefore obtained in compound forms.
4. Ozone is used for purification of pathogenic germs, treatment of cancer, AIDS, gangrene & many other illnesses. Other uses of ozone are:

- *Wastewater Treatment: Ozone is an effective disinfectant for treating municipal and industrial wastewater.*
- *Bleaching (Paper and Pulp): The consideration of the use of ozone in many phases of the pulping process is growing.*
- *Bottled Water / Beverage Industry (Bottle & Can Sterilization) process uses.*
- *Drinking Water (Pre / Post treatment): When ozone is applied, as a gas, for drinking water treatment, more importantly, it will effectively destroy bacteria and inactivate viruses more rapidly than any other disinfectant chemical.*

- *Food Processing (Sterilization / Fruit Washing)*
- *Textile Processes (Dye removal)*
    - *Air Pollution Control (Odor Control)*

5. In commerce, liquid oxygen is classified as an industrial gas and is widely used for industrial and medical purposes. To some people Liquid oxygen is important because it helps to breath.

   Aircraft: Liquid oxygen is great for use as breathing oxygen in some military aircraft.

   Spray: Liquid oxygen is also used to manufacture certain oxygen therapy sprays. These are used typically to heal wounds, insect bites and various skin conditions. If you have age spots on your face the Dr. will use liquid oxygen to burn them off. Liquid oxygen is used in many fields of the medical industry.

3.6 SULPHUR

Periods Allotted: 1 period

Competencies

After completing this section, students will be able to:

- *explain the occurrence of sulphur;*
- *discuss the uses of elemental sulphur.*

Forward Planning

Among the important principles of good teaching is the need for planning. Far from finding the middle ground spontaneity, planning provides a structure and context for teacher and students, as well as a framework for the evaluation process.

We have seen that one of the advantages of group discussions is that it provides opportunities for in-depth discussion, and strengthening of learning. Group discussion is also costly in terms of time and physical resources, so it is important to maximize the learning that can be achieved by forward planning and appropriate structuring of activities. Take enough time to prepare for the class. Read the contents on occurrence, and uses of sulphur. Get ready on the activities before you enter to the class.

Subject Matter Presentation

To start the discussion on occurrence and uses of sulphur, brief students with the natural color of sulphur and where sulphur is obtained in Ethiopia. Explain the reason why sulphur has been known since ancient times. Then discuss the allotropic forms of sulphur. Finally, give **Activity 3.6** and **Activity 3.7** to discuss in groups as a homework. The following points may help to harmonize the general idea:

China, Canada, and Russia are the main producers of sulphur in the world.

When recycling process is undertaken, it reduces the demand on sulphur sources. Recycling also helps in reducing atmospheric pollution resulting from the sulphur dioxide.

Discuss the uses of elemental sulphur like in preparation of match, preparation of sulphurdioxide (which is used as an insecticide – fumigant, vulcanization of rubber, preparation of sulphuric acid and preparation of gun powder.

Assessment

Assess each of a student's work throughout section this section. Your assessment of each students' work can be based on the record you have related to his/her involvement in:

- group discussion;
- presentation after discussion on activities;
- answering questions during mini-lecture or harmonizing
- doing class work and homework accordingly
- answering questions given as quiz or test.

Based on your record, check whether or not the suggested competencies are achieved. In case of students working above the minimum requirement level, appreciate their achievements and give them additional work. For those working below the minimum requirement level, arrange additional lesson time or give them additional exercises so that they can catch up with the rest of the class.

Answers to Exercise 3.6

1. Rhombic, Monoclinic and Plastic sulphur.
2. Sulphides and Sulphates.
3. S
4. Sulphur and oxygen
5. In medicines and making sulphuric acid.

3.7 USES OF COMMON COMPOUNDS OF NON- METALS

Periods Allotted: 2 Periods

Competencies

After completing this section, students will be able to:

- *explain the uses of some common compounds of non-metal.*

Forward Planning

Understanding the elements and the compounds they form is one of the more fundamental lessons in chemistry. Plan to assign each student to research uses of different compounds of non-metals. The number of compounds you assign to students will vary according to class size and number of classes, but try to cover at least the common ones allowing students to research more than one compound for extra credit, if necessary.

Teaching Aids

Display the teaching aids prepared and discuss the uses. Here you can use the periodic table as a teaching aid to indicate the elements that are contained in the compounds of the non-metals under discussion.

Subject Matter Presentation

Depending on students' academic level they will present their research findings to the class. Discuss the uses of some common non-metallic compounds to enable students to be familiar with the common uses. Try to integrate with the previous sections. **Activity 3.8** is designed to intensify the knowledge of students regarding common uses of common non-metal compounds. The following points will help to harmonize the general idea of the activity.

- CO_2 gas is used as a shield gas in welding to prevent the weld puddle from reacting with oxygen when it comes into contact with air.
- CO_2 gas is used in oil wells to increase oil discovery and maintain the pressure in the formation. CO_2 gas partially dissolves into the oil and reduces its velocity making the oil flow more easily from the bedrock and, therefore, increasing the amount of oil being extracted.
- CO_2 gas is used to carbonate soft drinks, soda water, beer and wine. Before artificial carbonation, beer and wine were carbonated through natural fermentation, but it is more convenient to use CO_2 gas instead.
- CO_2 gas is used to prevent fungal and bacterial growth in food products.
- CO_2 gas is used as a propellant in aerosol cans instead of other gases that are more harmful to the environment.
- Carbon dioxide extinguishes flames, and some fire extinguishers, especially those designed for electrical fires, contain liquid carbon dioxide under pressure.
- Plants require carbon dioxide to conduct photosynthesis.
- Liquid and solid carbon dioxide are important refrigerants, especially in the food industry, where they are employed during the transportation and storage of ice cream and other frozen foods. Solid carbon dioxide is called "dry ice" and is used for small shipments where refrigeration equipment is not practical. Solid carbon dioxide is always below −78.5 °C at regular atmospheric pressure.

- The manufacture of glass is one of the most important uses of sodium carbonate. When combined with silica and calcium carbonate and heated to high temperatures, then cooled rapidly, glass is produced. This type of glass is known as soda lime glass.
- Sodium carbonate is also used as a relatively strong base in various settings. For example, sodium carbonate is used as a pH regulator to maintain stable alkaline conditions necessary for the action of the majority of photographic film developing agents.
- It is a common additive in municipal pools used to neutralize the acidic effects of chlorine and raise pH.
- In chemistry, it is often used as an electrolyte. This is because electrolytes are usually salt-based, and sodium carbonate acts as a very good conductor in the process of electrolysis. In addition, unlike chloride ions, which form chlorine gas, carbonate ions are not corrosive to the anodes. It is also used as a primary standard for acid-base titrations because it is solid and air-stable, making it easy to weigh accurately.
- The greatest use of nitric acid is in the manufacture of ammonium nitrate, NH_4NO_3, for fertilizers. A large amount of nitric acid is used in the manufacture of explosives such as TNT, nitroglycerine and nitrocellulose. Nitric acid is also used for the pickling of stainless steel, the etching of metals, and the preparation of nitrates for various uses.
- The majority of the phosphoric acid produced is used for the production of fertilizers. See what is discussed under **Activity 3.5.**
- Calcium phosphate is used in the production of phosphoric acid and fertilizers
- Calcium phosphate is used in baking as a raising agent. It is also used in cheese products.
- Tricalcium phosphate is also used as a nutritional supplement and occurs naturally in cow milk, although the most common and economical forms for supplementation are calcium carbonate (which should be taken with food) and calcium citrate (which can be taken without food).
- It is used in a variety of dental products for remineralization and as diluents in some medications where it will give the tablet a grey colour in the absence of additional coloring agents.

- Most sulphur dioxide, SO_2 is used to make sulphuric acid, but some is used as a bleaching agent in the manufacture of paper products, oil, sugar and starch. Large quantities of SO_2 are used in the wine industry as fungicides for grape vines and as antioxidant of wines.
- Sulphuric acid is by far the most important industrial chemical. More than half of the sulphuric acid produced is used to make fertilizers. The rest is used in making paper, synhetic fibers, textiles, insecticides, detergents, dyes, drugs, paints, explosives, automobile batteries, etc.

Assessment

You assess each of the student's work continuously throughout the section. This can be done by preparing a performance sheet and recording the performance of every student. You can make records based on students' performance in discussing **Activity 3.8**, presenting their views after discussion.

By observing their performances from the record, provide them with feedback to improve students' learning. In addition, you can use self-assessment and peer assessment methods to enhance students' performance. Appreciate students who are working above the minimum required level and encourage them to continue working hard. For low achievers, identify their learning difficulties and help them to achieve the minimum required level for this section.

Answers to Unit Review Exercises

I- Multiple Choice Items

1.	D	2.	B	3.	D	4.	B	5.	A
6.	C	7.	D	8.	B	9.	B	10.	D
11.	B	12.	A	13.	A	14.	B		

II- Short Answer Questions

15. Solid at room temperature, insoluble in water, soluble in carbon disulphide, burns in air to form phosphorus pentoxide, etc.
16. The right hand side of the periodic table
17. Rhombic sulphur
18. phosphorus
19. Sulphur dioxide
20. Calcium carbonate
21. Sulphur

REFERENCES

A.Atkinson, certificate chemistry, 3rd edition, 1974, Longman Group Ltd, Aylesbury, England.

Darell D. Ebbing, General chemistry, Houghton Mifflin company, Boston.

Davis, Gailey and Whitten, principles of chemistry 1984, CBS College publishing.

Graham C.Hill, John Holman, chemistry in context, second Edition, 1983, Butler and Tanner ltd London.

Henry Dorin, chemistry, the study of matter, fourth edition, 1992, prentice Hall, Inc. Massachusetts.

Henry Dorin, vitalized Chemistry, 7th edition, college Entrance Book company, 1970, New york.

James E. Brady and Gerard E.Humiston, General Chemistry, 3rd editon, 1982, Hohn Wiley and Sons. Inc. New york.

Jerome L. Rosenberg, college chemistry, 6th Edition, 1980, McGraw-Hill Book company, New york.

Raymond change, General chemistry, 1st edition, 1986, Random House, New york.

Raymond E.Davis, principles of chemistry 1984 Saunders college Publishing, Philadelphia, USA

UNIT 4 ENVIROMENTAL CHEMISTRY

Number of Periods allotted: 20 Periods

Unit Overview

This unit gives emphasis to create awareness among the young generation on the effects of our daily activities on the environment in which we live. Its objective is aimed at introducing what activities of man make the environment uncomfortable for the survival of the future generation. Besides that, it gives information on how to protect our environment, wise utilization of natural resources and methods of improving usefulness of some natural resources than the form they are found in nature. Generally, the unit provides students with concepts associated to the current problems the globe is facing due to increased industrialization consumption of fossil fuels, unlimited use of agricultural chemicals and many other human activities.

The first section of the unit (4.1) deals with air. It gives emphasis to the composition of air, air pollution, air pollutants, sources and effects of air pollutants, global warming as well as its causes and effects.

The second section of the unit (4.2) gives emphasis to water. It introduces the causes of hardness of water, methods of removing hardness, causes of water pollution and its effects, and methods of water purification.

Section 4.3 introduces components of the soil, its composition acidic, alkaline and neutral soil, major plant nutrients, methods of improving fertility of soil and how to reduce soil acidity.

Section 4.4 gives emphasis to fuels. It explains what fossil fuels are, their formation and uses.

To teach the contents in this unit, it is advisable to implement gapped lecture, inquiry, group discussion, experiment, library research, investigation, presentation and cooperative learning.

Unit Outcomes

After completing this unit, students will be able to:

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

Main Contents

4.1 AIR

Periods allotted: 5 periods

Competencies

After completing this sub-unit, students will be able to:

- *describe the percentage of nitrogen, oxygen and carbon dioxide in the air*

- *list air pollutants*
- *discuss sources of SO_2, CO, NO_x (NO and NO_2)*
- *explain effects of SO_2, CO and NO_2 in the air*
- *define global warming*
- *discuss the causes of global warming*
- *discuss the effects of global warming*

Forward Planning

Read the contents in this section thoroughly. This will help you to make an appropriate plan on how to deal with the contents. After you familiarize yourself with the contents, prepare a plan of your own in such a manner to complete the whole section with in five periods. Your plan should include the contents, the suggested activities you deal with and other activities you perform during each period. Some of the suggested activities in the student text require library research (for example, **Activity 4.5**). So, your plan should show when to give students to perform the activities. Students may not have sufficient information about the activities. So you are advised to give these activities two or three days before the period you intended to deal with them. This will help you to make the class more interactive. You need to read this guide to get more information about the suggested activities and the methodologies you implement to teach the contents. Because the guide provides answers to the activities and additional notes on some parts of the section.

Teaching Acids

If possible, you can use videos on environmental pollution.

Subject matter Presentation

To teach the contents in this section, you are advised to implement group discussion, gapped lecture, inquiry, library research and presentation of researches and group discussion.

4.1.1 Composition of Air

Start teaching this section with the start-up activity. This activity enables students recall the definition of environment, gain concept on what environmental chemistry is and its

concerns. So, have them discus the start-up activity for some minutes. When they complete, invite two or three students to present their respective group's opinion to the rest of the class. After that harmonize their ideas with the fact as follows.

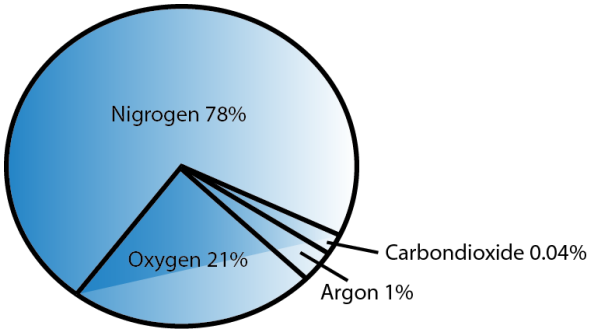
1. Environment refers to everything in our surrounding such as air, land, water, plants and animals, etc.
2. Environmental chemistry is the study of the origin, transport, reactions and effects of chemical species in the environment. Environmental chemistry is concerned with the study of
   - ♦ origin of pollutants of air, water and land.
   - ♦ how they enter into air, water and land.
   - ♦ the interactions with other substances.
   - ♦ the effect of pollutants on plants and animals and earth as a whole and.
   - ♦ the economic utilization of natural resources.

Generally, environmental chemistry is concerned with the protection of the environment to suit and maintain continuity of generation.

After that, continue teaching about composition of air. Start with **Activity 4.1.** This activity enables students to realize whether or not the composition of air is similar at all places and also recall differences among the two types of mixtures. Have them discuss **Activity 4.1** for some minutes. When they complete, give chance to two or three students from different groups to present the opinion, of their groups to the rest of the class. Following the presentations, tell them the following information to harmonize what they suggested with the fact.

1. The composition of air is not similar at all places due to different reasons. For example, atmospheric air of humid area contains higher amount of water vapor than dry areas; atmospheric air of highly industrialized areas contains higher percentage of carbon dioxide and other gaseous pollutants than non-industrialized areas, etc.
2. Clean air is a homogeneous mixture.

   Next, proceed to deal with the composition of air. You can ask them to suggest what the composition of air is before you tell to them. Following their response, tell them the composition of air and then continue with **Activity 4.2.** This activity enables students practice describing the composition of something using a pie charts. Allow them to draw a pie chart in groups for some minutes. When they complete, invite one student to draw the chart on the black board. Make sure that the drawing looks like the following



4.1.2 Air Pollution

After the students become familiar with the composition of air, proceed to deal with air pollution. First, you better introduce to students what environmental pollution is. Inform to them that environmental pollution is caused by materials; solid, liquid or gases that we dispose into it. These materials cause undesirable changes in our surroundings that have harmful effects on plants, animals and human beings. Next, continue to deal with **Activity 4.3.** This activity enables students to identify the human activities that release air pollutants and the types of contaminants released in to air. Thus, allow them discuss this activity for some minutes in groups. When they complete, give chance to two or three students to present the group's opinion to which they belong. Following the presentation, you can suggest the following.

1. Answer may vary, but mention burning wood to produce charcoal, road construction, combustion of fossil fuels such as petroleum natural gas and coal in industries or at home to cook food, production of cement etc.
2. Carbon monoxide, carbon dioxide, nitrogen monoxide, nitrogen dioxide, sulphur dioxide, vapor of petroleum smoke, etc.

After that, continue teaching about air pollution. First ask student to define what air pollution is. Next to their responses, tell them the accurate definition, what air pollutants are and some common air pollutants. Mention that air pollutants originate from different sources. You can give examples from those listed in the answer for **Activity 4.3**. Then proceed to deal with **Activity 4.4.** This activity helps students to investigate the sources of some air pollutants. Have them discuss this activity for some minutes in groups.

When they finish, invite two students form different groups to present the opinion of the group. After the presentations tell them the following points.

a. Sources sulphur dioxide (SO_2)
- Combustion of fossil fuels (petroleum, natural gas and coal) containing sulphur or sulphur compounds
- From industries extracting metals from sulphide ores
- Volcanic eruption

b. Sources of nitrogen oxides (NO and NO_2).
- Combustion of fossil fuels in industries (furnaces and car engines)
- Natural process like lightning.

c. Sources of carbon monoxide (CO)
- Incomplete combustion of fossil fuels in furnaces of industries, and car engines
- Forest fire

4.1.3 Effects of Air Pollutants

After introducing the sources of some air pollutants, proceed to deal with effects of air pollutants. Tell them some effects of air pollutants like causing acid rain, coughing and irritation to the lungs, etc. you can also mention the effects of chlorofluorocarbons (CFC_S) relating to the depletion of ozone layer. This layer protects all living things from dangerous rays like ultraviolet ray by absorbing it.

Next, proceed to **Activity 4.5.** This activity is suggested to enable students develop skills to investigate facts by reading and, writing as well as enhance their presentation skills Allow them to discuss on the contents of the written material they prepared in groups give intend to deal with his activity for some minutes. before the period you intend to deal with this activity for some munities in groups. After they complete, give chance to two students form different groups to present the investigation made by their groups. Following the presentations, harmonize what they suggested with the following.

Sulphur dioxide (SO_2) and nitrogen dioxide (NO_2).

Sulphur dioxide react with oxygen in the air to form sulphur trioxide (SO_3). Sulphur trioxide and nitrogen dioxide dissolve in rain water and form sulphuric acid (H_2SO_4) and nitric acid (HNO_3), respectively. This condition results in acid rain. Rain that falls to the surface of the earth becomes acidic. Acidic rain

- Lowers the PH of water in rivers, lakes, seas and oceans and affects the lives of aquatic plants and animals.
- Washes away heavy metal ions from the soil
- Damages building materials such as limestone, marble and iron

- Corrodes water pipes (iron and mild steel) resulting in the leaching of heavy metals

  Both SO_2 and NO_2 cause respiratory disease such as asthma and bronchitis in human beings.

- Nitrogen monoxide (NO) is highly reactive and combines with oxygen to firm Nitrogen dioxide.
- Carbon monoxide (CO) is produced as a result of incomplete combustion of petrol, coal, fire wood, etc. It is one of the most series air pollutants and is poisonous because of its ability to block the delivery of oxygen to organs and tissues by combining with hemoglobin. It greatly reduces the oxygen carrying capacity of the blood resulting in headache, weak eye sight, asphyxia and nervousness.

4.1.4 Global warming

After you complete the effects of air pollutants, proceed to deal with global warming. Start teaching this topic, by asking students what global warming is and its cause. Get response from some students. After getting feedback, define global warming and the causes of global warming. Tell to them about green- house gases and what is meant by green- house effect. Make sure that they have realized global warming and its cause, continue to treat **Activity 4.6.** This activity enables students to explain the effects of global warming on the world as a whole as well as on Ethiopia and also suggest solutions to the problem. So, have them discus the activity for some minutes in groups. When they complete, give the opportunity to two group representatives to present the opinion of their groups to the rest of the class. After the presentations, tell to students the following points.

1. (a) The effects of global warming on the world as a whole are:
   - climate change such as drought, non-seasonal rainfall, unusual warmth or coldness, etc.
   - melting of polar ice caps
   - rising levels of water of seas and oceans which results in over flooding of costal lines of the continents.

   (b) Global warming has the following effects on Ethiopia.

* climate change. This may include (I) unseasonal heavy rain fall that can cause damage to crops before harvest (II) shortage of rain during rain seasons resulting in drought and famine due to less crop yield.
* decreasing vegetation coverage of the country
* expansion of desert
* a decrease in the number of domestic and wild animals
* migration of endemic wild animals and birds
* reduction of agricultural output that results in poor economy.

2. Since carbon monoxide is the main cause for global warming, it is very important to reduce its emission into atmospheric air. This can be achieved by:

* using alternative energy sources such as hydroelectric power and electric energy from wind and solar energy (renewable energy sources) and reducing the use of petroleum, natural gas, coal, etc as sources of energy.
* increasing vegetation coverage (planting several millions of trees) so that carbon dioxide can be consumed by Photosynthesis and its concentration reduced.

Assessment

You should assess the work of each student throughout this section. Your assessment should be based on the records you have related to the involvement of each student in

- Group discussions on the start-up activitiys and **Activities 4.1** – 4.6
- Presentation after discussion
- His/her participation in answering oral question during mini- lecture.

You can also give them **Exercise 4.1** as a homework and /or conduct a quiz, cheek their work and record their performances. From your record, evaluate whether or not the suggested competencies for this section are achieved encourage students who are working above the minimum requirement level to continue working hard. For those students who are working below the minimum requirement level, arrange extra lesson time or give them additional exercise related to the contents in this section.

Additional Questions

* Name gaseous substances considered as green-house gases other than carbon dioxide and water vapor?
* Explain how increased concentration of carbon dioxide causes global warming.
* Smoke and dust are also considered as air pollutants. What effects do they cause on:
    a. plants
    b. human beings.

* What is the effect of acid rain on:
    a) aquatic animals and plants
    b) marble buildings
    c) iron objects.
* Explain how deforestation can enhance global warming.
* Can the use of fuels free from nitrogen and sulpur or their compounds help to reduce air pollution?

Answers to Additional Questions

1. Methane, nitrogen monoxide (NO)
2. In creased concentration of carbon dioxide causes global warming by absorbing the radiation of the sun reflected back by the earth to the atmosphere.
3. a. Hinder photosynthesis by reducing the amount of sun light that reaches the Earth's surface.
   b. They cause irritation to the eyes, nose and throat of human beings.
4. a. It lowers the P^H of water and can kill aquatic animals and plants.
   b. It causes erosion of buildings
   c. It causes rapid corrosion of iron objects and shorten the period of their uses.
5. Deforestation (cutting down trees) reduces the amount of carbon dioxide used for photosynthesis and increase the amount of CO_2 in air which leads to global warming.
6. Yes, because the use of nitrogen and sulphur free fuels reduces the emission of sulphur dioxide and nitrogen oxides into the atmosphere which inturn decreases acid rain and other harmful effects caused by these oxides.

Answers to Exercise 4.1

Part I

1. False 2. True 3. False 4. False 5. True

Part II

Refer to the student text and the teacher's guide to answers of question 6-12.

4.2 WATER

Periods allotted: 6 periods

Competencies

After completing this sub-unit, students will be able to:

- *define hard water as a water that does not form lather with soap*
- *state soluble salts of calcium and magnesium as the causes of hardness of water*
- *conduct an experiment to demonstrate the effect of hardness of water by taking rain water (tap water) and ground water*
- *describe boiling of water and adding washing soda as methods of softening hard water*
- *perform an experiment to soften hard water by boiling and adding washing soda.*
- *describe the improper ways of disposing domestic and industrial wastes and excessive use of agricultural wastes as the causes of water pollution*
- *write a report on the causes, effects and prevention of water pollution.*
- *describe the physical, biological and chemical water treatments*
- *conduct simple experiment to purify dirty water*

Forward Planning

Read the content in this section thoroughly to be familiar with basic concepts. Set a plan of your own that shows the contents, activities and experiments to be performed during each period so that contents in this section will be covered within six periods. Some of suggested activities such as **Activity 4.9** and **4.11** require library research. So you should give these activities two or three days before the periods you. Planned to deal with them. Six experiments are suggested in this section. Prepare the materials required to perform the experiments. Perform each of the experiments before you allow students to carry out them. In addition to that, you should plan when to arrange a trip for students to visit a local body of polluted water a local water treatment plant and when to give them the suggested project work.

Teaching Aids

Refer to the student text book for the materials required to conduct **Experiments 4.1**, **4.2, 4.3, 4.4, 4.5** and **4.6.**

Subject Matter Presentation

To teach the contents in this section you are advised to implement gapped lecture, inquiry, investigation, group discussion, presentation, and experiment as teaching methodologies.

4.2.1 Hardness of Water

Start teaching this section with **Activity 4.7.** This activity enables students to think why samples of water from different sources do not form lather with soap at the same rate. So allow them to discuss on this activity for some minute. After the discussions, invite two or more students from different groups to present the opinion of their respective groups. Following the presentations, tell them the following information to harmonize what they suggested during the presentation with the fact.

1. The answers may vary. They can suggest that peoples get water form wells, lakes, river, pipelines, etc.
2. Rain water is preferable for washing clothes with soap than ground water. This is because rain water forms lather with soap immediately while ground water doesn't. Thus, ground water wastes soap, and may leave stains on the cloth as well due to the formation of an insoluble substance.

After that, continue with the in- text question and get response from students. Following their response, define soft water and hard water in relation to the ability to form lather with soap. Introduce to students the cause for hardness of water, why this type of water doesn't form lather with soap immediately, and the interaction of the soap with dissolved substance responsible to the hardness. There proceed to deal with **Experiment 4.1.** This experiment enables students to discover the effect of hardness of water on soap. Have them perform the experiment in groups and write a laboratory reports about their findings. Invite two students from different groups to present what they identified to the rest of the class. After the presentations, make sure that the following points are included in their laboratory report on the observation and analysis part

a. The water samples in the first and second test tubes form a lather with soap rapidly.
b. The water in the third test tube forms lather with soap slowly
c. i. Rain water and distilled water

ii. Ground water.

After you suggest what the findings of students from the experiment should look like, continue to introduce to students about temporary hardness and permanent hardness in relation to dissolved salts they contain. Next to that, proceed to deal with **Activity 4.8.** This activity enables students to realize how calcium hydrogen carbonate is formed nature. So, allow students to discuss on this activity for some minutes in groups. When they complete, encourage two students from different groups to present the opinion of their group. After the presentations, tell them the following information to harmonize ideas.

1. Carbon dioxide + water → Carbonic acid (word equation)

   $CO_2 + H_2O \rightarrow H_2CO_3$
2. Carbonic acid + lime stone → Calcium hydrogen carbonate (Calcium carbonate)

   $H_2CO_3 + CaCO_3 \rightarrow Ca(HCO_3)_2$

After you harmonize ideas, continue to deal with **Experiment 4.2.** Allow the students to perform it in groups. Help them whenever they face problems in using the suggested steps in the procedure. When they finish the experiment, let them write laboratory report in groups, and representatives of two groups present their observation to the rest of the class. Make sure that the points in the presentations on observation and analysis part coincides with the following points.

a. When carbon dioxide is blown through lime water the solution urns milky due to the formation of an insoluble calcium carbonate.

   $Ca(OH)_2(aq) + (O_2(g) \rightarrow Ca\,CO_3(l) + H_2O(l)$
b. When more carbon dioxide is blown through the milky solution, it becomes clear again. This is because the carbon dioxide blown reacts with water to from carbonic acid. The acid then reacts with calcium carbonate to form a soluble calcium hydrogen carbonate and the solution turns clear.

   $H_2CO_3(aq) + CaCO_3(l) \rightarrow Ca(HCO_3)_2(aq)$
c. The formation of lather is not as rapid as it was in distilled or rain water. This is because the water in step 6 is temporary hard water. It contains. Calcium hydrogen carbonate which reacts with the soap and slows down the formation of lather.

4.2.2 Softening of Water

Continue to introduce to students what softening of water means. Give emphasis to what this process primarily involves and the method used to remove temporary hardness. You need to support what you explained about the method of removal of temporary hardness

with an experiment. To do so, have the students perform **Experiment 4.3** in groups. Assist them whenever they have doubt in applying the steps suggested in the procedure. When they complete the experiment, they should write a laboratory reports in groups and submit it to you for correction. While correcting their group reports make sure that the following points are included in the observation and analysis part of the experiment

a. i. The cold water sample forms lather with soap slowly because it is temporary hard water.
   ii. The boiled water sample forms lather with soap rapidly.

b. The difference in the duration of time they form lather is due to the fact that the cold water sample contain calcium ions which react with the soap and slows down the formation of lather. On the other hand, the boiled water doesn't contain calcium ions because boiling have converted the soluble calcium hydrogen carbonate to an insoluble calcium carbonate and thus form lather rapidly. In other word, the cold water is temporary hard water while the boiled water is soft because boiling has removed the hardness.

Next, introduce to students how lime scale is formed on the interior surface of kettles, pans and boilers. Tell to them some of the problems resulting from it and continue to deal with **Activity 4.9.** This activity enables students to investigate the formation of stalactites and stalagmites.

It is hoped that you have given this activity to students as suggested in the forward planning. So, have them discuss the activity in groups each member of the group producing the written document he/she prepared about the formations beforehand. When they complete, invite some students from different groups to present their findings. After the presentations, tell to students the following facts about the formation of stalactites and stalagmites.

When temporary hard water evaporates, the hydrogen carbonate forms a precipitate of carbonates. Thus, as the water drops from the roof of a cave, a little solid calcium and magnesium carbonate may be left on the roof and floor of the cave. The carbonate grows down from the roof and after hundreds of years forms a column, called **stalactite.** The solid carbonate also grows up from the floor and forms a column, called **stalagmite.**

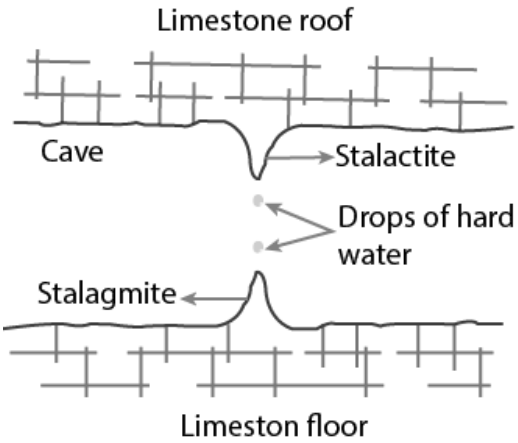


Figure 4.1 Stalactites and stalagmites

After introducing the formation of stalactites and stalagmites to students, continue with **Experiment 4.4.** Have the students perform this experiment in groups, write laboratory report and let two groups present their findings to the rest of the class. Following the presentations, inform to them the following points in relation to the observation and analysis part of the experiment.

a. When soap is dissolved in the water sample in each beaker, lather forms slowly.
b. Yes, there is a formation of an insoluble solid in the water sample in each beaker.
c. The formation of an insoluble solid in the water sample in each beaker shows that boiling cannot remove permanent hardness.

Based on the observation from the experiment, inform to students what scum is and how it is formed. Give emphasis to the formation of scum by the reaction of calcium ions and/or magnesium ion with the stearate ion of the soap. You can use the equation given in the student text to show the formation of scum. Then continue to introduce to students with the method of removing permanent hardness. Support your explanation with an experiment. You can use **Experiment 4.5** for this purpose. Allow the students to do it in groups, write a laboratory report and submit the report to you for correction. Make sure that their laboratory reports include the following points in the observation and analysis part of the experiment.

a. When sodium carbonate is dissolved into the water of one beaker, an insoluble solid settled to the bottom of the beaker
b. No, the water into which sodium carbonate is dissolved, forms leather with soap more rapidly. This is because calcium ions and/or magnesium ion present in the hard water are precipitated as carbonates when sodium carbonate is dissolved.

4.2.3 Water Pollution

Start teaching this topic by asking students to suggest what they know about water pollution. Get response from them and tell to them what water pollution is. Ask them again to define water pollutants and to suggest examples of water pollutants they know. Get feedback and appreciate them for the attempts they made to answer the questions. After that define water pollutants and tell to them the major water pollutants domestic wastes, agricultural chemicals and industrial wastes.

After students are introduced to water pollution and major water pollutants, proceed to deal with **Activity 4.10.** This activity enables students to identify different sources of waste water from their home. Have them discuss the activity for some minutes in groups. When they complete, invite one or two students to present the list of sources of waste water they identified. After the presentations, harmonize concepts using the following information.

The source of waste water that leaves our homes are

- water from toilets carrying human waste products
- water from cleaning different material carrying detergents
- water from washing
- water from cooking, etc.

Continue providing some information about agricultural wastes and industrial wastes to students. Next, proceed to deal with **Activity 4.11.** The activity is suggested to assist students to develop skills in investigating facts, writing, reading and gaining more information about something on their own. It is hoped that you have given this activity to students as suggested in the forward planning. So, allow them discuss what they investigated in their groups on the written document they prepared for some minutes. When they finish, give the chance for one group to present the report on domestic waste, the other on agricultural chemical and a third group on industrial waste. You need to give the opportunity to students of other groups to ask questions on the report of each group to make the class more interactive. Following the presentations, harmonize ideas suggested by the students with the fact using the following information.

Domestic Waste

The water or sewage that originate from washing different materials at home carry detergents to natural sources of water such as rivers, seas or streams and cause detergent Pollution.

Water from toilets and bath rooms carry human waste products and result in pollution.

Effects of domestic waste

Detergents are alkaline in nature. When discharged into natural water system, they increase the alkalinity of water and also it PH. This situation creates unfavorable condition to aquatic animals and plants, and can make them die. The release of sewage from homes to natural water systems can spread water -borne diseases such as **cholera**, **typhoid, hepatitis** and **polio.**

A agricultural chemicals

Agricultural chemical refers to fertilizers, pesticides and herbicides or weed killers. When used at agricultural fields, water runoff can carry them to natural water systems and cause pollution. The pollution of water that results from agricultural chemicals is known as agricultural pollution.

Effects of agricultural Chemicals

Excessive use of phosphate and nitrate fertilizers in agriculture causes them to be washed away and enter in to natural water systems. These dissolved minerals are very important plant nutrients. Their discharge into the water systems accelerates the growth of surface water plants like algae. This causes less light to reach to the bottom-living plants, reduces photosynthesis they need to live and then die. To rot the dead aquatic plants, bacteria multiply greatly and consume oxygen dissolved in the water at a faster rate than nature can replenish. Thus, the amount of oxygen decreases. The depletion of oxygen kills aquatic animals like fish and this process is called **eutrophication**. The use of phosphate detergents also results in eutrophication. Some of the pesticides and herbicides in agriculture stay for long without undergoing decomposition. They enter into natural water systems due to water runoff. Human beings and animals using water from this natural sources face a serious health problems. This is because the pesticides, for example, DDT can accumulate in our body systems without undergoing any decomposition for many years and produce harmful effects in humans and other animals.

Industrial Waste

Industrial waste that cause pollution to water discharged in the form of liquid (sewage) is called an **effluent.** It is liquid waste especially chemicals produced by factories. This

liquid waste may contain heavy metal ions, acidic or basic residues. The other industrial waste discharged to natural water systems is hot water after it is used in the cooling systems of the industries. Industrial waste gases that originate from the combustion of fossil fuel such as carbon dioxide and nitrogen dioxide also enter to water system in the form acid rain

Effects of industrial waste

Acidic and/or basic residues entering in to natural water system and acid rain cause pH changes in the water. Aquatic plants and animals need specific ranges of water pH for their survival. The changes in pH can kill these organisms. An increased concentration of toxic heavy metal ions kill organisms in water. In addition to that, toxic metal ions can be absorbed by marine animals like fish and stored in their body. When the fish is being eaten by animals such as man, the stored toxic metal ions can enter in to the circulatory system and cause damage to some tissues. The release of hot water from cooling systems of industries into lakes, rivers, lakes or seas, results in an increase in temperature of the water. This in turn makes water unfit for the survival of aquatic organisms.

Preventing Water Pollution

- Disposing domestic or industrial sewage into water of lakes, rivers and lakes only after appropriate treatment.
- Stop discharging hot water.
- Using alternative energy sources for industries that do not release gaseous substances that cause acid rain.
- Reducing the use of agricultural chemicals and increasing the use of organic fertilizers and biological methods to control pests.

You are expected to arrange transport and other facilities to enable students visit a local body of polluted water a head of time. During the visit students are expected to ascertain

- The causes of pollution and
- The effects of the pollution on organisms living in it and the surrounding area. During the visit, they can collect some bottles of polluted water for **Experiment 4.6.** After the visit, they should write a group report about their findings and the solution they recommend to overcome the pollution and present to the class.

After the presentations, allow the students to perform **Experiment 4.6** using polluted water they collected during their visit. When they complete they should write a laboratory reports in groups and submit to you for correction. The observation and analysis part in their reports may include the following points.

a. The answers may vary depending on the locality and extent of pollution. However, the two water samples are not expected to have the same clarity, smell and P^H.
b. Polluted water is expected to contain a higher amount of dissolved solids than pure water.

4.2.4 Water Purification

Start teaching this topic with **Activity 4.12.** This activity is designed to enable students investigate water purification techniques used in their locality. Have them discuss this activity for some minutes in groups. When they complete, give the opportunity to two students from different groups to present the opinion of their groups to the rest of the class. After that, harmonize the suggested ideas by students depending on the objective reality of your locality on sources from where people get water.

Continue to deal with the details on water purification and water treatment. Introduce to students the water treatment techniques. Physical treatment, chemical treatment and biological treatment. In addition to that, inform to students why it is not advisable to dispose waste water in to rivers, lakes, etc before treatment.

After that, you need to arrange transport and other facilities so that students can visit a local water treatment plant. The students should investigate everything suggested to do during their visit. They should write reports in groups about their findings and present to the rest of the class.

Finally, students are expected to do the project work. They should construct a model of water treatment plant and check whether or not it works properly by purifying dirty water.

Assessment

You are expected to assess the work of every student throughout this section. Your assessment should be based on the record you made in relation to the students involvement in:

- discussing **Activity 4.7 - 4.12**
- presenting ideas after discussion
- performing **Experiments 4.2 - 4.6**
- presenting the findings obtained from the experiments
- asking questions during visits

- explaining findings from visits
- answering oral questions during mini-lecture.

In addition to that, give them **Exercise 4.2** as a homework. Check their work and record the performance of each student. Based on all the record you made, evaluate whether or not the suggested competencies for this section are achieved. Praise students who are working above the minimum requirement level and encourage them to continue working hard. For students working below the minimum requirement level, arrange extra lesson time or give them additional exercises on contents that are not clear to them.

Additional Questions

*1 What are the differences between temporary hard water and permanent hard water in relation to:
   a. dissolved salts they contain
   b. method of softening?

*2 Write the chemical equation for the formation of scum in hard water containing magnesium ions.

*3 What are the disadvantages of hard water?

*4 Which water treatment technique is useful to make water free from harmful micro- organisms?

*5 What is the contribution of acid rain to water pollution?

Answers to Additional Questions

1. a. Temporary hard water contains hydrogen carbonate of calcium and/or magnesium while permanent hard water contains chlorides/ sulphate of calcium and/or magnesium.

   b. Temporary hard water is softened by boiling while permanent hard water by the addition of washing soda

2. mg^{2} + (aq) + C_{17} H_{35} COO- (aq) → Mg $(C_{17}H_{35}COO)_{2}$ (s)

3. It wastes soap, leave dirty marks on cloth, form lime scale or boiler scale on the interior surface of kettles, pans and boilers.

4. Chemical treatment (chlorination)

5. Acid rain lowers the p^H of water of rivers, lakes and seas or increase the acidity of natural water and make the water unfit for survival of aquatic animals and plants.

Answers to Exercise 4.2

Part I

1.	False	2.	False	3.	False	4.	True	5.	True
6.	True	7.	False	8.	True	9.	True	10.	True

Part II

11. Temporary and permanent
12. Permanent hardness
13. Water pollutants
14. Physical, chemical and biological.
15. Softening of water.

Part III

16. Refer to the student text
17. See the explanation given to **Experiment 4.2** in this guide.
18. See the note given for **Activity 4.9** in this guide.
19. Refer to the student text.
20. See the text
21. Domestic waste, agricultural chemicals and industrial wastes.

22-24. See the note given for **Activity 4.11**

4.3 SOIL

Periods allotted: 6 periods

Competencies

After completing this sub-unit, students will be able to:

- *define soil as a thin layer of natural material covering the surface of the Earth.*
- *list the percentage composition of the solid, the liquid and the gaseous portions of soil.*
- *describe the composition of the solid, the liquid and the gaseous portions of soil.*
- *conduct an experiment to show composition of soil*

- *tell that soil can be acidic, alkaline or neutral.*
- *list the major plant nutrients*
- *explain methods of improving soil fertility*
- *prepare ammonium nitrate*
- *prepare compost in the school compound.*
- *apply the compost in school garden.*
- *tell the type of soil that is favourable for crop production*
- *suggest some methods of correcting soil acidity and alkalinity*

Forward Planning

Read the contents in this section thoroughly in order to make a plan of your own. Your plan should be prepared in a manner that you can complete the contents within six periods. In your plan, indicate the contents, activities and experiments you will deal with during each period. In addition to that show the time you allot for each activity you intend to do some of the activities in this section require library research or consulting other people. For example, **Activity 4.16**, **4.17**, **4.19** and **4.2**0. So you need to plan to give this activities and the project work some days before the periods at which you intend to deal with them. There are five experiments to be performed in this section. Prepare the materials required for the experiments beforehand. Carry out all experiments before you allow students to perform them.

Teaching Aids

Refer to the student text for the materials required to conduct **Experiment 4.7**, **4.8**, **4.9**, **4.10** and **4.11**.

Subject Matter Presentation

You are advised to use gapped lecture, inquiry, investigation, group discussion, presentation and experiment teaching methodologies to deal with contents in this section.

4.3.1 The solid, liquid and gas components of soil

Start teaching this topic using **Activity 4.13**. This activity enables students to realize the process responsible to the formation of soil and the parent materials from which it is

developed. So, allow the students to discuss this activity for some minutes in groups. After they complete, give the chance to two students of different groups to present the opinion of their group. Following the presentations, harmonize the ideas suggested by students using the following information.

1. The parent materials from which soil developed are rock and organic matter (plants and animal remains)
2. Soil is formed by the process called **weathering** which involves breakdown of rocks and decay and decomposition of organic matter.
3. Soil is the top thin layer of natural material covering the surface of the earth.

Continue to introduce to students the components of soil and the percentage of each component. Inform to them the constituents of the solid portion, liquid portion and gaseous portion of soil. After that, proceed to deal with **Activity 4.14**. The activity is suggested to enable students realize that the percentages of solid, liquid and gaseous portion can vary depending on the condition of the soil. Have the students discuss **Activity 4.14** for some minutes in groups. When they complete, invite some students to presents what they discussed to the rest of the class. After the presentations, harmonize ideas using the following information.

1. The percentage of carbon dioxide in soil air is slightly higher than that of atmospheric air because decay and decomposition of organic matter in the soil releases carbon dioxide which remains trapped in the soil.
2. When the soil is dry it may contain less water (less than 25%) and more air (greater than 25%). When the soil is wet, water takes up some part of the volume of air. So, the percentage of water is higher than 25% while that of air is less than 25%.

After harmonizing concepts, continue to deal with **Experiment 4.7**. Allow the students to perform it in groups.

When they complete the experiment, let them write a laboratory report in groups about their observations and present their findings to the rest of the class. Give the chance of presentation only to two groups. Make sure that the ideas forwarded the presentations agree with the following points.

a. Yes there are particles that settle to the bottom of the beaker.
b. The largest particles sink to the bottom. The order in which they settle from bottom to top is large, medium and fine.
c. Yes, there is a component of soil that floats on the surface of water. It is humus.

Then proceed to **Experiment 4.8**. Allow the students to perform it in groups. Give them the necessary assistance whenever they face a trouble while they are doing the experiment. When they complete the experiment, they need to write laboratory reports

in groups. You can help them on the calculation part of the experiment. After they finish writing the report, invite two groups to present their findings. Following the presentations, harmonize ideas based on the experimental results you discovered when you perform the experimental before hand, and using the following information.

a. The water content reported needs to be closer to 25%
b. The percentage of humus may vary depending on the type of soil used and its place of origin.
c. The air content discovered in the experiment may vary depending on the dryness or wetness of the soil used. However, the percentage is closer to 25% unless it is too wet.
d. The particles left on the first sieve are bigger, on the second sieve medium while those passed through the holes of the second sieve are fine.
e. This is the time you discovered in step 9. The result obtained by different groups can be compared in this case.

4.3.2 Acidic and Alkaline Soil

Start teaching this topic by asking students to suggest, 1. How they can identify acidic and alkaline solutions 2. The type of ions that gives acidic and alkaline nature to the solutions

This will help you to relate what students have learned in unit 1, about acids and bases to this topic. Get response from two or three students. After that, tell them the following.

1. Acidic and alkaline solutions are identified by using indicators.
2. Hydrogen ion (H^+) gives acidic solutions their characteristic property while the hydroxide ion (OH^-) is responsible to the property of alkaline solutions.

Continue to inform to students that soil can be acidic basic or neutral in nature. Introduce to them how soil can be acidic, alkaline or neutral in relation to the concentration of H^+ and OH^-. Next, tell to them that acidity and alkalinity of soil is expressed in terms p^H and the p^H values for acidic, neutral and alkaline soils. In addition to this inform to them that all types of soil are not suitable for the growth of a specific crop and each crop can grow best only in a soil of specific pH range.

Then proceed to deal with **Experiment 4.9.** Let the students perform the experiment in groups on their own. Give guidance and the necessary assistance whenever they face

problems. After they complete the experiment, they should write a report in groups about their observation and present their findings to the rest of the class two groups can make presentations. Only following the presentations, check whether or not the contents in their presentation match with your findings when you perform the experiment before the session. You may also use the following information

a. The colour developed by the pH indicator paper can be the same or different depending on the locality where the soil samples are collected.
b. The colour developed can be yellow or orange if the soil is acidic green if it is neutral or somewhat blue if it is alkaline.
c. You can tell to them the pH from what you have observed when students compare the colour developed by the indicator with the standard colour chart.

After concluding the topic proceed to the following part.

4.3.3. Plant nutrients and Soil Improvement

Start teaching this topic with **Activity 4.15.** The activity enables students to realize what a fertile soil is and how fertility of soil is improved. Have the students discuss this activity in groups for some minutes. After they complete discussing the activity, give the opportunity to two students from different groups to present the opinion of their groups. Next to that, harmonize concepts as follows.

1. A fertile soil is soil that contains all minerals required for the growth of plants in sufficient quantities and in the form plants can utilize. It is also a soil that gives good crop yield.
2. Farmers add fertilisers to agricultural soil to improve its fertility so that it produces good crop yield.

Continue dealing with the contents by asking students to define plant nutrients, get feedback from some students. After that, tell to them the actual definition and introduce to students the major plant nutrients. Next proceed to **Activity 4.16.** This activity enables students to investigate the importance of each of the major plant nutrients on their own by reading different books. This activity should be given to students some days before the period you planned to deal with it. Check that all of the students have done and have brought a written note on the activity. Then, have them discuss what they individually investigated in groups for some time. When they complete, invite two group representatives to present the findings of their groups. Following the presentations, harmonize concepts suggested by the students with the following information.

a. **Nitrogen:** in the growth of plants nitrogen in used in the synthesis of amino acids, proteins, coenzymes and in the synthesis of chlorophyll.

b. **Potassium** is component of enzymes that facilitate photosynthesis and protein synthesis and facilitate water movement in calls of plants.
c. **Phosphorus** facilities early growth and root formation, quick maturity and promotes seed and fruit formation. It has also a role in the formation of some amino acids, proteins and high energy phosphate compound like Adenosine Triphosphate (ATP).
d. **Magnesium** is a constituent of chlorophyll molecule plant
e. **Calcium** is a plant cell wall component and plays role in the structure and permeability of cell membranes.
f. **Sulphur** is used by plants for the synthesis of sulphur containing amino acids and proteins. It is constituent of some vitamins and also required for nitrogen fixation in leguminous plants.

Method of improving soil fertility

Start teaching this topic by asking the following questions

1. Define fertile and infertile soil.
2. How can one improve the fertility of soil?
3. What are the two classes of fertilisers?

Get feedback from students on each question. Appreciate the students for their attempts and tell them the differences between fertile and infertile soil, the need for addition of fertilizers to soil and the two classes of fertilizers.

Give some examples of organic (natural) fertilisers and then proceed to deal with **Activity 4.17.** This Activity enables students to discover the effectiveness of different types of dung when used as fertilisers. Allow them to discuss this activity for some minutes in groups. After the discussion, let some groups present their opinion to the rest of the class. Next to that, harmonize what they suggested to the following.

All types of dung serve as fertilisers. The dung from cows, sheep, goats, and chickens contain finely divided mater. When the dung from these animals is added to soil, it can decay and decompose rapidly and supply plants with the required nutrients. On the other hand, the dung from donkeys, horses and pigs doesn't contain finely divided matter. So it requires more time to decay and decompose. As a result, it takes more time to supply plants with the necessary nutrients. Thus, the dung from cows, sheep, goats and chickens is more effective than the dung from other animals.

Continue to introduce to students about chemical fertilisers. Inform to them the three classes of chemical fertilisers and give them some examples. Inform to them what is meant by NPK fertiliser and proceed to **Experiment 4.10.** Allow them to perform the experiment in groups. You should inform to them follow the procedure strictly. You are also advised to supervise how they are doing closely giving them assistance whenever they face difficulty. After they complete the experiment, let them write a laboratory report in groups and submit it to you for correction. When you correct the reports, make sure that the following points are included in the observation and analysis part of the experiment.

a. Pink or red
b. The pink or red colour disappears and turns colorless
c. Yes, There is. It is ammonium nitrate
d. $NH_3+HNO_3 \rightarrow NH_4NO_3$

Or $NH_4OH + HNO_3 \rightarrow NH_4NO_3 + H_2O$

After the experiment, continue to deal with **Activity 4.18.** This activity assists students discover the advantages and disadvantages of organic and synthetic fertilisers and their effects on the soil and water pollution. Have them discuss this activity in groups for some minutes. When they complete, give the chance to some group representatives to present results of their group discussion to the rest of the class. Next, harmonize concepts using the following information.

Table 4.1 Advantages and disadvantages of organic and synthetic fertilisers

Organic fertilisers	Chemical (synthetic) fertilisers
- Do not contain readily available plant nutrients - Provide nutrients to plants slowly - Do not produce harmful effects on soil. - Do not have significant effect on water pollution.	- Contain readily available plant nutrients - Provide nutrients to plants rapidly. - Some fertilizers like ammonium chloride and ammonium sulphate increase soil acidity. - Excessive use of them is one of the causes of water pollution.

Next, proceed to the suggested project work. It is hoped that you have given this project work before the period you planned to deal with it. So allow students what they discovered to discuss in groups and them invite students form different groups to present their findings to the rest of the class. In addition to that, let them add the compost to the soil in your school garden.

To harmonize ideas, you can use the following note.

Compost preparation

Raw materials use are mixed plant residues, animal dung and urine, soil, wood ash, other organic wastes available on a farm, water and green materials.

Importance of aeration

After the raw materials are compacted into a pit, aeration (exposing the compacted material to air) is very important to avoid the formation of undesirable products. Aeration also helps unwanted gaseous substances to escape and avoid over heating of the compacted materials.

Importance of watering compost

Composting works best when the moisture content of the compacted material is quite sufficient. Too much moisture slow down the decomposition of the compacted materials and the material will smell. When the materials is too dry, decomposition is either very slow or does not occur at all.

Function of compost accelerators

Heat and micro-organisms are compost accelerators. Heat, which is very important in rapid composting, is supplied by the respiration of the micro-organisms as they break down the organic materials. The compacted material should be turned to prevent overheating and to aerate in order to keep the most active decomposers alive and continue functioning.

4.3.6. Acidity and alkalinity

Start teaching this topic by asking students the causes for acidity and alkalinity of soil. Get feedback from some students and remind them what the causes are. Next, inform to them that each crop can grow best in a soil with a particular pH range. Support this idea with examples and proceed to deal with **Activity 4.19.** The activity enables students to discover the pH range of soil suitable for the growth of a particular crop. It is hoped that you have given this activity to students before the period you intend to deal with it. So let every student produce a written document on the activity, discuss their findings in groups for some minutes. Next, give the chance to some group representatives to

present the findings of their groups to the rest of the class. After the presentations tell them the following information.

Table 4.2. pH ranges of soil suitable for the growth of some crops.

Type of crop	pH rang of soil suitable for its growth
Barley	4.5 – 7.5
Wheat	4.2 – 7.5
Sorghum	4.5 – 7.5
Maize	4.5 – 7.5

Continue to introduce to students that decay and decomposition of organic materials can produce organic acids in the soil and results in acidity. Tell them the substances that are added to soil to reduce its acidity and adjust the pH to a desired value. After that, proceed to **Activity 4.20.** The activity enables students to realize that the amount of lime, limestone or slaked lime that should be added to soil depends on its acidity. Have then discuss the activity for some minutes in groups. When they complete, invite students from different groups to present the opinion of their groups. Next to the presentations, harmonize concepts as follows.

1. The soil from farm place A is more acidic
2. a. owner of farm place A should add more lime

   b. owner of farm place B should add less lime.

Then continue with **Experiment 4.11.** Allow students to perform the experiment in groups, write a laboratory report and some group representatives present their findings to the rest of the class. Make sure that presentations of the students include the following points in the observation and analysis part.

a. Limestone (calcium carbonate) changes to calcium oxide (quick lime) on heating. The equation for the change is:
   $CaCO_3$ (s) heat Ca O(s) + CO_2 (g)
b. Calcium hydroxide or slaked lime will be formed when quick lime is dissolved in water. The equation for the reaction is:
   CaO (s) +H_2O (l) → Ca $(OH)_2$ (aq)
c. Red litmus paper is changed to blue and it shows that the solution is basic or alkaline.

After that, inform to them how the addition of limestone, quick lime or slaked lime can reduce acidity by releasing hydroxide (OH^-) ion in the soil. The following equations show how these substances release OH^- ion in the soil.

$$Ca\,CO_3 + H_2O \text{ (from soil)} \rightarrow Ca^{2+} + HCO_3^- + OH^-$$

$CaO + H_2O$ (from soil) $\rightarrow Ca^{2+} + 2OH^-$

$Ca(OH)_2 \rightarrow Ca^{2+} + 2OH^-$

The OH released by the substance reacts with H^+ of the soil to form water.

$OH^- + H^+ \rightarrow H_2O$.

You can mention only the reaction of OH^- and H^+ to show the effect of adding limestone, quick lime and slaked lime to acidic soil.

Next, proceed to **Activity 4.21.** This activity enables students to investigate the effect of sulphur and irrigation on acidity, and soil pH. Make sure that every student in each group has prepared a written document about the investigation he/she made. Allow them discuss the activity in group for some minutes.

When the complete, allow some group representives to present the results of their discussion to the rest of the class. After the presentations, tell them the following information.

When soil pH is higher and unfit for the growth of a specific crop, the soil pH can be reduced by the addition of elemental sulphur to the soil. Sulphur is oxidized by soil bacteria and form sulphuric acid, H_2SO_4 that lowers the soil pH and increases soil acidity.

Soils with a pH above 7.5 generally have a high calcium carbonate content, known as free lime. The use of irrigation leaches out some naturally occurring elements such as calcium and magnesium. This results in slight decrease in soil pH over many decades.

Answers to Exercise 4.3

Part I

1.	True	2.	False	3.	True	4.	True	5.	False
6.	False	7.	False	8.	True	9.	False	10.	False

Part II

11. Solid 50%, liquid 25% and gas 25%

12. The solid components of solid consists of minerals and organic matter or humus, the liquid component of soil consists of water and dissolved minerals, the gas component of soil consists of air.
13. The major plant nutrients are N, P, K, Mg, Ca and S.
14. Addition of fertilizers.

4.4 FUELS

Periods allotted: 6 periods

Competencies

After completing this sub-unit, students will be able to:

- *define fuel as a substance which releases heat energy when it is burnt (combusted)*
- *describe elemental composition of coal, natural gas and crude oil*
- *explain uses of coal, natural gas and crude oil.*

Forward Planning

Read the contents in this section thoroughly from the student text. Posing a plan of your own in such a manner that you can complete the contents with in three periods. Your plan should indicate the topics and contents, suggested activities you are going to deal with as well as other duties you. Perform during each periods and the duration of time culotted to everything you planned to do **Activity 4.23** and **Activity 4.26** require library research so these activities must be given to students to perform the research two or three days before the period you intend to deal with them. So, show when to give these activities to students in your plan. Read this guide to get more information about the suggested activities and method losies you implement to teach contents in this section. Prepare a chart that shows the major fractions obtained by fraction distillation of crude oil beforehand.

Teaching Aids

Chart showing some petroleum fractions.

Subject matter Presentation

You are advised to implement group discussion, inquiry, library research, gapped lecture and presentations by students as methodologies to teach contents in this section.'

4.4.1 Coal, Natural gas and Crude Oil

Start teaching this section wit **Activity 4.22.** This activity enables students to differentiate types of fuels used in daily lives to get energy. Have them discuss this activity for some minutes in groups. After the discussion, allow two students from different groups to present the opinion of their groups. Next to the presentations, harmonized ideas as follows

1. a. Answer can be different you can suggest fire wood, charcoal, dried cow dung, dried leaves, kerosene bottled gas, etc.
   b. You can suggest petrol, diesel fuel, naphtha, etc.
2. All materials mentioned above are called fuels.

After that, continue introducing to students the definition of fuel, what fossil fuel means and those classified fossil, fuel. Then, tell to them about the formations of mineral coal, crude oil and natural gas and proceed to deal with the composition of coal crude oil and natural gas.

4.4.2 Composition of coal crude oil and natural gas

To teach the composition of these fossil fuels, you can start by asking students to suggest what the constituents of petroleum, natural gas and mineral coal are recalling what they learnt in unit one. Get response from some students and tell to them the composition of each fossil fuel. Next, continue with **Activity 4.23**

The activity enables students to identify areas of the world where large deposits of coal, crude oil and natural gas are found. So, allow them discuss this activity for some minutes in groups. When they complete, invite two or three students to present the findings of their groups. After the presentations, tell to them the following information.

Areas of the world with large deposits of

1. Coal are United States, Russia, China, Australia, India, Germany, Ukraine, Kazakhstan, South Africa, Serbia, etc.
2. Crude oil are Venezuela, Saudi Arabia, Canada, Iran, Iraq, Kuwait, United Arab Emirates, Russia, Libya, Kazakhstan, etc.
3. Natural gas are Russia, Iran, Qatar, Saudi Arabia, United States, etc.

You can collect the work of each student for correction.

Next, inform to them the presence of deposits crude oil, natural gas and coal in Ethiopia. Mention areas where these deposits are found in the country and continue with the uses of fossil fuels.

4.4.3. Uses of coal natural and crude oil

Start teaching contents of their topic, ask students to suggest as many uses as possible they know about coal. After you get feedback tell to them the uses of coal. Inform to them how coal is converted to coke what is meant by destructive distillation and products of destructive distillation of coal. Next proceed to **Activity 4.24.** The activity enables students to recall the environmental problems and effects associated to carbon monoxide and sulphur dioxide. So, have them discuss this activity in groups for some minutes, when they complete, invite two students from different groups to share their ideas to the rest of the class. After the presentation, harmonize ideas using the information given for **Activity 4.5** in this guide.

Next, proceed to deal with what flue- gas desulphurization process is and its importance in reducing environmental pollution. Continue to deal with the uses of natural gas. Use **Activity 4.25** for this purpose. This activity will enable students realize the uses of natural gas as domestic fuel and industrial fuel. Thus, allow them to discuss the activity in groups for some minutes. When the complete, give chance to one or two group representatives to present the opinion of the group to the rest of the class. After the presentations tell the following points.

a. Natural gas is used as a domestic fuel in the form of bottled gas to get energy for cooking food, for lighting and warm rooms.
b. Natural gas is used as an industrial fuel in different industries to produce large quantity of energy they require for their production activities.

After that, continue to deal with uses of crude oil. First tell to them that it can not be used as a fuel in the form it is obtained from underground deposits. Next inform to them about the important of refining crude oil and how it is separated into useful fraction. Introduce to them some of the fractions obtained from crude oil and the difference between crude oil and petroleum. Then proceed to deal with **Activity 4.26.** This activity enables students to identity the uses of different petroleum fractions. Make sure that each student has brought a written material on the activity and allow them to discuss their individuals work in groups for some minutes. After they complete the discussion, let some students of different groups present their group opinion to the rest of the class. Next harmonize ideas using the information given in **Table 4.3.**

Table 4.3 uses of some petroleum products.

fraction	Uses

Bottled gas	- As fuel for stores to cook food - As fuel for domestic heating.
Gasoline (petrol)	- As fuel for internal combustion engines (engines of cars.)
Kerosene	- As fuel for kerosene stoves - As fuel for aero planes
Fuel oils	- As furnace fuel - As diesel engine fuel.
Lubricating oils (Greases, petroleum jelly)	- For lubrication of parts of machinery, gears, engines etc. - As an ointment (petroleum jelly)
Bitumen	- To make roads, water proofing, manufacture of printing

Finally, collect their work for correction.

Assessment

You need to assess the work of every student throug out this section. In order to do so, make a record on the performance of each student in relation to his/her participation in:

- Group discussion on **Activity 4.22**, **4.23**, **4.24**, **4.25**, and **4.26**
- Presenting ideas after discussion of activities
- Answering oral questions during gapped lecture summary.

You can also check the work of every student on **Activity 4.23** and **4.26** and record the performance. Give them **Exercise 4.4** as a homework, correct the work of each student and record the achievement of every student. Based on the records you made evaluate whether or not the suggested competencies for this section are achieved. Appreciate students working above the minimum requirement level and encourage them to continue working hard. In case of students who are working below the minimum requirement level, arrange extra lesson time or give them additional exercise.

Additional Question

1. Explain how coal is converted to coke? What other products are obtained during the process?
2. Is natural gas always found naturally together with crude oil?
3. Why don't we use crude oil as a fuel directly in the form it is obtained from underground deposits?
4. What is fractional distillation? How can this process separate crude oil into different components?
5. What is the difference between crude oil and petroleum?
6. How can industries involved in petroleum production bring crude oil and natural gas to the surface of the earth from underground deposits?
7. What petroleum product is used to make:
   a. Candle
   b. Roads?

Answers to Additional Questions

1. Coal is converted to coke by the process called destructive distillation or coking of coal. The products obtained in this process are coke, coal gas, ammonical liquor and coal tar.
2. No, it is not always found in association with crude oil. It is also found alone in large deposits.
3. Because **i.** it contains sulphur and nitrogen compounds that has to be removed during refining.
   ii. it is a mixture of many hydrocarbons that serve as a fuel for different types of engines.
   iii. it contains heavier components that cannot be used as a fuel.
4. It is a process of separating liquid mixtures based on differences in their boiling points. It is used to separate different fractions because their boiling point ranges are different.
5. Crude oil is unrefined form obtained from underground deposits while petroleum is used to describe fractions obtained after refining and distillation of crude oil.
6. By drilling wells of some hundreds or thousands of meters of depth unit the ol or natural gas deposit is reached.
7. a. paraffin wax
   c. Asphalt

Answers to exercise 4.4

1. Fuel is solid, liquid of gaseous substance that produces heat and light energy when it is burned.

2. Fossil fuel refers to fuels formed from animal and plant remains that decomposed for millions of years in absence of air and include crude oil, natural gas and coal.
3. Refer to the student text.
4. Crude oil and natural gas principally contain the elements carbon and hydrogen while coal mainly contains carbon.
5. Refer to the student text.
6. Flue gas desulphurization is the process of removing sulphur dioxide from exhaust gases of industries. It is important as it avoids the emission of sluphur dioxide to atmospheric air and reduces air pollution and the effect of acid rain due to sulphur dioxide.

Answer to Review Exercise on Unit 4

1.	A	2.	B	3.	D	4.	C	5.	A
6.	C	7.	B	8.	C	9.	A	10.	A
11.	C	12.	C	13.	A	14.	B	15.	C
16.	B	17.	A	18.	D	19.	D	20.	A
21.	C	22.	B	23.	D	24.	A	25.	B
26.	D								

REFERENCES

A.Atkinson, certificate chemistry, 3rd edition, 1974, Longman Group Ltd, Aylesbury, England.

Darrell D. Ebbing, Steven D. Gammon, ***General Chemistry***, 6th edition, 1999, Houghton Mifflin Company, New York.

Davis, Gailey and Whitten, principles of chemistry 1984, CBS College publishing.

Henry Dorin, vitalized Chemistry, 7th edition, college Entrance Book company, 1970, New york.

James E. Brady and Gerard E.Humiston, General Chemistry, 3rd editon, 1982, Hohn Wiley and Sons. Inc. New york.

Raymond E. Davis, Principles of Chemistry 1984 Saunders College Publishing, Philadelphia, USA.

WEBSITES

http://en.wikipedia.org/wiki/Environmental_Chemistry

http://chemistry.about.com/od/environmental chemistry/Environ.

http://en.wikipedia.org/wiki/Air_pollution

http://www./B/.gov/Gducation/ELSI/pollution-main.html

http://waterforliving.com

http://www.millipore.com

http://www.lentech.com

http://en.wikipedia.org/wiki/wastewater

http://www.ca.uky.edu/wkree/hardness.htm

http://hubcap.clemson.edu

http://en.wikipedia.org/wiki/soilph

http://www.the global education project.org/earth/energy-supply.php

UNIT 5 CALCULATIONS BASED ON FORMULAS

Periods Allotted: 11 periods

Unit overview

The contents in this unit are more of calculations. It enables students gain more knowledge on what they have learned in grade 7 and also develop skills in computing calculations. The unit introduces basic concepts of chemistry that students can use in their study at higher levels.

The first section of the unit (5.1) introduces the information they can get from chemical formulas.

Section 5.2 gives emphasis to introduce students with definition of atomic mass, molecular mass, formula mass and method of calculating atomic mass, molecular mass and formula mass.

Section 5.3 deals with the mole concept. It presents the definition of mole and how to calculate molar mass. Besides that, it introduces how one can calculate number of particles from a given mass or number of moles and vise versa. Section 5.4 gives emphasis to percentage composition. This section presents what percentage composition of a compound is, steps used to calculate percentage composition and how to apply the steps.

The last section of the unit (5.5) deals with the determination of formulas. The definitions of empirical formula and molecular formula are included. In addition to that, this section introduces the steps used to determine empirical formula from a given percentage composition of a compound or given mass of constituent elements. It also gives more information on the method of determining molecular formula from empirical formula and molecular mass or from percentage composition of the compound and its molecular mass.

To teach the contents in this unit, it is useful to apply gapped lecture, group discussion, presentation, inquiry, cooperative learning and independent work methodologies.

Unit outcomes

After completing this unit, students will be able to:

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

  define biology as the study

Main Contents

5.1 INTRODUCTION

Periods allotted: 1 periods

Competencies

After completing this sub-unit, students will be able to:

- *understand what information a chemical formula of a compound can provide.*

Forward planning

You are expected to read the contents in this section thoroughly to be familiar with the contents. Set your own plan how to complete the contents in a single period, manage students during group discussion on suggested activities and to implement suggested methodologies for the section.

Suggested teaching Methods

To teach the contents in this section, use group discussion, question and answer, gapped lecture methodologies.

Suggested Teaching aids

Teaching aid is not suggested for the section.

Subject matter presentation

After introducing the topic of the lesson, you can start teaching this section with the start-up activity. The activity helps students to realize how the mass of small particles like atoms, molecules and compounds can be determined. So, have the students discuss on the start-up activity for a few minutes in groups. When they complete, allow two students from different groups to present their respective group's opinion. When the presentation is complete, harmonize concepts using the following information.

1. It is impossible to determine the mass of a single teff seed using an ordinary balance.
2. a. Suppose that 1.0g 'teff' contains 10,000 seeds, then the mass of a single teff seed is

$$\frac{1.0g}{10,000} = 1.0 \times 10^{-4} g$$

   b. If the mass of a single teff seed is 1.0×10^{-4} g, then the total mass of seeds in a quintal will be;

   1 quintal = 100 kg = 100×1000 g = 10^5 g

   From this you can calculate the number of seed as;

   1 seed has a mass of 1.0×10^{-4} g, so the number of seeds in 10^5 g is approximately.

$$\frac{10^5 g \times 1 \text{ seed}}{10^{-4} \text{ g/seed}} = 1.0 \times 10^9 \text{seeds}$$

3. Tell them that the mass of atoms and molecules is determined using a device called mass spectrometer using a standard atom.
4. Counting teff seeds in terms of quintal simplify knowing how much of them are there in a given quantity as mole simplifies in describing the amount of atoms or molecules in a given amount of substance.

Then continue to deal with chemical formula. First, ask the students to define what chemical formula is. You can allow them to discuss in groups for about two minutes. After that, get feedback from two students of different groups and then tell them the appropriate definition. Next, write the formula, CO_2 on the board and ask them what information they can get from this formula. After you get respose from one or two students, tell them the information chemical formulas can provide as suggested in the student textbook. When you complete, proceed to deal with **Activity 5.1.**

This activity helps students to get better understanding on what information they can get from chemical formulas. Have them discuss **Activity 5.1** for a few minutes. When they complete, encourage three students from different groups present their group's findings to the rest of the class. To harmonize ideas suggested by the students with the actual fact, tell them that the formula:

a. H_2O represents water molecule, composed of hydrogen and oxygen atoms in the ratio 2:1 or 1:8 by mass, etc.

b. CaO stands for calcium oxide, composed of calcium and oxygen atoms in 1:1 ratio or 5:2 by mass, etc.

c. $C_6H_{12}O_6$ stands for glucose, composed of carbon, hydrogen and oxygen atoms in 1:2:1 ratio or 6:1:8 by mass, etc.

Assessment

You should assess how each student is doing throughout this section. Give students **Exercise 5.1** as a homework. Check their work and give them corrections. Your assessment can include recording how each student:-

- Involves in group discussion
- Presents after discussion
- Answers oral questions during lecture
- Does the home work given.

From your record, make sure that all students achieved the minimum required level. Encourage those working above the minimum requirement level. Give additional exercises for those working below the minimum requirement level.

Additional question

1. What information do the following formulas provide.

   a. $CaCO_3$ b. H_2SO_4

2. Does a chemical formula of a compound describe its properties?

Answers to additional questions

1. a. Represents calcium carbonate composed of calcium, carbon and oxygen atoms, ratio of atoms of calcium, carbon and oxygen 1:1:3, mas ratio of Ca, C and O is 10:3:12,etc.

   b. Stands for sulphuric acid composed of hydrogen, sulphur and oxygen, H:S:O atoms ratio 2:1:4 and mass ratio 1:16:32, etc.

2. It doesn't show any property of the compound.

Answers to Exercise 5.1

1. Chemical formulas of compounds: b, d, e, g and h, while a, c and f are chemical formulas for molecules of elements.

2. No, they can only show that the three compounds are composed of the elements nitrogen and oxygen.

5.2 ATOMIC MASS, MOLECULAR MASS AND FORMULA MASS

Number of Periods allotted: 2 periods

Competencies

After completing this section, students will be able to:

- *describe atomic mass*
- *define the terms molecular mass and formula mass.*
- *describe the steps of calculating molecular mass and formula mass*
- *calculate molecular mass and formula mass using formula of a compound and atomic masses.*

Forward Planning

Read the contents in this section thoroughly from the student text. You also need to refer the subject matter presentation part of this section to get more information about the suggested activities and methodologies you apply.

Set a plan of your own that shows the details of contents you deal with activities you perform during each period and the time you allot to each activity. Your plan should be

prepared in such a manner to complete the contents of this section within two periods. You also need to make ready a periodic table chart.

Suggested teaching aids

Periodic table.

Suggested teaching methods

You can apply group discussion, inquiry , gapped lecture and individual work to teach contents in this section.

Atomic mass

You can start teaching contents of this section with **Activity 5.2.** The activity is suggested to assist students recall and relate what they have learned in Grade 7 to the contents in this section. Allow your students to discuss on **Activity 5.2** for few minutes in groups. When they complete, encourage some students from different groups to present their groups opinion. After the presentations, inform them that:

1. The mass of an atom arises from its constituent particles: electrons, protons and neutrons.
2. The numerical information that can be obtained in the box where the symbol of an element is found are its atomic number and atomic mass.

Next to that, introduce to students the definition of atomic mass, why relative atomic mass is used instead of actual mass of atoms, the atom that serves as a standard in determining relative atomic mass and the unit of atomic mass.

Following that, proceed to deal with **Activity 5.3.** This activity is suggest to help students to discover why the atomic masses of most elements are not whole numbers and recall what isotopes are. So, have them discuss this activity for some minutes in groups. When they complete, invite two students from different groups to present their opinion. Next to the presentations, harmonize concepts using the following information.

1.

Atomic Number	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Atomic Mass	6.94	9.01	10.81	12.01	14.00	15.994	18.99	20.2	22.99	24.03	26.98	28.08	30.97	32.06	35.5	39.95

2. The atomic masses are not whole numbers. This is because the masses of elements written on the periodic table are average of the masses of the naturally occurring isotopes of the elements.

3. No, because there are atoms of the same element having the same atomic number but different masses called isotopes.

Based on this activity, help students recall what isotopes are and then define average atomic mass. Next to that, show them how they can calculate the average atomic mass using an example. Give emphasis to percent abundance of isotopes and their masses as the basic quantities required to calculate average atomic mass. Finally, give additional problems for students to practice calculating average atomic mass.

Molecular mass and formula mass

Start teaching this part by asking students to suggest definitions of molecular mass and formula mass. Get feedback from two or more students. After their responses, appreciate students for their attempts and tell them the appropriate definitions of molecular mass and formula mass. In addition to the definitions, introduce to students that the term molecular mass is used to describe the mass of molecular substances while formula mass mostly describes the mass of substances that do not exist in molecular form (ionic compounds).

Next, proceed to deal with the steps used in calculating molecular mass and formula mass. Your explanation should be supported by solving some problems. Following that, give exercises to students so that they can practice calculating molecular mass and formula mass.

Assessment

You should assess how every student is doing throughout this section. Your assessment must be based on the records you made in relation to how each student:

- Participates in discussions on **Activity 5.2** and **5.3.**
- Presents the opinion of the group after discussion.
- Answering oral questions during mini-lecture.
- Asking questions.

Give them **Exercise 5.2** as a class work or homework; correct their work and record their performances.

From your record, evaluate whether or not the suggested competencies for this section are achieved by all students. Appreciate students who are working above the minimum requirement level and give them extra work. In case of students who are working below

the minimum requirement level, arrange additional lesson time or give them additional questions on the contents they didn't understand.

Additional Questions

1. The two common isotopes of carbon have masses of 12 a.m.u and 13 a.m.u. If the average atomic mass of carbon is 12.011 a.m.u, what would the percent abundance of each isotope be?
2. Calculate the formula mass of:
   a. $K_2Cr_2O_7$ c. $Ca(ClO_3)_2$
   b. $KMnO_4$ d. $(NH_4)_2HPO_4$
3. Calculate the molecular mass of:
   a. Cl_2O_7 b. N_2O_5
   c. $H_2S_2O_7$ d. P_4O_{10}
4. Boron has two isotopes whose atomic masses are 11.0 a.m.u and 10.04 a.m.u. The percent abundance of the heavier isotope is 80.2%. Calculate the average atomic mass of boron.

Answers to Additional questions

1. Abundance of isotope with a mass of 12 a.m.u and 13 a.m.u is 98.9% and 1.1% respectively.
2. a. 294 a.m.u b. 158 a.m.u
   c. 207 a.m.u d. 132 a.m.u
3. a. 183 a.m.u b. 108 a.m.u
   c. 178 a.m.u d. 284 a.m.u
4. 10.81 a.m.u

Answers to Exercise 5.2

1. percent abundance of isotope of chlorine with a mass of 35 a.m.u is 75% and that of the isotope with a mass of 37 a.m.u is 25%.
2. a. 48 a.m.u b. 17 a.m.u c. 58 a.m.u d. 90 a.m.u
   b. 180 a.m.u f. 80 a.m.u g. 92 a.m.u h. 62 a.m.u
3. a. 101 a.m.u b. 184 a.m.u c. 142 a.m.u d. 210 a.m.u
   e. 146 a.m.u f. 120 a.m.u g. 261 a.m.u h. 80 a.m.u

5.3 THE MOLE CONCEPT

Number of periods Allotted 3

Competencies

After completing this section, students will be able to:

- *define mole and molar mass*
- *calculate number of moles of atoms, molecules or formula units from a given mass or number of particles and vise versa.*
- *convert a given number of moles of atoms or molecules or formula units to number of atoms, molecules or formula units and vise versa.*

Forward planning

Read the contents in this section from the student text thoroughly. Design a plan of your own that shows the contents you treat during each period so that you can complete the contents with in three periods. In your plan, indicate the activities you perform and the time allotted for each activity. Read the teachers' guide to get information about the suggested methodologies and more idea on the activities included in the student text on this section.

Suggested teaching aids

No teaching aid is suggested.

Suggested teaching methods

You can use group discussion, gapped lecture and question and answer methods of teaching for this section.

Subject matter presentation

Start teaching this section with **Activity 5.4.** The activity is suggested to help students realize how grouping similar substances can simplify counting large number of items as does grouping atoms, molecules and formula units in moles. Thus, have them discuss **Activity 5.4** in groups. When they complete, encourage two students from different groups to present the opinion of their groups. Following that, tell them selling in boxes consisting of one hundred eggs is simpler than selling them by counting the eggs one by one. Tell them that tablets are also sold in containers or boxes containing specific

number. This simplifies for the pharmacist to sell the required number of tablets to the purchaser without counting the tablets individually.

Next, continue to introduce to students why it is important to group atoms and molecules in moles relating to their small size and mass. Inform them that as eggs and tablets are counted interms of number of boxes, atoms, formula units and molecules are counted or their number expressed in moles. Then, define mole interms of Avogadro's number. You need to present the definition of mole interms of number of atoms, molecules and formula units. Besides that, make your presentation in a manner that students could differentiate what the mass of one mole of atoms, one mole of molecules and one mole of formula units would be. Support your explanation using some examples you also need to give emphasis to molar mass which is the same as the atomic mass, molecular mass and formula mass in grams.

Continue introducing to students how they can calculate the mass of a substance in grams from a given number of moles. Solve some problems as examples. Give them questions as a classwork so that they can make practice. Check their work and give corrections.

After that, continue introducing to students how the number of moles of a substances is calculated from a given mass as well as from number of particles. Solve some problems as examples and then give them **Activity 5.5** so that they can make practice.

The activity enables students to realize how they can calculate the number of moles from a given mass. Have them do this activity in groups for few minutes. When they complete, invite one students to do the activity on the blackboard. Finally, give correction.

After that introduce to them how they can calculate the number of particles from a given mass of a substance. Give them an example and then exercise to help them make practice.

Next, continue to deal with **Activity 5.6.** The activity enables students to practice how to relate number of moles of a substance to the number of particles. So, allow them to do the activity in groups for some minutes. When they complete, allow one or two students to do the activity on the blackboard. After that, give correction if there are errors committed.

Assessment

You need to assess the work of every student throughout this section. You can evaluate the work of every student by recording his/her involvement in:

- The discussion on **Activity 5.4 - 5.6**
- Presentation after discussion on **Activity 5.4 - 5.6**
- Answering questions during presentation, harmonizing or summarizing concepts.

Give them **Exercise 5.3** as a homework, check their work and record their performances. From the cumulative record you have, check whether or not the suggested competencies are achieved by the students. Appreciate students who are working above the minimum requirement level and give them extra work. For students who are working below the minimum require level, arrange extra lesson time or give them additional exercises so that they can catch up the rest of the class.

Additional Questions

1. How many hydrogen atoms are there in:
   a. 2 mol NH_3 b. 5 mol $C_6H_{12}O_6$
   c. 3 mol H_2O d. 7 mol HCl
2. How many molecules or formula units are equivalent to:
   a. 0.5 mol O_2 b. 8 mol N_2
   c. 2.5 mol KCl d. 3.4 mol $NaNO_3$
3. How many grams are equivalent to:
   a. 0.5 mol $CaCO_3$ b. 2 mol NH_3
   c. 4 mol H_2SO_4 d. 10 mol Na_2CO_3
   e. 2.6 mol MgO f. 3.7 mol H_2O_2

Answers to the Additional questions

1. a. 3.613×10^{24} c. 3.613×10^{24}
   b. 3.61×10^{25} d. 4.215×10^{24}
2. a. 3.011×10^{23} c. 1.5055×10^{24}
   b. 4.818×10^{24} d. 2.05×10^{24}
3. a. 50 g d. 1060 g
   b. 34 g e. 104 g
   c. 392 g f. 125.8 g

Answers to Exercise 5.3

1. a. 85.5 g b. 44.8 g c. 285 g d. 23.4 g
   b. 48 g f. 450 g
2. a. 0.25 mol b. 0.25 mol c. 2.5 mol d. 1.25 mol
   e. 15 mol f. 2.5 mol g. 3 mol h. 0.4 mol

3. a. 1.2044×10^{24} b. 9.033×10^{23} c. 3.011×10^{23}

4. a. 1.2044×10^{24} b. 1.8066×10^{24}
   c. 4.5165×10^{23} d. 3.011×10^{24}
   e. 1.2044×10^{24} f. 1.5055×10^{23}

5. a. 9.033×10^{23} b. 1.2044×10^{24}

6. a. 30 mol b. 2.5 mol c. 0.15 mol d. 4 mol
   e. 9 mol f. 60 mol

5.4 PERCENTAGE COMPOSTION OF COMPOUNDS

Total number of periods allotted 2

Competencies

After completing this section, students will be able to:

- *describe percentage composition of a compound*
- *describe the steps of determining percentage composition*
- *calculate percentage composition of a compound from its formula*

Forward planning

Read the contents in this section from the student text. Set a plan of your own in a way that you can complete the content in two periods. In your plan, indicate the activities you perform, the contents to be treated, the time allotted to each activity and how to manage students during discussion.

Teaching Aids

No teaching aid is suggested for this section.

Suggested teaching methods

You can use group discussion, inquiry and gapped lecture to teach the contents in this section.

Subject Matter presentation

You can start teaching contents in this section with **Activity 5.7.** The activity enables students to develop skills on how to calculate percentage of an element in a compound. So, allow them to discuss **Activity 5.7** for some minutes in groups. When they complete, invite one student to show how their group managed the activity on the black board. After that tell them what the percentage of hydrogen is. Use the following information.

$$\%\text{ of hydrogen} = \frac{\text{mass of hydrogen}}{\text{mass of water}} = \frac{29}{18g} \times 100 = 11.11\%$$

You can also ask them to calculate the percentage of oxygen and then. Continue teaching on percentage composition of a compound. You better begin by asking students to define what percentage composition is based on how they determined the percentage of hydrogen in the suggested activity. Following their response, tell them the actual definition. Introduce to students the formula used to calculate percentage composition of a compound as follows.

$$\%\text{ composition} = \frac{\text{Mass of element in the compound}}{\text{Molar mass of the compound}} \times 100$$

In form to student the steps followed to calculate the percentage of each element in a compound. Solve some problems to show how they can apply the steps. Give them exercise as classwork or homework, check their work and tell them the correct answers. Finally, let them know that the sum of the percentages of the elements in a compound may not sometimes add up to exactly 100% due to some errors.

Assessment

Evaluate how every student is doing throughout this section. Your evaluation should be based on the record you have on how he/she is involving in:

- Group discussion
- Presentation after discussion
- Answering questions during mini-lecture

Besides that, give **Exercise 5.4** as a homework, check their work and include their performance to your record. Based on what you observe from the records you have, see whether or not the students have achieved the suggested competences for this section. Appreciate those working above the minimum requirement level and also give them additional work. For those working below the minimum requirement level you can arrange extra lesson time or give them additional questions.

Additional questions

1. Calculate the percentage of water of crystallization in each of the following compounds.

   a. $CuSO_4.5H_2O$ b. $Na_2CO_3.10H_2O$ c. $Fe_2O_3.3H_2O$

2. Calculate the percentage by mass of the constituent elements in each of the following compounds.

   a. Na_2SO_4 b. $Mg(HCO_3)_2$

   c. $Al_2(SO_4)_3$ d. KOH

Answers to additional questions

1. a. 36.07% b. 62.94% c. 25.23%
2. a. Na = 32.4%, S = 22.54%, O = 45.07%
   b. Mg = 16.44%, H = 1.4%, C = 16.44%, O = 65.75%
   c. Al = 15.8%, S = 28.1%, O = 56.1%
   d. K = 69.6%, O = 28.6%, H = 1.8%

Answers to exercise 5.4

1. a. Ca = 24.4%, N = 17.07%, O = 58.5%
   b. Na = 43.4, C = 11.3%, O = 45.3%
   c. Na = 57.5%, O = 40%, H = 2.5%
   d. N = 25.93%, O = 74.07%
   e. Fe = 28%, S = 24, O = 48%
   f. C = 60%, H = 4.4%, O = 35.6%
2. a. 21.2% b. 46.7% c. 35% d. 21.2%
3. a. 7.17% b. 30% c. 47.06% d. 36.8%
   b. 40% f. 17.02%

5.5 DETERMINATION OF FORMULAS

Total number of periods allotted 3

Competencies

After completing this, section students will be able to:

- *define empirical and molecular formulas*
- *describe the steps of determining empirical formula*
- *determine empirical formula of a compound from a given percentage composition or mass ratio*
- *describe the relationship between empirical formula and molecular formula*
- *describe the steps of determining molecular formula.*
- *determine molecular formula of a compound from empirical formula and molecular mass*

Forward planning

Read the contents in this section thoroughly from the student text. This will help you to make a plan how to deal with the contents. After reading the whole contents in this section, prepare a plan of your own so that you can complete the contents within three periods. In your plan, show the details of the activities you perform, the contents and the time allotted to each activity. You are also advised to read this teacher guide to gain more information about the suggested activities in the student text and methodologies you follow.

Prepare a chart showing empirical formulas and molecular formulas of some compounds.

Teaching Aids

Chart that shows molecular formulas and empirical formulas of some compounds.

Subject matter presentation

In order to teach this section, you are advised to implement group discussion, gapped lecture, inquiry and individual work methods of teaching.

Start teaching this section with **Activity 5.8.** This activity enables students to distinguish between empirical formula and molecular formula. Thus, allow them discuss **Activity 5.8** for some minutes. After they finish, invite two students from different groups to present the opinion of their respective groups. After that, harmonize what they suggested with the fact as follows.

a. The formula, $C_6H_{12}O_6$, indicates a molecule of glucose that consists of six carbon atoms, twelve hydrogen atoms and six oxygen atoms. The formula CH_2O shows that glucose contains carbon, hydrogen and carbon atoms in the ratio 1:2:1.

b. $C_6H_{12}O_6$ is the molecular formula and CH_2O is the empirical formula of glucose.

Continue teaching empirical formula and molecular formula. First, ask students to suggest what is meant by molecular formulas and empirical formula. Give chance to two or three students to respond to your question. After you get response, define molecular formula and empirical formula. Give examples to show empirical formulas and molecular formulas of some compounds. You can use the chart you prepared for teaching this part of the lesson.

After introducing to students about molecular formula and empirical formula, tell your students that some compounds can have the same empirical formula and molecular formula. Support your explanation with some examples.

Continue to deal with the method of determining empirical formula of a compound. First, introduce to students the steps that should be followed. After that, solve one problem to acquaint students with the steps and then give them one problem to solve it individually. Check how they are doing and give support when they face any trouble in applying the steps. Finally, give correction and additional problems as home work to enable them practice more.

Note: When you apply the steps to determine empirical formula of a compound, if one of the numbers you obtained in step 4 is of the type 1.25 or 1.333…, you should not discard the numbers after the decimal point. Instead, covert the numbers into improper fractions. For example, $1.25 = 1\frac{1}{4} = \frac{5}{4}$ while $1.333 \approx 1\frac{1}{3} = \frac{4}{3}$.

Students should realize how to determine the empirical formula of a compound from its composition expressed in percentage by mass of each element. In addition to that, solve some problems as examples to enable them understand how they can determine empirical formula of a compound when the masses of the constituent elements are given. Next, give them an exercise to practice, check their work and give the necessary corrections.

Make sure that they have understood determining empirical formula of a compound from given percentages and given masses of the constituent elements in a compound and then continue teaching on how the molecular formula of a compound is determined. First, introduce to them that the molecular formula is a whole number multiple of the empirical formula and the molecular mass of a compound is also a multiple of empirical formula mass. Next, inform to them the steps followed to determine molecular formula.

To help them understand the steps, first solve one problem on how to determine the molecular formula when the percentages of the constituent elements and the molecular mass of the compound is given. After that, give them one question so that they can practice. Support students facing a problem in applying the steps. Next, check their work and give correction.

Then, proceed to introduce to them how they can determine molecular formula if the empirical formula and molecular mass is given. Solve one question as an example and give them additional questions to practice.

Finally, give them **Exercise 5.5** as a homework to do it individually.

Assessment

You should assess the work of each student throughout this section. To do that you need to make a record about each student's performance;

- During discussion on **Activity 5.8**
- On presentation after discussion.
- In solving problems given as a classwork's.
- In answering questions during mini-lecture
- In solving problems in Exercise 5.5.

Based on the cumulative record you have about the students, make sure that the suggested competencies are accomplished. Praise students who are working above the minimum requirement level and also give them additional work. If there are students who are working below the minimum requirement level, arrange them extra lesson time or give them additional questions to help them catch up with the rest of the class.

Additional questions

1. A compound is composed of 93.75% carbon and 6.25% hydrogen by mass. What is the:
   a. empirical formula of the compound
   b. molecular formula of the compound if its molecular mass is 128 a.m.u.
2. Analysis of 15g of a compound proved that it contains 6 g carbon, 1 g hydrogen and 8 g oxygen.
   a. What is the empirical formula of the compound?
   b. What is the molecular formula of the compound if its molecular mass is 60 a.m.u?
   c. Is the empirical formula of the compound similar to its molecular formula?

Answers to Additional questions

1. a. C_5H_4 b. $C_{10}H_8$
2. a. CH_2O b. $C_2H_4O_2$ c. No

Answers to Exercise 5.5

1. C_6H_6 2. C_3H_6 3. P_2O_5 4. Na_2SO_4

Answers to Review exercise on unit 5

Part I

1. True
2. False
3. True
4. False
5. False
6. True
7. False
8. True

Part II

9. B
10. C
11. D
12. A
13. B
14. C

Part III

15. a 97.75 g b. 412.75 g c. 158.4 g d. 1418.4 g
16. a. 4.6875 mol, 2.823×10^{24} atoms
    b. 2.5 mol, 1.5055×10^{24} atoms
    c. 3 mol, 1.8066×10^{24} atoms
    d. 2.5 mol, 1.5055×10^{24} atoms
17. a. 1 mol b. 0.5 mol c. 37.4 mol
18. a. 95 g b. 111.86 g c. 60 g d. 3550 g
19. a. 220g, 5 mol b. 4.2 g, 0.15 mol
20. C_2H_6O
21. $C_4H_{10}O_2$

REFERENCES

A.Atkinson, certificate chemistry, 3rd edition, 1974, Longman Group Ltd, Aylesbury, England.

Darell D. Ebbing, General chemistry, Houghton Mifflin company, Boston.

Davis, Gailey and Whitten, principles of chemistry 1984, CBS College publishing.

Graham C.Hill, John Holman, chemistry in context, second Edition, 1983, Butler and Tanner ltd London.

Henry Dorin, chemistry, the study of matter, fourth edition, 1992, prentice Hall, Inc. Massachusetts.

Henry Dorin, vitalized Chemistry, 7th edition, college Entrance Book company, 1970, New york.

James E. Brady and Gerard E.Humiston, General Chemistry, 3rd editon, 1982, Hohn Wiley and Sons. Inc. New york.

Jerome L. Rosenberg, college chemistry, 6th Edition, 1980, McGraw-Hill Book company, New york.

Raymond change, General chemistry, 1st edition, 1986, Random House, New york.

Raymond E.Davis, principles of chemistry 1984 Saunders college Publishing, Philadelphia, USA

CHEMISTRY SYLLABUS
GRADE 8

General Objectives of Grade 8 Chemistry

1. *To Develop Understanding and Acquire Knowledge of:*

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

2. *To Develop Skills and Abilities of:*

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

3. *To Develop the Habit and Attitude of:*

- having an interest and curiosity towards the environment.
- being responsible about the safety of oneself, others and the environment.
- appreciating and predicting clean and healthy living.
- being cooperative, being systematic, thinking rationally.

UNIT 1: CLASSIFICATION OF COMPOUNDS *(17 Periods)*

Unit outcomes: Students will be able to:

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

Competencies	***Contents***	***Suggested activities***
Students will be able to:	***1. Classification of compounds***	
• Tell that compounds are classified as organic and inorganic	**1.1 Introduction** *(1 period)*	Students should be aware that chemical compounds can be loosely divided into two groups called organic compounds and inorganic compounds. Students could discuss the historic origins of these terms, and in particular the relationship between organic chemicals and living things. More able students could find out about the 'vis vitalis' and the significance of Wohler's synthesis of urea, an organic chemical, from inorganic starting materials.
• Define organic compounds as the study of carbon containing compounds	• Organic compounds	Students should be aware of the modern definition of organic chemistry as the chemistry of carbon excluding the chemistry of carbonates, hydrogencarbonates, carbon monoxide and carbon dioxide which are inorganic
• Define inorganic compounds as the study of non-carbon containing compounds	• Inorganic compounds	Students should be aware of the modern definition of inorganic chemistry as the chemistry of elements and their compounds other than carbon
	1.2 Organic compounds *(4 periods)*	

Competencies	*Contents*	*Suggested activities*
• Write the general formula of alkanes, alkenes and alkynes • Write the specific chemical formulas of the first ten members of alkanes, alkenes and alkynes	• Formula	Students should be aware that organic compounds are classified into groups – called homologous series – on the basis of a functional group. Students should understand that hydrocarbons are organic compounds whose molecules are composed of hydrogen and carbon only – hence the name. They should be made aware of the three groups of hydrocarbons: alkanes, alkenes and alkynes Students should appreciate that all members of a group can be represented by a general formula: Alkanes – can be expressed by the general formula C_nH_{2n+2}, where n is the number of carbon atoms. Alkenes – have the general formulas C_nH_{2n} Alkynes –the general formula C_nH_{2n-2} Students should use the general formula to write the actual formulas of alkanes, alkenes and alkynes for different values of n. Students could be asked to give examples of molecular formulas of alkanes, alkenes and alkynes.
• Name the first ten members of alkanes, alkenes and alkynes	• Nomenclature	Students should understand that the name of a hydrocarbon is derived from the number of carbon atoms present (prefix) and the ending it contains (suffix). Students should be given the prefixes used for hydrocarbons containing up to 10 carbon atoms: 1 meth, 2 eth, 3 prop, 4 but, 5 pent, 6 hex, 7 hept, 8 oct, 9 non, 10 dec Students should be given the suffixes for the three groups of hydrocarbons: alkanes – ane,

Competencies	*Contents*	*Suggested activities*
		alkenes –ene, alkynes –yne. Students could be asked to construct the name of a compound from information given e.g. an alkene containing 7 carbon atoms is heptene. They could also be asked to deduce the molecular formula of a hydrocarbon from its name e.g. butane is an alkane containing 4 carbon atoms
• List some common uses of organic compounds	• Importance	Students should be able to identify important uses of some hydrocarbons. These could include: • Methane – fuel gas • Propane and butane – bottled gas (buta gas) • Octane – component of petrol (fuel for engines) • Decane-components of kerosene (for cooking and lighting) • Ethene and propene – feedstock for polymers(starting material for plastics) • Ethyne – at high temperature for cutting and welding Students could also identify important uses of organic chemicals other than hydrocarbons. These could include: • Ethanol – in alcoholic drinks • Ethanoic acid – in vinegar • Formalin - preservation
	1.3 Inorganic compounds *(12 periods)*	
• Tell that inorganic compounds are classified into oxides, acids, bases		Students should be aware that, just as with organic compounds, inorganic compounds can be classified into groups according to

Competencies	*Contents*	*Suggested activities*
and salts		their composition and their properties. These include: • Oxides • Acids • Bases • Salts
• Define oxides	• Oxides	Students should understand that oxides are formed when elements react with oxygen. Oxides can be classified as follows:
• Classify oxides into metallic and non metallic • Give examples of metallic and non metallic oxides. • Define acidic oxide and basic oxide, • Give examples of acidic and basic oxides. • Describe the properties of acidic oxides and basic oxides. • Explain the preparations of acidic oxides and basic oxides. • Prepare sulphur dioxide in the laboratory by burning sulphur in air	- Types of oxides Metallic oxides Non metallic oxides - Properties of oxides • Preparation of oxides	• Metallic oxides - binary compounds containing only metals and oxygen. eg. Na_2O, Al_2O_3, MgO • Non-metallic oxides - binary compounds containing non metals and oxygen. • eg. CO_2, , SO_3, H_2O • Basic oxides react with acids – most oxides of metals • Acidic oxides react with bases – most oxides of non-metals
• Use moist blue litmus paper to test the acidic nature of sulphur dioxide • Prepare magnesium oxide in the laboratory by burning magnesium ribbon in air • Use red litmus paper to test the basicity of magnesium oxide in water solution		Students should explore two of the methods of preparing oxides. These could include: • Direct synthesis • Thermal decomposition. Students could prepare oxides by heating elements in air or in pure oxygen. These could include: • Carbon – to form carbon dioxide, an acidic oxide • Iron wool – to form iron oxide,

Competencies	*Contents*	*Suggested activities*
• Define acid as a substance that releases hydrogen ions in water solution. • Give some common examples of acids. • Define PH as the measure of acidity or alkalinity of a solution • Describe PH scale • Explain preparation of acids by direct combination of elements and reaction of acidic oxide with water • Describe the properties of acids • Conduct experiments on the properties of acids. • List some common uses of hydrochloric acid, nitric acid and sulphuric	• Acids - The PH scale - Preparation	a basic oxide Students should prepare sulphur dioxide, an acidic oxide, by burning sulphur in air in a gas jar. The resulting gas should be shaken with a small amount of water and litmus solution or blue litmus paper should be added to demonstrate that the resulting solution is acidic. Students should prepare magnesium oxide, a basic oxide, by burning magnesium in air in a gas jar. The resulting powder should be shaken with a small amount of water and litmus solution or red litmus paper should be added to demonstrate that the resulting solution is alkaline (basic). Students could investigate the formation of oxides by the thermal decomposition of: • Copper hydroxide • Copper carbonate • Copper nitrate Students could be asked to predict the nature of the oxides formed by some metals, such as sodium and calcium, and some non-metals such as carbon and phosphorus. Students should appreciate that acids are a group of substances that all release hydrogen ions, H+, when in aqueous solution. and they have soon taste. Students should give list of some acidic substances in their daily life. These could include lemon juice, vinegar, sour talla and milk. Students should be able to name

Competencies	*Contents*	*Suggested activities*
acid • Define base as a substance that neutralises an acid • Define an alkali as a substance that releases hydroxide ions in aqueous solution • Give some common examples of bases • Prepare bases by the reaction of metals with water and basic oxides with water • Describe the properties of alkalis • Investigate properties of bases experimentally • List some common uses of sodium hydroxide, magnesium hydroxide and calcium hydroxide • Define dilute and concentrated acid and base • Describe concentrated acidic and alkaline solutions • Describe dilute acidic and alkaline solutions • Explain the safety	- Properties - Uses of hydrochloric acid, nitric acid and sulphuric acid • Bases - Preparation - Properties	the three common laboratory acids: • Hydrochloric acid • Nitric acid • Sulphuric acid Students could also identify less common acids including: • Methanoic (formic) acid • Ethanoic (acetic) acid • Benzoic acid Students should be aware that the PH scale ranges from 0 - 14. Students should be familiar with preparation of the three common laboratory acids. This could include the direct synthesis followed by dissolution in water and reaction of acid anhydride with water. • Dinitrogen penta oxide • Nitric acid • Sulphur trioxide • Sulfuric acid • Hydrogen and chlorine • Hydrochloric acid Students should investigate the properties of acids by experiment. This could include: • Effect on acid-base indicators • Reaction with metals (e.g. iron, zinc, aluminium, magnesium), • Reaction with carbonates and hydrogencarbonates • Neutralising effects on bases As a result of these experiments students should deduce the general properties of acids. Students should research the uses of the three common laboratory

Competencies	*Contents*	*Suggested activities*
precautions while working with acids and bases	- Uses of sodium hydroxide, magnesium hydroxide and calcium hydroxide • Dilute and concentrated acids and alkalis • Precautions in working with acids and bases	acids. These could include: • hydrochloric acid – pickling metals • nitric acid – fertilisers, explosives • sulphuric acid – fertilizer, carbatteries etc. Students should appreciate that bases are a group of substances that all react with acids by neutralising them to form salts. They should also know that bases which are soluble in water are called alkalis. Alkalis release hydroxide ions, OH-, when in aqueous solution and have better taste. Students should be able to name the three common laboratory alkalis: • Sodium hydroxide solution • Calcium hydroxide solution • Ammonia solution Students should be able to name some common bases including metal oxides and hydroxides. Students should already be familiar with the preparation of the alkali magnesium hydroxide from previous work on metal oxides. This could be extended to provide a general route to the preparation of alkalis. Students could prepare calcium hydroxide by heating calcium in air/oxygen and dissolving the resulting calcium oxide in water. Students should investigate the properties of bases by experiment. This could include:

Competencies	*Contents*	*Suggested activities*
		• Effect on acid-base indicators • Neutralising effects on acids As a result of these experiments students should deduce the general properties of alkalis. Students should research the uses of common bases. These could include: • Sodium hydroxide - oven cleaner, soap making, making artificial fibres such as rayon • Magnesium hydroxide – in anti-acid preparations • Calcium hydroxide – limewater, mortar, neutralises acidic soils Students should be able to define concentrated and dilute acidic and basic solutions. Students should appreciate that acids and alkalis may be used as concentrated and dilute solutions. For most laboratory experiments we work with dilute solutions since they are less hazardous. Students should be aware of the corrosive nature of both acids and alkalis and take suitable precautions when working with them. These precautions should include: • Wearing eye protection (goggle) • Wearing protective clothing such as an apron or laboratory coat • Keeping reagent bottles stoppered when not in use • Wiping up all spillages straight

Competencies	*Contents*	*Suggested activities*
		away with a wet cloth
• Give some common examples of salts	• Salts	Students should give some common salts. These could include: • Sodium chloride (table salt) • Sodium bicarbonate • Calcium carbonate • Diammonium phosphate (DAP) • Potassium nitrate
• Name some common salts	• Naming salts	Students should appreciate that in chemistry the term 'salt' applies to a group of compounds. In order to avoid confusion common salt should be referred to as table salt and not just salt. Students should already be aware from the work on acids and bases that acids react with bases to produce a group of chemicals called salts. Students could discuss groups of salts and relate their names to the acid from which they are derived e.g. • Chlorides (hydrochloric acid) • Nitrates (nitric acid) • Sulphates (sulphuric acid)
• Define salts as compounds that are composed of the positive ions of a base and the negative ions of an acid. • Tell that salts are classified as binary and ternary • Define binary salts • Define ternary salts • Give examples of binary and ternary salts	• Classification of normal salts - Binary salts - Ternary salts	Students could derive the name of a salt prepared from a given base and acid e.g. sodium hydroxide + hydrochloric acid → sodium chloride.
• Explain direct elemental combination and neutralization reactions as methods of salt preparation	• Preparation - Direct combination	Students could suggest a combination of a base and an acid to make a named salt e.g. copper oxide + sulphuric acid → copper sulphate From the names of the salts, students should deduce that a salt consists of positive ions (provided by the base) and negative ions

Competencies	*Contents*	*Suggested activities*
		(provided by the acid).
	- Neutralization	Students should understand that salts can be classified according to the number of elements they contain. Binary salts, such as sodium chloride, contain two elements, sodium and chlorine while ternary salts, such as sodium sulphate, contain three elements, sodium, sulphur and oxygen. Students could be given examples of salts and asked to classify them as binary or ternary, and to write their formulas. Students should appreciate that some salts can be made by the direct combination of elements e.g. sodium chloride results from burning sodium in chlorine. They should appreciate that this works for some chlorides but not for nitrates and sulphates. Students should appreciate that the more general and useful method of preparing salts is by neutralisation reactions involving acids and bases. Students should prepare salts using different routes including: • Basic oxide + acid • Metal hydroxide + acid Students should appreciate that not every method is suitable for preparing every salt. Students could discuss suitable reactions for preparing samples of named salts.
• List some uses of common salts	• Uses	Students should research the important uses of particular salts. These could include:

Competencies	*Contents*	*Suggested activities*
		• Sodium chloride • Calcium carbonate • Sodium bicarbonate • Potassium nitrate • DAP Students could prepare a three-minute presentation on the preparation and uses of important salts.

Assessment

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

Students at minimum requirement level

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

Students above minimum requirement level

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

Students below minimum requirement level

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

UNIT 2: SOME IMPORTANT METALS (12 Periods)

Unit Outcomes: Students will be able to:

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

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

Competencies	*Contents*	*Suggested Activities*
		report on the properties of Fe, Ag and Au to their class.
	2.2 Sodium and potassium *(2 periods)*	
• Explain the occurrence of sodium and potassium	• Occurrence	Students should appreciate that sodium and potassium are in Group 1 of the Periodic Table and are therefore too reactive to occur as native metal.
• List common ores of sodium and potassium	• Important ores	Students could discuss what would happen if metallic sodium or potassium was left in soil for any length of time.
• Discuss the uses of sodium and potassium	• Uses	Students could discuss why sodium and potassium were not isolated until the early nineteenth century while other metals like gold, silver and copper have been known since ancient times. Students should identify the main ores of sodium and potassium including: • Sodium – halite (table salt) • Potassium – sylvite Students should be aware that these elements are too reactive to be used as metals. Students could research the uses of potassium and sodium compounds including: • Some Potassium salts in fertilisers • Potassium nitrate and potassium chlorate in explosives • Potassium mangante(VII) as medicine (drying agent) Students could research the uses of sodium compounds including: • Sodium chloride as a

Competencies	*Contents*	*Suggested Activities*
		preservative and as food additive • Sodium hydroxide in soap making and other industrial processes • Sodium carbonate and sodium sulphate in glass industry.
• Explain the occurrence of magnesium and calcium	**2.3 Magnesium and calcium** *(2 periods)* • Occurrence	Students should appreciate that magnesium and calcium are in Group 2 of the Periodic Table and are therefore too reactive to occur as native metal. Students could carry out an experiment in which they leave samples of metallic magnesium or calcium in soil for a couple of weeks to observe the effect this has on the metals.
• List common ores of magnesium and calcium	• Important ores	Students could discuss why magnesium and calcium were not isolated until the early nineteenth century while other metals like gold, silver and copper have been known since ancient times.
• Discuss the uses of magnesium and calcium	• Uses	Students should identify the main ores of magnesium and calcium including: • Magnesium – dolomite, magnesite • Calcium – limestone, dolomite Students should be aware that magnesium is used in flares and fireworks. They should link this to the bright light emitted when magnesium burns in air. Magnesium is also used with aluminium to make low density alloys. Students could research the uses of some magnesium compounds.

Competencies	*Contents*	*Suggested Activities*
		These could include: • Magnesium oxide – furnace lining • Magnesium hydroxide, chloride, sulphate, citrate – medical uses Students should be aware that calcium has limited use as a metal. It is used in the manufacture of some other metals, and in some alloys. Students could research the uses of some calcium compounds. These could include: • Calcium oxide/hydroxide – soil acidity • Calcium compounds in building materials such as cement, mortar, gypsum and marble Students should remember that aluminium is in Group 3 of the Periodic Table and is too reactive to occur as native metal.
	2.4 Aluminium *(1 period)*	
• Explain the occurrence of aluminium	• Occurrence	
• List common ores of aluminium	• Important ores	Students could discuss why aluminium was not isolated until the early nineteenth century while other metals like gold, silver and copper have been known since ancient times. They could also discuss why, when first discovered, it was more expensive than gold.
• Discuss the uses of aluminium	• Uses	Students should identify the main ores of aluminium including: • Bauxite Students should be aware of the uses of aluminium including: • Cooking utensils • Door and window frames • Low density alloys

Competencies	*Contents*	*Suggested Activities*
• Explain the occurrence of iron • List common ores of iron • Discuss the uses of iron	**2.5 Iron** *(1 period)* • Occurrence • Important ores • Uses	Students should be aware that iron has been known since ancient times. From this they should deduce that it is easier to extract iron from its ores than the metals discussed in the previous sections. Students should identify the main ores of iron including: • haematite • magnetite Students should be aware that iron is most frequently used as the alloy steel, which is stronger than pure iron. Students should discuss the uses of iron/ steel including: • Building construction – girders (Ferro) • Fabrications – car bodies etc. • Common items e.g. bicycle frames, tin cans etc.
• Explain the occurrence of copper and silver • List common ores of copper and silver • List the uses of copper and silver	**2.6 Copper and silver** *(1 period)* • Occurrence • Important ores • Uses	Students should be aware that both copper and silver have been known since ancient times. Students should also be aware that both metals can be found as native metal i.e. as metal in the ground. From this they should deduce that copper and silver are easy to be extracted from their ores. Students should identify the main ores of copper and silver including: • Copper – native metal, chalcopyrite, chalcocite, malachite • Silver – native metal, argentite Students should discuss the uses of

Competencies	*Contents*	*Suggested Activities*
		these metals including: • Copper – electrical wiring, piping, coinage • Silver – electrical wiring and ornaments
	2.7 Gold, platinum and tantalum *(2 periods)*	
• Explain the occurrence of gold platinum and tantalum	• Occurrence	Students should be aware that gold and platinum have been known since ancient times although very little attention was paid to platinum as it was neither prized nor used in the same way as gold.
• List common ores of gold, platinum and tantalum	• Important ores	Students should be aware that both gold and platinum are found as native metal. From this they should be able to make certain deductions about their reactivity.
• List the uses of gold platinum and tantalum.	• Uses	Students should know that tantalum was discovered around two hundred years ago. Students should identify the main ores of gold, platinum and tantalum including: • Gold – native metal, calaverite • Platinum - native metal, sperrylite • Tantalum – tantalite Students should discuss the uses of these metals including: • Gold – electrical wiring, jewellery • Platinum – jewellery, catalyst • Tantalum – capacitors, surgical uses
	2.8 Alloys *(2 periods)*	
• Define the term alloy	• Advantages of alloying metals	Students could be asked to define alloys Use some common alloys to introduce the idea of modifying the

Competencies	*Contents*	*Suggested Activities*
• Give examples of some common alloys • Describe the importance of alloying • Identify the components of some common alloys • Describe some of the common properties of alloys • Explain the uses of some common alloys	• Some common alloys and their uses	properties of a metal by mixing other elements (often but not always other metals). These alloys could include: • Steel – iron and carbon • Brass – copper and zinc • Bronze – copper and tin • Cupronickel – copper and nickel • Electrum – gold and silver Students could discuss why alloys were often used in ancient times e.g. bronze and electrum, because people had no means of separating the metals. Students could discuss why an alloy might be more useful than a pure metal. For example, pure gold is very soft and jewellery made of pure gold would soon wear away so other metals are added to harden the gold. Students could research how the purity of gold is expressed – 24 carat is pure gold thus 18 carat is 75% gold etc. Students could research other alloys and find out why they are used. These could include: • Duralumin – an alloy of aluminium, magnesium, copper and manganese which still has a low density but is stronger than pure aluminium. As the result it is used in air craft industry. • Solder – an alloy of lead and tin which has a low melting point so it can be easily melted to join copper wires and pipes • Bronze – an alloy of copper and

Competencies	*Contents*	*Suggested Activities*
		tin which is harder than pure copper. It is used in making general metal work, medals, coins and sculptures. • Stainless steel – an alloy of iron, carbon, chromium, nickel which is strong but does not rust. It is used for making cuttlery, tools and surgical instruments • Brass - an alloy of copper and zinc. It is used to make ornaments, nuts and bolts and musical instruments. Students should link the properties of an alloy to the ways in which it is used.

Assessment

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

Students at minimum requirement level

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

Students above minimum requirement level

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

Students below minimum requirement level

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

UNIT 3: SOME IMPORTANT NON-METALS (10 Periods)

Unit Outcomes: Students will be able to:

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

Competencies	***Contents***	***Suggested Activities***
Students will be able to:	***3. Some important non-metals***	
• Mention the general properties of Non metals	**3.1 General properties of non-metals** *(1 period)*	Students should appreciate that some non-metals are just as important as metals although they are used in completely different ways. Let the students list some common non-metals and discuss their uses. Students should be able to identify general properties of most non-metals including: • Poor thermal and electrical conductor • Non-malleable and non-ductile, • Non-lustrous • Low M.P. and Low B.P.
	3.2 Carbon *(2 periods)*	
• Explain the occurrence of carbon	• Occurrence	Students should recognise carbon as the basis of all life forms on the Earth. They had already been introduced to carbon chemistry in Unit 1 and been made aware of the historic link between organic chemistry and living organisms. Students should be aware that carbon exists in three solid forms at

Competencies	*Contents*	*Suggested Activities*
• Discuss the uses of elemental carbon	• Uses	room temperature: diamond, graphite and fullerenes. They should be aware of the term 'allotropes' which describes different forms of the same element in the same physical state. They should be able to understand properties of diamond – including rigid structure, hard, electrical insulator. Students should discuss the uses of diamond related to its properties. These could include: • Jewellery – attractive appearance • Cutting and grinding – very hard • Heat sinks – good thermal conductors Students should be able to understand some properties of graphite like electrical conductivity, softness and slippery. Students should discuss the uses of graphite related to its properties. These could include: • Pencils – softness • Graphite greases – slippery • Electrodes in motors – provides electrical contact but soft so wears out without wearing the motor parts • Electrodes in dry cell – conducts electricity

Competencies	*Contents*	*Suggested Activities*
	3.3 Nitrogen *(2 periods)*	
• Explain the occurrence of nitrogen	• Occurrence	Students should be aware that nitrogen forms around $^4/_5$ths of the air.
• Conduct an experiment to estimate the nitrogen content		Students should appreciate that nitrogen is much less reactive than oxygen and when substances are heated in air they react with oxygen far more than nitrogen. Students could investigate practical methods of estimating the nitrogen content of air by removing oxygen and carbon dioxide, and be aware of the limitations of accuracy of this method as it does not remove argon (bell jar experiment)
• Discuss the uses of elemental nitrogen	• Uses	Students should be aware that nitrogen is essential to the growth of plants. Most plants cannot absorb atmospheric nitrogen but obtain nitrogen by absorbing nitrogenous compounds (e.g. nitrates, ammonium compounds, urea) in soil water. Students could research the role of nitrogen-fixing and denitrifying bacteria in the root nodules of leguminous plants, and in the soil. Students should be aware that Nitrogen is used to produce ammonia.
	3.4 Phosphorous *(1 period)*	
• Explain the occurrence of phosphorous	• Occurrence	Students should appreciate that phosphorus has two common allotropes, white phosphorus and red phosphorus. Students should appreciate that,

Competencies	*Contents*	*Suggested Activities*
• Discuss the uses of elemental phosphorus	• Uses	owing to its reactivity with air and other substances containing oxygen, phosphorus is not found as the element, but as compounds which are largely phosphates. For this reason phosphorous is usually kept under water. Students should investigate and discuss the uses of elemental phosphorus. These could include: • Formation of phosphoric acid • Military applications such as incendiary bombs • Matches • In alloys such as phosphor bronze Students could also research the uses of some important compounds of phosphorus including phosphoric acid, sodium tripolyphosphate, calcium phosphate and organophosphorus compounds. Students could investigate the importance of phosphorus in living things – both plants and animals.
	3.5 Oxygen *(1 period)*	
• Explain the occurrence of oxygen	• Occurrence	Students should be aware that oxygen forms around $^1/_5$ths of the air. They should appreciate that oxygen is the active component of air.
• Discuss the uses of elemental oxygen	• Uses	Students could also be made aware that oxygen is present in water and that oxygen can be obtained from

Competencies	*Contents*	*Suggested Activities*
		water by using electrical energy Students should be aware that oxygen is essential for combustion and for respiration (life giving) for cutting and welding and as rocket fuel.
• Explain the occurrence of sulphur	**3.6 Sulphur** *(1 period)* • Occurrence	Students should appreciate that sulphur has three allotropes: rhombic sulphur, monoclinic sulphur and plastic sulphur. Students should be aware that sulphur is commonly found as a yellow solid at room temperature and has been known since ancient times.
• Discuss the uses of elemental sulphur	• Uses	Students could research the countries which are the main providers of elemental sulphur. They should be aware that it is found in Ethiopia (Afar region.) Students could discuss the advantages of recycling elemental sulphur including: • Reducing demand on resources • Reducing atmospheric pollution resulting from sulphur dioxide Students should be aware of the uses of elemental sulphur including: • Preparation of match • Preparation of sulphurdioxide (fumigant)

Competencies	*Contents*	*Suggested Activities*
• Explain the uses of some common compounds of non-metals.	**3.7 Uses of common compounds of non metals** *(2 periods)* • Carbon dioxide • Sodium carbonate • Nitric acid • Phosphoric acid • Calcium phosphate • Sulphur dioxide • Sulphuric acid	• Vulcanization of rubber • Preparation of sulphuric acid • Preparation of gunpowder Students should be familiar with the uses of a number of common non- metallic compounds. These could be dealt with isolation or integrated into the previous sections. For example, carbon dioxide could be discussed as part of the work on carbon. Groups of students could research the uses of one compound and prepare a brief summary that could be shared with the class. Uses could include: • Carbon dioxide – fire extinguishers, carbonated drinks • Sodium carbonate – washing soda, making glass • Nitric acid – fertilisers, explosives • Phosphoric acid – food processing, chemical reagent • Calcium phosphate – rising agent, fertilizers • Sulphur dioxide – bleaching agent, preparation of sulphuric acid, fumigant • Sulphuric acid – chemical reagent in most industries

Assessment

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

Students at minimum requirement level

Students working at the minimum requirement level will be able to: Know the general properties of non-metals and how to differentiate non-metals from metals, explain the occurrence and uses of carbon, nitrogen,

phosphorus, oxygen and sulphur, explain the uses of some common compounds of non metals like carbon dioxide, sodium carbonate, nitric acid phosphoric acid, calcium phosphate, sulphur dioxide and sulphuric acid.

Students above minimum requirement level

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

Students below minimum requirement level

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: ENVIRONMENTAL CHEMISTRY (20 Periods)

Unit Outcomes: Students will be able to:

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

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

Competencies	*Contents*	*Suggested Activities*
• Explain effects of SO_2, CO and NO_2 in the air	• Effects of air pollutants	• Particulates • Pollen Students should understand that there is more than one oxide of nitrogen present in air. Students should discuss sources of the following specific pollutants: • Sulphur dioxide – combustion of fossil fuels • Nitrogen oxides – combustion of fuels in furnaces and car engines • Carbon monoxide – incomplete combustion of fuels Students should research the effects of three pollutants and discuss their findings. The effects should include: • Sulphur dioxide and nitrogen oxides – acid rain – lowering of the pH of rivers and lakes; defoliation; release of heavy metals from soil; erosion of building materials like limestone; increase in iron/mild steel corrosion; respiratory diseases • Carbon monoxide – incomplete combustion of hydrocarbon fuels – absorption into the blood to replace oxygen leading to asphyxia Students should appreciate that although carbon dioxide occurs in the air as a result of natural processes, human activities have resulted in a small but significant increase in atmospheric levels. Students should understand that the Earth is heated by the Sun and that it, in turn, is constantly radiating heat back out into space. Certain gases in the upper atmosphere, including carbon dioxide, prevent some of this heat from escaping so it is directed back to Earth. This is called the greenhouse effect. This effect was essential for raising the temperature of the Earth to a level where life as we
• Define global warming • Discuss the causes of global warming	• Global warming - Causes of global warming	
• Discuss the effects of global warming	- Effects of global warming	

Competencies	*Contents*	*Suggested Activities*
		know it is able to live but there has been a small but significant increase in greenhouse gases which has led to an enhanced greenhouse effect resulting in global warming. Students should discuss the effects of global warming including: • Climate change • Melting polar caps • Rising sea levels Students should discuss the effects on Ethiopia and the effects on the world as a whole.
• Define hard water as a water that does not form lather with soap • State soluble salts of calcium and magnesium as the causes of hardness of water • Conduct an experiment to demonstrate the effect of hardness of water by taking rain water (tap water) and ground water • Describe boiling of water and adding washing soda as methods of softening hard water • Perform an experiment to soften hard water by boiling and adding washing soda.	**4.2 Water** *(6 periods)* • Hardness of water • Softening of water	Students should understand that water hardness is related to the ability of water to form a permanent lather with soap and that it is caused by certain calcium and magnesium salts dissolved in the water. The salts dissolve in water as rain water collects on the ground and flows through rocks such as limestone and dolomite. Students could carry out experiments using distilled water, hard water (ground water) and soap solution to observe the effect of hardness. Students should be aware that water hardness can be classified as: • Temporary – caused by dissolved calcium/magnesium hydrogencarbonates • Permanent – caused by dissolved calcium/magnesium chlorides and/or sulphates Students should discuss the formation of calcium hydrogencarbonate by the reaction of carbonic acid (formed when carbon dioxide dissolves in rain water) and limestone. Students could experiment by blowing carbon dioxide through limewater.

Competencies	*Contents*	*Suggested Activities*
• Describe the improper ways of disposing domestic and industrial wastes and excessive use of agricultural wastes as the causes of water pollution • Write a report on the causes, effects and prevention of water pollution. • Describe the physical, biological and chemical water treatments	• Water pollution - Water pollutants - Domestic waste - Agricultural chemicals - Industrial wastes	Initially it goes milky but then clears as additional carbon dioxide dissolves in the limestone causing the precipitate to redissolve forming temporary hard water ($Ca(HCO_3)_2$.) Students should link this process to temporary hardness by appreciating that when temporary hard water is heated the carbon dioxide is driven off and soluble calcium hydrogencarbonate is converted to insoluble calcium carbonate. $CaCO_3(s) + H_2O(l) + CO_2(g) \rightleftharpoons Ca(HCO_3)_2$ Students could boil temporary hard water and test its ability, before and after, to form a permanent lather – in order to satisfy themselves that boiling does remove temporary hardness. Students should understand why limescale forms and discuss some of the problems resulting from lime scale. Students could discuss the formation of stalactites and stalagmites. Students could boil permanent hard water and test its ability, before and after, to form a permanent lather – in order to satisfy themselves that boiling does not remove permanent hardness. Students could try to form a permanent lather with permanent hard water and note the formation of scum. Students should appreciate that soap contains sodium stearate and that scum is the result of the formation of insoluble calcium stearate. In order to remove permanent hardness, the calcium (or magnesium) ions must be removed by precipitation using sodium carbonate or washing soda. Calcium ions are precipitated as insoluble calcium carbonate. $Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$ Students could add washing soda to

Competencies	*Contents*	*Suggested Activities*
• Conduct simple experiment to purify dirty water	• Water purification - Physical treatment - Biological treatment - Chemical treatment	permanent hard water and test its ability, before and after, to form a permanent lather – in order to satisfy themselves that adding washing soda removes permanent hardness. Students should appreciate that much of the water that leaves their homes is no longer pure. They could make a list of the sources of waste water e.g. water from toilets carrying human waste products, water from cleaning carrying detergents, water from washing, water from cooking. They should also appreciate that there are other sources of water pollution including: • Run off from fields carrying fertilisers which have not been absorbed from soil together with other agricultural chemicals which exist as residues on and in the soil • Liquid wastes from factories Students could investigate the effects of water pollution using the internet or other resources such as the library. They should be given key words such as sewage, eutrofication, effluent, acid rain, agricultural pollution and detergent pollution. They should choose one aspect of water pollution and write a report outlining the causes, effects and how it can be controlled or prevented. Students could investigate the problems caused by releasing nitrates and phosphates into the environment in waste water. Students could visit a local body of water which is polluted. They should try to ascertain the cause of the pollution, observe the effects that the pollution is having on the organisms that live in the water and in surrounding area, and suggest how the pollution could be

Competencies	*Contents*	*Suggested Activities*
		remedied. Students could carry out a simple analysis of a sample of polluted water by comparing it with pure water. They could compare properties such as pH, clarity, smell, amount of dissolved solids. Students could visit a local water treatment plant and find out about the processes necessary to turn raw sewage into water that is safe to release into lakes and rivers. Such processes include: • Screening to remove large pieces of solid waste • Filtration to remove fine suspended particles • Action of bacteria to break down waste products • Chlorination to kill harmful organisms • Addition of chemicals like aluminium sulphate to improve clarity Students could make a model of a water treatment plant in which water is filtered and then chlorinated. They could test whether each of these procedures removed micro-organisms using agar gel plates to grow colonies of organisms.

Competencies	*Contents*	*Suggested Activities*
	4.3 Soil *(6 periods)*	
• Define soil as a thin layer of natural material covering the surface of the Earth. • List the percentage composition of the solid, the liquid and the gaseous portions of soil. • Describe the composition of the solid, the liquid and the gaseous portions of soil. • Conduct an experiment to show composition of soil	• The solid, liquid and gas components of soil	Students could be asked to define soil. Students should appreciate that soil is a growing medium in which plants grow. The soil provides a plant with stability as well as water and minerals essential for growth. Students should be aware that soil consists of components that exist in three physical states, • The solid component - minerals and organic matter • The liquid component - water • The gas component - air. Students could investigate the components of soil by placing soil in a jar with water, shaking the mixture and leaving it to settle. They will see a gradation of particles starting with the largest at the bottom the finest at the top. Humus will float on the water.
• Tell that soil can be acidic, alkaline or neutral. • List the major plant nutrients • Explain methods of improving soil fertility	• Acidic and alkaline soil • Plant nutrients and soil improvement • Major plant nutrients	Students can investigate different characteristics of soil: • Water content – by drying a known mass in an oven at 100 °C • Humus content – by heating a known mass of dry soil on a tin lid with a Bunsen burner • Air content – by mixing 50 cm^3 of soil with 50 cm^3 of water and measuring the total volume • Particle size distribution – by passing a known volume of dry powdered soil through a series of sieves • Water retention – by timing how long it takes water to pass down a column of soil These experiments could be carried out on a single type of soil or on different soils and the results for each soil

Competencies	*Contents*	*Suggested Activities*
		compared.
	• Methods of improving soil fertility	Students should appreciate that the pH of soil is an important factor in determining its suitability for growing different crops.
• Prepare ammonium nitrate		Students could test samples of soil to determine their pH.
		Students should be aware that the major plant nutrients are:
		• Nitrogen
• Prepare compost in the school compound.		• Potassium
		• Phosphorus
• Apply the compost in school garden.		• Magnesium
		• Calcium
		• Sulphur
		Students should be aware that plants need nutrients in order to grow and remain healthy, and that they obtain these minerals from the soil.
• Tell the type of soil that is favourable for crop production		Students could research the importance of major nutrients.
		Students should be made aware that there are two main groups of fertilisers: naturally occurring fertilisers and chemical fertilisers.
	• Acidity and alkalinity	Students could identify different types of naturally-occurring fertilisers such as animal dung. They should also be made aware of green fertilisers.
• Suggest some methods of correcting soil acidity and alkalinity		Students could investigate the effectiveness of different types of dung as fertilisers.
		Students could identify different types of chemical fertilisers such as urea, DAP, ammonium nitrate and potassium sulphate. Students should understand what is meant by an NPK fertiliser.
		Students could make ammonium nitrate by mixing equivalent amounts of ammonia and nitric acid, and

Competencies	*Contents*	*Suggested Activities*
		evaporating the solution to dryness. Students could discuss the advantages and disadvantages of the two main groups of fertilizers. The work on fertilisers could be linked in to the work on water pollution in Section 4.2 in this unit. Excessive use of fertilisers is a source of water pollution. Students should be given a group project work to consult agricultural development agents to prepare compost and apply in school garden Students could discuss what materials will produce compost. Students should find out about: • The importance of ensuring aeration of compost. • Why it is necessary to water the compost • The function of compost accelerators Students should be aware that different crops require different nutrients in different proportions and, as a consequence, each crop grows best in soil within a particular pH range. Students could find the best pH range for growing different crops e.g.: • Potatoes 5.5 – 6.5 • Oats 5.5 – 7.0 • Beans 6.0 – 7.5 Students should understand that when organic materials, such as dead leaves, animal wastes etc. decay, organic acids are produced and these lower the pH of the soil so, over the years, soil naturally becomes more acidic. Students could measure the pH of different soil samples taken from different locations.

Competencies	*Contents*	*Suggested Activities*
		Students should appreciate that in order to prepare the soil to produce good yields of crops, it is often necessary to raise the pH by spreading lime in the form of limestone, quick lime or slaked lime. Students should appreciate that different amounts are needed to reduce the pH of different types of soil. Students could heat limestone strongly to make quicklime, and then add water to the quicklime to make slaked lime. Students could know the effect of lime on changing pH. Students could research how it is possible to reduce the pH of soil using sulphur and irrigation.
	4.4 Fuels *(3 periods)*	Students could be asked to define fuel.
• Define fuel as a substance which releases heat energy when it is burnt (combusted) • Describe elemental composition of coal, natural gas and crude oil	• Coal, natural gas and crude oil - Composition	Students should understand that coal, natural gas and crude oil are collectively called fossil fuels. Once refined, they provide a range of fuels. Students should know that coal is an impure form of carbon which formed by the decay of plant material in the absence of air. Students should know that crude oil and natural gas are mixtures of hydrocarbons which formed by the decay of huge deposits of plant and animal remains in the sea which decayed in the absence of air.
• Explain uses of coal, natural gas and crude oil	- Uses	The composition of hydrocarbons should be linked to the work already carried out in Unit 1. Students could carry out research to identify those areas of the world where large deposits of fossil fuels are to be found. Students should also be aware that it is expected that there are deposits of crude oil, coal, and natural gas in different

Competencies	*Contents*	*Suggested Activities*
		parts of Ethiopia. Students should appreciate that coal is a solid fuel. For domestic use if it generally left as small pieces but when used in power stations it is first pulverised into a fine dust. This makes it easier to move within the power station and ensures a more efficient combustion. Students could research how coal is converted to another fuel called coke. Coke is used in the manufacture of iron. Students should be aware that heating coal in the absence of air produces coke, ammoical liquor, coal tar, coal gas. Students could discuss the environmental problems associated with burning coal, and in particular the oxidation of any sulphur or sulphur compounds present in it to form acidic sulphur dioxide. Students could understand fuel gas desulphurisation processes to reduce the sulphur dioxide emissions from power stations. Students should appreciate that natural gas is a gaseous fuel. It can be transferred from place to place along pipes. Students should know that the main constituent of natural gas is methane, but that other small proportions of other gases like ethane and carbon dioxide are also present. Students should discuss the importance of natural gas as a domestic and industrial fuel. Students should appreciate that crude oil is a mixture of many different hydrocarbons and is of no use as a fuel in the form in which it appears out of the ground. The crude oil must undergo a number of different processes, collectively called refinning in order to

Competencies	*Contents*	*Suggested Activities*
		obtain a range of different fuels and other useful products including: • Bottled gases • Petrol • Diesel oil • Kerosene • Fuel oils • Lubricating oils • Bitumen Students should appreciate that the term petroleum is often used to describe the products after refining thus crude oil produces petroleum products. Students could research the uses of the different petroleum products. Students should be aware that crude oil contains sulphur compounds and that these must be removed from the fuels to prevent the formation of acidic products when the fuels are burnt in engines, and atmospheric pollution when the waste gases are released.

Assessment

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

Students at minimum requirement level

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

Students above minimum requirement level

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

Students below minimum requirement level

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

UNIT 5: CALCULATIONS BASED ON FORMULAE (11 Periods)

Unit Outcomes: Students will be able to:

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

Competencies	***Contents***	***Suggested Activities***
Students will be able to:	***5. Calculations based on formulas***	
	5.1 Introduction *(1 period)*	Students should understand that the chemical formula of a compound provides information about the type and proportion of atoms present. This information can be used to carry out different calculations relating to composition and reacting masses.
	5.2 Atomic mass, molecular mass and formula mass *(2 periods)*	
• Describe atomic mass	• Atomic mass	Students should understand that the atomic mass of an element is the mass of atoms of that element. Since atoms are very small, atomic masses are not measured in kilograms and grams, but in atomic mass units. Conventionally, scientists do not assign a unit to atomic masses, molecular masses or formula masses.
• Define the terms molecular mass and formula mass.	• Molecular mass and formula mass	Students could use the information given in a Periodic Table, or in data tables, to find the atomic masses of different elements.
• Describe the steps of calculating molecular mass and formula mass • Calculate molecular mass and formula mass using formula of a compound and atomic masses.	• Calculating molecular mass and formula mass	Students should link atomic mass back to the work on atomic structure carried out in Grade 7. Students could discuss the existence of isotopes and how the atomic mass of an element is a weighted average of the isotopes present which reflects their relative proportions.

Competencies	*Contents*	*Suggested Activities*
		Students should appreciate that the mass of a molecule of an element or a compound is the sum of the masses of the individual atoms it contains. Students should calculate the molecular masses of molecules of elements and of covalent compounds by adding the atomic masses of all of the atoms present in the molecule. Students should appreciate that it is not possible to give the molecular mass of an ionic compound since ionic compounds do not exist as molecules. The concepts of ionic and covalent bond should be treated at the higher grades. Students should know that for ionic compounds we give the formula mass which is the mass of the ions present in their lowest possible ratio of whole numbers. Students should calculate the formula masses of ionic compounds, starting with simple binary compounds and progressing to more complex examples.
• Define mole and molar mass	**5.3 The mole concept** *(3 periods)* • Mole • Molar mass	Students should discuss how some things are grouped together e.g. • Eggs are sometimes sold in boxes containing a specific number • Tablets are sold in boxes containing specific numbers Use the idea of grouping to introduce the mole as a group of particles. Students should appreciate that

Competencies	*Contents*	*Suggested Activities*
• Calculate number of moles of atoms, molecules or formula units from a given mass or number of particles and vise versa. • Convert a given number of moles of atoms or molecules or formula units to number of atoms, molecules or formula units and vise versa.		since the mass of individual atoms and molecules is very small we use a scaling factor to convert these very small masses into masses in grams. This scaling factor is called the mole. Students should know that a mole of any substance is a group containing 6.022×10^{23} particles of that substance whether the particles are atoms, molecules or ions. This figure is referred to as avogadro number. Students should understand that the mass of one mole of a substance is its atomic, molecular or formula mass expressed in grams e.g. • One mole of carbon atoms has a mass of 12 g • One mole of water molecules has a mass of 18 g • One mole of sodium ions has a mass of 23 g Students should calculate the mass of moles of a substance first by working out its atomic, molecular or formula mass and then expressing this value in grams. Students should calculate the number of moles a substance from a given mass or number of particles. Students should be able to state the number of particles present in a given amount, in moles, of a substance. Students should be able to state the number of moles of a substance which is equivalent to a given number of particles.
• Describe percentage composition of a compound	**5.4 Percentage composition of compounds** *(2 periods)*	Students should be aware that the composition of a compound can be expressed as the percentage, by mass, of each element in the

Competencies	*Contents*	*Suggested Activities*
• Describe the steps of determining percentage composition • Calculate percentage composition of a compound from its formula		compound. $\%\,\text{comp.} = \frac{\text{Mass of Element}}{\text{Formula mass of a comp.}} \times 100$ Students should use the atomic masses of the elements present together with the molecular or formula mass to determine the percentage composition of a compound. For example, to determine the percentage composition of magnesium carbonate ($MgCO_3$) proceed as follows: • the formula mass of $MgCO_3$ is 24 + 12 + (3 x 16) = 84 • atomic mass of magnesium = 24 • percentage by mass of magnesium = (24/84) x 100 = 28.57% • atomic mass of carbon = 12 • percentage by mass of carbon = (12/84) x 100 = 14.29% • atomic mass of oxygen = 16 • percentage by mass of oxygen = (3 x 16/84) x 100 = 57.14% Students should be aware that, owing to errors resulting from rounding, total percentages of the different elements in a compound may sometimes not add up to exactly 100%. Students should carry out similar calculations to determine the composition by mass of elements in other compounds. Students could carry out calculations to determine the percentage by mass of a particular element in a series of compounds e.g.

Competencies	*Contents*	*Suggested Activities*
		• the percentage by mass of nitrogen in a series of fertilisers • the percentage by mass of oxygen in a series of metal oxides
• Define empirical and molecular formulas • Describe the steps of determining empirical formula	**5.5 Determination of formulas** *(3 periods)* • Empirical formula • Molecular formula	Students should understand that the molecular formula of a compound gives the number of atoms of each type of element present. The empirical formula gives the number of atoms of each type of element in the lowest possible ratio. Students should appreciate that • sometimes the molecular formula and the empirical formula of a substance are the same, for example ethanol: molecular formula = C_2H_6O empirical formula = C_2H_6O
• Determine empirical formula of a compound from a given percentage composition or mass ratio • Describe the relationship between empirical formula and molecular formula • Describe the steps of determining molecular formula.		• different compounds may have the same empirical formula, for example ethene (C_2H_4), butene (C_4H_8) and hexene (C_6H_{12}) all have the same empirical formula CH_2. Each of these compounds consists of carbon atoms and hydrogen atoms in the ratio of 1 to2 Students should understand how to find the empirical formula of a compound from its composition expressed in percentage by mass of each element. For example: • The composition by mass of a compound is 92.3% carbon and 7.7% hydrogen. • The atomic mass of a carbon atom is 12 while the atomic mass of a hydrogen atom is 1.

Competencies	*Contents*	*Suggested Activities*
• Determine molecular formula of a compound from empirical formula and molecular mass		• Atoms of carbon and hydrogen must be present in the compound in the ratio of (92.3/12) : (7.7/1) = 7.7 : 7.7 • The simplest ratio of carbon to hydrogen is 1:1 therefore the empirical formula of the compound is CH Students should appreciate that the empirical formula only gives the ratio of the atoms present and tells nothing about the molecular formula. Students should calculate the empirical formulas of compounds from their percentage composition by mass. Students should appreciate that to find the molecular formula of a compound from its percentage composition that an additional piece of information is required – the molecular mass of the compound. For example: • The empirical formula of a compound is CH_2. • The molecular mass of the compound is 70. • The mass of the CH_2 unit = 14 therefore the compound must contain 70/14 = 5 x CH_2 • The molecular formula of the compound is C_5H_{10}. Students should calculate the molecular formulas of compounds from their empirical formulas and molecular masses. Students should calculate the molecular formulas of compounds from their percentage by mass composition and molecular masses.

Assessment

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

Students at minimum requirement level

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

Students above minimum requirement level

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.