South Sudan

Secondary Chemistry 4

Teacher's Guide

Secondary Chemistry has been written and developed by Ministry of General Education and Instruction, Government of South Sudan in conjunction with Subjects experts. This course book provides a fun and practical approach to the subject of Chemistry, and at the same time imparting lifelong skills to the students.

The book comprehensively covers the Secondary 4 syllabus as developed by Ministry of General Education and Instruction.

Each year comprises of a Student's Book and Teacher's Guide.

The Teacher's Guide provide:

- Full coverage of the national syllabus.
- A strong grounding in the basics of chemistry.
- Clear presentation and explanation of learning points.
- A wide variety of practice exercises, often showing how chemistry can be applied to real-life situations.
- It provides opportunities for collaboration through group work activities.
- Stimulating illustrations.

All the courses in this secondary series were developed by the Ministry of General Education and Instruction, Republic of South Sudan. The books have been designed to meet the primary school syllabus, and at the same time equiping the pupils with skills to fit in the modern day global society.

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Secondary Chemistry 4 Teacher's Guide

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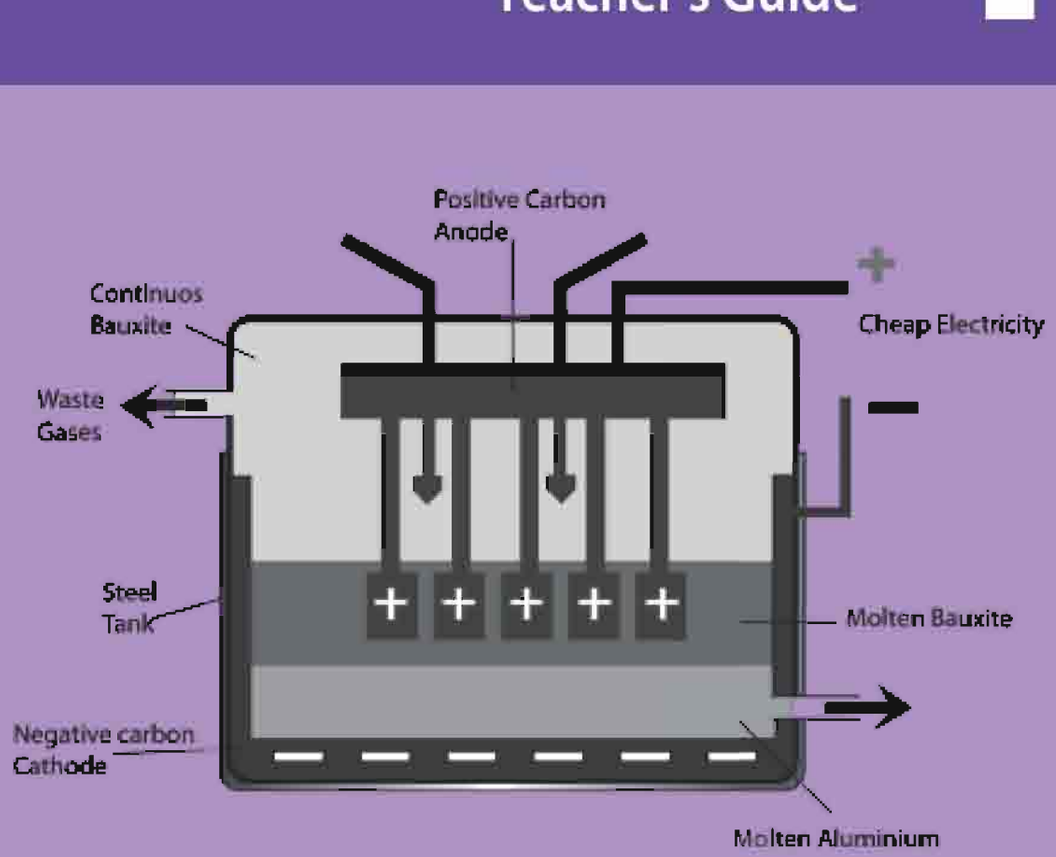

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South Sudan

SECONDARY 4

Chemistry

Teacher's Guide 4

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FOREWORD

I am delighted to present to you this Teacher's Guide, which is developed by the Ministry of General Education and Instruction based on the new South Sudan National Curriculum. The National Curriculum is a learner-centered curriculum that aims to meet the needs and aspirations of the new nation. In particular, it aims to develop (a) Good citizens; (b) successful lifelong learners; (c) creative, active and productive individuals; and (d) Environmentally responsible members of our society. This textbook, like many others, has been designed to contribute to achievement of these noble aims. It has been revised thoroughly by our Subject Panels, is deemed to be fit for the purpose and has been recommended to me for approval. Therefore, I hereby grant my approval. This Teacher's Guide shall be used to facilitate learning for learners in all schools of the Republic of South Sudan, except international schools, with effect from 4th February, 2019.

I am deeply grateful to the staff of the Ministry of General Education and Instruction, especially Mr Michael Lopuke Lotyam Longolio, the Undersecretary of the Ministry, the staff of the Curriculum Development Centre, under the supervision of Mr Omot Okony Olok, the Director General for Quality Assurance and Standards, the Subject Panelists, the Curriculum Foundation (UK), under the able leadership of Dr Brian Male, for providing professional guidance throughout the process of the development of National Curriculum, school textbooks and Teachers' Guides for the Republic of South Sudan since 2013. I wish to thank UNICEF South Sudan for managing the project funded by the Global Partnership in Education so well and funding the development of the National Curriculum, the new textbooks and Teachers' Guides. I am equally grateful for the support provided by Mr Tony Calderbank, the former Country Director of the British Council, South Sudan; Sir Richard Arden, Senior Education Advisor of DfID, South Sudan. I thank Longhorn and Mountain Top publishers in Kenya for working closely with the Ministry, the Subject Panels, UNICEF and the Curriculum Foundation UK to write the new textbooks. Finally, I thank the former Ministers of Education, Hon. Joseph Ukel Abango and Hon. Dr John Gai Nyuot Yoh, for supporting me, in my role as the Undersecretary, to lead the Technical Committee to develop and complete the consultations on the new National Curriculum Framework by 29 November 2013.

The Ministry of General Education and Instruction, Republic of South Sudan, is most grateful to all these key stakeholders for their overwhelming support to the design and development of this historic South Sudan National Curriculum. This historic reform in South Sudan's education system is intended to benefit the people of South Sudan, especially the children and youth and the future generations. It shall enhance the quality of education in the country to promote peace, justice, liberty and prosperity for all. I urge all Teachers to put this textbook to good use.

May God bless South Sudan. May He help our Teachers to inspire, educate and transform the lives of all the children and youth of South Sudan.

Deng Deng Hoc Yai, (Hon.)
Minister of General Education and Instruction, Republic of South Sudan

Table of content

PART I

Introduction

Book organisation

This teacher's guide is organised into two main sections Part 1 is the general in t roduction n section detailing information on competence based curriculum and pedagogical issues.

The main elements of Part 1 are:

- **Background in formation to the new curriculum** - It gives a brief overview of the general requirements of the new South Sudan competence-based including the guiding principles, the competences the students are expected to acquire, crosscutting issues to be addressed during learning.
- **Basic requirements for an effective Science lesson** - It highlights the teacher and learner's roles for effective teaching and learning of Science, teaching and learning resources, grouping learners for learning and teaching methods

Part 2 provides a topic -to - topic guide to the teacher on how to facilitate learners to acquire the knowledge, skills and attitudes envisaged in each unit. This part is therefore structured into units

The main elements of each unit guide are:

- Unit heading
- Learning objectives
- **Contribution to learner's competences:** The section explains how the unit/topic will facilitate the learner to acquire to the specified competences. These competences will be discussed in detail later in the next section.

Cross cutting issues to be addressed

The section outlines the specific cross cutting issues that will be addresses through infusion as the learners do the activities and interacts with concepts planed for the unit This is meant to make the teacher conscious on and be on the look out for suitable opportunities through out the teaching and learning process in the entire unit to address the cited cross cutting issues. These issues will be discussed in detail later in this section.

Note: a unit or topic may not necessarily address all the cross cutting issues outlined in the curriculum

- **Suggested teaching and learnin g activities-** This section provides guidance to the teacher on how to facilitate students to learn by doing the activities outlined in the student's book. It also guides the teacher on how to assess the learning.

Background Information on the new curriculum

The aim of the South Sudan Competence-based Curriculum is to develop in the learners competences that will enable them interact with the environment in more practical ways.

It clearly defines the knowledge, skills and at t it u des that the learner should acquire by doing the specified learning activities.

a. Learner's competences to be attained

Competencies are statements of the characteristics that learners should demonstrate, which indicate they have the ability to do something to the required level of performance. The following are the four competencies envisaged in this curriculum:

1. Critical and creative thinking

Chemistry lessons and activities facilitate learners to acquire these competences by giving then opportunities to:

- Plan and carry out investigations, using a range of sources to find information
- Sort and analyse information and come to conclusions
- Suggest and develop solutions to problems, using their imaginations to create new approaches
- Evaluate different suggested solutions

2. Communication

Chemistry lessons and activities facilitate learners to acquire these competences by giving then opportunities to:

- Read and comprehend critically a variety of types and forms of texts during research activities.
- Write reports on scientific investigations and activities.

- Speak clearly and communicate ideas and science related information coherently.
- Listen and comprehend scientific facts presented by fellow classmates, group members, teachers and resources persons.
- Use a range of media, technologies and languages to communicate messages, ideas and opinions.

3. Cooperation

Chemistry lessons and activities facilitate learners to acquire these competences by giving then opportunities to:

- Work collaboratively towards common objectives when doing activities.
- Be tolerant of others and respectful of differing views, when working together
- Adapt behaviour to suit different situations
- Negotiate, respect others' rights and responsibilities, and use strategies to resolve disputes and conflicts
- Contribute to environmental sustainability

4. Culture and identity

Chemistry lessons and activities facilitate learners to acquire these competences by allowing them to:

- Take pride in South Sudanese identity and the diverse nature of South Sudanese society.
- Build understanding of South Sudanese heritage in relation to the wider world
- Appreciate and contribute to the development of South Sudanese culture
- Value diversity and respect people of different races, faiths, communities, cultures, and those with disabilities.

(b) Cross-cutting issues to be addressed during learning

These are issues that are of high national priority and hence have been incorporated in the learning process. The three cross-cutting issues for that should be addressed through the teaching/learning process are:

(i) Environment and sustainability

A well-conserved environment is obviously key to our health and survival. It is therefore important for the Chemistry teacher to make use of the opportunities that arise in the process of teaching and learning Science through activities to sensitise learners on the importance of conserving the environment. One way is by ensuring that the learners always dispose off the waste materials at the end of an activity in ways that do not pollute the env ironment.

(ii) Peace education

Peace is critical for a society to flourish and for every individual to focus on personal and national development.

The Science teacher needs to be in the fore front in educating his/her students on the need for peace, for example by encouraging group work in the learners activities and showing the them ways of solving peacefully interpersonal problems that occasionally arise during interactions and discussions.

(iii) Life Skills

Learners need to progressively acquire some skills abilities and behaviors that will help them effectively deal with the events and challenges of every day lif e . Such skills include first aid, communication skills, conflict resolution, basic ICT skills etc. The Science teacher should as much as possible facilitate the learners to acquire these skills whenever an opportunity arises in the lesson execution

Basic requirements for an effective Chemistry lesson

Teacher's role and basic skills for effective Chemistry lesson

The teacher is the most important resource for an effective. Science lesson. (a) Some of the key roles of the Science teacher include:

- Organising the classroom to create a suitable learning environment.
- Preparing appropriate materials for learning activities.
- Engaging students in variety of learning activities.
- Encouraging and accepting student autonomy and initiative.
- Allowing student responses to drive lessons, shift instructional strategies,
- Familiarizing themselves with learners understandings of concepts before sharing their own understandings of those concepts.
- Encouraging learners to engage in dialogue, both with the teacher and one another.

Engaging students in experiences that posecontradictions to their initial hypotheses and then encouraging discussion.

- Providing time for learners to construct relationships and create metaphors.
- Using a variety of teaching and assessment methods.
- Adjusting instructions to the level of the learner.
- Nurturing learners' natural curiosity.
- Motivating learners to make them ready for learning.
- Coordinate learners' activities so that the desired objectives can be achieved.
- Assessing learners' activities and suggest solutions to their problems.
- Assist learners to consolidate their activities by summarising the key points learnt.

(b) Some of the key skills that the Chemistry teacher should have include:

- Creativity and innovation.
- Makes connections/relations with other subjects.
- A high level of knowledge of the content.
- Effective disciplining skills manage adequately the classroom
- Good communicator.
- Guidance and counselling.

Learner's role in learning Chemistry

Learning takes place only when the learner acquires the intended knowledge, skills and attitudes. As such, learning is a highly personal and individual process. Thus, a learner must be actively engaged in the learning exercise.

- For active participation in learning, the learner should:
- Raise questions about what is observed.
- Suggest solutions to the problems observed.
- Take part in planning investigations with appropriate controls to answer specific questions.
- Carry out investigations to search for answers with the help of materials in search of patterns and relationships while looking for solutions to problems.

- Working collaboratively with others, communicating their own ideas and
- Considering others' ideas.
- Expressing themselves using appropriate Science terms and representations in writing and talk.
- Engaging in lively public discussions in defence of their work and explanations.
- Applying their learning in real-life contexts.
- Reflecting critically about the processes and outcomes of their inquiries.

Teaching and learning resources

These refer to things that the teacher requires during the teaching process. They include:

- The classroom
- Textbooks
- Wall charts and wall maps
- Materials and apparatus
- Various tools and equipment
- Science models
- Resource persons
- Firms such as hydroelectric power stations, engineering firms among others

(a) Classroom as a learning environment

A Classroom generally refers to the place where learning takes place. Learners learn from everything that happens around them, such as the things that they hear, see, touch, taste, smell and play with.

Classroom organisation

- It is important for the teacher to make the classroom an attractive and stimulating environment. This can be done by:
- Carefully arranging the furniture in the classroom in an organised way. to allow free movement of learners and the teacher.
- Putting up learning and teaching aids on the walls. Examples are wall charts, pictures and photographs.

- Displaying teaching models.
- Providing objects for play for example toys.
- Having a display corner in the classroom where learners display their work.
- Setting a corner for storing materials so as not to obstruct learners or distract them.
- Spreading out the learners evenly so that they do not interfere with one another's activities.
- Setting up the materials for the series of lessons or activities going on for a number of days or weeks in a location where they do not interfere with other daily activities
- Organizing the sitting arrangement such that learners face the lighted areas of the room.
- Choosing the most appropriate location for the teacher and the chalkboard such that they are visible to all learners and the teacher has a good view of all learners in the class.

(b) Apparatus and materials

For learners to study Chemistry through the activity method, a number of materials and apparatus are required. The important role played by materials in learning has been felt for centuries. This is noted for instance in the old Chinese proverb that says:

- When I hear I forget
- When I see I remember
- When I do I under stand

Since Science is highly practical subject, materials help the teacher to convey his/her points, information or develop skills simply and clearly, and to achieve desired results much faster.

Some of the materials that a teacher requires for Science activities and calculations can be collected from the local environment.

Many others can be improvised while some have to be purchased. Whether collected, improvised or purchased, there are certain materials that are valuable to have around almost all the time.

These include:

(i) Chemistry Kit

A Chemistry kit is a special box containing materials, apparatus and equipment necessary to conduct an array of experiments. The content of the Science kit depends on the curriculum requirements per level. Most Chemistry kits are commercially available and target particular levels of learners. However, the teacher is encouraged to come up with a kit based on the syllabus requirement

(ii) Models

A model refers to a three-dimensional representation of an object and is usually much smaller than the object. Several models are available commercially in shops. Examples of Science models include models of electric motors, hydraulic systems among others. These models can be purchased by schools for use during Science activities.

(iii) Resource persons

A resource person refers to anybody with better knowledge on a given topic area. Examples include health practitioners such as doctors, nurses and laboratory technologists, agricultural extension officers, environmental specialists among others. Depending on the topic under discussion, the teacher can organise to invite a resource person in that area to talk to learners about the topic. The learners should be encouraged to ask as many questions as possible to help clarify areas where they have problems.

(iv) Improvisation

If each learner is to have a chance of experimenting, cheap resources must be made available. Complicated apparatus may not always be available in most schools. Such sophisticated equipment made by commercial manufacturers are usually expensive and majority of schools cannot afford them. The teacher is therefore advised to improvise using locally available materials as much as possible.

(vi) Scheduling learning activities and venues

Some of the activities suggested in the student's good planning and scheduling in order to get accurate results. An example is observing some effects of environmental factors on plant growth illustrated in unit 14. The teacher should therefore think

ahead while making the scheme of work so that the prevailing weather pattern and the most appropriate timing are considered..

Grouping learners for learning activities

Most of the Science activities suggested in the student's book are carried out in groups and therefore the teacher should place 2 or 3 desks against each other and then have a group of learners sitting around those desks.

In certain activities, the teacher may wish to carry out a demonstration. In this case, the learners should be sitting or standing in a semicircle, or arranged around an empty shape of letter "U" such that each learner can see what the teacher is doing clearly and without obstruction or pushing. If the learners are involved in individual work, each learner can work on the floor or on the desk or a portion of the desk if they are sharing. In this case, they need not face each other.

Grouping learners for learning has increasingly become popular in recent years. In fact, the shift from knowledge-based to competence curriculum will make grouping the norm in the teaching process.

Learning grouping can be formed based one or a number of the following considerations:

- Similar ability grouping
- Mixed ability grouping
- Similar interests grouping
- Common needs grouping
- Friendship grouping
- Sex-based grouping

Grouping learners in a Chemistry class has several advantages that include:

- The individual learner's progress and needs can easily be observed.
- The teacher-learner relationship is enhanced.
- A teacher can easily attend to the needs and problems of a small group.
- Materials that were inadequate for individual work can now be easily shared.

- Learners can learn from one another.
- Cooperation among learners can easily be developed.
- Many learners accept correction from the teacher more readily and without feeling humiliated when they are in a small group rather than the whole class.
- Learners' creativity, responsibility and leadership skills can easily be developed.
- Learners can work at their own pace.
- The type of "grouping" that a teacher may choose may be dictated by:
- The topic or task to be tackled.
- The materials available.
- Ability of learners in the class (fast, average, slow).

Class size

There is no one method or approach to teaching that is appropriate to all lessons. A teacher should, therefore, choose wisely the method to use or a combination of methods depending on the nature of the topic or subtopic at hand.

Teaching methods

There are a variety of possible methods in which a teacher can help the learners to learn. These include:

(a) Direct exposition

(b) Discovery or practical activity

(c) Group, class or pair discussion

(d) Project method

(e) Educational visit/ field trips

(f) Teacher demonstration

(g) Experimentation/Research

The particular technique that a teacher may choose to use is influenced by several factors such as the:

- Particular group of learners in the class.
- Skills, attitudes and knowledge to be learned.
- Learning and teaching aids available.
- Local environment.
- Teacher's personal preference
- Prevailing weather condition.
- Requirements of Science syllabus

(a) Direct exposition

This is the traditional way of teaching whereby the teacher explains something while the learners listen. After the teacher has finished, the learners may ask questions. However, in a competence-based curriculum, this technique should be used very minimally.

(b) Guided Discovery

In this technique, the teacher encourages learners to find out answers to problems by themselves. The teacher does this by:

- Giving learners specific tasks to do.
- Giving learners materials to work with.
- Asking structure

or guided questions that lead learners to the desired outcome. Sometimes learners are given a problem to solve and then left to work in an open-ended manner until they find out for themselves.

This is the most preferred method of teaching in the implementation of competency- based curriculum.

(c) Group/class discussion or pair work

In this technique, the teacher and learners interact through question and answer sessions most of the time. The teacher carefully selects his/her questions so that learners are prompted to think and express their ideas freely, but along a desired line of thought. The method leads learners from the known to unknown in a logical sequence; and works well with small groups. The method boosts confidence in learners and improve interpersonal and communication skills.

The main disadvantage of this method is that some learners maybe shy or afraid to air their opinions freely in front of the teacher or their peers. It may give them more confident learners a chance to dominate the others.

(d) Project method

In this approach, the teacher organises and guides a group of learners or the whole class to undertake a comprehensive study of something in real life over a period of time such as a week or several weeks.

Learners using the project method of studying encounter real life problems, which cannot be realistically brought into a normal classroom situation. A project captures learners' enthusiasm, stimulates their initiative and encourages independent enquiry. The teacher, using the project method, must ensure that the learners understand the problem to be solved and then provides them with the necessary materials and guidance to enable them carry out the study.

The main disadvantage of this method is that if a project is not closely supervised, learners easily get distracted and therefore lose track of the main objective of their study. Studying by the project method does not work well with learners who have little or no initiative.

(e) Educational visits and trips and nature walks

This is a lesson conducted outside the school compound during which a teacher and the learners visit a place relevant to their topic of study. An educational visit/nature walk enables learners to view their surroundings with a broader outlook that cannot be acquired in a classroom setting. It also allows them to learn practically through first- hand experience. In all "educational visit/nature walk lessons", learners are likely to be highly motivated and the teacher should exploit this in ensuring effective learning. However, educational visits are time consuming and require a lot of prior preparation for them to succeed. They can also be expensive to undertake especially when learners have to travel far from the school.

(f) Demonstration lessons

In a demonstration, the teacher shows the learners an experiment, an activity or a procedure to be followed when investigating or explaining a particular problem. The learners gather around the teacher where each learner can observe what the teacher is doing. It is necessary to involve the learners in a demonstration, for example by:

- Asking a few learners to assist you in setting up the activity.
- Requesting them to make observations.
- Asking them questions as you progress with the demonstration.
- This will help to prevent the demonstration from becoming too teacher centred.

When is a demonstration necessary?

A teacher may have to use a demonstration, for example when:

- The experiment/procedure is too advanced for learners to perform.
- The experiment/ procedure is dangerous.
- The apparatus and materials involved are delicate for learners to handle.
- Apparatus are not enough for all learners or groups.

UNIT 1

Identification of ions and gases

Refer to learner's book page 1 to 10

Learn about	Key inquiry questions
• Learners should design and carry out practical investigations using aqueous sodium hydroxide and aqueous ammonia to identify and describe the cations (e.g. aluminium, ammonium, calcium, copper(II), iron(II), iron(III), lead(II) and zinc) etc. • They should find out about the procedures to test, identify and describe the anions (e.g. carbonate, chloride, iodide, nitrate, sulphate, sulphite etc.) and identify gases (e.g. ammonia, carbon dioxide, chlorine, hydrogen, oxygen and sulfur dioxide etc.) • They should use these procedures in practical situations so that understand the procedures and reagents used. They should work individually and in small groups to record and evaluate their observations and results.	• How do you identify ions and gases in the laboratory?

Knowledge and understanding	Skills to be acquired	Attitudes and values
By the end of this unit, learners should be able to: • Understand the procedures to test, identify and describe the anions • Understand the procedures and reagents	By the end of this unit, learners should be able to: • Design and carry out practical investigations using aqueous sodium hydroxide and aqueous ammonia to identify and describe the cations • Use procedures to test, identify and describe the anions	By the end of this unit, learners should be able to: • Appreciate the importance of ions in understanding chemistry
Contribution to the competencies: Creative and critical thinking: experimentation, analysis, interpretation etc. Communication: use of range of media to present experimental results. Co-operation: work in collaboration **Links to other subjects:** Biology		

Introduction to the unit

Learners up to this time may have been much involved with quantities of substances (e.g. moles) and generalized study of properties of substances/ compounds rather than the qualitative analysis/tests. In this unit the learner is being introduced to and required to appreciate the qualitative aspects of substances. Make the learners aware of the importance of the knowledge of qualitative analysis – the identification tests for ions are such one area of qualitative chemical analysis. In the field of medicine, this knowledge is applied when testing for diseases, dosage administration, and contamination of blood. In manufacturing industry, it is used in analyzing the components of the products and ensuring acceptable composition of products ingredients for high standard quality products as well as the welfare of the consumers.

This study has crucial links in biological study where traces of contaminants in body of living organisms can be monitored such as the level of lead metal (very poisonous) in even in very small quantities, amount of sodium or potassium in the body of human beings and sometimes in certain crops is equally critical for their survival/good growth and development.

Cross cutting issues to be incorporated

1. Environment awareness and sustainability

Under the study of investigation of identification of gases, some of these such as chlorine and sulphur dioxide are environmentally harmful and even are health hazards to users if not properly handled. Poisonous gases e.g. chlorine must be handled in fume chamber.

Emphasise too much release of carbon dioxide and sulphur dioxide gases into the air have cumulative air pollution effects and accompanying environmental degradation. As well proper disposal of used salts at the end of laboratory activities must be observed.

2. Gender awareness

Encourage learners to take learning of chemistry very serious particularly the girl child. Female students should be motivated to excel and take up science courses in their career choices such as analytical chemistry, microbiology/

laboratory technician, chemical/textile engineering, technology based courses. They must have good understanding and mastery of chemistry that promote critical and creative thinking skills in the areas of study of ions..

3. Life skills

Learners can be encouraged to be financial responsible, to appreciate expenses incurred in purchases of reagents (chemicals) and even costs of apparatus used which most of them cannot be improvised. They should handle apparatus very careful for avoid unnecessary breakages and where there is occurrence report immediately to the teacher or laboratory technician.

Competencies to be developed

1. Co-operation

This topic involves a lot of practicals (experiments). Encourage learners to work as team with no bias in terms of gender, tribe or culture. Gifted learners to appreciate their slow learning counter parts and provide assistance where need be. Remind learners team work helps the tasks to be done much faster, more efficiently and with minimal bad incidences in the laboratory.

2. Communication

Encourage all learners irrespective of their abilities to participate in the class or group discussions, during presentations by asking questions. During each experiment/activity they rotate the position of secretary among the group members to give group member to develop their presentation skills.

All learners should also be encouraged to write summary notes at the end of the lesson as this will help improve their writing skills. Tell learners that communicating results of investigations either through oral presentations or written is as critical and important as the investigation itself in real science world. It helps the information to be consumed clearly by the intended recipients.

3. Critical and creative thinking

Encourage learners to develop inquisitive thoughts by asking them questions such as why certain investigations are conducted in a given procedural manner, what is likely to happens if a given reagent or different concentrations was used, if they

could be alternative methods (or procedures). Discussion corner quizzes in the learner's book or as a teacher you can come up with more questions (diagnostic assessment questions) to stimulate learners' critical thinking/creativity.

It is important they appreciate the normal procedures of carrying out investigations, calculations and handling apparatus. If they think there are better or innovative ways of doing these investigations they should feel to suggest (this is what constitute science symposium in schools which aims to make learners be innovators and scientifically skilled).

Preparation for the lesson

Note: Effective teaching/learning of concepts in this unit involves carrying out experiments (herein referred to as activities). Learners must be organized into suitable group sizes according the class number and resources available.

Arrange for the availability of required apparatus for class activities/experiments. Collect necessary charts, videos, photographs and necessary reference materials. Ensure your notes are up to date keeping in mind difficult concepts that cause troubles to learners explain such very well.

1.1 Identification of ions

Refer to the learner's book page 1

Resources: Each group will require 8 test tubes on a rack, 8 labels, 2M ammonia solution, 2M sodium hydroxide, 2 droppers, soluble salts of Al, Zn, Pb, Fe^{2+} and Fe^{3+} and Ca^{2+}

Learning activities

1. Introduce this unit by review with the learners the previously acquired knowledge on the formation of ions, ionic bonding, about formation salts by double decomposition (precipitation reactions) and electrolysis of salts – knowledge learners acquired in Secondary 2. Aso review with the learners about solubility of salts in water.

2. Invite the learners to try to state what they understand of the terms: cations and anions. Let them attempt to explain the origin of naming of these ions in such a manner and which topic they encountered the names.

3. Then clearly define to the class the meaning of these terms (cations and anions) as used in Chemistry if the learner's did not get it correct and inform them the terms were used in electrolysis with the names of the ions originating in relation to the electrode each ion migrate to during electrolysis process.

4. With your guidance let the learners list the cations and anions on the chalk board.

Identification tests for cations

1. As part of introduction to activity 1.2 let the learners do activity 1.1 in the learner's book. You may as well take through the measures to observe when carrying out qualitative analysis.

2. Take the learners through the procedure in activity 1.2 and 1.3 to familiarize with what shall be required of them in the actual experiment.

3. Put the students in groups of two or any suitable size depending on your class size and allow them to collect all necessary apparatus and chemicals.

4. Under your supervision, let the learners carry out the experiments (activity 1.2 & 1.3) in the learner's book as you move around checking the progress of every group.

5. Help the learners to make and record correct observations.

6. Allow the groups to discuss their findings, draw conclusions and each group to present their results (observations) to the rest of the class.

7. Let the learners compare their findings with the ones provided in the tables below.

Sample test results

(i) Using aqueous sodium hydroxide

Cation	Observations on adding a few drops of aqueous NaOH	Observations on adding excess aqueous NaOH
Al^{3+}	White precipitate (ppt)	White precipitate dissolves forming colourless solution
Ca^{2+}	White ppt	Precipitate persists (insoluble)
Cu^{2+}	Blue ppt	Precipitate persists (insoluble)
Fe^{2+}	Green ppt	Precipitate persists (insoluble)
Fe^{3+}	Reddish brown ppt	Precipitate persists (insoluble)
Pb^{2+}	White ppt	Precipitate dissolves (soluble) forming colourless solution
Zn^{2+}	White ppt	Precipitate dissolves/soluble forming colourless solution

(ii) Using ammonia solution

Cation	Observations on adding a few drops of aqueous NaOH	Observations on adding excess aqueous NaOH
Al^{3+}	White precipitate (ppt)	White precipitate insoluble
Ca^{2+}	No ppt	No ppt
Cu^{2+}	Blue ppt	Precipitate soluble forming a deep blue solution
Fe^{2+}	Pale green ppt	Precipitate insoluble
Fe^{3+}	Brown ppt	Precipitate insoluble
Pb^{2+}	White ppt	Precipitate insoluble
Zn^{2+}	White ppt	Precipitate soluble forming colourless solution

Note: Emphasise to the learners on the importance of use of correct terms on reporting about observations made such as white precipitate forms/white ppt. Where there is nothing observed it is to be reported as "no observable change/ reaction" not as "no reaction".

Additional information to the Teacher

When a few (3) drops of sodium hydroxide are added to the solutions of cations (metal salts) the precipitates that form i.e. observed are the insoluble metal hydroxides. Ask the learners the following:

(i) What type of reaction is taking place? Ans. Precipitation reaction/double decomposition.

(ii) Are the products formed soluble or insoluble and why? Most are insoluble/ refer to tables on page 20 . All hydroxides are insoluble salts except those of potassium, sodium and ammonia.

(iii) Why are some insoluble hydroxides dissolve in excess reagents? Explain to learners using equations formation of complex compounds

(iv) How do you classify the metal whose salts form complex compounds? Ans: Transition metals

Aluminium, lead and zinc precipitates dissolve in excess sodium hydroxide as they react with sodium hydroxide to form complex ions (which are soluble) as outlined in the table below. This is a property of amphoteric oxide.

Summary of amphoteric oxides/hydroxides

Oxide	Hydroxide	Formula of simple salt from nitric (V) acid	Formula of complex salt from sodium hydroxide
ZnO	$Zn(OH)_2$	$Zn(NO_3)_2$	$Na_2Zn(OH)_4$ Sodium tetrahydroxozincate(II) $[Zn(OH)_4]^{2-}$

PbO	$Pb(OH)_2$	$Pb(NO_3)_2$	$Na_2Pb(OH)_4$ Sodium tetrahydroxoplumbate(II) $[Pb(OH)_4]^{2-}(aq)$
$Al2O_3$	$Al(OH)_3$	$Al(NO_3)_3$	$NaAl(OH)_4$ Sodium tetrahydroxoaluminate(II) $[Al(OH)_4]^-$

With ammonia solution all the cations in the table form a precipitate except that of calcium. In excess ammonia precipitate of zinc and copper dissolve to form complex ions, tetraamine zinc (II) ions and tetra amine copper (II) ions respectively.

$$Cu(OH)_2\ (s) + 4\ NH_3\ (aq) \longrightarrow Cu\ [NH_3)_4]^{2+}(aq) + OH^-(aq)$$

Let the learners discuss the questions provided under discussion corner and then proceed individually to carry out the assignment given under "work to do" section in the learner's book.

Identification test for anions

1. Learners are now aware what anions are.
2. Let the learners discuss the questions provided under the discussion corner in the learner's book to jog their memory about anions.
3. Let them assemble all the apparatus and chemicals needed for the experiment (activity 1.5). For the apparatus and chemicals required refer to learner's book.
4. Under your supervision, let the learners carry out the experiments (activity 1.4 & 1.5) in the learner's book as you move around checking the progress of every group.
5. Help the learners to make and record correct observations.
6. Allow the groups to discuss their findings, draw conclusions and each group to present their results (observations) to the rest of the class.
7. Let the learners compare their findings with the ones provided in the table below.

Anion	Procedure	Observations
Carbonate	Add dilute nitric acid to the solid sodium carbonate. Pass any gas produced through calcium hydroxide solution.	Effervescence occurs. The gas produced turned lime water milky i.e. forms white precipitate confirming the gas is carbon dioxide.
Chloride	Add dilute nitric acid to aqueous chloride, followed by 3 drops of silver nitrate.	A white precipitate forms.
Iodide	Put about $5cm^3$ of iodide solution in a test tube. Add 3 drops of nitric acid followed 3 drops of lead (II) nitrate.	A bright yellow precipitate forms.
Nitrate	Add $2cm^3$ of sodium hydroxide to $2cm^3$ of nitrate solution, drop aluminium foil into the solution and warm gently. Test any gas produced by damp red litmus paper.	A colourless gas produced. The gas turns moist red litmus paper blue.
Sulphate	Add 2 cm^3 of dilute nitric acid to a solution of sulphate, followed by barium nitrate solution	A white precipitate forms.
Sulphite	Add 2 cm^3 of nitric acid to sulphite solution and test gas produced using a filter paper dipped in potassium dichromate solution.	A colourless gas produced. The gas turns the soaked filter paper from orange to green.

8. Let the learners discuss in groups the questions provided under the discussion corner in the learner's book. Then individually do the Check your progress 1 in the learner's book.

Additional information

It is important that you explain to the learners the following:

Dilute hydrochloric acid can be used in place of nitric acid for the test for presence of carbonates.

Why dilute acids, especially nitric acid is added to solutions of some anions during test confirmations. And why concentrated acids are not used e.g. they are strong oxidizing agents in such state and as well can be very explosive with most reactions.

The need to make correct inferences which demand they have good knowledge of chemistry/properties of substances being dealt with/under investigations.

Answers to the Check your progress 1.1

Refer to learner's book page 8

1. Add 3 drops of lead (II) nitrate and warm. If the precipitate form does not dissolve in warming water comfirm sulphate ions are present.
2. Put a portion of one of the substances in a test tube and add potassium iodide solution if a yellow precipitate is formed (that is lead (II) iodide), it is a lead salt and if there is no observable reaction i.e. test is negative then it confirms the presence of aluminium salt.
3. i. Chloride ions

   ii. Sulphate ions

1.2 Identification of gases

Refer to learner's book page 9

Preparation for the lesson

- Arrange for the availability of apparatus and reagents required for experiments on identification of gases.

- Apparatus and materials: Two test tubes, calcium grain, 40 cm3 beakers, wooden splint, 2M ethanoic acid, small piece of calcium carbonate, two boiling tubes, calcium hydroxide, hydrogen peroxide (30 volumes), rubber stopper and glass beads.
- Safety precaution: Handling the acid and hydrogen peroxide must be done carefully. If there is spillage on your skin rinse immediately with a lot of clean water. Wear goggles and an apron all the times.

Learning activities

1. Before carrying out activity 1.6, review the properties of common gases already covered in Secondary 2.
2. Guide the learners to collect and assemble all the apparatus and reagents they need for this activity. Reagents: calcium carbonate, sodium sulphite, dilute hydrochloric acid, manganese dioxide, zinc granules, hydrogen peroxide, ammonium salt and sodium hydroxide.
3. Leading the class, let the learners suggest how the gases to be identified can be prepared in the laboratory. Guide them appropriately as indicated below.
   - **CO_2** - To obtain carbon dioxide heat calcium carbonate in a boiling tube and pass the gas produced through lime water.
   - **SO_2** - To test for sulphur dioxide add dilute hydrochloric acid into a test tube containing sodium sulphite and test for the gas produced using a filter paper soaked in acidified potassium dichromate
   - **Cl_2** - To test for chlorine add hydrochloric acid into a test tube containing manganese dioxide and heat, test for the gas using moist red and blue litmus papers
   - **O_2** - To test for oxygen, add hydrogen peroxide to manganese dioxide and introduce a glowing splint.
   - **H_2** - To test for hydrogen, add dilute hydrochloric acid into zinc granules and introduce a burning splint.
   - **NH_3** - To test for ammonia, mix ammonium salt with sodium hydroxide and heat, introduce moist red litmus paper.

4. Let the learners proceed to perform the confirmatory tests for the gases as outlined in the learner's book as well as the table below.

Gas	Procedure	Observations
Ammonia	Hold a moist red litmus paper	Red litmus turns blue
Carbon dioxide	Bubble the gas through lime water	A white precipitate is formed
Chlorine	Hold moist red and blue litmus papers	Red litmus turns blue then bleached. The blue litmus paper is as well bleached.
Hydrogen	Introduce a lighted splint in the gas	A 'pop' sound is produced
Oxygen	Introduce a glowing splint in the gas	Relights a glowing splint
Sulphur dioxide	Introduce a filter paper soaked in acidified potassium dichromate	Orange filter paper turns green

Learning Assessment

- It is important that you carry out continuous learning assessment during the course of the learning of this unit. You may ask learners some oral questions in the course of the lesson to gauge their knowledge and understanding of the tests procedures for the identification of ions and gases.
- Learner's acquisition of skills can be assessed by asking the learners to demonstrate how to test for presence of cations, anions or gases given in non label substances provided to them using suitable reagents. Provide guidance and correct where necessary. Assess their environment awareness.
- Listen and gauge learners language competence during class discussion, group presentations during experiments and correct accordingly as you encourage them to improve.
- You may consider use of Check your progress, work to do, and discussion corner quizzes provided in the learner's book to engage their competencies and learning progress, providing remedial actions where necessary.

Answers to Check your progress 1.2

Refer to learner's book page 10

1. Pass the suspected gas through lime water (calcium hydroxide solution), if the solution turns milky the gas is carbon dioxide.
2. A ring of white substance formed is ammonium chloride.

$$HCl\ (g) + NH_3\ (g) \longrightarrow NH_4Cl(s)$$

UNIT 2 Energy changes in chemical reactions

Refer to learner's book page 11 to 32

Learn about	Key inquiry questions
• Learners should understand enthalpy change in terms of exothermic (H negative) and endothermic (H positive) reactions and also represent energy changes by energy profile diagrams, including reaction enthalpy changes and activation energies. • They should explain bond breaking as an endothermic process and bond making as an exothermic process and also explain overall enthalpy changes in terms of the energy changes associated with the breaking and making of covalent bonds. • They should calculate heat of reactions using both theoretical data and that obtained experimentally.	• How do you measure energy changes in chemical reactions?

Knowledge and understanding	Skills to be acquired	Attitudes and values
• Understand energy changes in chemical reactions	• Design or plan an investigation, select techniques, apparatus and materials to determine heat of reactions. Calculate heat of reactions. Represent energy changes by energy profile diagram	• Appreciate the importance of energy change in understanding chemistry

Contribution to the competencies:

Critical and creative thinking: experimentation, analysis
Communication: use of range of media to present experimental results
Co-operation: work in collaboration

Links to other subjects:

Biology: variation of temperature

Physics: measure of heat and energy

Introduction to the Unit

This unit is to help the learners appreciate the aspect of energy changes and their monitoring in reactions and its crucial role in the outcomes of these reactions. For example a number of industrial processes such as Contact process, Ostwald process, Haber process the heat changes impact on their efficiency and general output.

Cross cutting issues to be incorporated

1. Environment awareness and sustainability

Under the study of investigation of identification of gases, some of these such as chlorine and sulphur dioxide are environmentally harmful and even are health hazards to users if not properly handled. Poisonous gases e.g. chlorine must be handled in fume chamber.

Emphasise too much release of carbon dioxide and sulphur dioxide gases into the air have cumulative air pollution effects and accompanying environmental degradation. As well proper disposal of used salts at the end of laboratory activities must be observed..

2. Life skills

Learners should be encouraged to make good and critical decisions on apparatus and materials for different experiments acknowledging costs of non-improvised items, design and planning including time management of the activities as this influences their success.

Competencies to be developed

1. Co-operation

Discuss how this is to be achieved during group working such as every group member is assigned role to play. Need to respect and appreciate others, their opinions and improve one another's ideas.

2. Communication

Promote among learners the various communication skills

i. Listening skills – engage learners by asking them questions on procedure or alternative ways if they are aware, content and planning during experiment to gauge their attentiveness.

ii. Encourage learners to ask questions themselves.

iii. Observe and ensure how learners are taking notes, recording data to improve on their written communication.

iv. Allow groups to make presentation, discuss the experiment results, and draw appropriate conclusions.

3. Critical and creative thinking

Encourage this by involving the learners to design, plan and carry out the proposed activities/tasks in the learner's book. Activity questions contained in the learner's book are meant to achieve this. You can as well come up with your own.

2.1 Introduction and heats of reactions

Refer to learner's book page 11

1. The introduction provided in the learner's book presents some interesting scenarios involving energy changes/heats of reactions being of useful applications. But rarely do many people take cognizance of this.

3. Group task 1 is to help learners remind themselves of what they had previously learnt and crucial link and continuity with this unit, appreciating pedagogical aspect of learning. Learners had performed many reactions in the laboratory involving evolution of heat, others requiring heat to start off, while others do not need heat to start them off. Learners' imaginative/ critical thinking might begin to be tested on what brings about all these differentiations.

4. Explain to the learners what are heats of reactions. Clearly define the following terms to the class: enthalpy, enthalpy change. Give the learners opportunity to suggest where else they could have encountered such terms and state what is their understanding of these words.

5. Let learners state the reactions, which give out heat and those that absorb heat. Some examples are given in the learner's book.
6. Organise the learners to do activity entitled "Group Task 2" in the learner's book. This is to help learners now begin appreciating usefulness in heat changes even in the lives of people, livestock where temperatures are monitored as well as in most industrial processes where heat measurement and control is very important.
7. In general this introduction is to bring to the understanding of the learners that chemical processes and some physical processes give out heat or take in heat.

2.2 Exothermic and Endothermic reactions

Refer to learner's book page 12

Learning activities

1. Ask the learners to attempt to define these terms. This is to offer the fast learners opportunity to vent out their ideas as some could have gone ahead in reading/learning. Take the learners through the meanings of exothermic and endothermic reaction as provided in the learner's book.

2. Ask the learners where in their opinions they think this energy being released or absorbed is coming from. Also important, illustrate and explain the following terms associated with exothermic/endothermic reactions: surrounding, system, symbols of H and enthalpy change, ΔH.

3. Remind the learners that conditions which enthalpy is measured is important e.g. constant pressure, since some reactions are accompanied with heat changes with pressure variations. For example when gases are subjected to high pressures there is release of heat to the surroundings.

4. Organise the learners to do the individual task 1 in the learner's book for 5-10 minutes. This is important to help to orientating their minds on classifying the different experience in everyday life. Then proceed to guide them to do activity 2.1 and 2.2. let the learners discuss the activity questions suggested under each of the activities to promote their critical and creativity skills such as analytical thinking.

5. As you conclude the discussion on this sub topic, remind the learners that exothermic and endothermic classification of reactions is just another of the many methods of categorizing reactions. You can ask the learners to mention the other ways of classifying reactions such as: decomposition reactions, displacement reactions, oxidation/reduction reactions, precipitation reactions e.t.c. These classifications are important in chemistry and good applications in various industrial uses/medical consumption and everyday activities e.g. extraction of metals by either reduction or electrolysis depending on reactivity of a given metal.

2.3 Energy profile diagrams

Refer to learner's book page 15

Learning activities

1. Explain what energy profile diagrams are. Liken them to bar charts line graphs that representing given set of processed information or collected and analysed data. Ask learner to give the other name for energy profile diagram i.e. energy level diagram, as this they may come across in other textbook just to clear confusion that could arise during personal study.

2. Using relevant diagrams as provided in the learner's book, illustrate the energy profile diagrams for both exothermic and endothermic reactions.

3. Illustrate to the learners how the energy diagrams are constructed/drawn, that is: enthalpy change is on the Y-axis and reaction path on x-axis. Ask the learners to attempt why this is the case. (Response: it is the unit measured that is put on y-axis to make it possible to do so.)

4. Ask the learners, as you conclude the discussion why the correct positioning of the products and reactants must be ensured in the construction of the diagrams bringing their attention to the discussion in the learner's book, that is;

5. In an exothermic reaction, the products formed are at a lower energy than the reactants. ΔH is indicated as negative.

6. In an endothermic reaction the products formed are at a higher energy level than the reactants. ΔH is indicated as positive.

7. Let the learners discuss the questions under the discussion corner in suitable group size and as well individually do the Check your progress 2.1.

Additional information to the teacher

During the activities

Ensure all the necessary precautions are taken into account during the experiments e.g proper handling of corrosive substances and their disposal at the end of the activity.
Assist the learners to make correct deductions taking into account the temperature rise or fall. For example when a reaction proceeds by absorbing heat from the environment, the temperature of the environment/surrounding drops and this depicts endothermic reactions. Therefore the product(s) in this reaction are formed at a higher energy. When the reaction proceeds by releasing heat to the environment, the temperature of the environment would increase hence the products formed at a lower energy. These changes in temperatures are detected by feeling with the palm of the hand/use of thermometer.

Heat change of reaction = (heat of products) – (heat of reactants)

Answers to Check your progress 2.1

Refer to learner's book page 17

1. a. Negative

   b. Positive

   c. Positive

2. Exothermic reaction- heat is released.

2.4 Bond breaking and bond formation

Refer to learner's book page 17

Learning activities

1. Introduce the discussion by reviewing with the learners what they already know about chemical bonds. See the discussion questions provided in the learner's book.

2. Let the learners attempt to explain what happens during chemical reactions in terms bonds realignments. Help them to appreciate that in any chemical reaction, bonds are first broken then new bonds are formed as products occur. Ask why this must happen for a reaction to take place. Remember this forms the foundation of chemistry – study of reactions and how they can occur in that manner.

3. Explain to the learners why bond breaking is an endothermic reaction and bond formation is an exothermic reaction. Let learners attempt to explain what bond energy is. Inform the learners that every chemical bond has bond energy associated with it, and that it is possible to determine the bond energy of various chemical bonds and this has done experimentally for example the bond dissociation energy contained in table 2.1 in the learner's book.

4. Ask the learners the importance of bond energies, bringing to their attention that it is useful in knowing energy content of fuels/enthalpy change hence aiding in the choice of fuel for various domestic and industrial consumptions.

5. Mention bond energy may vary slightly depending on the compound it occurs. Ask the learners why could be the case. For example, the intensity or little of the intermolecular forces/Van der Waals forces may antagonize these bond energies increasing or decreasing their overall net effect.

6. Inform the learners, the bond energy during new bond formation and the bond dissociation is the same. Ask the learners why this is the case. Tell them, it obeys the law of conservation of energy.

Additional information to the teacher

You can provoke the learner's critical thinking, by asking such questions as given below.

(i) Why is the H - H covalent bond has the strongest bond dissociation energy?

(ii) Why Br – Br bond has the weakest bond dissociation energy?

Responses to the above questions: the covalent bond between the hydrogen atoms is the strongest because the hydrogen atoms are very small and their attracting nuclei are closest strongly pulling the shared pair of electrons (their atomic radii are small). Therefore the bond requires large amount of energy to be broken. The converse is true for Br – Br bond energy.

2.5 Calculating enthalpy changes using bond energies

Refer to learner's book page 19

Learning activities

1. Bond energies are used as well to determine enthalpy of formation of compounds or given reactions. Emphasize that if overall:

   - More energy is used in bond breaking than released during bond formation, the net energy is positive thus the process is endothermic,
   - Less energy is used in bond breaking than the amount of energy released during bond formation, the net energy is negative thus the process is exothermic.

2. Guide the learners stepwise how to calculate the enthalpy changes using bond energies as shown in the learner's book e.g. enthalpy of formation of hydrogen chloride. Give some unworked examples and Check your progress 2 for the learners to do individually, correctly them as is necessary.

3. Emphasise the following important learning point as the learner's practice calculation of the enthalpies;

   (i) Note the number of bonds broken and how many bonds. Ask the learners to suggest they can determine this. [From reaction equations]. Hence the reason one must write reaction equation if one is not provided with one.

   (ii) The appropriate positive (+) or negative (-) signs must be included in the workings

   (iii) Included the measurement unit for the energy i.e. kilojoules (kJ or kJ mol-1)

   (iv) When calculating standard enthalpies, temperature and pressure conditions used must be stated. Included as well is the standard enthalpy reaction name. Ask them why it is important this to be done. Examples of standard enthalpies of reactions include:

   - Hf denotes the standard enthalpy of formation.
   - Hc denotes the standard enthalpy of combustion.
   - Hn denotes the standard enthalpy of neutralisation.

(v) If the reaction equation is not given, write it down before proceeding to do the calculations. Ask them why this is important.

(vi) In some working, one may be required to draw the energy level diagram for such a reaction.

4. To determine the resultant sum of energy, the following equation is used ΔHr = (sum of energy released when new bonds are formed) – (sum of energy needed to break bonds in reactants)

Answers to Check your progress 2.2

Refer to learner's book page 22

1. a. The weak H-H bond in hydrogen is broken, as well as the O=O double bond in oxygen

   b. = -486 kJ

2. $2H_2(g) + O_2(g) \longrightarrow 2H_2O(l)$ ΔH=-486KJ

3. –83.68 kJ/mol

Determining enthalpies of reactions by experiments

Refer to learner's book page 23

Suggested teaching and learning activities

1. Organise learners to work in groups of four or five to allow smooth work progress and good division of tasks such as recording of results, taking of readings, noting down procedures.

2. Guide the learners on how to use $Mc\Delta T$ to calculate the various standard enthalpies. Emphasise to the learners that the mass in grams is regarded to be equal to that of measurement given cm3 because the density of the solution is normally assumed to be 1g/cm3. The specific heat capacity is normally given in kJ/kg/K or J/g/K.

3. Lead the learners through:

Activity 2.3: Determining the enthalpy of neutralisation

This activity is to assist learners to know how to calculate enthalpy of neutralization reactions. They should be able to understand what enthalpy of neutralization is. Let the learners follow the instructions given in the learner's book, supervising the learners' observation and data collection and recording skills. Ensure all the group members are co-operating and adequately involved in the activities.

This is activity involves determining the enthalpy of neutralization reactions between;

- 2M nitric acid and potassium hydroxide
- 2M hydrochloric acid and ammonium hydroxide

Though learners are required to design, plan and carry out this activity, your guidance is paramount. You can ask the learners such questions as:

- Does the temperature rise or fall?
- Is the reaction exothermic or endothermic?
- Will the sign of ΔH for this reaction be +ve or –ve? Give reasons for your answer
- How did you find the temperature change and average temperature for this reaction
- Why was the lagging of the beaker is necessary?
- Write the chemical and ionic equations for the reactions.

After performing these activities take the learners through worked example provided in the learner's book.

Additional information to the teacher

The temperature rises seen in the activities above indicate that they are exothermic reactions. ΔH is therefore negative. Note that when we measure the temperature rise using a known volume of acid being neutralized by an known volume of an alkali, it is possible to calculate the enthalpy change for that neutralization as demonstrated in the worked example in the learner's book.

Experiments have shown that for strong acids and strong alkali neutralization reactions, the value of energy liberated is about 57kJ mol-1. This is because the strong acids and strong alkalis completely dissociate in aqueous solution.

When a strong acid e.g. hydrochloric acid is neutralized by a weak base e.g. ammonium hydroxide slightly less heat energy is produced. The energy released in this case is 52.2kJ mol-1. Further when both weak acid reacts with weak alkali, even lower heat energy is liberated. For example in neutralization reaction between ethanoic acid and aqueous ammonia, the energy produced is 51.5kJ mol-1. Ask learners to attempt give explanation for this trend. This is because some energy, about 5.5kJ mol-1 must first be used in ionizing the ethanoic acid and ammonium hydroxide. Consequently lesser heat energy is liberated.

Determining enthalpies of: solution, displacement and combustion

For the activities involving determining enthalpy change of solution and displacement, the learners are required to design, plan and carry out these experiments on their own. Your guidance still is essential but avoid doing it for them. Observe and assist as is necessary as they design, plan and conduct the activities. This helps to stretch their imagination and critical thinking.

Make rounds among the groups, observing the skills in handling apparatus, taking readings in appropriate manner and proper recording of data/results.

Enthalpy of dissolution ammonium nitrate in water

- What is the temperature of the solution when the solids completely dissolved? Why did your palms felt so cold?
- Did the temperature rise or fall? What does this indicate about the reaction? Was it easy taking the temperature? What improvements do you suggest to make it easier for temperature readings?
- ΔH for dissolution of ammonium nitrate is +83.6kJ mol-1. State briefly the experimentsl error that could have contributed to the difference between this value and your findings.

Enthalpy of displacement reaction

- What happens to the colour of the solution? Why was there colour change?
- What do you observe at the bottom of the beaker?
- What do you conclude?
- Does the temperature rise or fall? What do you conclude?

Enthalpy of combustion

- Why was it not necessary to burn all the ethanol?
- The amount of heat evolved when a fuel is burnt is theoretically higher than the value obtained practically. Mention four errors/assumptions in this experiments which could be responsible for the poor results obtained.

Special emphasis to the teacher

In general guide the learners through the experiment and make sure that all the precautions in these experiments are adhered to. Take the learners through the worked examples on how to calculate enthalpy change using the formulae, $MC\Delta T$ and use the number of moles dissolved to find the molar heats of solution, displacement and combustion respectively.

Notice that is not necessary to burn all the ethanol. The little burnt is all transferred into the water. It is assumed that none of the heat produced is lost by anyway such carried away by wind, or some being absorbed by the beaker or the thermometer. Also when only a little of fuel is burnt, the amount of heat liberated is not referred to molar heat of combustion. We must find the mass of one mole of the fuel and calculate the molar heat of combustion of that specific fuel used.

Define the meaning of the molar enthalpies of the reactions investigated;

Molar enthalpy of combustion of a substance, AHc is the enthalpy change when one mole of a substance is completely burnt in oxygen.

Molar enthalpy of displacement is the enthalpy change when one mole of the substance is displaced from its solution.

Hess's law

Take the learners throught the discussions on Hess's law given in the learner's book. State the importance of the law in calculating of heats of formation of some products.

Guide the learners on how to use the Hess' law to calculate the molar enthalpy of formation. You can use the worked given in the learner's book.

Lesson assessment

Observation – watch learners carrying out the various suggested activities/ tasks. Correct them as is necessary in selection and arranging of apparatus/ chemicals, taking readings and data recording.

Oral questions – use this to engage the learners to ascertain their understanding of the procedures and why certain tasks are done. Activity questions, discussion corner quizzes provided and the ones given above can be of help. You can come up with more questions.

Written tests – allow the learners to do the various self evaluation exercises given in the learner's book e.g. Work to Do, Check your progress tests to measure how well the learning outcomes are being achieved.

Answers to Check your progress 2.3

Refer to learner's book page 32

1. i) Mass of burnt ethanol =1.5g

   Mass of water=500g

   Change in temperature=9.5

   Q= MCΔT

   500gx4.2j/g/kgx9.5

   =19,950J

   ii) 1.5g = 19950 J

   46g=611,800 J

2. $4CH_4$ =4 × 413 = 1652

   2O = O =2 × 497= 994

   4C0 = 4 × 740 = 2960

   2OH = 2 × 463 = 926

   =6532J

UNIT 3 Chemical Kinetics, Equilibrium and Electrochemistry

Refer to learner's book page 33 to 71

Learn about	Key inquiry questions
• Learners should use a range of sources to investigate the effect of concentration, pressure, particle size and temperature on the speed of reactions and explain these effects in terms of collisions between reacting particles. They should describe and understand the effect of catalysts (including enzymes) on the speed of reactions, explain how pathways with lower activation energies account for the increase in speeds of reactions, and suggest a suitable method for investigating the effect of a given variable on the speed of a reaction, and interpret data obtained from practical investigations. • Learners should also work collaboratively to predict how changes in properties (e.g. volume, concentration, temperature) will change	• How long does it take for a chemical reaction to occur under a set of conditions? • How enthalpy and entropy determine the effectiveness of chemical reactions? • How do voltaic cells and electrolytic cells differ? • How can we predict what will happen to rates of reaction, equilibrium and electro potential when conditions change?

Learn about
• reactions at equilibrium and also understand and define the concepts of equilibrium, enthalpy and entropy. They should explain electro-chemistry through designing and carrying out investigations to establish how chemical reactions produce electricity, and how electricity is used to force reactions to occur (electrolysis).

Knowledge and understanding	Skills to be acquired	Attitudes and values
• Understand chemical kinetics (rates of reactions), equilibria, redox reaction and electrochemistry	• Investigate the effect of concentration, pressure, particle size and temperature on the speed of reactions • Suggest a suitable method for investigating the effect of a given variable on the speed of a reaction • Predict how changes in properties (e.g. volume, concentration, temperature) will change reactions at equilibrium	• Appreciate the importance of kinetics in understanding electro-chemistry

Skills to be acquired
• Carry out investigations to establish how chemical reactions produce electricity, and how electricity is used to force reactions to occur
Contribution to the competencies: Critical and creative thinking: experimentation, analysis Communication: use of range of media to present experimental results Co-operation: work in collaboration **Links to other subjects:** Biology

Introduction to the Unit

This unit is about the application of chemistry in our day to day life. Many households, companies and institutions use electricity. The unit helps the learners to understand how chemical reactions can bring about electricity. It also helps them to understand how electricity can affect certain chemical reactions and how this knowledge is utilized in a number of industrial processes.

Cross cutting issues to be incorporated

1. Environment awareness and sustainability

Learners should be aware that carbon dioxide is linked to global warming so during experiment least of amount of this gas be released into the atmosphere.

2. Peace and values education

Emphasise to learners the importance of working harmoniously with each other during group work and class activities

3. Life skills

Learners should be encouraged to make good and critical decisions on apparatus and materials for different experiments acknowledging costs of non-improvised items, design and planning including time management of the activities as this influences their success.

Competencies to be developed

1. Co-operation

During group work all learners should participate in the various tasks and respect each other's views and contribution in spite of their different abilities.

2. Communication

Develop various communication skills through presentation, notes taking, watching videos, asking and answering question and report writing.

3. Critical and creative thinking

Design, planning and carrying out experiments and activities suggested in the learner's book. You can as well come up with your own.

Introduction to Chemical Kinetics

Refer to learner's book page 33

Lesson activities

1. Use interesting scenarios to capture learners' attention when introducing this unit particularly on rates of reaction. Some are provided in the learner's book at the introduction. Ask learners to also give some reactions with different rates. Inform the learners that reaction rates can be measured or determined.
2. Let the learners perform the group task 1 and the individual task provided in the learner's book as a prerequisite to the learning of this unit.
3. Define clearly the rate of reaction.

3.1 The Collision Theory and Activation Energy (Ea)

Refer to learner's book page 34

1. Introduce this lesson by organizing and allowing learners to discuss in groups or as a class the questions contained in the 'Discussion corner' section in the learner's book .
2. Summarise the discussion by clearly defining what activation energy is, explaining what the collision theory is all about and its relationship with rate of reactions as outlined in the learner's book.

3. Evaluate the learners' critical thinking and understanding by asking them if all reactions need activation energy to start off including exothermic reactions. They had briefly encountered this aspect in the previous unit.

Additional information to the teacher

Essentially, a chemical reaction is the result of collisions between molecules. According to this collision theory, if the collision is strong enough, it can break the chemical bonds in the reactants, resulting in a rearrangement of the atoms to form products. The more the molecules collide, the faster the reaction. Increase in the numbers of fruitful collisions per unit time influences rate of reactions. The factors that the learners shall study as influencing rate of reaction must be appreciated within the context of either increasing or decreasing collisions of reacting particles. The more particles collide the higher the chances of more fruitful collisions and the faster the rate of reactions. The converse is also true.

Answers to Check your progress 3.1

Refer to learner's book page 36

1. Reaction rates are determined by observing the changes in the concentrations of reactants or products over a specific time frame.
2. Check for correct answers
3. Collision Theory is based on the idea of collisions taking place for a reaction to occur. Particles must collide with enough energy in order to react (energy enough to be equal to, or more than the activation energy- the minimum amount of energy required for particles to react. Without achieving the activation energy, a reaction will not occur.

3.2 Determination of the rate of chemical reaction

Refer to learner's book page 36

1. This lesson guides the learner on how, in practice, one can establish or measure rate of a reaction. Consider going through the discussion corner questions either in groups or as a class activity.
2. Giving examples of different reactions let the learners predict how the rate of such reactions can be measured in real time.
3. Guide them through the various methods of measuring reaction rate as outlined in the learner's book.

3.3 Factors affecting rates of reaction

Refer to learner's book page 37

Learning activities

1. With your guidance let the learners give some of the factors that influence rate of reactions.
2. You may consider using individual task 2.2 in the learner's book, at the start of the learning session, to capture the learners' attention and interest. This provides them with the right frame of mind to appreciate that all along they have been practicing some of these principles incognito.
3. Discuss all the factors affecting rate of reaction as outlined in the learner's book such:
   - Concentration of reactants
   - Temperature
   - Surface area
   - Pressure
   - Catalysts
   - Light (type and intensity)
4. Organise the learners in suitable group size according to resources available and their number. Observe gender equity where possible. Let the learners do the setting up of the apparatus and carry out the experiments. Instruct them to follow the procedure as laid out in the experiments. Move around checking the progress

   Note: For some suggested activities, the learners are to come up with their own procedure, do the designing, planning and conduct the experiments. Provide your assistance as is necessary.
5. Let the learners make proper observations, record the results from the experiment, plot the graph of 1/time against temperature and comment on the shape of the graph.
6. After each experiment let them discuss their observations, the findings and the activity-based questions provided under each activity, after which they can do a presentation in class.

7. Building on their presentations after every activity/experiment, explain the effect of each the factor on the rate of reaction as outlined in the learner's book. Emphasise use of equations where applicable.
8. For each activity, let the learners state the method used to determine the rate of reaction and suggest another alternative method where applicable.

Additional information to the Teacher

Activity 3.1

Refer to learner's book page 38

1. Demonstrating effect of concentration on rate of reaction, you can introduce this activity reminding the students on preparation of colloidal sulphur.
2. Allow the learners in groups to discuss the data obtained and draw the graph.
3. The graph I should be a curve. Graph II is a straight line. A sketch of volume of acid used (x-axis) against 1/t.
4. The explanation for the shape of graph I is that as more amount of water is added i.e. diluted there is a decrease in concentration. Decrease in concentration reduces the rate of reaction causing an increase in time taken for reacting particles to collide to form products.
5. From graph II, when the graph is correctly plotted the time taken for the cross to be obscurred for the volume of the acid given are as provided under each.

Answers to activity questions

Refer to learner's book page 39

(i) 13 cm^3

1/t at 13 cm^3 on the graph => 2.75×10^{-2}

t = 1 / 2.75×10^{-2} = 36.3636 seconds

(ii) 15 cm^3

1/t at 15 cm^3 on the graph => 3.35×10^{-2}

t = 1 / 3.35×10^{-2} = 29.8507 seconds

(iii) 15cm^3

1/t at 17cm^3 on the graph => 4.0×10^{-2}

t = 1 / 4.0×10^{-2} = 25.0 seconds

6. From graph II ,determining the volume of the acid used if the time taken for the cross to be obscurred is:

(i) 25 seconds

1/t => 1/25 = 4.0×10^{-2}

Reading from a correctly plotted graph;

4.0×10^{-2} correspond to 17.0 cm^3

(ii) 30 seconds

1/t => 1/30 = 3.33×10^{-2}

Reading from a correctly plotted graph;

3.33×10^{-2} correspond to 14.7 cm^3

(iii) 40 seconds

1/t => 1/40 = 2.5×10^{-2}

Reading from a correctly plotted graph;

2.5×10^{-2} correspond to 12.3 cm^3

Reaction equation

$Na_2S_2O_3$ (aq) + 2HCl(aq) $\rightarrow$ 2NaCl (aq)+ SO_2 (g) + S(s) + H_2O(l)

Ionically:

$S_2O_3^{2-}$ (aq) + $2H^+$ (aq) $\rightarrow$ SO_2 (g) + S(s) + H_2O(l)

Activity 3.2

Refer to learner's book page 40

1. Introduce this discussion reminding the learners on kinetic theory of matter. Take them through the procedure by demonstrating to them how they are supposed to carry out the experiment.
2. Let the learners discuss their observations, analyse the data obtained and draw the graph.

Note : As the temperature increases the rate of reaction also increases. This is due to increase in the kinetic energy of the particles, which accelerate the rate of effective collisions.

Activity 3.3

Refer to learner's book page 43

Allow the learners in groups to discuss the data obtained and draw the graphs.

Sample results for marble chips/calcium carbonate

Time(seconds)	0.0	30.0	60.0	90.0	120.0	150.0	180.0	210.0	240.0
Mass of marble $CaCO_3$	2.5	2.0	1.8	1.4	1.2	1.0	0.8	0.5	0.5
Loss in mass	0.0	0.5	0.7	1.1	1.3	1.5	1.7	2.0	2.0

Sample results for powdered calcium carbonate

Time(seconds)	0.0	30.0	60.0	90.0	120.0	150.0	180.0	210.0	240.0
Mass of powdered $CaCO_3$	2.5	1.9	1.5	1.3	1.0	0.8	0.5	0.5	0.5
Loss in mass	0.0	0.6	1.0	1.2	1.5	1.7	2.0	2.0	2.0

The rate of reaction was faster in the second experiment using powdered calcium carbonate because it had more larger surface area than marble chips exposed/available for more collisions or increased contact area for the reacting particles.

Activity 3.4

Refer to learner's book page 45

1. Organise the learners in a way to help them easily carry out the suggested activity.
2. Relate the number of students to the number of particles and then vary the area of operation, which should be linked to volume size.
3. Emphasize that reduction in volume leads to an increase in pressure.
4. Explain to the learners that the increased pressure increases the number of collisions which in turn increases the number of effective collisions resulting in faster rate of reaction.
5. Let learners observe how often the fellow learners bump into each other in small area (i.e. lesser volume) discovering the impact pressure on effective collisions.
6. Link this knowledge to the number of industrial processes as outlined in the learner's book.

   (a) Contact process for manufacture of sulphuric acid

   $2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$

   (b) Haber process for manufacture of ammonia

   $N_2(g) + 3H_2(g) \longrightarrow 2NH_3(g)$

   (c) Ostwald's process for the manufacture of nitric acid

   $4NH_3(g) + 5O_2(g) \longrightarrow 4NO\ (g) + 6H_2O\ (l)$
7. Emphasise that the effect of pressure on reaction rate is not felt in solids and liquids. This is because the solid and liquid particles have fixed positions in their strong bonds and therefore no degree of freedom (Kinetic Theory of matter).

Activity 3.5

Refer to learner's book page 47

1. Let the learners know there are reactions both in school laboratories and industrial processes where catalysts are used.
2. Mention also that in the human body catalysts in the form of enzymes are essential in most biological processes. Emphasise that the catalysts/enzymes

are specific for a given type of reaction though a few catalysts can be used in more than one reaction such as platinum and finely divided iron catalysts.

3. In the activity take the learners through the reaction without a catalyst then a second one with a catalyst. Ask the learners if they can notice any difference in the amount of oxygen collected.
4. Emphasize to the learners the fact that a catalyst lowers the activation energy of a chemical reaction hence increasing the rate of reaction. Guiding the learners, let them brainstorm the characteristics of catalyst e.g. do not take part in the reaction, remain chemically unchanged at the end of the reaction, the form may however changed, it is specific, can be rendered ineffective/poisoned by presence of unwanted products (e.g. dust particles), does not supply the energy required for a reaction to start.
5. Let the learners list down some of the catalysts used in some industrial processes.

Answers to Check your progress 3.2

Refer to learner's book page 50

1. • Surface area of a solid reactant.
   - Concentration or pressure of a reactant.
   - Temperature.
   - Nature of the reactants.
   - Presence/absence of a catalyst.
2. If the concentration of a dissolved reactant is increased, or the pressure of a reacting gas is increased: The reactant particles become more crowded. There is a greater chance of the particles colliding. The rate of reaction increases.
3. a. Check for correct graph sketch
   b. The higher the temperature the faster the rate of reaction.
4. a. A substance that increases the rate of a chemical reaction without itself undergoing any permanent chemical change.
   b. Catalysts increase the rate of reaction without being used up. They do this by lowering the activation energy needed. With a catalyst, more collisions result in a reaction, so the rate of reaction increases. Different reactions need different catalysts.

3.4 Chemical equilibria

Refer to learner's book page 51

1. Let the learners look up for the meaning of the word equilibria from the Internet or dictionary. Let them as well react to the photo provided in the learner's book page 51. Let them try to explain why the boy and the girl are not balancing on the sea saw and suggest how they can be made to balance.
2. Link the illustration above with reactions equilibria introducing the concept of Le Chatelier's principle capturing the aspects of reversible reactions as outlined in the learner's book. Clearly state in which type of reaction is found occurrence of dynamic equilibrium.
3. Let the learners do individual task provided in the learner's book page 53.
4. Discuss the factors that affect the system according Le Chatelier's principle, that is:
   - Concentration
   - Pressure
   - Temperature and
   - Catalyst as outlined in the learner's book.
5. There are suggested activities for the various factors affecting system at equilibrium in the learner's book. Organise the class to carry them out. At the end every activity there are activity-based questions which you should encourage the learners to discuss in their groups as they analyse their observations and results of the experiments.
6. Let the learners, as may be possible, compare their findings with those of the other groups and make presentations in the class.
7. Thereafter building on their presentation summarise the discussions on effect of each factor using the guidance provided in the learner's book.

Additional information to the teacher

Effects of concentration on dynamic equilibrium. Remind the learners that it is the ions present (i.e. hydrogen ions or hydroxide ions) that are responsible for the colour change. Caution the learners that bromine is poisonous and the experiment must carried out in a fume chamber.

Effect of pressure on dynamic equilibrium. Review with the learners kinetic theory of matter and the effect of pressure on the rate of chemical reaction. Emphasize that pressure only affects gaseous reactants and products. Explain to them the how the total number of moles on either the reactant side or product side can affect the equilibrium if pressure was to be varied. You can use videos from YouTube.com to assist in explanation. Mention some of the industrial processes affected by change in pressure such as:

(i) Haber process

Increase in pressure of the Nitrogen/Hydrogen mixture favours the formation of more molecules of Ammonia gas in Haber process. Yield of ammonia is thus favoured by high pressures.

Reaction equation: $N_2(g)$ + $3H_2(g)$ ⟶ $2NH_3(g)$

Gay Lussacs law 1Volume 3Volume 2Volume

4 volumes / molecules of nitrogen and hydrogen react to form 2 volumes / molecules of ammonia. Increase in pressure shift the equilibrium forward, to the right, where there is less volume or molecules. More ammonia is therefore produced to reduce the pressure. Decrease in pressure shift the equilibrium backward, to the left where there is more volume / molecules favouring low production / yield of ammonia.

(ii) Contact process

Increase in pressure in the reaction of the sulphur (IV) oxide and oxygen mixture favours the formation of more sulphur (VI) oxide gas in the Contact process. The yield of sulphur (VI) oxide gas is thus favoured by high pressures.

Chemical equation: $2SO_2(g)$ + $O_2(g)$ ⟶ $2SO_3(g)$

Gay Lussacs law 2Volume 1Volume 2Volume

3 volumes / molecules of sulphur (IV) oxide / oxygen mixture react to form 2 volumes / molecules of sulphur (VI) oxide gas. Increase in pressure shift the equilibrium forward, to the right, where there is less volume / molecules. The yield of sulphur (VI) oxide gas therefore increases. Decrease in pressure shifts the equilibrium backward, to the left where there is more volume / molecules. Therefore the yield of sulphur (VI) oxide gas decreases.

(iii) Ostwalds process

Chemical equation: $4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(g)$

Gay Lussacs law	4Volume	5Volume	4Volume	6Volume

9 volumes / molecules of ammonia and oxygen mixture react to form 10 volumes/molecules of nitrogen (II) oxide gas and water vapour. The yield of nitrogen (II) oxide gas and water vapour is thus favoured by low pressures. Increase in pressure shift the equilibrium backward to the left where there is less volume / molecules. Thus the yield of nitrogen (II) oxide gas and water vapour decreases. Decrease in pressure shifts the equilibrium forward to the right where there is more volume / molecules. The more yield of nitrogen (II) oxide gas and water vapour increases/favoured.

Note: If the water vapour is condensed on cooling, then:

Chemical equation: $4NH_3(g) + 5O_2(g) \longrightarrow 4NO(g) + 6H_2O(l)$

Gay Lussacs law	4Volume	5Volume	4Volume	0Volume
Avogadros law	4molecule	5molecule	4molecule	0Molecule

9 volumes / molecules of ammonia/oxygen mixture react to form 4 volumes / molecules of nitrogen (II) oxide gas since there is no vapour. Increase in pressure shifts the equilibrium forward, to the right, where there is less volume / molecules. Therefore the yield of nitrogen (II) oxide gas increases. Decrease in pressure shifts the equilibrium backward, to the left, where there is more volume / molecules. Thus the yield of nitrogen (II) oxide gas decreases.

Effect of temperatures on dynamic equilibrium. Introduce this discussion by reviewing with the learners exothermic and ethothermic reactions as well as effect of temperatures on rates of reactions. Organise the learners to do activity 3.8 to demonstrate the effect of temperature on the equilibrium of nitrogen dioxide and dinitrogen tetraoxide. Help the learners to relate the change in colour to the change in temperature giving explanation as provided in the learner's book. Caution the learners that the experiment should be done in a fume chamber since nitrogen dioxide is poisonous.

Nitrogen dioxide and dinitrogen tetraoxide can exist in dynamic equilibrium in a closed test tube. Nitrogen dioxide is a brown gas. Dinitrogen tetra oxide is a yellow gas.

$$2NO_2(g) \longrightarrow N_2O_4(g)$$

(red brown) (yellow)

On increasing temperature, the mixture becomes more brown. On cooling the mixture the gas turns yellow.

Effect of Catalyst on dynamic equilibrium. Emphasize to the learners that a catalyst has no effect on the position of equilibrium. It only speeds up the rate of attainment.

Answers to Check your progress 3.3

Refer to learner's book page 59

1. The rate of forward reaction is the same as backward reaction and no observable change takes place.

2. • Not affect the equilibrium
   • Forward reaction

3. Favour forward reaction

4. a. Check for correct tabulation

   b. Initial mass of the reactants

   c. Check for correct graph

   d. The reaction is fast in the beginning when the reactants are present.

5. Dynamic equilibrium is when a reaction capable of going forward or reverse direction comes to equilibrium and goes forward and backward. The same number of molecules forming as there is separating so the reaction continues but it's that there is no change on either side products or reactants.

3. 5 Electrochemistry

Refer to learner's book page 60

Learning activities

1. Be reminded that the overriding learning outcome is that the learners should be able to understand how chemical reactions produce electricity which is a widely applied concept in production of dry cells and car batteries commonly used in many homes.
2. Introduce the lesson by allowing learners in groups and individually to carry out the group task and individual task proposed in the learner's book page 60.
3. Define clearly the relevant terms bringing out the differences where needful. Such terms include: electrochemical/voltaic cell, electrolytic cell, electrochemistry, electrolysis, redox reactions, reduction, oxidation, enthalpy and entropy.

Redox reactions

1. Brainstorm with the learners the meanings of oxidation and reduction in terms of oxygen, hydrogen and transfer of electrons. Some of the learners could be conversant with oxidation and reduction in terms of oxygen addition or removal from a substance.
2. Guide the learners now through all the aspects of oxidation and reduction as outlined in the learner's book.
3. Remind the learners on the importance of the oxidation numbers and how they can be used to determine whether a species has undergone reduction or oxidation.
4. Guide the learners through individual task.
5. Let the learners try to explain how some of this apparatus work in producing electricity. The procedure for carrying out the experiment is provided in the learner's book.

Electrochemical cell

1. Describe what electrochemical cell is referring the learners to the set up in activity 3.8. Let them identify all the components of electrochemical. Using the discussion provided in learner's book explain the following:

   i. Half cell

   ii. Salt bridge and its function

   iii. Where oxidation and reduction occurs

   iv. Which half-cell acts as anode and cathode.

2. Guide learners on writing of half equations for the reactions in each electrochemical cell and how to obtain reduction potentials/standard electrode potential using hydrogen as the reference electrode. Emphasize the importance of these reduction potentials and why they are called potentials linking the potential energy learnt in Physics.

3. Discuss the guidelines for writing the electrochemical reactions as outlined in the learner's book.

4. In groups or class as whole let them respond to the questions under the discussion corner on page 65 of the learner's book.

5. Calculation of e.m.f of cell. Once again review with the learners the standard electrode potentials in table 3.7. Take the learners through the formula used in calculation of E and worked examples as outlined in the learner's book.

6. Let then do Check your progress 2 in the learner's book page 68.

Answers to Check your progress 3.4

Refer to learner's book page 68

1. This is set up of a metal dipped in its own salt solution, which produces potential difference. Salt bridge helps in completing the circuit. It also provides positive and negative ions to replace those used up at the electrodes which enable the balancing of charges on ions formed at the electrodes.

2. A half-cell is half of an electrolytic or voltaic cell, where either oxidation or reduction occurs.

3. a) Ag and Pb

From the table above:

$2Ag^+ (aq) + 2e^- \longrightarrow 2Ag(s)$ $E^\circ = +0.80V$(higher E° /Right Hand Side diagram)

$Pb^{2+} (aq) + 2e^- \longrightarrow Pb(s)$ $E^\circ = -0.13V$(lower E°/ Left Hand Side diagram)

$Pb(s) \longrightarrow Pb^{2+} (aq) + 2e^-$ $E^\circ = +0.13$(reverse lower E° to derive cell reaction / representation)

Overall E° = E° higher- E° lower / E° RHS - E° LHS/ E° oxidized- E° reduced

Substituting:

Overall $E^\circ = +0.80 - (- 0.13) = +0.93V$

Overall redox equation:

$2Ag^+ (aq) + Pb(s) \longrightarrow Pb^{2+} (aq) + 2Ag(s)$ $E^\circ = +0.93V$

Overall conventional cell representation:

$Pb(s) / Pb^{2+} (aq)$ 1M, // 1M,$2Ag^+ (aq) / Ag(s)$ $E^\circ = +0.93V$

b)Chlorine and Bromine

From the table above:

$2e^- + Cl_2(g) \longrightarrow 2Cl^- (aq)$ $E^\circ = +1.36V$(higher E° /Right Hand Side diagram)

$2e^- + Br_2(aq) \longrightarrow 2Br^- (aq)$ $E^\circ = + 0.13V$(lower E°/ Left Hand Side diagram)

$2Br^- (aq) \longrightarrow Br_2(aq) + 2e^-$ $E^\circ = -0.13$(reverse lower E° to derive cell reaction / representation)

Overall E° = **E° higher- E° lower / E° RHS - E° LHS/ E° oxidized- E° reduced**

Substituting:

Overall E° = $- 0.13 - (- 1.36) = +1.23V$

Overall redox equation:

$2Br^-(aq) + Cl_2(g) \longrightarrow 2Cl^-(aq) + Br_2(aq) \quad E^\circ = +1.23V$

Overall conventional cell representation:

$Cl_2(g) / 2Cl^-(aq)\ 1M, \ // \ 1M, 2Br^-(aq) / Br_2(aq) \quad E^\circ = +1.23V$

Chlorine displaces bromine from bromine water. When chlorine gas is thus bubbled in bromine water, the pale green colour fades as displacement takes place and a brown solution containing dissolved bromine liquid is formed. This reaction is feasible /possible because the overall redox reaction has a positive E° value.

c) Strongest oxidizing agent and the strongest reducing agent.

From the table above:

$2e^- + F_2(g) \longrightarrow 2F^-(aq) \quad E^\circ = +2.87V$(highest E° /strongest oxidizing agent)

$2e^- + 2K^+(aq) \longrightarrow 2K(aq) \quad E^\circ = -2.92V$(lowest E°/ strongest reducing agent)

$2K(aq) \longrightarrow 2K^+(aq) + 2e^- \quad E^\circ = +2.92V$ (reverse lower E° to derive cell reaction / representation)

Overall E° = E° higher- E° lower / E° RHS - E° LHS/ E° oxidized- E° reduced

Substituting:

Overall $E^\circ = +2.87 - (-2.92) = +5.79V$

Overall redox equation:

$F_2(g) + 2K(s) \longrightarrow 2F^-(aq) + 2K^+(aq) \quad E^\circ = +5.79V$

Overall conventional cell representation:

$2K(s) / 2K^+(aq), 1M, \ // \ 1M, 2F^-(aq) / F2(g) \quad E^\circ = +5.79V$

4. The redox reactions in an electrochemical/voltaic is commercially applied to make the:

   (a) Dry /primary/Laclanche cell.

   (b) Wet /secondary /accumulators.

5. a. C

   b. A-has the highest ease of electrons

   c. Check for correct cell representation.

3.6 Role of electricity in electrolysis (electrolytic cell)

Refer to Learner's Book page 69

Learning activities

1. Introduce the lesson by reviewing with the learners the meaning of electrolysis, anode, cathode, electrolyte/electrolytic solution and the electrolytic process.
2. Let the learners explain the role of anode, cathode and electrolytic solution in the electrolysis process. As well organize learners in groups to respond to the content under review corner provided in the learner's book. Let them make presentation to the class.
3. Revisit reduction and oxidation in terms of electrons transfer.
4. Remind the learners on the properties of ionic compounds in terms of mobility of ions in transferring electric current. You can review some of experiments carried out in Secondary 2 under electrolysis such as: electrolysis of acidified water, dilute/concentrated solution of sodium chloride, molten sodium/lead II chloride.
5. In our main discussion at under sub topic; about role of electricity in electrolysis, first ask the learners to explain the role of water in electrolysis.

6. Ask the learners if in absence of electricity, electrolysis can take place justifying their answers. Once again organize learners in groups to discuss the questions under the discussion corner in the learner's book page ---.
7. Take the learners through role of electricity in electrolysis and the importance of this in a number of functions e.g. electrolytic reductions of reactive metals during their extractions.

Answers to check your progress 3.5

Refer to learners book page 71

1. Cathode, due to preferential discharge
2. Solid, water

UNIT 4

Composition of ores of some common metals and appropriate methods of extraction

Refer to learner's book page 72 to 101

Learn about	Key inquiry questions
• Learners should build on what they already know about metals from the periodic table and use a range of sources to investigate the compositions of chief ores of some metals (mainly sodium, aluminium, zinc, iron, copper, chromium). • Learners should design methods of extraction of metals and describe the ease of obtaining metals from their ores by relating the elements to their positions in the reactivity series.	• How do you extract metals from their chief ores? • How do you purify impure metals?

Knowledge and understanding	Skills to be acquired	Attitudes and values
By the end of this unit, learners should be able to: • Name and know compositions of ores of some common metals and appropriate methods of extractions	By the end of this unit, learners should be able to: • Use a range of sources to investigate the compositions of chief ores of some metals • Design methods of extraction of metals	By the end of this unit, learners should be able to: • Appreciate the importance of understanding the composition of ores to facilitate their extraction
Contribution to the competencies: Critical and creative thinking: investigations Communication: presentation of work results Co-operation: group work **Links to other subjects:** Geography		

Introduction for the unit

The unit introduces the learners to the chemical reactions involved in extraction and even purification of some metals. The learners already have adequate knowledge about these metals and even the general extraction principles/methods obtain from other subjects like Geography (e.g. minerals and mining). There are well versed with some of the general properties of these elements learnt in earlier classes. As a teacher, your objective is to help the learners to appreciate that these metals are obtained from certain ores (chief ores) viable for commercial exploitation and the chosen method of extraction is related to the position of the metal in the reactivity series. So at the introduction of this unit, revisit the reactivity series of metals as well as the standard electrode potentials learnt in the previous unit.

Mention some of the metals ores occurring in South Sudan if existing, their site locations and as well those in East and Central Africa and the rest of Africa. Highlight the environment impact of extraction of these metals and how they can be mitigated against.

Cross cutting issues to be incorporated

1. Environment awareness and sustainability

this is the most important cross cutting issues. Inform the learners though the metals are useful in many ways in human life, they pose great danger to the environment and its sustainability. Let the learners come up with better ways they think such environment harzards caused by extraction of metals can be remedied

2. Peace and values

Emphasise to learners the occurrence of minerals can be either a curse or blessing to a country and the community. They must at all times regard the presence of minerals in their locality and country as important natural resource for their well being as well as everyone in the nation avoiding all kinds of unnecessary conflicts

3. Life skills

Learners can be encouraged to be financial responsible, to appreciate expenses incurred in purchases of reagents (chemicals) and even costs of apparatus used which cannot be improvised. They should handle apparatus very careful for avoid unnecessary breakages and where there is occurrence report immediately to the teacher or laboratory technician.

Competencies to be developed

1. Co-operation

During projects, research work and experiment. Ensure all learners are participating in the various group activities, respecting each other's views and contribution in spite of their different abilities.

2. Communication

Encourage all learners irrespective of their abilities to participate in the class or group discussions, during presentations by asking questions and questions & answers sessions to either introduce or wrap up the lessons, as experiment progresses.

All learners should also be encouraged to write summary notes at the end of the lesson as this will help improve their writing skills. Tell learners that communicating results of investigations either through oral presentations or written is as critical and important as the investigation itself in real science world. It helps the information to be consumed clearly by the intended recipients.

3. Critical and creative thinking

Design, plan and carry out some of the suggested experiments and activities in the learner's book. This can also be achieved when learners are making models for various equipment used in extraction of the metals where possible.

Preparation for the lessons

Remember most of the learning coverage in this unit is theory-based particularly the extraction process of the metals. Therefore ensure the following teaching aids are available to improve the understanding and mastery of the expected learning outcome.

(i) Relevant video link

(ii) Charts / photograph showing processes or stages of extraction of the various metals

(iii) Models of the Down's cell, Hall cell and blast furnace.

- Plan for availability of substances (to be used as ores) for tests for the presence of the various metals.
- Provide numerous reference materials such as textbooks, journals, mining-related magazines and newspaper cuttings dealing with extraction of the metals under study.

General approach to teaching and learning in this unit

1. In the teaching and learning of this unit, the following broad instruction guidelines can be adopted:
   a. Naming and investigating all the various ores of the metals and identifying the chief ores for extraction. Explain to the learners the reason for the choice of the given ore for extraction purposes.
   b. Appropriate method of extraction for each metal ore and its purification where need be. Guide through the various stages of extraction.
   c. How to test for the presence of given metal in an ore or percentage concentration of metal ore.
   d. The importance and uses of the metals in the society.
   e. The environment impact and even social and economic challenges that comes with the extraction of the metals.
2. You will be required to organise the learners in groups to carry out the test experiments for the various metal ores.
3. Guide learners in the designing and construction of extraction method models for the various metal ores where possible.

4.1 Introduction and extraction of sodium

Refer to Learner's Book page 72

Learning activities

1. Brainstorm with learners on the extraction methods of metals.
2. Help the learners identify the chief ore from which sodium is extracted. List the other ores in which sodium occurs as well. Discuss the extraction process as outlined in the learner's book.
3. Emphasise on the correct writing of all the chemical equations involved in extraction of sodium in the Down's cell.
4. Enable the learners to understand and appreciate why sodium is extracted by electrolysis based on its position in the reactivity series.

Answers to Check your progress 4.1

Refer to learner's book page 78

1. (i) Carbon graphite/Titanium. This because they are cheap and inert / do not influence/affect the products of electrolysis

   (ii) Using a steel gauze/diaphragm separating the cathode from anode.

   (iii) $2Cl^-(l) \longrightarrow Cl_2(g) + 2e^-$

2. (i) Calcium chloride

   (ii) To reduce the cost of production

3. The sodium produced react explosively/vigorously with water in the aqueous sodium chloride.

4. Sodium oxide, Na_2O (in limited air); Sodium peroxide, Na_2O_2 (in excess air).

4.2 Extraction of aluminium

Refer to Learner's Book page 79

1. Help the learners to identify the chief ore from which aluminium is extracted while listing other ores from which aluminium can be extracted or occurs.
2. Guide and emphasise to the learners the writing of the chemical equations at the different stages of aluminium extraction from bauxite ore by electrolysis.
3. Let learners understand and appreciate why aluminium is extracted by electrolysis based on its position in the reactivity series.
4. Guide the learners to carry out activity 4.2 on test for presence of Al^{3+} in compounds. Lead the learners in discussing the observations made and making proper inferences/conclusions.
5. Go through the flow diagram summary of extraction of aluminium with the learners.

Results of the experiments / Activity 4.1

i) To the first portion add sodium hydroxide dropwise until in excess

Observations	Conclusion
White ppt soluble in excess	Al^{3+}, Pb^{2+}, Zn^{2+}

ii) To the second portion add ammonia solution dropwise until in excess

Observations	Conclusion
White ppt insoluble	Al^{3+}, $Pb^{2+,}$

iii) To the third portion add three drops of sodium sulphate

Observations	Conclusion
No white ppt	Al^{3+}

Answers to Check your progress 4.2

Refer to learner's book page 84

1. A. - Carbon (IV) oxide gas/$CO_{2\,(g)}$

   B. - Aluminium sulphate (VI) / $Al_2(SO_4)_3$

   C. - Aluminium hydroxide / $Al(OH_4)_3$

   D. – Tetrahydroxoaluminate (III) / $[Al(OH_4)_3]$

   E. - Aluminium hydroxide / $Al(OH)_3$

   F. - Aluminium chloride/ $AlCl_3$

2. (a) Refer to the learner's book page 79-81.

   (b) To remove the water of crystallization.

   (c) To lower the melting point of aluminium oxide from about 2015° C to 900° C so as to lower /reduce cost of production i.e. cost of electricity.

   (d) Oxygen produced at anode reacts with carbon to form carbon (IV) oxide gas that escape thus corroded or get depleted at intervals.

(e) In making of aeroplane parts, buses, tankers, utensils, sauce pans, spoons, making of overhead electric cables.

3. Refer to the learner's book page 83.

4. Check for correct arguments and suggestions.

4.3 Extraction of copper

Refer to Learner's Book page 84

1. Help the learners to identify the chief ore from which copper is extracted. List as well the other ores in which copper occurs.
2. Guide the learners on proper writing of the chemical equations involved at the different stages of extraction of copper from copper pyrites by reduction process. Remind the learners to understand why reduction method is chosen for copper extraction based on its lower position in the reactivity series.
3. Discuss the purification of copper and the importance of this process during the extraction.
4. Guide the learners to do carry out activity 4.2. Let the learners discuss the observations and draw accurate conclusions.
5. Summarise the discussions by going through the flowchart diagram summary of extraction of copper provided in the learner's book.

Results of activity 4.2

Observations	**Conclusion**
A blue precipitate that dissolves forming a deep blue solution.	Cu^{2+} present

4.4 Extraction of iron

Refer to Learner's Book page 88

1. Help the learners to identify the chief ore from which iron is extracted while listing the other ores in which iron is present.
2. Guide the learners in the writing of chemical equations involved in extraction of iron (haematite) by reduction process mentioning suitability of the method based on its position in the reactivity series.

3. Guide the learners to carry out activity 4.4 on test for presence of Fe^{2+} or Fe3+ in compounds. Lead the learners in discussing the observations made and making proper inferences/conclusions.
4. Go through the flow chart summarising the extraction of aluminium with the learners.

Results of Activity 4.3

Observations	Conclusion
Brown ppt/ Green ppt, insoluble in excess	Fe^{3+} / Fe^{2+}

Answers to Check your progress 4.3

Refer to Learner's Book page 92

1. Check for learner's arguments.
2. Reducing agent - Hot carbon monoxides. Check for correct equation
3. To remove impurity: silicon dioxide. Check for correct equation

4.5 Extraction of zinc

Refer to Learner's Book page 92

1. Help the learners to identify the chief ore from which zinc is extracted listing the other ores as well.
2. Guide the learners in writing of chemical equations of the reactions of the different stages of extraction of zinc from the chief ore. Let the learners understand why zinc is extracted by reduction method based on its position in the reactivity series.
3. Let the learners carry out activity 4.4 on testing for presence of zinc in compounds. Then allow the learners to discuss their observations and draw relevant conclusions.
4. Review the learners through the flow diagram on extraction of zinc in the learner's book.

Results of Activity 4.4

Observations	Conclusion
White ppt soluble in excess forming colourless solution	Zn^{2+}

4.6 Extraction of Chromium

Refer to Learner's Book page 96

1. Help the learners to identify the chief ore from which chromium is extracted and the other chromium ores.
2. Guide the learners in writing the chemical equations for the reaction stages of extraction of chromium mentioning the reduction of its ore using aluminium.

Learning assessment

In this unit the following assessment methods can be helpful.

Observation – This is most suitable during experiments / activities, learners making correction observations, proper handling of apparatus and use of reagents and following the correction procedure or suggestion of better alternatives.

Group presentation – You may consider learners doing research from journals, textbooks and internet, compiling a report and making presentations to the whole class. This offers a good opportunity to unearth areas not well understood for further redress. This as well will help them to improve their communication skills e.g. listening skills, articulation skills and even writing skills.

Product – Appraise the models made by the learners for the Down's cell, Hall Cell and Blast furnace ensuring the learners capture the reaction equations for the different stages.

Evaluative / formative assessment – Let the learners do questions provided in the learner's book at the end sub topic or under the discussion corner. These will bring to fore the content areas, which might have been well understood for, further remedial studies.

Answers to Check your progress 4.4

Refer to learner's book page 97

1. a. Refer to learner's book page 83

   b. It is reactive

   c. Refer to learners book page 81

   d. At the cathode, reduction takes place as electrons are gained:

   $Al^{3+}(aq) + 3e^- \longrightarrow Al(s)$

   At the anode, oxidation takes place as electrons are lost:

   $2O_2^-(aq) \longrightarrow O_2(g) + 4e^{--}$

   e. An amphoteric oxide is an oxide that can act as either an acid or base in a reaction to produce a salt and water.

2. a. Substances that cannot be recycled

   b. Recycling of waste materials

4.7 Properties of metals

Refer to learner's book page 98

1. Solicit ideas from the learners by brainstorming on the general physical properties of metals.
2. Let the learners study data in Table 4.1 in the learner's Book and suggest the physical properties of these metals.
3. Link the data in the table to the physical properties of these metals and explain areas where there are deviations to the general physical properties of metals.
4. The general physical properties are as follows:
   - They are solids at room temperatures.
   - They are shiny.

- They have high densities.
- They are good conductors of heat and electricity.
- They are malleable and ductile.

5. There are some exceptions to the above generalizations for example, the low melting points of sodium, the colour in of sodium and aluminium exposed to air etc. clarify these anomalies by explaining and giving reasons to why they have those physical properties. Refer to the respective pages in the learner's book.
6. Explain the meaning of malleable and ductile. Refer to Fig. 4.10 and 4.11 in the learner's Book for further understanding.
7. Instruct learners to attempt Check your progress 4.5.

Answers to Check your progress 4.5

Refer to learner's book page 98

1. Sodium has a few delocalized electrons decreasing the strength of the metallic bond.
2. They have free or delocalized electrons in their structure.
3. Malleable – capable of being hammered into thin sheets.

   Ductile – capable of being drawn into wires.

4.8 Chemical properties of some metals

Refer to learner's book page 100

1. Organise learners into groups depending on the availability of resources.
2. Let the learners follow the procedures as outlined in experiment 4.5 in the Learner's Book. Learner shave already come across this experiment in form one and two. Many times, we refer them to those experiments. Remember that at every level different concepts are being taught.
3. Make sure that the learners are safe from any danger. They should make sure that they do not point towards the other learners as they are heating.
4. Ask the learners to make their observations carefully and make conclusions accordingly. Tell them to record their observations.

5. Lead them in a discussion to describe and explain the reactions of these metals with substances. Lead them to write balanced chemical equations for the reactions

6. Instruct learners to attempt Check your progress 4.6.

Answers to Check your progress 4.6

Refer to learner's book page 101

1. Aluminium is usually coated with a thin layer of aluminium oxide, which prevents reactions.

2. a.

Metal:	**Reaction**
Magnesium	Very slow with cold water, but vigorous with steam.
Zinc	Quite slow with steam.
Iron	Slow with steam.
Copper	No reaction with steam.

   b. Reactivity series of metals

   c. Check for correct equations. Hint Some metals react with water to form hydroxides and hydrogen gas. However, some metals do not react with water but steam to form metal oxides and hydrogen gas.

   d. alkaline solutions

3. All of the alkali metals react vigorously with chlorine gas. Each reaction produces a white crystalline salt. The reaction gets more violent as you move down Group 1, showing how reactivity increases down the group.

   It is dangerously explosive.

   a. Reddish brown gas is produced

   $$Zn(s) + 4\ HNO_3\ (l) \longrightarrow Zn(NO_3)_2\ (aq) + 2\ NO_2\ (g) + 2\ H_2O\ (l)$$

   b. A gas with a pungent smell is produced

   $$Cu(s) + 2H_2SO_4\ (l) \longrightarrow CuSO_4\ (aq) + SO_2\ (g) + 2H_2O(l)$$

UNIT 5

Analytical techniques and methods of determinations of structures

Refer to learner's book page 96 to 118

Learn about	Key inquiry questions
• Learners should access a range of sources of information and look at models to describe analytical techniques of determining structures. • The descriptions of techniques or methods should include: chromatography, infrared spectroscopy, nuclear magnetic resonance, ultra-violet and mass spectroscopy. • They should design and carry out investigations and use a range of media to communicate their work results.	• How can analytical techniques be used to determine structures?

Knowledge and understanding	Skills to be acquired	Attitudes and values
• Describe analytical techniques and methods of determination of structures	• Design and carry out investigations and use a range of media to communicate their work results.	• Appreciate the importance of accurate analytical techniques in chemistry
Contribution to the competencies: Critical and creative thinking: analyzing results Communication: presentation of work results Co-operation: group work **Links to other subjects:** Biology		

Introduction to the Unit

This unit forms the core learning of inorganic chemistry which plays functions in many life areas. The study deals with chemical composition and structures of compounds and their determination. In higher learning it is referred to analytical chemistry. It is very important in solving a broad range of problems from the medical area, crime investigations and analysis to ensuring food safety. Inform learners that satisfactorily performance requires high level training and skills in using these methods and instruments. As such very few professionals are available in Africa continent. Thus the learners should make every effort and work hard to successfully pursue the careers in such fields.

Learners need to be encouraged to research a lot using most current science journals, newspaper cuttings, use of internet but with regard to reputable sites, charts and photographs of relevant materials.

Cross cutting issues to be attained

1. Environment awareness and sustainability

This unit involves use of chemicals, some of which could be environment harmful, plant parts for investigations. Conservation of nature and minimal destruction/ disturbance to living organisms or their habitats must be observed. Disposal of used reagents must be correctly done especially in activities involving paper chromatography.

2. Peace and values

Emphasise to learners the occurrence of minerals can be either a curse or blessing to a country and the community. They must at all times regard the presence of minerals in their locality and country as important natural resource for their well being as well as everyone in the nation avoiding all kinds of unnecessary conflicts

3. Life skills

Avoid exposure to scorching sun heat, radiations e.g. overuse of x-rays examination, carcinogenic materials which may put heavy demand use on the medical diagnostic machines such as MRI machines, CT scan machines which also emit radiations and uses a lot of nitrogen (greenhouse gas) in their cooling.

Competencies to be developed

1. Co-operation

Foster team spirit among the learners devoid of bias in respect of gender, tribe or culture. Gifted learners to appreciate their slow learning counter and provide assistance where need be. Remind learners the nation need skilled personal in medicine, analytical chemists to help alleviate human suffering in every corner of the country.

2. Communication

Encourage all learners irrespective of their abilities to participate in the class or group discussions, during presentations by asking questions. During each experiment/activity they rotate the position of secretary among the group members to give group member to develop their presentation skills.

All learners should also be encouraged to write summary notes at the end of the lesson as this will help improve their writing skills. Tell learners that communicating results of investigations either through oral presentations or written is as critical and important as the investigation itself in real science world. It helps the information to be consumed clearly by the intended recipients.

3. Critical and creative thinking

Encourage learners to develop inquisitive thoughts by asking them questions such as why they think the equipment used in analytical chemical investigations are expensive, very few professionals are available in the country and what they think can be done address these problems. Discussion corner quizzes in the learner's book or as a teacher you can come up with more questions (diagnostic assessment questions) to stimulate learners' critical thinking/creativity.

Preparation for the lessons

Note: Effective teaching/learning of concepts in this unit involves carrying out experiments/ activities. Learners must be organized into suitable group sizes according the class number and resources available.

Arrange for the availability of required apparatus as per activities/experiments. Collect necessary charts, videos, photographs and necessary reference materials. Ensure your notes are up to date keeping in mind difficult concepts and terms that troubles learners that such should be well addressed.

5.1 Chromatography

Refer to the learner's book page 103

1. Introduce by reviewing the concept of paper chromatography the learners had covered in Secondary 1, as technique of separating mixtures.
2. Lead the learners to carry out paper chromatography. In case of poor resolution of spots help the learners in doing two way chromatography. Discuss the types of chromatography (two way and thin layer chromatography) helping learners to calculate the Rf values and how it is used in identifying the compound.
3. Clearly explain to the learners the meanings of the various terms: mobile phase, stationary phase, solvent front, retardation factor/relative flow. Mention different solvents are used in chromatographs.

4. Discuss the advantages and areas of applications of the various chromatography methods.
5. Let the learners do activity 5.1 to reinforce and assess their understanding of concept learnt.

Answers to Check your progress 5.1

Refer to learner's book page 108

1. a Check for correct diagram

   b. Glucose and galactose

2. Z

5.2 Infrared spectroscopy, nuclear magnetic resonance, ultra-violet and mass spectroscopy

Refer to the learner's book page 109

Learning activities

Note: If possible ensure there are videos or Youtube downloads from the internet for use since this is very abstract concept at this level for the learners. There is also need to facilitate resource persons' talks and field trips to research centers, forensic laboratories or highly advanced hospitals to observe some of these equipment. These greatly diffuse the abstractness nature of these concepts while generating much interest in the learning.

1. You may consider introducing learning of these sub units in a number of ways as is possible or convenient for your case;
   i. Invite resource person to give talk.
   ii. Organizing a visit to a facility (e.g. hospital or relevant research institution) for the learners to observe the equipment
   iii. Giving the learner research work to do and make presentations.
2. Discuss how the various techniques work, areas of application, their benefits and shortcomings if any.
3. Emphasise most of these equipment are very expensive to procure and maintain thus the cost of their usage which often is out of reach by many people, for example CT scan and MRI scan are very expensive but highly effective medical diagnostic means.

Learning assessment

It is important that you carry out continuous learning assessment during the course of the learning of this unit. You may ask learners some oral questions in the course of the lesson instruction to gauge their knowledge and understanding of analytical technique and working principle. Are they explain their differences, areas of use and why particular methods are used in specific areas.

Learner's acquisition of skills can be assessed by asking the learners to demonstrate how to use paper chromatography, and analyses the different solutes/components on the adsorbent paper/materials given reagents. Provide guidance and correct where necessary. Assess their environment awareness.

Listen and gauge learners language competence during class discussion, group presentations during experiments and correct accordingly as you encourage them to improve.

You may consider use of self progress check, work to do, research assignments, report writing on field visits or talk shows and discussion corner quizzes provided in the learner's book to engage their competencies and learning progress. providing remedial actions where necessary.

Answers to Check your progress 5.2

Refer to learner's book page 112

1. The analysis of infrared light interacting with a molecule.
2. The region to the right-hand side of the diagram (from about 1500 to 500 cm-1) usually contains a very complicated series of absorptions.

   Infrared spectrum -An ordered array of the components of an emission or wave
3. The amount and frequencies of the light absorbed is related to the functional groups and structure of the compound.
4. Infrared light is used in industrial, scientific, and medical applications. Infrared imaging is used extensively for military and civilian purpose.

Answers to Check your progress 5.3

Refer to learner's book page 115

1. i. The angular momentum of a nucleus if the nucleus has an odd number of protons and neutrons.

   ii. is a physical phenomenon in which nuclei in a magnetic field absorb and re-emit electromagnetic radiation.

2. Refer to learner's book page 113

3. Offers the ability to overcome local energy barriers.

Answers to Check your progress 5.4

Refer to learner's book page 118

1. Infrared uses light waves while MRI uses a powerful magnetic field, radio frequency pulses

2. Ultra violet spectroscopy

3. Refer to learner's book page 116

UNIT 6 Organic chemistry

Refer to learner's book page 119 to 215

Learn about	Key inquiry questions
• Learners should explore a range of sources of information to understand the basic concepts of organic chemistry such as homologous series, functional group, general formula and structural formula, isomerism, fractional distillation and cracking of alkanes, and polymers. • They should be able to identify and name unbranched alkanes, alkenes, alcohols and carboxylic acids and recognise that materials such as plastics, detergents and medicines and food are examples of organic compounds. • Learners should explore ways of assessing the impacts of the use of synthetic materials and the environmental issues related to the use of plastics.	• How do hydrocarbon derivatives differ? • How do saturated and unsaturated hydrocarbon differ? • Why is a study of hydrocarbons important to our understanding of living things and industrial processes

Knowledge and understanding	Skills to be acquired	Attitudes and values
• Understand organic chemistry, including isomerism, fractional distillation and cracking of alkanes, chloroalkanes, alkenes, alcohols, carbonyl group compounds, aromatic chemistry, amines, amino acids, polymers, synthesis and analysis	• Explore ways of assessing the impacts of the use of synthetic materials and the environmental issues related to the use of plastics	• Appreciate the importance of organic chemistry to the world's economy
Contribution to the competencies: Critical and creative thinking: analyzing Communication: presentation of work results Co-operation: group work **Links to other subjects:** Environment and sustainability: pollution		

Introduction to the unit

Organic chemistry plays great role in the life people and economy of nations worldwide. Think about these important fractions of hydrocarbons such as petrol, kerosene, natural gas which support economies of countries. Alkenes, alkynes and other compounds of organic chemistry e.g. carboxylic acids, alkanols, alkanone and esters equally have useful applications in our day to day life. Most drugs we use starting from pain killers, to antibiotics and malaria undergo organic synthesis.

Organic chemistry is perhaps the most important aspects of chemistry that you will study at any level of advanced chemistry.

As you introduce this unit before delving into the complex discussions on the structures and properties of organic compounds, begin with the known e.g. the compounds that are daily in use within learners' settings/environment. This will help them to appreciate the need and value of study of organic chemistry as from these early stages of learning.

Cross cutting issues to be attained

1. Environment awareness and sustainability

Some of the products generated through organic synthesis such as synthetic polymers have brought serious environmental challenges. Some of the products e.g. polyvinyl chloride (PVC), plastic bags and other plastic products are non-biodegradable. The combustion of hydrocarbons equally release a lot of carbon dioxide gas into the atmosphere as well sulphur dioxide from sulphur fuels. Carbon dioxide is a greenhouse gas a major contributor toward global warming.

2. Peace and values

Emphasise to learners the occurrence of minerals can be either a curse or blessing to a country and the community. They must at all times regard the presence of minerals in their locality and country as important natural resource for their well being as well as everyone in the nation avoiding all kinds of unnecessary conflicts

3. Life skills

Avoid exposure to scorching sun heat, radiations e.g. overuse of x-rays examination, carcinogenic materials which may put heavy demand use on the medical diagnostic machines such as MRI machines, CT scan machines which also emit radiations and uses a lot of nitrogen (greenhouse gas) in their cooling.

Competencies to be developed

1. Co-operation

Ensure the learners are cooperating with one another during group work / activities. Every group member should be encouraged to participate during the discussion of the results, drawing of conclusions and presentations in the class.

2. Communication

Encourage all learners irrespective of their abilities to participate in the class or group discussions, during presentations by asking questions. During each experiment/activity they rotate the position of secretary among the group members to give group member to develop their presentation skills.

All learners should also be encouraged to write summary notes at the end of the lesson as this will help improve their writing skills. Tell learners that communicating results of investigations either through oral presentations or written is as critical and important as the investigation itself in real science world. It helps the information to be consumed clearly by the intended recipients.

3. Critical and creative thinking

Learners should be encouraged analytical skills and inquisitive attitude. This has led to many discoveries and improvement of existing ideas (i.e. innovations). In the treatment of experimental results emphasis should on proper analysis. Learners be challenged to come up, for example, with better ways of managing synthetic polymer wastes within their surroundings.

Preparation for this unit

A lot of content learning in this unit may appear abstract to most learners. Therefore if possible make arrangement for the availability of models for the various hydrocarbons, charts and any useful large materials and even journal for references. Also collect videos or arrange for video –links (YouTube on the internet) where possible.

Organize for field visit to oil refinery site if there is one nearby or a plastic manufacturing factory in the course of this topic study to help learners appreciate the many uses of hydrocarbons.

6.1 Hydrocarbons

Refer to Learner's book page 119

1. This lesson shall cover the following content areas/sub topics.
   - Alkanes

- Alkenes
- Alkynes

2. In teaching of the content areas, it would be prudent to use a consistent method of presentation to make it easier for the learners to see similarities and differences of the different hydrocarbons. If possible your discussion take the format given below;
   - Naming / nomenclature of the different homologous series. Rules / guidelines on how to write / derive the names using the IUPAC system of nomenclature.
   - Isomerism and drawing structures of the hydrocarbons and their isomers.
   - Occurrence
   - Preparation and properties of hydrocarbons
   - Uses
   - Demerits such environmental issues and negative social/economic effects of hydrocarbons as are possible.

6.2 Alkanes

Refer to Learner's book page 121

1. Introduce this unit and the study of alkanes by reviewing covalent bonding in various compounds and then narrowing it down to covalent bonding between carbon and hydrogen. Hence the name hydrocarbon, consisting of carbon and hydrogen only.
2. Let the students draw the covalent bonding between carbon and hydrogen for methane (CH_4) with your guidance. Notice any difficulty faced by any of the learners and correct accordingly. In groups of two each, provide more alkanes and let them draw the covalent bonds. After this exercise the students should appreciate that carbon can only form a maximum of 4 covalent bonding with hydrogen atoms.
3. Writing molecular formulas of alkanes

4. Provide the general formular for alkanes i.e C_nH_{2n+2}
   - Show learners how to derive the prefixes for alkanes names based on the number of carbon atoms in each compound. For example

Number of carbon atoms (n)	Prefix	Suffix
1	Meth	ane
2	Eth	ane
3	Prop	ane
4	But	ane
5	Pent	ane
6	Hex	ane
7	Hept	ane
8	Oct	ane

5. Emphasize that the suffix always depict the homologous series to which the given series to belong, for this case it is alkane. In all cases of this chemistry the prefix will not change but the suffix will change to depict the homologous series of the compound.
6. In groups of two, ask the learners to practice writing the formulas of alkanes up to six carbon atoms in the chain, and assigning their names. The formulas they write are the molecular formulas of alkanes.
7. Write the formulas for the first three alkanes how the hydrogen atoms are bonded around the carbon atoms. Let them understand that this is the structural formula. With your guidance let the learners practice drawing the structural formula as well writing condensed formula either in groups of two or as a whole class activity on the chalk board.
8. Isomerism in alkanes. Introduce alkyl group branches as substituent groups. Emphasize that alkyl groups can never fall on the first or last carbon atoms because if this happens it may actually be part of the longest continuous chain. With this in mind, the teacher using examples of molecular formulas show how different structures can arise from a given molecular formular. The structures formed are actually the isomers. Then the teacher should clearly

define what isomers are and give molecular formulae of, for example, pentane for the learners in groups of two to practice writing its isomers.

9. Occurrence of alkanes. Ask the learners whether they have ever encountered alkanes in their daily life. Organise the learners in groups of 4 and let them research from textbooks, charts and internet the sources of alkanes and their uses. Each group should make a presentation to the rest of the class. Note that in the findings crude oil is listed as one of the sources of alkanes. With your guidance the learners understand how crude oil is separated into its various fractions. Explain using a diagram as shown in the learner's book why fractional distillation is used instead of simple distillation. Let the learners appreciate the role of cracking of alkanes in the production of smaller molecule alkanes in greater demand in the world economy.
10. Discuss the physical properties and preparations of alkanes as outlined in the learner's book and any other appropriate one at this level of study. Always ask learners as you discuss each type of reaction such as:
    - Why is it called substitution reaction?
    - What conditions are required for these reactions to take place?
    - Write equation of the chemical reaction taking place.

Answers to Check your progress 6.1

Refer to learner's book page 136

1. a. Transform crude oil into useful products such as liquefied petroleum gas (LPG), gasoline or petrol, kerosene, jet fuel, diesel oil and fuel oils.

   b. Components of crude oil

2. It produces smaller, more useful alkenes
3. a. 3, dimethylheptane

   b heptane

   c. Butane

4. Check learners work

6.3 Alkenes

Refer to Learner's book pages 136

1. Alkenes have at least a double bond between carbon atoms. The double bond is the functional group is the –ene.
2. Make clear distinction between alkenes and alkanes such as presence or lack of double bond, saturated and unsaturated compounds.
3. Nomenclature of alkenes, emphasizing on the longest continuous chain forming the parent name where there is branching with double bond being assigned the lowest count. In the naming of alkenes, the suffix -ane is replaced with -ene (showing the its homologous series. In the naming of alkene the position of the double bond must be given before the name or after the prefix as shown below. Draw various straight chain alkenes and let the learners identify the names. For example;

   (i) $CH_3CH{=}CHCH_2CH_2CH_3$ 2-Hexene or Hex-2-ene

   (ii) $CH_3CH_2CH{=}CHCH_2CH_3$ 3-Hexene or Hex-ene

   ($CH_2{=}CHCH_2CH_2CH_2CH_3$ 1-Hexene or Hex-1-ene

4. Using the opportunity in naming such as above, introduce the concept of positional isomerism. The structure change brought by the change in the position of the double bond. In groups of two, let learners assign molecular formulae of an alkene and draw all its possible positional isomers. You can also allow them to introduce alkyl groups. This offers the teacher another opportunity to introduce and conclude about branching / structural isomerism.
5. Reactions of alkenes. Discuss the reactions of alkenes as outlined in the learner's book. Emphasize on the fact that alkenes undergo addition reactions, which results on the formation of a single product. Explain the double bond breaks creating room for possible bonding on either side of the two carbons that had the double bond.

   (i) The addition reaction with bromine is used as test for unsaturation. The colour changes from yellow to colourless.

   (ii) Hydrogenation is another example of addition reaction employed commercially in production of margarine and cooking fats.

- Another very important industrial application, the reaction involving breaking of alkenes double bonds allowing room for self addition to form polymers used in production of polyvinyl chloride (PVC) and polyethene exploited in making of PVC pipes and many household plastic items.

Answers to Check your progress 6.2

Refer to learner's book page 148

1. a. Butene

   b. Butene

   c. 3, methylpentene

2. Check for correct structural formula
3. Check for learners opinions

6.4 Alkynes

Refer to learner's book page 101

1. Brainstorming and discussion can be used accompanied by activity on construction of models.
2. Alkynes are hydrocarbons that have at least one triple bond between two carbon atoms.
3. Let the learners suggest whether one can have an alkyne of a molecule with one carbon atom. They should be able to give reasons for their answers.
4. You should make use of models to illustrate the structure of alkynes.
5. Let the learners participate by constructing their own models.
6. It should be emphasized that the family of alkynes form a homologous series like alkanes and alkenes and that the same principles used in naming alkanes or alkenes also apply in naming of alkynes. The "ane"ending of the corresponding alkanes are replaced by "yne". The general formula of alkynes is C_nH_{2n-2}
7. Let the learners predict the structures and names of the first six alkynes. This has been explained step by step on page 151 in the Learner'sBook. They can then compare their results with Table 3.8 in the Learner's Book.

8. Let them note that IUPAC names of straight chain alkynes are derived the same way as for straight chain alkenes except that the name ending for alkynes is -yne.

9. The alkyne names are based on the longest continuous chain containing the triple bond. The chain is numbered so that the first carbon atom of the triple bond has the lowest possible number.

10. Let the learners follow the rules in alkenes to name pent-1-yne and 3-methylbut-1-ene.

11. They should realise that the same rules in alkenes can be used to name alkynes.

Isomerism

12. The learners should realise that, just like alkenes, alkynes can have two types of isomers.

    - Positional isomers
    - Chain isomers.

13. Let the learners use the knowledge of isomers of alkenes to find the isomers of pent-1-yne. They should be able to compare their answers with those given as examples in the Learner's Book.

Preparation and properties of ethyne

1. Follow the procedures as outlined in Experiment 6.8 and illustrated in Fig. 6.6 in the Learner's Book.

2. The reaction between calcium dicarbide and water is highly exothermic and is first placed in the flask in order to absorb some of the heat produced and to prevent the flask from cracking.

3. Ask the learners the following questions to enhance participation and ensure that the learners are following the process.

    – What is the colour of ethyne?
    – Does it have a smell?
    – Why is ethyne collected over water?

4. Let them record their observations and conclusion in their notebooks. They should be able to compare their results with the physical properties of ethyne listed in their book.

5. Let the learners study the trends in physical properties of the alkynes in Table 6.7 in the Learner's Book.

6. Ask them to compare the trends in physical properties of alkanes, alkenes and alkynes. The trends are the same. It implies that the reasons for the observed trends are the same.

   (i) Densities increase due to increase in molecular mass.

   (ii) Melting points and boiling points increase due to increase in intermolecular forces.

Answers to check your progress 6.3

Refer to learner's book page 160

1. C_4H_6, Check for correct structural formula
2. Check for correct structural formula for the isomers. But-1-yne and But -2-yne.
3. It has a triple bond i.e unsaturated
4. $2\ C_2H_2\ (g) + 5\ O_2 \longrightarrow 4\ CO_2\ (g) + 2\ H_2O\ (g)$ + lots of heat
5. Refer to learner's book page 160

6.5 Alkanols

Refer to Learner's book page 160

1. Introduce these sub topics using examples of common products made of these substances or substances themselves where possible.
2. Discuss the nomenclature of the compounds, mentioning their functional group, their properties (physical and chemical), uses and effects where applicable e.g. for alcohols (social and health effects of alcohol misuse). Guide the learners to carry out esterification reaction and smell to get the sweet smell of esters showing the learners how to write the reaction equations and the name of the ester.
3. Draw and name the straight chain alcohols.

Emphasise on the general formulae of alcohols and the functional group in alcohols as the -OH.

4. Mention the shifting of the functional group in alcohols leading to creation of positional isomers and hence formation of primary, secondary and tertiary alcohols.

Answers to check your progress 6.4

Refer to learner's book page 163

1. Check or correct molecular formular.
2. • Alcohols are synthesised chemically or biologically
   • They do not pollute the environment

6.6 Carboxylic acids (Alkanoic acids)

Refer to Learner's book page 163

1. Introduce the lesson by reviewing the previous acquired knowledge on acids, asking the learners questions such as:
   a. What is acid ?
   b. Differentiate between strong acids and weak acids giving examples for each.
   c. Define organic acid and inorganic acid.
   i. Then explain what carboxylic acids (organic acids) are.
2. Provide the general formula of carboxylic acids indicating its functional group. Let the learners notice that naming of carboxylic acid is similar to that of alcohols with the -ol being replaced with –oic in the acids. For example

n	$C_nH_{2n+1}COOH$	Prefix	Suffix	Name
0	HCOOH	Methan	oic	Methanoic acid
1	CH_3COOH	Ethan	oic	Ethanoic acid
2	C_2H_5COOH	Propan	oic	Propanoic acid
3	C_3H_7COOH	Butan	oic	Butanoic acid
4	C_4H_9COOH	Pentan	oic	Pentanoic acid
5	$C_5H_{11}COOH$	Hexan	oic	Hexanoic acid

3. Reactions of carboxylic acids. Emphasize that carboxylic acids react in the same way as mineral acids but at a slower speed since they are weak acids. The carboxylic acids with one functional group are monobasic and their anions and reactions depict a valency of one.

Answers to Check your progress 6.5

Refer to learner's book page 174

1. a. Methyl methanoate

   b. $CH_3OH(aq) + HCO_2H(aq) \longrightarrow HCO_2CH_3(aq) + H_2O(l)$

2. It is partially ionized in solution.

3. Bonding and packaging of electrons

4. Methylethanoate

   $CH_3OH + CH_3CH_2COOH \longrightarrow CH_3CH_2COOCH_3 + H_2O$

5. Check for correct formulae

6.7 Detergents

Refer to learner's book page 175

1. To introduce detergents brainstorm with the students what they know about detergents. The following suggested questions can assist you.

   - What is a detergent?
   - Name some of the detergents that you know.
   - Describe what you have observed when you use detergents to clean and when you do not use it.

2. Since the students use detergents every day, they will be able to give you some information that they already know.

3. Summarise by clarifying what are detergent

4. Introduce them to the two types of detergents giving examples from the list they have given from the brainstorming.

Soapy detergents

1. Let the students be in groups depending on the availability of resources.

2. Soap can be prepared from different oils and even fat from different animals. If resources are available, groups can use different fats and oils.

3. Let the students strictly follow the procedure as outlined in experiment 6.10 in the Student's Book.

4. The questions given in procedures 8 and 9 in the Student's Book should be able to guide the students to make observations, conclusions and record them in their notebooks.

5. Point out to the students that soap is made by treating vegetable or animal fat with concentrated sodium hydroxide solution followed by precipitating the soap with salt.

6. Explain to them what saponification reaction means.

7. The students should be able to know and understand the structural formula of a typical octadecanoate. It is very important for the students to realise that octadecanoate is not the only form of ester that is used in preparation of soap but is just an example of many.

8. Lead them to write word and chemical equations for the reaction between the octadecanoate and sodium hydroxide to form soap .

9. Point out the purpose of adding sodium chloride salt in the process of preparing the soap.

10. Wind up with the discussion by referring the students to Fig 6.7 on page 178 of Students Book which is a summary of the process of soponification.

11. Brainstorm using probing questions to find out what the students know about the mode of action of soap detergents, their mode of action and pollution effects. The following suggested questions can be used.

    - What kind of soap do you use to wash your clothes/utensils?
    - How does it remove the dirt from your clothes/utensils?

Soapless detergents

1. Introduce soapless detergents as a result of need to improve on soap detergents. Emphasise that unlike soapy detergents, it does not form scum with hard water.

2. For the students to clearly visualize the formation of a soapless detergent review of reaction of ethene with concentrated sulphuric acid and ethanol with concentrated sulphuric acid is very important. This is because it gives a direct link on the chemical reactions taking place during formation of soapless detergent in industrial manufacture of soapless detergents.

    - To test the characteristic of soapless detergent, repeat experiment on the effect of soapy detergent on hard water and use soapless detergent instead.
    - Summarise the discussion by pointing out to the students examples of soapless detergents.

3. Let them name other examples of soapless detergents they may be aware of.

4. Instruct learners to attempt check your progress 6.6

Answers to check your progress 6.6

Refer to learner's book page 188

1. Soapy detergents are prepared by hydrolyzing vegetable oil or animal fat using an alkali while soap less detergent are made from byproducts of crude oil distillation.

2. Refer to learner's book pages 180 – 182

3. a. Introduction of harmful substances to water.

b. presence of substances in water

c. and d. refer to learners book page 187.

6.8 Polymers and fibres

Refer to Learner's book page 188

1. Introduce the lesson by asking learner to do a research on polymers and fibres
2. Provide them with reference materials
3. In their groups let them discuss and write a report.
4. Allow them to present their findings.
5. Build on their findings to expain polymers and fibres as outlined in the learners book.

Answers to Check your progress 6.7

Refer to learner's book page 199

1. i. one

   ii. many
2. Check for correct diagram of polymer Q
3. Many more units can be added
4. i. Additional polymerasation

   ii. Refer to learner's book page 199
5. Pollution of the environment
6. i. Toluene

   ii. PVC

7. Check for correct structure

6.9 Alkanals and Alkanones

Refer to learner's book page 200

1. Introduce the lesson by reviewing the structures of alkanes, alkenes, alkynes and alkanoic acids. This will enable learners to relate to the structures of alkanals and alkanones. They will follow the same procedure when naming.

2. Bring to learners attention tables 6.19 and 6.20 on the structures and formulae.

3. Organize learners into convenient groups to perform the practical activities. Learners will help you to collect materials required.

4. Instruct learners to write a report and compare their findings.

5. Use their finding to explain physical and chemical properties of alkanals and alkanones as outlined in the learner's book as they take notes.

6. Instruct learners to attempt check your progress 6.8.

Answers to Check your progress 6.8

Refer to learner's book page 212

1. Check for correct molecular formulae

2. Tollen's test, Fehling's test, Brady test

3. Increase with increase of molecular structure

6.10 Organic compounds

Refer to Learner's book page 213

1. Introduce the discussions on each group of the compound by showing their uses or products made from them.

2. Describe their functional groups and nomenclature.

3. Discuss their physical properties and chemical reactions clearly guiding learners on how to write the reaction equations.

4. Brainstorm with the learners' uses of the compounds or give learners research assignment on the same and thereafter giving a summary of the uses.

Answers to Check your progress 6.9

Refer to learner's book page 215

1. (a) Amino acids have Nitrogen joined to at least the alkyl group while amides have a carbonyl group between Nitrogen and R.

   (b) Carboxylic compounds have COO bond while Carbonyl compounds have C = O.

   Notice that carboxyl group contains a carbonyl group.

Learning assessment

In this unit the following assessment methods can be helpful.

Observation – This is during experiments / activities, learners making correction observations, proper handling of apparatus and use of reagents and following the correction procedure or suggestion of better alternatives.

Group presentation – You may consider learners doing research from journals, textbooks and internet, compiling a report and making presentations to the whole class on uses of the organic compounds studied above. This will help them to improve their communication skills e.g. listening skills, articulation skills even writing skills and as well foster good interpersonal skills.

Evaluative / formative assessment – Let the learners do questions provided in the learner's book at the end sub topic or under the "Discussion Corner" and "Work to Do" section either in groups or individually. These will bring to fore the content areas, which might not have been well understood for, further remedial studies.

UNIT 7

Introduction to Nuclear Chemistry

Refer to learner's book page 216 to 225

Learn about	Key inquiry questions
• Learners should understand and define nuclide, radioisotopes, radioactivity, radioactive decay, binding energy, nuclear fission and nuclear fusion and balance equations for nuclear reactions. • They should also predict modes of nuclear decay reactions and carry out calculations of binding energy and nuclear reactions rates.	• How do nuclear reactions and chemical reactions differ? • How are unstable atoms converted to more stable atoms? • How do we determine the rates of nuclear decay reactions? • How can nuclear reactions be used for radiation and medical imaging?

Knowledge and understanding	Skills to be acquired	Attitudes and values
• Understand and explain nuclear reactions	• Predict modes of nuclear decay reactions • Calculate the rate of decay reactions and binding energy	• Show concern for environmental safety
Contribution to the competencies: Critical and creative thinking: imagination and descriptions Communication: presentation of work results **Links to other subjects:**		

Introduction to the unit

This can be a very interesting topic to teach and be appreciated by learners depending on your approach. It is important to begin with the known side of nuclear reactions / chemistry such as the infamous atomic bomb used in Nagasaki in Japan and its devastating effect during World War II, use of x rays in hospitals, use of chemotherapy in treatment of cancer, nuclear power plants to generate electricity in some countries and threats by some nations to use nuclear weapons. These are some of the everyday life experiences and applications of nuclear chemistry. So inform the learners that unit shall look at the very basic principles how nuclear reactions work.

Cross cutting issues to be attained

1. Environment awareness and sustainability

This unit involves use of chemicals, some of which could be environment harmful, plant parts for investigations. Conservation of nature and minimal destruction/ disturbance to living organisms or their habitats must be observed. Disposal of used reagents must be correctly done especially in activities involving paper chromatography.

2. Peace and values

Emphasise to learners the occurrence of minerals can be either a curse or blessing to a country and the community. They must at all times regard the presence of minerals in their locality and country as important natural resource for their well being as well as everyone in the nation avoiding all kinds of unnecessary conflicts

3. Life skills

Avoid exposure to scorching sun heat, radiations e.g. overuse of x-rays examination, carcinogenic materials which may put heavy demand use on the medical diagnostic machines such as MRI machines, CT scan machines which also emit radiations and uses a lot of nitrogen (greenhouse gas) in their cooling.

Competencies to be developed

1. Co-operation

Foster team spirit among the learners devoid of bias in respect of gender, tribe or culture. Gifted learners to appreciate their slow learning counter and provide assistance where need be. Remind learners the nation need skilled personal in medicine, analytical chemists to help alleviate human suffering in every corner of the country.

2. Communication

Encourage all learners irrespective of their abilities to participate in the class or group discussions, during presentations by asking questions. During each experiment/activity they rotate the position of secretary among the group members to give group member to develop their presentation skills.

All learners should also be encouraged to write summary notes at the end of the lesson as this will help improve their writing skills. Tell learners that communicating results of investigations either through oral presentations or written is as critical and important as the investigation itself in real science world. It helps the information to be consumed clearly by the intended recipients.

3. Critical and creative thinking

Encourage learners to develop inquisitive thoughts by asking them questions such as why they think the equipment used in analytical chemical investigations are expensive, very few professionals are available in the country and what they think can be done address these problems. Discussion corner quizzes in the learner's book or as a teacher you can come up with more questions (diagnostic assessment questions) to stimulate learners' critical thinking/creativity.

Preparation for the lesson

Remember most of the learning coverage in this unit is theory-based. Therefore ensure the following teaching aids are available to improve the understanding and mastery of the expected learning outcome.

(i) Relevant video link

(ii) Charts / photographs showing nuclear power plants, medical imaging photographs, x-ray machine.

7.1 Introduction and types of radiations

Refer to Learner's Book page 216

Learning activities

1. Introduce the topic by reviewing with the learners about properties of atoms such as consisting of sub atomic parties (nuclear compositions of atoms) and the isotopes.
2. Ask learners how atoms attain their stability. Link the nuclear composition and atomic numbers and their influence on stability / instability of atoms in terms of p/n ratio using relevant examples.
3. Brainstorm with the learners about the three types of radiations. Allow them to lead the discussion as much as possible. Refer to the Learner's Book as is necessary.

7.2 Nuclear fission and nuclear fusion

Refer to Learner's Book page 220

1. If there is learning chart or video link on this content, let the learners first interact with it. Lead the class to discuss the meanings and difference between nuclear fission and nuclear fusion.
2. Emphasize on the use of equations to identify whether a radioactive isotope has undergone nuclear fusion or fission.
3. Explain the applications of nuclear fission and fusion in nuclear power plants and formation of nuclear weapons. At this point reiterate the benefit for peace and harmony overriding any effort of war.
4. Guide the learners in defining binding energy and take the learners through calculations involving binding energy.
5. Then put the learners into suitable group size and supervise them as they research from textbooks and internet differences between nuclear reactions and chemical reactions. Let the learners as well to come up with similarities between nuclear reactions and chemical reactions.

7.3 Rate of decay

Refer to Learner's Book page 223

1. Describe what radioactive decay series using nuclear decay as outlined in the learner's book page 223. Explain the term radioactive disintegration.
2. In groups of two or three, give learners examples to practice writing radioactive decay series.
3. Guide the learners on how to calculate rate of decay as illustrated in the learner's book. Mention the background count, and how it handled when measuring radiations count/rate of decay. Let the learners know that there is an instrument for measuring radiations called Geigler Muller machine.

7.4 Applications and environment impact of radioactivity

Refer to Learner's Book page 224

1. Introduce this lesson by showing learner's charts or video illustrating uses of radioactivity. Ask them to give some uses of radioactivity they could be aware of.

2. Outline the uses of radioactivity as well environment impact of some radioactivity uses. A few examples are provided in the learner's book.

3. It may be advisable to give learners in group, research assignment on uses and environment challenges of some of the uses of radioactivity. Let each group make a presentation to the whole class.

Answers to Check your progress check 7.1

Refer to Learner's Book page 225

1. Radiocarbon dating works by comparing the three different isotopes of carbon. Isotopes of a particular element have the same number of protons in their nucleus, but different numbers of neutrons. This means that although they are very similar chemically, they have different masses.

2. Background radiation is a measure of the ionizing radiation present in the environment at a particular location which is not due to deliberate introduction of radiation sources. It is detected by using Geiger-Muller tube.

3. Carbon 14, it is the most unstable.