Chemistry

Teacher's Guide

Secondary 2

FOREWORD

Dear teacher,

Rwanda Basic Education Board is honoured to present Senior Two Chemistry Teacher`s Guide which serves as a guide to competence-based teaching and learning to ensure consistency and coherence in the learning of the Chemistry subject. The Rwandan educational philosophy is to ensure that learners achieve full potential at every level of education which will prepare them to be well integrated in society and exploit employment opportunities.

In line with efforts to improve the quality of education, the government of Rwanda emphasizes the importance of aligning teaching and learning materials with the syllabus to facilitate their learning process. Many factors influence what they learn, how well they learn and the competences they acquire. Those factors include the relevance of the specific content, the quality of teachers' pedagogical approaches, the assessment strategies and the instructional materials available. We paid special attention to the activities that facilitate the learning process in which learners can develop ideas and make new discoveries during concrete activities carried out individually or with peers. With the help of the teachers, learners will gain appropriate skills and be able to apply what they have learnt in real life situations. Hence, they will be able to develop certain values and attitudes allowing them to make a difference not only to their own life but also to the nation.

This is in contrast to traditional learning theories which view learning mainly as a process of acquiring knowledge from the more knowledgeable who is mostly the teacher. In competence-based curriculum, learning is considered as a process of active building and developing of knowledge and understanding, skills and values and attitude by the learner where concepts are mainly introduced by an activity, situation or scenario that helps the learner to construct knowledge, develop skills and acquire positive attitudes and values.

In addition, such active learning engages learners in doing things and thinking about the things they are doing and they are encouraged to bring their own real experiences and knowledge into the learning processes. In view of this, your role is to:

- Plan your lessons and prepare appropriate teaching materials.
- Organize group discussions for learners considering the importance of social constructivism suggesting that learning occurs more effectively when the learner works collaboratively with more knowledgeable and experienced people.
- Engage learners through active learning methods such as inquiry methods, group discussions, research, investigative activities and group and individual work activities.

- Provide supervised opportunities for learners to develop different competences by giving tasks which enhance critical thinking, problem solving, research, creativity and innovation, communication and cooperation.
- Support and facilitate the learning process by valuing learners' contributions in the class activities.
- Guide learners towards the harmonization of their findings.
- Encourage individual, peer and group evaluation of the work done in the classroom and use appropriate competence-based assessment approaches and methods.

To facilitate you in your teaching activities, the content of this teacher`s guide is self-explanatory so that you can easily use it. Even though this teacher`s guide contains the answers for all activities given in the learner's book, you are requested to work through each question and activity before judging learner's findings.

I wish to sincerely extend my appreciation to REB staff who organized the editing process of this Teacher`s Guide. Special gratitude also goes to lecturers, teachers, illustrators and designers who supported the exercise throughout. Any comment or contribution would be welcome to the improvement of this textbook for the next edition.

Dr. MBARUSHIMANA Nelson

Director General, REB

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Joan Murungi,
Head of CTLRD

Contents

FOREWORD ..... *iii*

ACKNOWLEDGEMENT ..... *v*

Introduction to the Teacher's Guide ..... *vii–x*

Pedagogical Approach ..... *xi–xxii*

Chemistry Dictionary ..... *xxiii–xxvi*

Sample Competence-based Lesson Plan ..... *xxvii–xxxi*

Unit 1: Chemical Bonding 1–16

1.1 Learning Objectives 1
1.2 Lessons and Time Allocation 2
1.3 Content Map 3
1.4 Supplementary Information for the Teacher 4
1.5 For More Information Visit 5
1.6 Assessment 5
1.7 Additional Activity 6
1.8 Teaching Methodology and Learning Activities 7
1.9 Answers to In-text Exercises 11
1.10 Answers to Unit Assessment 14
1.11 Project 16

Unit 2: Trends in Properties of Elements in the Periodic Table 17–30

2.1 Learning Objectives 17
2.2 Lessons and Time Allocation 17
2.3 Content Map 18
2.4 For More Information Visit 19
2.5 Assessment 19
2.6 Additional Activity 20
2.7 Teaching Methodology and Learning Activities 21
2.8 Answers to In-text Exercises 25
2.9 Answers to Unit Assessment 28

Unit 3: Water Pollution 31–43
3.1 Learning Objectives 31
3.2 Lessons and Time Allocation 31
3.3 Content Map 32
3.4 Supplementary Information for the Teacher 33
3.5 For More Information Visit 36
3.6 Assessment 36
3.7 Additional Activity 36
3.8 Teaching Methodology and Learning Activities 37
3.9 Answers to In-text Exercises 39
3.10 Answers to Unit Assessment 41
3.11 Project 43

Unit 4: Effective Ways of Waste Management 44–56
4.1 Learning Objectives 44
4.2 Lessons and Time Allocation 44
4.3 Content Map 45
4.4 Supplementary Information for the Teacher 46
4.5 For More Information Visit 49
4.6 Assessment 49
4.7 Teaching Methodology and Learning Activities 50
4.8 Answers to In-text Exercises 53
4.9 Answers to Unit Assessment 54
4.10 Project 56

Unit 5: Categories of Chemical Reactions 57–70
5.1 Learning Objectives 57
5.2 Lessons and Time Allocation 58
5.3 Content Map 58
5.4 Supplementary Information for the Teacher 59
5.5 For More Information Visit 60
5.6 Assessment 60
5.7 Additional Activity 61
5.8 Teaching Methodology and Learning Activities 62
5.9 Answers to In-text Exercises 65
5.10 Answers to Unit Assessment 68

Unit 6: Preparation of Salts and Identification of Ions 71–83

6.1 Learning Objectives 71
6.2 Lessons and Time Allocation 72
6.3 Content Map 73
6.4 Supplementary Information for the Teacher 74
6.5 For More Information Visit 74
6.6 Assessment 75
6.7 Teaching Methodology and Learning Activities 75
6.8 Answers to In-text Exercises 78
6.9 Answers to Unit Assessment 81
6.10. Project 83

Unit 7: The Mole Concept and Gas Laws 84–100

7.1 Learning Objectives 84
7.2 Lessons and Time Allocation 85
7.3 Content Map 86
7.4 Supplementary Information for the Teacher 87
7.5 For More Information Visit 87
7.6 Assessment 87
7.7 Teaching Methodology and Learning Activities 88
7.8 Answers to In-text Exercises 91
7.9 Answers to Unit Assessment 97
7.10 Project 100

Unit 8: Preparation and Classification of Oxides 101–111

8.1 Learning Objectives 101
8.2 Lessons and Time Allocation 101
8.3 Content Map 102
8.4 For More Information Visit 103
8.5 Additional Activity 103
8.6 Teaching Methodology and Learning Activities 103
8.7 Answers to In-text Exercises 106
8.8 Answers to Unit Assessment 109
8.9 Project 111

Unit 9: Electrolytes and Non-electrolytes 112–121

9.1 Learning Objectives 112
9.2 Lessons and Time Allocation 112
9.3 Content Map 113
9.4 Supplementary Information For The Teacher 114
9.5 For More Information Visit 116
9.6 Assessment 116
9.7 Additional Activity 117
9.8 Teaching Methodology and Learning Activities 118
9.9 Answers to In-text Exercises 119
9.10 Answers to Unit Assessment 120

Unit 10: Properties of Organic Compounds and Uses of Alkanes 122–131

10.1 Learning Objectives 122
10.2 Lessons and Time Allocation 122
10.3 Content Map 123
10.4 Supplementary Information for the Teacher 124
10.5 For More Information Visit 125
10.6 Assessment 125
10.7 Additional Activity 126
10.8 Teaching Methodology and Learning Activities 126
10.9 Answers to In-text Exercises 128
10.10 Answers to Unit Assessment 130
10.11 Project 131

INTRODUCTION TO THE TEACHER'S GUIDE

The purpose of this teacher's guide is to help the teacher of Chemistry implement the Chemistry syllabus. It is designed to stimulate you to create exciting and meaningful teaching programmes and lessons by enabling you to choose relevant and purposeful teaching activities. It will encourage you to research and look for new and challenging ways of facilitating students' learning in Chemistry.

The Teacher's Guide provides direction for you to use the competence-based approach in your classroom. It provides examples of teaching and learning strategies for Chemistry and examples of assessment tasks and activities. Teaching and learning is focused on student learning. Activities in the classroom, and laboratory are designed to help the students achieve the key unit competences. This teacher guide will enhance your creativity and help you develop teaching level programmes, and meaningful and interesting lessons.

THE COMPETENCE-BASED APPROACH

A competence-based approach takes learning to higher levels by providing challenging and engaging learning experiences which require deep thinking rather than just memorisation. This is an approach where teaching and learning is based on discrete skills rather than dwelling on only knowledge or the cognitive domain of learning. Its focus is on what young people can do rather than just on what they know. This approach addresses learners' individual needs, interests, abilities and backgrounds, creating an environment where learning activities are organised in a way that encourages learners to construct the knowledge either individually or in groups in an active way. With the help of the teachers, whose role is central to the success of the syllabus, learners gain appropriate skills and the ability to apply what they have learned in real life situations. Hence, they are able to make a difference not only to their own lives but also to the success of the nation.

RATIONALE OF TEACHING AND LEARNING OF CHEMISTRY

Chemistry and Society

Chemistry, one of the natural science subjects, is an important discipline that has contributed significantly to the global socio-economic transformation. This level of contribution has been achieved through the range of important life changing discoveries by chemists. These discoveries have led to new technologies in the production of small-scale and industrial products that are beneficial to both people and the environment.

Application of the knowledge of chemistry is evident across a number of industries, including medicine, pharmaceuticals, textiles, petrochemicals and food processing. In particular, chemistry has played a role in the harmonisation of man's needs with the conservation of nature and environment.

Chemistry and Learners

Chemistry is a worthwhile subject because it prepares students for the real world of work through career paths like medicine, agriculture, pharmacy, chemical engineering, food science, environmental studies and many others. Chemistry provides skills that guide the construction of theories and laws that help to explain natural phenomenon and manage people and the environment.

Chemistry provides answers to the problems faced in our modern society through empowering students to be creative, innovative and to use independent approaches to solve problems. Students come to know and explore the properties of substances, as well as the processes in which those substances take part, and of materials obtained through modern industry.

Competences

Competence is defined as the ability to use an appropriate combination of knowledge, skills, attitudes, values and behaviour to successfully accomplish a particular task. That is, the ability to apply learning with confidence in a range of situations. Basic competences are addressed in the stated broad subject competences, in the objectives highlighted on year by year basis and in each of the units of learning. The generic competences are basic competences that must be emphasised and reflected in the learning process. These are briefly described below and teachers will ensure that learners are exposed to tasks that help them acquire these skills.

a. Generic competences

- **Critical and problem solving skills:** The acquisition of such skills will help the learners think imaginatively, innovatively and broadly to evaluate and find solutions to problems encountered in our surroundings.
- **Creativity and innovation:** The acquisition of such skills will help the learners take initiative and use imagination beyond knowledge provided in classroom to generate new ideas and construct new concepts.
- **Research:** This will help the learners find answers to questions based on existing information and concepts and use it to explain the phenomena from gathered information.
- **Communication in official languages:** Teachers, irrespective of being language teachers, will ensure the proper use of the language of instruction by learners.

This will help the learners communicate clearly and confidently and convey their ideas effectively through speaking and writing and use the correct language structure and relevant vocabulary.

- **Co-operation, inter-personal management and life skills:** This will help the learners co-operate as a team in whatever tasks are assigned and to practise positive ethical and moral values while respecting rights, feelings and views of others. The learners will perform practical activities related to environmental conservation and protection. They will also advocate for personal, family and community health, hygiene and nutrition and respond creatively to a variety of challenges encountered in life.
- **Lifelong learning:** The acquisition of such skills will help the learners update their knowledge and skills with minimum external support. The learners will be able to cope with the evolution of advances in knowledge for personal fulfilment in areas that are relevant to their improvement and development.

b. Broad chemistry competences

During the learning process, the learner should be able to:

- Demonstrate knowledge, understanding and skills of chemistry subject matter (concept) that would enable him/her to access chemistry and related courses at advanced level.
- To develop skills in laboratory procedures and techniques, carried out with due regard for safety, together with the ability to assess the use and limitations of these procedures.
- Analyse scientific phenomena relating to real life experiences. Use the principles of scientific methods and the application of experimental techniques to solve specific problems.
- Demonstrate curiosity, research skills, creativity and innovative skills.
- Conduct scientific research: Collect data, present, analyse, interpret and draw appropriate conclusions.
- Contribute to sustainable development by reducing the impact of chemical waste on the environment.
- Apply the knowledge of chemistry to make scientifically informed decisions on the choice of chemical products on the market.
- Develop attitudes relevant to chemistry such as concern for accuracy and precision, objectivity, integrity, enquiry, initiative and inventiveness.
- Promote awareness that scientific theories and methods have developed, and continue to do so, as a result of the co-operative activities of groups and individuals.
- Develop attitudes on which scientific investigations depend, such as honesty, persistence, critical thinking and tolerance of uncertainty.

c. Key competences at the end of senior two

- Relate the nature of the bond to properties of compounds.
- Describe the trends and patterns in properties of elements in groups and periods.
- Suggest the ways of water pollution control.
- Suggest different ways of transforming wastes into useful materials.
- Differentiate between the types of chemical reactions.
- Determine the pH of aqueous solutions using a pH-metre.
- Prepare a salt from suitable starting materials.
- Determine the composition of compounds by mass, volume and number of moles.
- Identify cations and anions present in a solution.
- Prepare and classify oxides based on their properties.
- Distinguish between non-electrolyte, weak and strong electrolytes.
- Compare the properties of organic and inorganic compounds and explain the uses of alkanes in daily life.

PEDAGOGICAL APPROACH

The constructivist approach of teaching science which reinforces the inquiry-based instruction will be at the heart of the implementation of the new revised syllabus.

ROLE OF THE LEARNER

The approach considers the learning process to involve the construction of meaning by learners.

- Simply, it emphasises the need for children to think about scientific activity in order to make the sense of and understand the scientific concepts being introduced. Traditionally, science instruction has relied heavily on teacher-led, direct instructional strategies with learners being the recipients of knowledge.
- In this syllabus, the learners are in the driver's seat which implies that, they will construct their knowledge by posing questions, planning investigations, conducting their own experiments, analysing and communicating results.
- More specifically, while engaging in inquiry, the learners will describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. By so doing, the learners will take ownership of the learning process.

Over time learners will get involved in the following activities:

- observing and, where possible, handling and manipulating real objects; pursuing questions which they have identified as their own even if introduced by the teacher;
- taking part in planning investigations with appropriate control to answer specific questions;
- using and developing skills of gathering data directly by observation or measurement and by using secondary sources; using and developing skills of organising and interpreting data, reasoning, proposing explanations, making predictions based on what they think or find out;
- working collaboratively with others, communicating their own ideas and considering others' ideas;
- expressing themselves using appropriate scientific 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 self critically about the processes and outcomes of their inquiries.

These activities will help the learners not only acquire the content knowledge, but also a number of skills, including how to approach a problem, identify important resources, design and carry out hands-on investigations, analyse and interpret data, and, perhaps most importantly, recognise when they have answered the question or solved the problem.

ROLE OF THE TEACHER

The role of the teacher will remain critical however. Instead of being the "sage on the stage", the teacher will rather be "the guide on the side" who acts as a facilitator in a variety of ways which include:

- encouraging and accepting learner's autonomy and initiative;
- using raw data and primary sources, along with manipulative, interactive, and physical materials;
- using cognitive terminology such as classify, analyse, predict, and create while framing tasks.
- allowing learner's responses to drive lessons, shift instructional strategies, and alter content;
- familiarising 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;
- encouraging learners' inquiry by posing thoughtful, open-ended questions and asking learners to question each other;
- seeking elaboration of learners' initial responses;
- engaging learners in experiences that pose contradictions to their initial hypotheses and then encouraging discussion;
- providing time for learners to construct relationships and create metaphors;
- nurturing learners' natural curiosity.

TEACHING AND LEARNING STRATEGIES

To assist and encourage the learners to learn, you perform certain tasks. These are referred to as teaching strategies. You need to engage the learners directly in learning but there are times when you have to take charge of the learning in the class and teach particular concepts or ideas.

Some Useful Teaching and Learning Strategies

- **Lecture:** If a demonstration covers skills, the teachers will often use a lecture to reach knowledge-based objectives. Teachers choose to lecture when they have a limited amount of time, when the background information is not available or easily accessible to learners (e.g., the material is not in print), or when the concepts could be best clarified through verbal explanation.
- **Brainstorming:** This method is used in groups to support and encourage creative problem solving.
- **Discussions:** Discussions are a way of exploring issues. Discussions can occur between teacher and learners and also between learners and learners.
- **Debates:** A debate is a fair and formal way of discussing a topic or an issue. It normally takes place after preparations between two groups – one for the topic and one against the topic.
- **Group work:** The purpose of group work is to give learners opportunities to share ideas and at the same time learn from group members. Every group should have a group leader to supervise the group's activities such as delegating tasks and consulting the teacher. Group work activities can take place anywhere: in the classroom, under a tree, on a riverside, at the beach, in a forest or school garden.
- **Peer teaching and learning:** This is organised as a partnership activity. One learner performs while the other observes and assists in making corrections and suggesting new ideas and changes. The teacher's role in this strategy is to observe as well encourage positive interaction and effective communication through which the intended outcome is achieved.
- **Demonstrations:** Science demonstration lessons are usually practical lessons where demonstration steps or procedures are outlined and then followed, when others are observing and taking notes. Demonstrations can be conducted by the teacher, learners or an expert from a Science related background. Learners can then repeat the same demonstration lesson. In any learner demonstration, supervision is required at all times.
- **Project:** The learners can demonstrate physically their understanding of the outcomes in various activities they have chosen to investigate.
- **Excursions and field trips:** Excursions and field trips are a valuable and positive addition to any Science programme. Science teachers should take every opportunity to study and increase their knowledge of local resources and places suitable for excursions. On any excursion, identify the safety measures required to ensure the learners' safety.
- **Making models:** Models can be used to show a Science concept. Models can be working models or built to scale if they are demonstration models.

- **Collecting and observation:** Observing is an open ended activity. Observations may be carried out over a short or long period. Specific or general observations may be made and data collected to be classified and analysed later.
- **Testing predictions:** This involves making a prediction and testing it. Choose a problem you want to investigate, carry out background research on the problem and predict what might happen.
- **Research using internet or library books:** Research involves collection of data and analysing them in order to gain new information or knowledge about a particular subject. Any form of research must be well-planned and those who will be involved must be notified well in advance.
- **Using the internet for classroom activities**
  - Where appropriate, incorporate computer sessions as part of planned learning experiences.
  - Design activities that provide the opportunity for students to access, compare and evaluate information from different sources.

Special Needs Education and Inclusive Approach

All Rwandans have the right to access education regardless of their different needs. The underpinning of this provision would naturally hold that all citizens benefit from the same menu of educational programmes. The possibility of this assumption is the focus of special needs education. The critical issue is that we have persons/learners who are totally different in their ways of living and learning as opposed to the majority. The difference can either be emotional, physical, sensory and intellectual learning challenged traditionally known as mental retardation.

These learners equally have the right to benefit from the free and compulsory basic education in the nearby ordinary/mainstream schools. Therefore, the schools' role is to enrol them and also set strategies to provide relevant education to them. The teacher therefore is requested to consider each learner's needs during teaching and learning process. Assessment strategies and conditions should also be standardised according to the needs of these learners.

Learning strategies for the learners with SEN

Learners with learning disabilities sometimes do not intuitively pick up on learning strategies. Introducing a variety of strategies, using them across a number of learning environments and discussing with the students which ones work best and where, is a valuable exercise. It provides insight into learning styles, different ways to organise thinking, and ways to make effective plans.

Study skills

- Provide study guides or help the learners create their own.
- Encourage study groups, in order to support auditory learners and provide context for learning information.
- Have learners generate possible test questions from which to study.
- Have learners put one fact only on post-it notes, and then organise them into clusters/clumps on their desks. Discuss why each clump has been assembled and how the facts relate to one another.
- Have learners use a highlighter and work as group to identify key words or ideas. Discuss how the highlighted text relates to the overall topic and subtopics of the piece.

Test-taking

- Help learners learn how to identify which questions to answer first.
- Teach learners to skim through the test and answer the easiest questions first, before proceeding to the more challenging questions.
- Show them how to use a watch to judge how much time to spend on a question depending on the mark value.
- Teach the process of elimination for multiple choice or true and false questions. Teach the use of a mini map or outline for essay questions.
- Encourage learners to highlight key or signal words in test questions.
- Teach the strategy of explicitly identifying the steps in multi-step questions.

Memory

- Teach visualisation, cognitive mapping and mnemonic strategies.
- Provide advance notice for tests, to allow for longer study time.
- Teach learners to divide information into categories.
- Exaggerate and use humour in presentations and studying tasks.
- Use visual, auditory and kineasthetic modes of presenting and exploring material.
- Provide frequent, regular opportunities to practice.

Note-taking

Taking notes involves a combination of quickly processing language, recalling spelling and engaging fine motor skills. Learners with learning disabilities can have immense difficulty with this kind of writing. Teachers should directly teach learning strategies that enable learners to develop skills in taking useful notes and at the same time consider arranging for learners to have access to peer helper notes.

Alternate Teaching Approaches

Approach 1: The 5Es—Engage, explore, explain, elaborate and evaluate

This '5Es' is a constructivist approach based on the idea that learners learn best when they participate in activities that give them opportunities to work things out for themselves. As the names suggests, there are five phases; engage, explore, explain, elaborate and evaluate.

1. Engage

In this phase:

- teachers engage learners in activities that capture their interests and stimulate curiosity,
- learners raise questions,
- teachers verify learners' prior understandings of the topic,
- learners compare ideas.

2. Explore

In this phase, learners undertake hands-on activities where they:

- experience the phenomenon or concept,
- explore the questions they have raised, test their ideas and solve problems.

3. Explain

Only after learners have had opportunities to explore, they have opportunities to:

- compare their ideas with scientific explanations,
- use scientific terminology,
- construct explanations that can be justified using information collected.

4. Elaborate

In this phase, learners have opportunities to:

- apply what they have learnt to new contexts,
- develop a deeper understanding of the problem or phenomenon as they discuss and compare ideas.

5. Evaluate

In this phase, learners and the teacher:

- look for evidence of changes in learners' ideas, beliefs and skills,
- evaluate what learners know and can do.

Approach 2: The interactive approach

The interactive approach involves a teacher-learner partnership in which the learner and the teacher discuss and co-operate in selecting the topic. The learners are active participants and this helps improve their understanding about familiar and unfamiliar concepts as well as their learning processes.

There are five phases in this approach; preparation, exploration, learners' questions, investigations and reflection.

1. Preparation

In this initial phase, teachers:

- select the topics jointly with learners
- verify learners' prior understandings of the topic
- assemble background information.

2. Exploration

In this phase, learners:

- clarify the topic and focus their thinking on particular aspects of the topic
- participate in an activity, preferably hands-on, that enables them to become more familiar with the topic.

3. Learners' questions

In this phase, learners:

- explore the topic and pose further questions for investigation.

4. Investigations

In this phase, learners and the teacher:

- select questions to investigate
- plan and carry out investigations to finalise their answers to the selected questions.

5. Reflection

In this phase, learners have opportunities to:

- compare their views on the topic before and after exploration, questioning and investigation
- reflect on what has been determined and what needs further exploration.

Approach 3: Predict, observe, explain

This approach is based on learners drawing on their own experiences to make predictions. There are three phases in this approach: predict, observe and explain.

1. Predict

In this phase:

- teachers pose the question and allow time for learners to think about and clarify the question
- learners make a prediction and give reasons for their prediction
- teachers and learners accept all predictions without judgement
- learners may change their minds as they share their predictions and reasons.

2. Observe

In this phase, teachers or learners perform relevant activities, either as a class demonstration, in a group or individually, and learners record their observations.

3. Explain

In this phase, learners attempt to explain their observations which may conflict with their original prediction. Teachers encourage learners to reflect on their predictions and modify them to better fit the observations.

ASSESSMENT

Assessment is the process of evaluating the teaching and learning processes through collecting and interpreting evidence of individual learner's progress in learning and to make a judgment about a learner's achievements measured against defined standards. Assessment is an integral part of the teaching-learning processes. In the new competence-based curriculum assessment must also be competence-based; whereby a learner is given a complex situation related to his/her everyday life and asked to try to overcome the situation by applying what he/she learned.

Glossary for Assessment

The following glossary will help teachers to ask learners specific questions and understand what is expected in responses to examinations and assessment tasks.

Account	Account for: state reasons for, report on. Give an account of: narrate a series of events or transactions
Analyses	Identify components and the relationship between them; draw out and relate implications
Apply	Use, utilise, employ in a particular situation

Appreciate	Make a judgment about the value of
Calculate	Ascertain or determine from given facts, figures or information
Classify	Arrange or include in classes or categories
Compare	Show how things are similar or different
Construct	Make; build; put together items or arguments
Contrast	Show how things are different
Deduce	Draw conclusions
Define	State meaning and identify essential qualities
Demonstrate	Show by example
Describe	Provide characteristics and features
Discuss	Identify issues and provide points for and/or against
Distinguish	Recognise or note or indicate as being distinct or different from; to note differences between
Evaluate	Make a judgement based on criteria; determine the value of
Examine	Inquire into
Explain	Relate cause and effect; make the relationships between things evident; provide why and/or how
Identify	Recognise and name
Interpret	Draw meaning from
Investigate	Plan, inquire into and draw conclusions about
Justify	Support an argument or conclusion
Outline	Sketch in general terms; indicate the main features of
Predict	Suggest what may happen based on available information
Propose	Put forward (for example, a point of view, idea, argument, suggestion) for consideration or action
Recommend	Provide reasons in favour
Summarise	Express, concisely, the relevant details
Synthesise	Putting together various elements to make a whole

Types of Assessment

Formative and continuous assessment (Assessment for learning)

Continuous assessment involves formal and informal methods used by schools to check whether learning is taking place. When a teacher is planning his/her lesson, he/she should establish the criteria for performance and behaviour changes at the beginning of a unit. Then at the of end of every unit, the teacher should ensure that all the learners have mastered the stated key unit competences basing on the criteria stated, before going to the next unit. The teacher will assess how well each learner masters both subject and generic competences described in the syllabus and from this, the teacher will gain a picture of the all-round progress of the learner.

Summative assessment (Assessment of learning)

When assessment is used to record a judgment of a competence or performance of the learner, it serves a summative purpose. Summative assessment gives a picture of a learner's competence or progress at any specific moment. The main purpose of summative assessment is to evaluate whether learning objectives have been achieved and to use the results for the ranking or grading of learners, for deciding on progression, for selection into the next level of education and for certification.

This assessment should have an integrative aspect whereby a learner must be able to show mastery of all competences.

Teacher's Role in Assessment

- to develop and implement effective school assessment and reporting practices within school assessment and reporting programmes
- to discuss with learners the assessment, recording and reporting procedures that meet the learning needs of individuals and groups of learners, develop learners' knowledge, skills and understanding of effective assessment and reporting methods
- to maintain and share relevant records of learners' progress while maintaining confidentiality where appropriate
- to plan tasks and activities which provide sufficient evidence to show that particular competency has been mastered by learner
- to report learners' progress and achievements to learners, parents, guardians, teachers and others
- to use assessment information to inform and enhance their teaching and learning practices
- to make valid reports on learners' achievement of outcomes, attitudes and values using the appropriate reporting or certification systems.

Assessment and Recording Methods

Assessment methods are the ways that teachers can collect information about learners' learning. Teachers record evidence of learners' learning and use it to make judgements about learners' achievement of the learning objectives. To ensure that assessment is fair and balanced, teachers should use a range of assessment methods including:

Observation

Teachers can gather much information about learners' learning by observing them in both formal and informal situations inside and outside the classroom. Observation is used largely for assessing skills and so is best suited to assess skills-based activities. It can also be used to assess learners' knowledge and attitudes when they are expressed orally.

Formal assessment tasks that use observation as the assessment method might include:

- oral presentations
- group work
- practical activities.

Informal observations can occur when learners work on normal learning activities both inside and outside the classroom. It is useful to inform the learners that you are assessing them and to make sure they know the assessment criteria that you want them to demonstrate. In this way, more learners are likely to be successful.

Learners can also observe and give constructive feedback on each other's performances using the same assessment criteria. This is called peer assessment.

Record keeping

This is gathering facts and evidence from assessment instruments and using them to judge the student's performance by assigning an indicator against the set criteria or standard. Assessment procedures generate data in the form of scores which will be carefully recorded and stored in a portfolio. These scores will contribute to remedial actions and alternative instructional strategies. They will also be used to provide feedback to the learners and their parents to check learning progress and to provide advice, as well as be used in the final assessment of the students.

This portfolio is a folder (or binder or even a digital collection) containing the student's work as well as the student's evaluation of the strengths and weaknesses of their work. Portfolios reflect not only the work produced (such as papers and assignments), but also provide a record of the activities undertaken over time as part of student learning. The portfolio output (formative assessment) will be considered only enough for three years of A level. It will also serve as a verification tool for each learner that he/she attended the whole learning activity before he/she undergoes the summative assessment for the subject. The results from the portfolio will contribute 50% of the summative assessment for each year.

Item Writing in Summative Assessment

Before writing a question paper, a plan or specification of what is to be tested or examined must be developed that shows the units or topics to be tested on, the number of questions in each level of Bloom's taxonomy and the marks allocation for each question. In a competence-based curriculum, questions from higher levels of Bloom's taxonomy should be given more weight than those from knowledge and comprehension level.

Before developing a question paper, the item writer must ensure that the test or examination questions are tailored towards competence-based assessment by doing the following:

- Identify topic areas to be tested on from the subject syllabus.
- Outline subject matter/content to be considered as the basis for the test.
- Identify learning outcomes to be measured by the test.
- Prepare a table of specifications.
- Ensure that the verbs used in the formulation of questions do not require memorisation or recall answers only but also the test for broad competences as stated in the syllabus.

Reporting to Parents

The wider range of learning in the new curriculum means that it is necessary to think again about how to share a learner's progress with his/her parents. A single mark is not sufficient to convey the different expectations of learning that are in the learning objectives. The most helpful reporting is to share what students are doing well and where they need to improve. A simple scale of "Meeting expectations very well", "Meeting expectations", and "Not meeting expectations" for each of knowledge/understanding, subject skills and competences in a subject will convey more than a single mark. For school-based assessments these scores do not need to be added up.

CHEMISTRY DICTIONARY

Absorption: A chemical or physical process by which one thing takes in or soaks up energy or a liquid or other substance from another.

Acidification: Reduction in the pH of the ocean over an extended period of time, caused primarily by uptake of carbon dioxide (CO_2) from the atmosphere.

Alkaline: Having a pH greater than 7.

Anhydrous: Containing no water especially a crystalline compound.

Anion: A negatively charged ion.

Antacid: A medicine that prevent or correct acidity; especially in the stomach.

Antiperspirants: A substance that is applied to the skin, especially under the arms, to reduce sweating.

Antiseptic: Preventing the growth of disease-causing micro-organisms.

Bauxite: An amorphous clayey rock that is the chief commerical ore of aluminium.

Biodegradable waste: Waste which can be broken down, by micro-organisms.

Borax: A white compound which occurs as a mineral in some alkaline salt deposits and is used in making glass and ceramics.

Breeding ground: An area where birds, fish, or other animals habitually breed.

Burning: On fire.

Carbohydrates: A large group of organic compounds occurring in foods including sugars, starch, and cellulose.

Catalyst: A substance that increases the rate of a chemical reaction without taking part in the reaction.

Cation: A positively charged ion.

Combustion: The process of burning something.

Composting: Composting is the process of converting plant and animal waste materials into manure.

Concrete: A building material made from a mixture of broken stone or gravel, sand, cement, and water.

Corrosive: Harmful or destructive.

Cosmetics: Cosmetics are care substances used to enhance the appearance or odour of the human body.

Covalent: The sharing of electrons between atoms.

Crystal: A crystal is a solid where the atoms form a periodic arrangement.

Crystallisation: A separation technique that is used to separate a solid that has dissolved in a liquid.

Crystallise: Form or cause to form crystals.

Crystals: A piece of a homogeneous solid substance having a natural geometrically regular form.

Dandruff: Small pieces of dead skin in a person's hair.

Dazzling: Extremely bright.

Deflagrate: Sharp combustion, burning with flame.

Deflagrating spoon: A long vertical handled spoon with cover used in deflagration experiments.

Deodorants: A substance which removes unpleasant smells, especially body odours.

Detergents: A water-soluble cleansing agent which combines with impurities and dirt to make them more soluble.

Diamond: One of the known allotropes of carbon.

Diode: A semiconductor device with two terminals, typically allowing the flow of current in one direction only.

Ductile: Able to be drawn out into a thin wire.

Electrolysis: A chemical decomposition produced by passing an electric current through a liquid or solution containing ions.

Electrolyte: A liquid which contains ions and can be decomposed by electrolysis.

Electronic configuration: The distribution of electrons of an atom.

Endothermic: A chemical reaction or process in which heat energy is absorbed.

Energy recovery: *Energy recovery* from waste is the conversion of non-recyclable waste materials into useable heat, electricity, or fuel through a variety of processes.

Eutrophication: The process of nutrient enrichment of aquatic ecosystems.

Excess: An amount of something that is more than necessary.

Exothermic: A chemical reaction or process in which heat energy is released.

Fermentation: The chemical breakdown of a substance by bacteria, yeasts, or other micro-organisms.

Fertilisers: A substance added to soil or land to increase its fertility.

Flammable: Easily set on fire.

Fluorescent: Very bright in colour.

Fungicides: A chemical that destroys fungus.

Garbage: Waste materials (or rubbish) especially household wastes, are called garbage.

Global warming: Increase of Earth's average surface temperature due to effect of greenhouse gases.

Granule: A small compact particle of a substance.

Graphite: A grey crystalline allotropic form of carbon which occurs as a mineral in some rocks.

Hydrated: Combined chemically with water molecules, compounds containing water molecules.

Hydrocarbon: A compound of hydrogen and carbon.

Ignition: The action of setting something on fire or starting to burn.

Immerse: Dip or submerge in a liquid.

Incinerator: It is a vessel where incineration occurs. Incineration is a waste treatment process that involves the combustion of organic substances contained in waste materials.

Ingredient: Any of the foods or substances that are combined to make a particular dish.

Inorganic Compounds: Compounds that do not contain a carbon to hydrogen bond, also called a C–H bond. Examples include carbon dioxide, carbon monoxide and carbonates.

Insufficient: Not enough; inadequate.

Landfill: A landfill site is a site for the disposal of waste materials by burial.

Laxative: A medicine used to treat and prevent constipation.

Liberate: To release gas during a chemical reaction.

Lipids: An important component of living cells, fatty acids that store energy in living cells.

Lipids: *These* are a group of naturally occurring molecules that include fats, waxes, fat-soluble vitamins such as vitamins A, D, E, and K.

Malleable: Able to be hammered or pressed into shape without breaking or cracking.

Mercerising: A chemical treatment for increasing lustre and strength of the yarn or fabric.

Metal: A material that is hard, opaque, shiny and has good electrical and heating conductivity.

Metalloid: A chemical element with properties in between those of metals and non-metals.

Neutralise: To make an acidic or alkaline substance chemically neutral.

Noble gases: The gaseous elements helium, neon, argon, krypton, xenon, and radon.

Non-biodegradable waste: Waste that cannot be broken down. It remains in the environment as such.

Non-metal: A material that does not have properties of metals.

Nuclear reactor: A device used at nuclear power plants for electricity generation.

Nucleic Acid: A complex organic substance present in living cells, especially DNA or RNA

Ores: The ores are extracted from the earth through mining; they are then refined to extract the valuable element, or elements.

Organic compounds: Compounds containing carbon.

Ornaments: A thing used or serving to make something look more attractive.

Pharmaceutical drugs: A drug used to diagnose, cure, treat, or prevent disease.

Phenolphthalein: A colourless crystalline solid (pink in alkaline solution) used as an acid-base indicator.

Phytoplankton: These are single-celled organisms of lakes, streams and oceans that make their own food from sunlight through photosynthesis.

Pollutant: Substances that cause pollution.

Polluter pays principle: Whosoever causes pollution should have to pay to clean it up, one way or another.

Pollution: Contamination of the environment with substances those are harmful to living beings.

Precipitate: A solid substance deposited from a solution after a chemical reaction.

Prolonged: Continuing for a long time.

Radioactive substance: A radioactive substance is unstable and produces dangerous kinds of radiation.

Reluctant: Resistant.

Severe: Causing very great pain.

Sewage: Wastewater that often contains faeces, urine and laundry waste.

Sprinkle: a small quantity or amount of something scattered over an object or surface.

Sprinkled: Spray.

Stirring: Mixing thoroughly.

Tangy: having a strong, piquant flavour or smell.

Thermal decomposition: It is a chemical decomposition caused by heat.

Thermometer: An instrument for measuring temperature.

Toxic products: Capable of causing injury or death, especially by chemical means; poisonous.

Urea: A water-soluble compound used as fertiliser.

Waste management: Waste management includes all those activities and action required to manage waste.

Waste recycling: *Recycling* is processing used materials (*waste*) into new, useful products.

Water-borne diseases: Diseases caused by micro-organisms in water.

Water pollution: Addition of foreign substances which produce harmful effects and decrease usefulness of water.

Weapons: A thing designed or used for inflicting physical harm or damage.

SAMPLE COMPETENCE–BASED LESSON PLAN

School Name: ..... Teacher's Name: .....

Term	Date	Subject	Class	Unit	Lesson No.	Duration	Class size
I		Chemistry	S2	1	1/12	40 minutes	52 learners

Learners with SEN	**Visual Impairment (3):** Seat the learners so that they can see the teacher pointing to illustrations and see the teacher's facial expressions and gestures as they read. Arrange for a Braille Book if the learner is completely blind. **Hearing Impairment (1):** Seat the learner in front of the teacher so that he/she can hear the lesson. Arrange for hearing aids if the learner requires so.
Unit title	Chemical Bonding
Key unit competency	To be able to relate the nature of bonding to properties of substances.
Title of lesson	Stability of Atoms
Plan for this class	Inside the class
Instructional objectives	Provided with electron configuration of some elements, learners should be able to explain accurately how atoms acquire stability.
Materials	Computer and projector.
References	• Ordinary Level Chemistry Syllabus, Secondary 2, REB, 2015 • Comprehensive Chemistry Student's Book, Secondary 2 • Comprehensive Chemistry Teacher's Guide, Secondary 2 • McMurry, J.E., Fay, R.C. (2014). *General Chemistry, Atoms First, 2nd edition*. Pearson Education. p. 26. • Internet and library materials • English dictionary

Timing	Description of teaching and learning activities		Generic competences and cross-cutting issues to be addressed
	The teacher reviews previous knowledge of learners by asking few questions and guides the learners to carry out an activity to help them understand the concept of Stability of Atoms.		
	Teacher activities	**Learner activities**	
Introduction 10 minutes	• The teacher asks questions to review previous knowledge of learners. **Possible questions:** – *What do you know about atoms, molecules and ions?* – *Can you distinguish between them?* – *Give an example of cation and anion.* • The teacher announces the new lesson title, *i.e.*, Stability of Atoms.	• Learners answer the questions. **Possible answers:** – *An atom is the basic unit that makes up all matter; a molecule is an electrically neutral group of two or more atoms held together by chemical bonds and an ion is an atom or a molecule with a net positive or negative electrical charge.* – *Atoms and molecules are distinguished from ions by their lack of electrical charge.* – *An example of cation is Sodium (Na^+) and an anion is Oxide (O^{2-}).*	**Communication:** Learners discuss with each other and convey their views in the class-room.

Development of the Lesson 25 minutes	• The teacher asks the learners to take a glass full of water and try adding water into it. **Ask following question:** – *Are you able to add water into this glass?* • The teacher asks the learners to now take another glass of water but quarter (one-fourth) filled and try adding water into it. **Ask following question** – *Are you able to add water into the glass now?* • The teacher asks the learners to discuss their observations with each other and then read the lesson Stability of Atoms from the Student's Book. After learners read the lesson, the teacher asks following questions. – *What is the meaning of stability of atoms?* – *How can an atom achieve stability?*	• The learners take a glass full of water and try adding water into it. **Expected answer.** – *No* • Learners now take a quarter (one-fourth) filled glass and try adding water into it. **Expected answer.** – *Yes* • Learners read the lesson Stability of Atoms from the Student's Book and come up with answers. – *Stability of atoms means achieving balanced nucleus that does not contain excess energy.* – *An atom can achieve stability by gaining, losing or sharing electrons with other atoms.*	**Creativity and innovation:** The learners express their ideas in a variety of ways, that is, through drawing and writing. **Cross-cutting Issues** **Peace and Values Education:** Discussion among the learners from different backgrounds during learning promotes social cohesion which builds a more peaceful society.

	– *Draw a diagram showing stability of atoms and explain it to the class.*	– *Learners will draw and explain the diagram in class.*	
Conclusion and Lesson Assessment 5 minutes	The teacher asks the learners what they learned from today's lesson.	Learners summarise what they have learned from today's lesson. • The force which links the atoms (or ions) in molecule is called a chemical bond (or just "bond"). • The atoms combine with one another to achieve the inert gas electron arrangement and become more **stable**. • An atom can achieve the inert gas electron arrangement (Stability) in three ways: – By losing one or more electrons (to another atom). – By gaining one or more electrons (from another atom). – By sharing one or more electrons (with another atom).	**Communication:** Learners convey what they have learned in the classroom.

	Assessment Ask the following questions from Exercise 1.1 – *What do you mean by a chemical bond?* – *When a bond is formed, each atom acquires a stable configuration similar to* _____ – *Generally, metals lose electrons to achieve inert gas electron arrangement. (True or False)* – *Which of the following is not a noble gas?* (*a*) *Helium* (*b*) *Neon* (*c*) *Hydrogen* (*d*) *Argon* – *Among, phosphorus, sulphur, and calcium which element achieves stability by losing electron?*	Learners answer the questions. – *The force which links the atoms (or ions) in molecule is called a chemical bond.* – *noble gas.* – *True* – (*c*) – *Calcium achieves stability by losing two electrons.*	
Teacher self-evaluation	• All the learners were able to explain accurately how atoms acquire stability. • All the SEN learners were able to explain accurately how atoms acquire stability. • The teaching strategies and techniques used were very efficient in meeting instructional objective, hence no changes needed in teaching approach.		

UNIT 1: CHEMICAL BONDING

(*Refer to the Student's Book*)

1.1 LEARNING OBJECTIVES

At the end of this lesson students should be able to:

Knowledge and Understanding	Skills	Attitudes and Values
• Explain the nature of ionic, covalent and metallic bonding.	• Show the formation of bonds using dot and cross diagrams.	• Develop a sense of orderliness and self-confidence in presentations of results.
• State the typical physical properties of ionic compounds, and of covalent compounds.	• Classify various chemical compounds as ionic or covalent.	• Respect the procedures while carrying out experiments.
• Explain the physical properties of metals in terms of their structure.	• Perform experiments to show the physical properties of metals, ionic compounds and covalent compounds.	• Appreciate that being soluble in water is not sufficient evidence to indicate a compound is ionic.

1.2 LESSONS AND TIME ALLOCATION

Lessons	Periods required	Total periods
1.1 Stability of Atoms	1	**10**
1.2 Formation of Ions from Atoms	1	
1.3 Ionic Bonding	1	
1.4 Formation of Ionic Bond	1	
1.5 Properties of Ionic Compounds		
1.6 Covalent Bonding	1	
1.7 Formation of Covalent Bond	1	
1.8 Properties of Covalent Compounds		
1.9 Giant Covalent Structures • Diamond and its Properties • Graphite and its Properties • Uses of Diamond and Graphite	1	
1.10 Metallic Bonding	1	
1.11 Formation of Metallic Bond	1	
1.12 Properties of Metals		
Assessment	1	

1.3 CONTENT MAP

Introduction

This unit discusses the nature of ionic, covalent and metallic bonding. It explains the typical physical properties of ionic compounds, and of covalent compounds. Besides, it describes the physical properties of metals in terms of their structure.

Classroom Organisation

Whole class orientation, individual work and then working in groups

Teaching and Learning Materials

- Paper, Pen, Pencil, Computers, and Internet connection

Teaching Aids

- **Audio-video:** Video showing formation of covalent and ionic bonds
- **Notes:** List of covalent and ionic compounds
- **PowerPoint Presentation:** Physical Properties of covalent and ionic compounds
- **Visual:** Structure and images showing diamond and graphite
- **Vocabulary:** Terms associated with chemical bonding

Activities

- Illustrate the physical properties of metals
- Using atomic models discuss the formation of covalent bonds and make a presentation
- Carry out experiments which illustrate the physical properties of ionic and covalent compounds

Competences Practised

- Literacy
- Numeracy
- Critical thinking
- Creativity and innovation
- Research and problem solving
- Communication in official languages
- Co-operation, inter-personal relations and life skills

Revision

- Objective type questions are provided at the end of each unit.
- Short answer type questions are provided at the end of each unit.

Assessments

- A formative assessment task of image collection
- A formative assessment of creativity

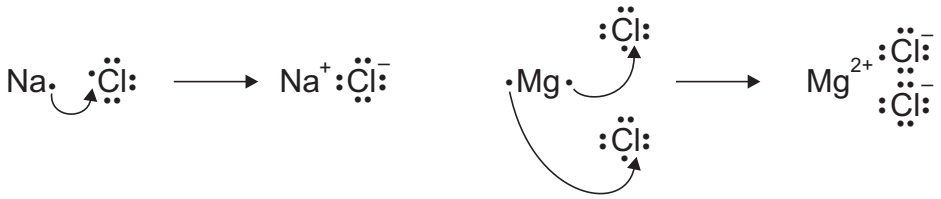
1.4 SUPPLEMENTARY INFORMATION FOR THE TEACHER

Chemical Bond is defined as the attractive forces which hold the various chemical constituents (atoms, ions, etc.) together in different chemical species.

Lewis Symbols Valence electrons are reported by dots around the chemical symbol of element, *e.g.*,

Ionic Bond

A chemical bond formed by complete transference of electrons from one atom (metal) to another (non-metal) and hence, each atom acquire the stable nearest noble gas configuration, is called ionic bond or electrovalent bond.



Ions

Atoms carrying either positive or negative charge are termed ions. Atoms carrying positive charge are called cations and atoms that carry negative charge are called anions. Metals usually form cations while non-metals (except H) usually form anions.

Covalent Bond

A chemical bond formed between two atoms by mutual sharing of electrons between them so as to complete their octets or duplets, is known as covalent bond and the number of electrons contributed by each atom is known as covalency.

Single covalent bond

A covalent bond formed by the mutual sharing of one pair electrons is called a single covalent bond, or simply a single bond. A single covalent bond is represented by a small line (—) between the two atoms.

Double covalent bond

A covalent bond formed by mutual sharing of two pair of electrons is called a **double** covalent bond, or simply a double bond. A double covalent bond is represented by two small horizontal lines (═) between the two atoms. For example, O═O, O═C═O etc.

Triple covalent bond

A covalent bond formed by mutual sharing of three pair of electrons is called a **triple** covalent bond, or simply a triple bond. A triple covalent bond is represented by three small horizontal lines (≡) between the two atoms. For example, N≡N, HC≡CH etc.

Polar covalent bond

If a covalent bond is formed between the different atoms, the shared pair is displaced towards the more electronegative atom causing greater concentration of electron density around the more electronegative atom. Such a covalent bond develops some ionic character and is called polar covalent bond. For example, HCl.

1.5 FOR MORE INFORMATION VISIT

- http://www.chem4kids.com/files/atom_bonds.html
- http://encyclopedia.kids.net.au/page/io/Ionic_bond
- http://encyclopedia.kids.net.au/page/ch/Chemical_bond
- http://www.ducksters.com/science/chemistry/chemical_bonding.php
- http://encyclopedia.kids.net.au/page/me/Metallic_bond
- http://www.sciencekids.co.nz/sciencefacts/chemistry/diamond.html

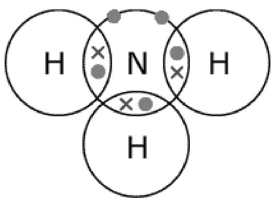
1.6 ASSESSMENT

1. When a Na atom loses one electron, it gets a charge of _____.
2. When a Cl atom gains an electron, it gets a charge of _____.
3. Covalent bond is formed between atoms of _____.
4. In a covalent bond, electrons are _____.
5. Hydrogen Fluoride has a (an) _____ bond and its chemical formula is _____.
6. Draw dot and cross formula of (*i*) ammonia, (*ii*) water, (*iii*) Carbon dioxide.

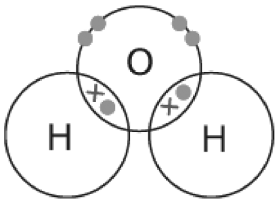
Answers

1. +1 **2.** –1 **3.** non-metals **4.** shared
5. covalent, HF

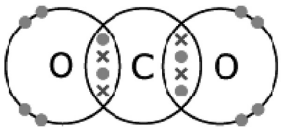
6.



(*i*) Ammonia



(*ii*) Water



(*iii*) Carbon dioxide

1.7 ADDITIONAL ACTIVITY

Testing Conductivity and Melting Point

Materials required

Conductivity apparatus, small beakers, 4 test tubes, test tube tongs, striker, Bunsen burner, Calcium chloride, Ammonium chloride, Distilled water, Sucrose, Sodium chloride, salicylic acid

Procedure

Testing conductivity: Use the conductivity probe and lab pro to determine whether the following materials conduct electricity: sodium chloride, sucrose, calcium chloride, salicylic acid, ammonium chloride. Record your data in the data table below.

Data Table 1: Conductivity

Compound	Conductivity
Sodium chloride	
Sucrose	
Calcium chloride	
Salicylic acid	
Ammonium chloride	

Testing melting point: To test the melting point of the substances, take the following steps.

1. Take approximately 0.5 g of sodium chloride in a test tube.
2. Heat the test tube over a Bunsen burner and record in Data Table 2 the amount of time required for the solid to melt. If the solid takes longer than 2 minutes to melt in a blue flame, note this.
3. Use the following solids: sodium chloride, sucrose, calcium chloride, salicylic acid, ammonium chloride.

Data Table 2: Melting Point		
Compound	**Did Substance Melt?**	**Time to Melt (s)**
Sodium chloride		
Sucrose		
Calcium chloride		
Ammonium chloride		

Post lab questions

1. Draw conclusions and summarise your data in the table below.

Compound	Bond Type	Support from Data
Sodium Chloride		
Sucrose		
Calcium chloride		
Salicylic acid		
Ammonium chloride		

1.8 TEACHING METHODOLOGY AND LEARNING ACTIVITIES

Lesson 1: Stability of Atoms (*Refer to the Student's Book*)

- The teacher should introduce the lesson by asking the learners to carry out **Activity 1.1**.

Activity 1.1: Showing stability of atoms (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity on their own and then discuss their observations with their classmates. He/She should further brainstorm the learners with the leading questions given in the activity.
- After completion of activity, the teacher should ask the learners to read lesson 1 and discuss with them how atoms achieve stability.
- He/She should further ask the learners to do **Exercise 1.1** to assess achievement of objectives.

Lesson 2: Formation of Ions from Atoms (*Refer to the Student's Book*)

- The teacher should ask the learners to carry out **Activity 1.2** to learn about formation of ions.

Activity 1.2: Illustrating formation of ion (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to illustrate formation of ions from atoms. He/She should further brainstorm the learners with the leading questions given in the activity.
- After completion of activity, the teacher should ask the learners to read the lesson and discuss with them how ions are formed.
- He/She should further ask the learners to do **Exercise 1.2** to assess the achievement of objectives.

Lesson 3: Ionic Bonding (*Refer to the Student's Book*)

- The teacher should ask the learners to read the text given in the Student's Book on Ionic Bonding.
- He/She should discuss some of the common ionic compounds, their formulae and the ions present in them with the learners.
- He/She should further ask the learners to do **Exercise 1.3** to assess the achievement of objectives.

Lesson 4: Formation of Ionic Bond (*Refer to the Student's Book*)

- The teacher should ask the learners to read the text given in the Student's Book on formation of Ionic bonds.
- With the help of examples given in the Student's Book, the teacher should discuss the formation of ionic bonds with the learners.
- After discussion, ask them to do **Exercise 1.4** to assess the achievement of objectives.

Lesson 5: Properties of Ionic Compounds (*Refer to the Student's Book*)

- The teacher should ask the learners to carry out **Activity 1.3**.

Activity 1.3: Illustrating physical properties of ionic compounds
(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to illustrate physical properties of ionic compounds.
- After completion of the activity, the teacher should ask the learners to tell what they infer about the nature of the compound from their observations.
- Thereafter, he/she should ask the learners to read the text given in the Student's Book and then discuss the general properties of ionic compounds with the learners.
- After the learners read the lesson, ask them to do **Exercise 1.5** to assess the achievement of objectives.

Lesson 6: Covalent Bonding (*Refer to the Student's Book*)

- The teacher should ask the learners to read the text given in the Student's Book on Covalent Bonding.
- After the learners read the lesson, the teacher should discuss the concept of covalent bonding and the formulae and nomenclature of some covalent compounds with the learners.
- He/She should further ask the learners to do **Exercise 1.6** to assess the achievement of objectives.

Lesson 7: Formation of Covalent Bond (*Refer to the Student's Book*)

- The teacher should ask the learners to read the text given in the Student's Book on formation of covalent bond.
- With the help of examples given in the Student's Book, the teacher should discuss the formation of covalent bonds with the learners.
- After discussion, ask them to do **Exercise 1.7** to assess the achievement of objectives.

Lesson 8: Properties of Covalent Compounds (*Refer to the Student's Book*)

The teacher should ask the learners to carry out **Activity 1.4**.

Activity 1.4: Illustrating physical properties of covalent compounds

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to illustrate physical properties of covalent compounds.
- After completion of the activity, the teacher should ask the learners to tell what they infer about the nature of the compound from their observations.
- Thereafter, he/she should ask the learners to read the text given in the Student's Book and then discuss the general properties of covalent compounds with the learners.
- After discussion, ask them to carry out **Activities 1.5** and **1.6** to detect an ionic or covalent bond.

Activity 1.5: Detecting an ionic bond or covalent bond (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book.
- He/She should ask the learners to conclude the bond present in the sample on the basis of their observations and make a report on the properties of ionic and covalent compounds.

- Thereafter, he/she should ask the learners to read the text given in the Student's Book and discuss the differences between ionic compounds and covalent compounds.

Activity 1.6: Identifying ionic and covalent compounds (*Refer to the Student's Book***)**

- The teacher should guide the learners to carry out the activity on their own.
- After the learners carry out the activity, ask them to do **Exercise 1.8** to assess the achievement of objectives.

Lesson 9: Giant Covalent Structures (*Refer to the Student's Book*)

- The teacher should ask the learners to read the text given in the Student's Book on Giant Covalent Structures.
- With the help of examples given in the Student's Book, he/she should discuss with the learners the properties and uses of diamond and graphite.
- After discussion, ask the learners to do **Exercise 1.9** to assess the achievement of objectives.

Lesson 10: Metallic Bonding (*Refer to the Student's Book*)

- The teacher should ask the learners to read the text given in the Student's Book on metallic bonding.

Lesson 11: Formation of Metallic Bond (*Refer to the Student's Book*)

- The teacher should ask the learners to read the text given in the Student's Book on formation of metallic bond.
- With the help of the diagram given in the Student's Book, the teacher should discuss with the learners the **electron sea model** for metallic bonding proposed by Loreutz.
- After discussion, ask the learners to do **Exercise 1.10** to assess the achievement of objectives.

Lesson 12: Properties of Metallic Bond (*Refer to the Student's Book*)

- The teacher should ask the learners to carry out **Activity 1.7** and **Activity 1.8**.

Activity 1.7: Illustrating the properties of metals (*Refer to the Student's Book***)**

- The teacher should provide samples of iron, copper, aluminium, sodium, carbon and iodine to the learners and guide them to carry out the activity as per the procedure given in the Student's Book and to note down their observations about the properties of metals.
- He/She should ask them to carry out **Activity 1.8** to illustrate conduction of heat and electricity in metals.

Activity 1.8: Illustrating conductivity of heat and electricity of metals

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity on their own and record their observations regarding properties of metals. He/She should further brainstorm the learners with the leading questions given in the activity.
- After completion of the activity, the teacher should ask the learners to read the text on properties of metals given in the Student's Book and discuss among themselves.
- After discussion, ask the learners to do **Exercise 1.11** to assess the achievement of objectives.

1.9 ANSWERS TO IN-TEXT EXERCISES

Exercise 1.1 (*Refer to the Student's Book*)

1. The force which links the atoms (or ions) in molecule is called a chemical bond.

2. When a bond is formed, each atom acquires a stable configuration similar to **noble gas.**

3. True

4. (*c*); *Explanation:* Noble gases are helium, neon, argon, krypton, xenon and radon.

5. Calcium achieves stability by losing two electrons.

Exercise 1.2 (*Refer to the Student's Book*)

1. An **ion** is an atom or a molecule in which the total number of electrons is not equal to the total number of protons, giving the atom or molecule a net positive or negative electrical charge.

2. (*a*); *Explanation:* Cl^- is anion and Na^+, Mg^{2+}, and Al^{3+} are cations.

3. A metal loses its outermost electron(s) to form a positive ion or **cation**. Metal ions carry positive charges because the number of positively charged protons in the nucleus becomes greater than the number of negatively charged electrons surrounding it.

4. True

5. (*i*) Anion: Chloride ion (Cl^-), Hydroxide ion (OH^-), Bromide ion (Br^-), etc.
(*ii*) Cation: Sodium ion (Na^+), Calcium ion (Ca^{2+}), Aluminium ion (Al^{3+}), etc.

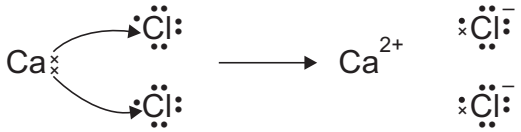
Exercise 1.3 (*Refer to the Student's Book*)

1. Ionic compounds: Sodium chloride, magnesium chloride (for more example refer to textbook "Comprehensive Chemistry for Rwanda Schools Student's Book—Secondary 2" Table 1.5).

2. True
3. Ions present in calcium nitrate are calcium ion (Ca^{2+}) and nitrate ion (NO_3^-).
4. Ionic compounds are made up of a **metal** and a **non-metal**.
5. Ammonium chloride is an ionic compound made up of only non-metals.

Exercise 1.4 (*Refer to the Student's Book*)

1. Formation of $CaCl_2$ using cross-dot



2. (*a*)
3. True

Exercise 1.5 (*Refer to the Student's Book*)

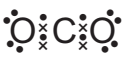
1. Ionic compounds conduct electricity when dissolved in water because ionic solid (crystal) is broken down to form ions. These ions help in conducting electricity.
2. (*c*); *Explanation:* Ionic compounds are usually soluble in water but insoluble in organic solvents like petrol and kerosene.
3. False; *Explanation:* Ionic compounds have high melting and high boiling points.
4. Ionic compounds are usually **crystalline** solids.

Exercise 1.6 (*Refer to the Student's Book*)

1. The chemical bond formed by sharing of electrons between two atoms is known as a **covalent bond**.
2. Refer to textbook "Comprehensive Chemistry for Rwanda Schools Student's Book—Secondary 2" Table 1.7.
3. When a **non-metal** combines with another **non-metal**, covalent bond is formed.
4. (*d*); Refer to textbook "Comprehensive Chemistry for Rwanda Schools Student's Book—Secondary 2" Table 1.7.

Exercise 1.7 (*Refer to the Student's Book*)

1. Formation of CO_2 using cross-dot



2. (*b*)
3. False; *Explanation :* Refer to textbook "Comprehensive Chemistry for Rwanda Schools Student's Book—Secondary 2" Table 1.7.

4. In the formation of covalent bonding, **sharing** of electrons takes place in the **outermost** shells of atoms.

Exercise 1.8 (*Refer to the Student's Book*)

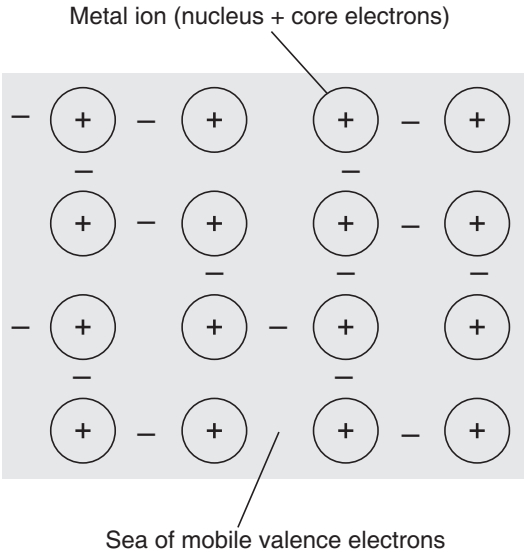
1. **True;** Only some of the covalent compounds are solids. For example glucose, urea, and wax are solid covalent compounds.
2. Most covalent compounds are usually **insoluble** in water, but **soluble** in organic solvents.
3. Glucose, sugar and urea are soluble in water.
4. Most covalent compounds do not conduct electricity because they do not contain ions.
5. (*b*); *Explanation:* Covalent compounds have usually low melting points and low boiling points.

Exercise 1.9 (*Refer to the Student's Book*)

1. True
2. (*a*); *Explanation:*
   - Graphite has very high melting point.
   - Graphite is a good conductor of electricity.
   - Diamond burns on strong heating to form carbon dioxide gas.
3. Diamond is used in making jewellery because of its extraordinary brilliance.
4. (*c*)
5. Diamond and graphite have very **high** melting point.

Exercise 1.10 (*Refer to the Student's Book*)

1. Loreutz proposed the theory of electron gas model or **electron sea model** for metallic bonding.
2. True
3. The force which binds various metal atoms together is called **metallic bond**.
4. 3D model of electron sea



5. Refer to "Comprehensive Chemistry for Rwanda Schools Student's Book—Secondary 2" Sub-unit 1.11.

Exercise 1.11 (*Refer to the Student's Book*)

1. Silver metal is the best conductor of electricity.

2. False; *Explanation:* Copper metal is a better conductor of heat than aluminium metal.

3. Metals are **malleable**. This means that metals can be hammered into thin sheets.

4. The cooking utensils are made of metals because they are good conductors of heat.

5. (*d*); All statements are correct.

1.10 ANSWERS TO UNIT ASSESSMENT

I. Multiple Choice Questions (*Refer to the Student's Book*)

1. (*d*)	**2.** (*c*)	**3.** (*b*)	**4.** (*a*)	**5.** (*a*)
6. (*d*)	**7.** (*d*)	**8.** (*c*)	**9.** (*a*)	**10.** (*a*)

II. Open Ended Questions (*Refer to the Student's Book*)

1. An atom achieves a stable configuration by

- Metals atoms with one, two or three electrons in the outermost shell lose electron(s) to form positively charged ions (cations)
- Non-metals atoms with five, six or seven electrons in the outermost shell gain three, two and one electron(s) to form negatively charged ions (anions)

- Two non-metallic elements with four to seven outermost electrons may gain electrons by sharing them with each other.

2. Covalent compound is formed when atoms achieve a stable electronic configuration by sharing of electrons.

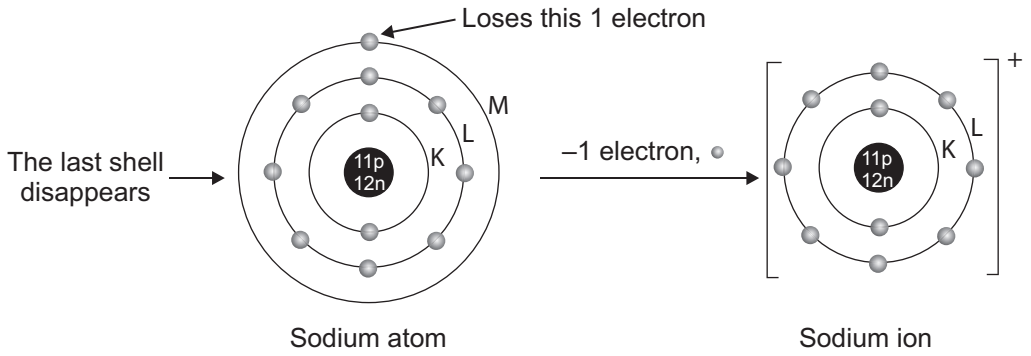
Ionic compounds are formed by attraction of positive and negative ions.

3. Comparison between the properties of ionic and covalent compounds are given in the following table:

Ionic Compounds	Covalent Compounds
They have high melting and boiling points.	They have low melting and boiling points.
They conduct electricity.	They do not conduct electricity.
These compounds are crystalline solid.	Generally, covalent compounds are liquid or gases.
Examples: Sodium chloride, Ammonium chloride, calcium oxide, etc.	Examples: Carbon dioxide, methane, sucrose, urea, etc.

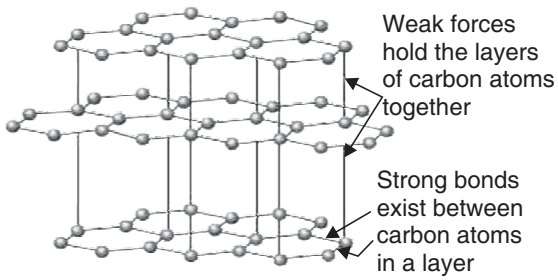
4. Formation of Sodium Ion (Na^+). The atomic number of sodium is 11. So, one atom of sodium contains 11 electrons. The electronic configuration of sodium is 2, 8, 1. We find that sodium atom has one electron in its last shell (M shell). This is not a stable configuration. To become stable, sodium atom donates its one electron of M shell to other atoms (like chlorine). In this way, the whole M shell is removed and the L shell has eight electrons. As the last shell now has eight electrons, the atom is now stable.

When sodium atom loses one electron, it has 11 protons but 10 electrons. Due to 1 more proton than the number of electrons, sodium ion has a positive charge. The diagrammatic representation of the formation of sodium ion is shown in figure.



Formation of Sodium Ion

5. **Ionic compounds:** Sodium chloride (NaCl), Calcium chloride ($CaCl_2$), Sodium hydroxide (NaOH), Sodium fluoride (NaF), Calcium hydroxide ($Ca(OH)_2$)
   Covalent Compounds: Water (H_2O), Methane (CH_4), Ammonia (NH_3), Carbon dioxide (CO_2), Benzene (C_6H_6)
6. Sodium chloride solution conducts electricity whereas distilled water does not.
7. The uses of diamond are:
   (*a*) It is used for cutting and grinding other hard materials.
   (*b*) It is used for making jewellery.
   (*c*) It is also used in the tip of glass cutter.
   (*d*) A sharp diamond-edged knife called keratome is used by eye surgeons to remove cataract from the eyes.
8. The structure of graphite is



9. The Physical properties of metals are:
   (*a*) Metals are lustrous (or shiny). This means that metals have a shiny appearance.
   (*b*) Metals are usually strong. For example, iron metal (in the form of steel) is very strong and is used in the construction of bridges, buildings and vehicles.
   (*c*) Metals are ductile.
   (*d*) Metals are malleable.
   (*e*) Metals are good conductors of heat and electricity.

III. Practical-based Questions

(*Refer to the Student's Book*)

1. (*c*) **2.** (*b*) **3.** (*c*) **4.** (*c*) **5.** (*a*)
6. (*a*)

1.11 PROJECT

(*Refer to the Student's Book*)

The teacher should guide the learners to carry out the project on their own.

UNIT 2: TRENDS IN PROPERTIES OF ELEMENTS IN THE PERIODIC TABLE

(*Refer to the Student's Book*)

2.1 LEARNING OBJECTIVES

At the end of this unit, the learners would be able to:

Knowledge and Understanding	Skills	Attitudes and Values
• Describe trends in reactive elements with acids, water, and halogens. • Explain the trends in the physical properties across a period and down a group.	• Classify elements into metals, metalloids and non-metals. • Compare and contrast the physical properties of metals and non-metals using simple experiments. • Compare the reactivity of metals across the period and down the group with the help of simple experiments.	• Respect the procedures during practical activities. • Develop teamwork in group activities. • Appreciate that some elements exhibit a mixture of the properties of metals and non-metals and are therefore best described as metalloids.

2.2 LESSONS AND TIME ALLOCATION

Lessons	Periods required	Total periods
2.1 Classification of Elements • Variation in Metallic and Non-Metallic Characters Across a Period • Variation in Metallic and Non-Metallic Characters Along a Group • Metals • Non-Metals • Metalloids	1	**8**

2.2 Physical Properties of Metals	1	
2.3 Physical Properties of Non-Metals		
2.4 Trends in Reactivity for Metals and Non-Metals • Reactivity of Metals • Reactivity of Non-Metals	1	
2.5 Chemical Properties of Metals • Reaction of Metals with Water • Reaction of Metals with Acids • Reaction of Metals with Halogens • Reaction of Metals with Oxygen	1	
2.6 Chemical Properties of Non-Metals • Reaction of Non-Metals with Halogen (Chlorine) • Reaction of Non-Metals with Oxygen	1	
2.7 Comparison Among the Physical and Chemical Properties of Metals and Non-Metals	1	
2.8 Uses of Metals and Non-Metals	1	
Assessment	1	

2.3 CONTENT MAP

Introduction

This unit discusses trends in reactive elements with acids, water, and halogens. It also explains the trends in the physical properties across a period and down a group.

Classroom Organisation

Whole class orientation, individual work and then working in groups.

Teaching and Learning Materials

- Paper, Pen, Pencil, Computers, and Internet connection

Teaching Aids

- **Audio-video:** Video showing reaction of different elements with acid, water, oxygen and halogen.
- **Notes:** Chemical formula of metal oxide, metal chloride, metal salt, non-metal oxide, and non-metal chloride.

- **PowerPoint Presentation:** Showing reactivity of metals and non-metals with acids, water, and halogens.
- **Visual:** Different types of metals.

Activities

- In groups, use the Periodic Table to classify elements into metals, metalloids and non-metals.
- Carry out experiments to illustrate the difference between properties of metals and non-metals.
- Carry out experiments to show the reaction of metals with water, acids and oxygen.

Competences Practised

- Literacy
- Numeracy
- Critical thinking
- Creativity and innovation
- Research and problem solving
- Communication in official languages
- Co-operation, inter-personal relations and life skills

Revision

- Objective type questions are provided at the end of each unit.
- Short answer type questions are provided at the end of each unit.

Assessments

- A formative assessment task of image collection
- A formative assessment of creativity

2.4 FOR MORE INFORMATION VISIT

- http://www.chem4kids.com/files/elem_intro.html
- http://www.ducksters.com/science/periodic_table.php
- http://www.ducksters.com/science/chemistry/nonmetals.php
- http://www.sciencekids.co.nz/sciencefacts/metals.html
- http://encyclopedia.kids.net.au/page/no/Non-metal

2.5 ASSESSMENT

1. Name a metal which can be cut with a knife?
2. Which metal is the best conductor of electricity?

3. Which metal is the poorest conductor of electricity?
4. Which metal is the most ductile?
5. Which metal is the best conductor of heat?
6. Which metal can melt in your hand by body heat?
7. Which metal is the poorest conductor of heat?
8. What is the nature of oxides of metal?
9. What is the nature of oxides of non-metal?
10. Which non-metal conducts electricity?
11. Which non-metal is lustrous?
12. Why metals are hard and have high melting point?
13. A zinc plate was kept in a $CuSO_4$ container. After few days, the zinc plate developed holes. Why?

Answers

1. Sodium
2. Silver
3. Iron
4. Gold
5. Silver (and copper)
6. Gallium
7. Lead (and mercury)
8. Basic
9. Acidic
10. Graphite, allotrope of carbon conduct electricity.
11. Iodine
12. Metals are hard and have high melting and boiling points because of the strong electrostatic forces which exist among the cations and delocalised electrons. Moreover, they have giant structures which result in so big magnitudes of electrostatic forces
13. Zinc reacts with copper sulphate to form zinc sulphate. Because of chemical reaction the zinc plate developed holes.

2.6 ADDITIONAL ACTIVITY

Reactivity of Metals with Acid

1. Take three element samples.
2. Put each metal sample in a separate test tube.
3. Add exactly five drops of acid to each well.

4. Observe each well for three minutes. Record any changes or occurrences and decide whether the sample reacted with acid or not (changes include: colour change or bubbling).

2.7 TEACHING METHODOLOGY AND LEARNING ACTIVITIES

Lesson 1: Classification of Elements (*Refer to the Student's Book*)

- The teacher should introduce the lesson by asking learners to carry out **Activity 2.1**.

Activity 2.1: Distinguishing metallic and non-metallic objects

(*Refer to the Student's Book*)

- The teacher should ask learners to collect five objects made of metals and five made of non-metals and compare the physical properties of metallic objects and non-metallic objects.
- After the activity, the teacher should ask the learners to observe figure 2.1 (Periodic table).
- He/She should discuss with the learners the elements in periodic table and ask them to carry out **Activity 2.2**.

Activity 2.2: Categorising elements into metals, non-metals and metalloids

(*Refer to the Student's Book*)

- The teacher should split class into small groups and ask them to classify all elements of periodic table into metals, metalloids and non-metals.
- After completion of the activity, discuss with learners that in the periodic table, there is a regular variation in the properties of elements in groups and periods.

Variation in Metallic and Non-metallic Characters Across a Period

(*Refer to the Student's Book*)

- The teacher should ask the learners to observe figure 2.2 (*a*) and read the given text in the Student's Book.
- After learners read the text, ask them to do **Exercise 2.1** to assess the achievement of objectives.

Variation in Metallic and Non-metallic Characters Along a Group

(*Refer to the Student's Book*)

- The teacher should ask the learners to observe figure 2.2 (*b*) and (*c*) and read the given text in the Student's Book.
- After learners read the text, ask them to do **Exercise 2.2** to assess the achievement of objectives.

Metals (*Refer to the Student's Book*)

- The teacher should ask the learners to read the text related to metals given in the Student's Book.
- After learners read the text, ask them to do **Exercise 2.3** to assess the achievement of objectives.

Non-metals (*Refer to the Student's Book*)

- The teacher should ask the learners to observe **figure 2.3 (*b*)** and read the text related to non-metals given in the Student's Book.
- After learners read the text, ask them to do **Exercise 2.4** to assess the achievement of objectives.

Metalloids (*Refer to the Student's Book*)

- The teacher should ask the learners to observe **figure 2.4** and read the text related to metalloids given in the Student's Book.
- After learners read the text, ask them to do **Exercise 2.5** to assess the achievement of objectives.

Lesson 2: Physical Properties of Metals (*Refer to the Student's Book*)

- The teacher should begin the lesson by asking the learners to carry out **Activity 2.3**.

Activity 2.3: Illustrating physical properties of metals (*Refer to the Student's Book*)

- The teacher should ask the learners to collect some metallic objects and note their physical properties. Ask them to make a report on their findings.
- He/She should ask the learners to read the text related to physical properties of metals given in the Student's Book and carry out **Activities 2.4 to 2.8** illustrating various physical properties of metals.

Activity 2.4: Illustrating the appearance of metals (*Refer to the Student's Book*)

- The teacher should provide to learners the samples of iron, copper, aluminium and magnesium and guide them to perform the activity as given in the Student's Book.

Activity 2.5: Illustrating the variation of hardness in metals

(*Refer to the Student's Book*)

- The teacher should provide to learners small pieces of iron, copper, aluminium, and magnesium and guide them to perform the activity as given in the Student's Book.

Activity 2.6: Illustrating the malleability of metals (*Refer to the Student's Book*)

- The teacher should provide to learners some pieces of iron, zinc, lead and copper and guide them to perform the activity as given in the Student's Book.

Activity 2.7: Illustrating thermal conductivity in metals

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the steps given in the Student's Book.

Activity 2.8: Showing that a metal conducts electricity (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the steps given in the Student's Book.
- After learners read the text and carry out the activities, ask them to do **Exercise 2.6** to assess the achievement of objectives.

Lesson 3: Physical Properties of Non-metals

(*Refer to the Student's Book*)

- The teacher should begin the lesson by asking the learners to carry out **Activity 2.9**.

Activity 2.9: Showing that a non-metal does not conduct electricity

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the steps given in the Student's Book.
- After completion of the activity, ask the learners to read the text related to the physical properties of non-metals given in the Student's Book and carry out **Activity 2.10**.

Activity 2.10: Illustrating thermal conductivity in non-metals

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity, as per the steps given in the Student's Book.
- After learners read the text and carry out the activities, ask them to do **Exercise 2.7** to assess the achievement of objectives.

Lesson 4: Trends in Reactivity of Metals and Non-metals

(*Refer to the Student's Book*)

- The teacher should ask the learners to read the text related to reactivity of metals and non-metals.

- After learners read and discuss the text, ask them to do **Exercise 2.8** to assess the achievement of objectives.

Lesson 5: Chemical Properties of Metals (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out **Activity 2.11**.

Activity 2.11: Illustrating reaction of metals with water

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to illustrate reaction of metals with water.
- After completion of the activity, the teacher should ask the learners to read the text related to the reaction of metals with water given in the Student's Book and then discuss the reactivity of different metals with water.
- After discussing reaction of different metals with water, ask the learners to carry out **Activity 2.12**.

Activity 2.12: Illustrating reaction of metals with dilute acids

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to illustrate reaction of metals with acids.
- After completion of the activity, the teacher should ask the learners to read the text related to the reaction of metals with acids given in the Student's Book.
- The teacher should further ask the learners to read the text related to reaction of metals with halogens and with oxygen as given in the Student's Book.

Activity 2.13: Illustrating reaction of metals with oxygen

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the steps given in the Student's Book.
- After completion of the activity, ask the learners to read the text related to reaction of metals with oxygen.
- After learners read and discuss the text, ask them to do **Exercise 2.9** to assess the achievement of objectives.

Lesson 6: Chemical Properties of Non-metals

(*Refer to the Student's Book*)

- The teacher should ask the learners to read and discuss the text related to chemical properties of non-metals.
- After learners read and discuss the text, ask them to do **Exercise 2.10** to assess the achievement of objectives.

Lesson 7: Comparison Among the Physical and Chemical Properties of Metals and Non-metals (*Refer to the Student's Book*)

- The teacher should ask the learners to read and discuss among themselves the text given in the Student's Book on comparison among the physical and chemical properties of metals and non-metals.

Lesson 8: Uses of Metals and Non-metals (*Refer to the Student's Book*)

- The teacher should ask the learners to read and discuss among themselves the text given in the Student's Book on uses of metals and non-metals.
- After learners read and discuss the text, ask them to do **Exercise 2.11** to assess the achievement of objectives.

2.8 ANSWERS TO IN-TEXT EXERCISES

Exercise 2.1 (*Refer to the Student's Book*)

1. On moving from left to right in a period, the metallic character of elements **decreases**.

2. Sodium, magnesium and aluminium are three metals in third period of periodic table.

3. True

4. (*b*); *Explanation:* Silicon (Si)is the only metalloid among all the given options.

Exercise 2.2 (*Refer to the Student's Book*)

1. On moving down in a group of the periodic table, the non-metallic character of elements **decreases**.

2. True

Exercise 2.3 (*Refer to the Student's Book*)

1. Mercury (Hg) is the only liquid metal.

2. A majority of known **elements** (about 80%) are metals.

3. True

4. (*a*)

5. The main metal deposits in our country are **tin**, **coltan** and **tungsten**.

Exercise 2.4 (*Refer to the Student's Book*)

1. Bromine (Br) is the only liquid non-metal.
2. Total eleven non-metals are gases. *Explanation*: Hydrogen, Nitrogen, Oxygen, Fluorine, Chlorine and six Noble gases.
3. True
4. (*b*)
5. Non-metals are also used to make **vegetable oil**, **acids**, **fertilisers**, and **fungicides**.

Exercise 2.5 (*Refer to the Student's Book*)

1. The metalloids are Boron, Silicon, Germanium, Arsenic, Antimony, Tellurium and Polonium
2. True
3. Silicon is used in making **computer chips**.
4. (*d*)

Exercise 2.6 (*Refer to the Student's Book*)

1. Gold metal is yellow in colour.
2. Uses of metals are:
   - gold and silver are used for making jewellery
   - iron is used in machines, chains and vehicles
   - copper and aluminium are used in making electrical wires and utensils
   - aluminium foils are used for packing medicines and cigarettes
   - tungsten is used in making filaments of bulb
3. All metals can be beaten (hammered) into very thin sheets without breaking. This property of metals is called malleability.
4. All metals are good conductors of electricity because they contain free electrons. These free electrons can move easily through the metal and conduct electric current.
5. (*c*)

Exercise 2.7 (*Refer to the Student's Book*)

1. True
2. **Oxygen** and **Hydrogen** are colourless non-metals.
3. Graphite, an allotrope of carbon, is used for making electrodes.
4. Non-metals do not conduct heat and electricity because they have no free electrons which are necessary to conduct heat and electricity.
5. (*d*)

Exercise 2.8 **(***Refer to the Student's Book***)**

1. As we go down in a group of metals, the tendency of their atoms to lose electrons increases, and hence, their chemical reactivity also increases.
2. (*b*)
3. As we go down a group of non-metals the tendency of their atoms to gain electrons decreases, thus their reactivity decreases.
4. True

Exercise 2.9 (*Refer to the Student's Book*)

1. **Steam** is a gaseous form of water.
2. False; *Explanation*: Generally, metals react with cold water or hot water to form metal hydroxide and hydrogen gas.
3. False; *Explanation*: Generally, metals react with steam to form metal oxide and hydrogen gas.
4. (*i*) $\underset{\text{Sodium}}{2Na(s)} + \underset{\substack{\text{Water}\\\text{(cold)}}}{2H_2O(l)} \xrightarrow{} \underset{\substack{\text{Sodium}\\\text{hydroxide}}}{2NaOH(aq)} + \underset{\text{Hydrogen}}{H_2(g)} + \text{Heat}$

   (*ii*) $\underset{\text{Magnesium}}{Mg(s)} + \underset{\substack{\text{Dilute hydrochloric}\\\text{acid}}}{2HCl(aq)} \xrightarrow{} \underset{\substack{\text{Magnesium}\\\text{chloride}}}{MgCl_2(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$

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

   (*iv*) $\underset{\text{Aluminium}}{2Al(s)} + \underset{\text{Chloride}}{3Cl_2(g)} \xrightarrow{} \underset{\substack{\text{Aluminium}\\\text{chloride}}}{2AlCl_3(s)}$

   (*v*) $4K(s) + O_2(g) \longrightarrow 2K_2O(s)$
5. Gold and Silver **do not** react with dilute acids.
6. Hydrogen gas is not evolved when a metal reacts with **nitric acid**.

   At low concentrations of nitric acid , magnesium reacts with nitric acid to liberate hydrogen gas. $Mg(s) + HNO_3(aq) \longrightarrow Mg(NO_3)_2(aq) + H_2(g)$
7. True

Exercise 2.10 (*Refer to the Student's Book*)

1. **True**
2. Non-metals react with **chlorine** to form covalent chlorides.
3. (*c*); *Explanation*: Non-metals react with oxygen to form acidic oxides or neutral

oxides.

4. (*i*) $\underset{\text{Hydrogen}}{2H_2(g)} + \underset{\text{Oxygen}}{O_2(g)} \xrightarrow{} \underset{\text{Water}}{2H_2O(l)}$

(*ii*) $\underset{\text{Carbon}}{C(s)} + \underset{\text{Chlorine}}{2Cl_2(g)} \xrightarrow{} \underset{\text{Carbon tetrachloride}}{CCl_4(g)}$

5. True

Exercise 2.11 (*Refer to the Student's Book*)

1. (*a*) **True** (*b*) **False** (*c*) **True** (*d*) **True** (*e*) **False**

2. (*a*) Sulphur is used for making **fire crackers**, **gun powder** and **sulphuric acid**.
(*b*) Silicon is used for making **microchips**.
(*c*) Sodium is used in **nuclear reactors**.

3. **Argon** is used in electrical bulbs and fluorescent tubes.

4. **Tin** is used for coating iron containers for packaging food.

5. **Steel and iron** are used for making machines.

2.9 ANSWERS TO UNIT ASSESSMENT

I. Multiple Choice Questions (*Refer to the Student's Book*)

1. (*c*)	**2.** (*a*)	**3.** (*b*)	**4.** (*c*)	**5.** (*a*)
6. (*c*)	**7.** (*c*)	**8.** (*b*)	**9.** (*a*)	**10.** (*c*)

II. Open Ended Questions (*Refer to the Student's Book*)

1. Metals are ductile, means they can be drawn into thin wires. All the metals are not equally ductile. Gold and silver are the best ductile metals. Just one gram of gold can be stretched into a wire of about 2 km length.

Metals are malleable, means they can be beaten (hammered) into very thin sheets without breaking. This property of metals is called malleability. Gold and silver are the most malleable metals. These can be beaten into very thin sheets called foils. Aluminium foils are used for packing medicines and cigarettes.

2. **Metals** are lustrous, malleable, ductile and are good conductors of heat and electricity. They are solids at room temperature, except mercury which is a liquid. Examples: Iron, copper, aluminium, magnesium, etc.

Non-metals have properties opposite to that of metals. They are neither malleable nor ductile. They are bad conductors of heat and electricity, except for graphite, which conducts electricity. Example: Oxygen, hydrogen, nitrogen, helium, argon, etc.

3. Liquid metal: Mercury

Liquid non-metal: Bromine

4. (*a*) Aluminium (*b*) Oxygen (*c*) Gallium (*d*) Phosphorus (*e*) Sodium

5. I. $\underset{\text{Potassium}}{2K(s)} + \underset{\text{Water (cold)}}{2H_2O(l)} \longrightarrow \underset{\substack{\text{Potassium}\\\text{hydroxide}}}{2KOH(aq)} + \underset{\text{Hydrogen}}{H_2(g)} + \text{Heat}$

II. $\underset{\text{Magnesium}}{Mg(s)} + \underset{\text{Steam}}{H_2O} \longrightarrow \underset{\substack{\text{Magnesium}\\\text{oxide}}}{MgO(s)} + \underset{\text{Hydrogen}}{H_2(g)}$

III. $\underset{\text{Magnesium}}{Mg(s)} + \underset{\substack{\text{Water}\\\text{(Hot)}}}{2H_2O(l)} \longrightarrow \underset{\substack{\text{Magnesium}\\\text{hydroxide}}}{Mg(OH)_2(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$

IV. $\underset{\text{Calcium}}{Ca(s)} + \underset{\substack{\text{Sulphuric acid}\\\text{(dilute)}}}{H_2SO_4(s)} \longrightarrow \underset{\substack{\text{Calcium}\\\text{sulphate}}}{CaSO_4(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$

V. $\underset{\text{Silver Bromide}}{2AgBr(s)} \xrightarrow[\text{Decomposition}]{\text{Light}} \underset{\text{Silver}}{2Ag(s)} + \underset{\text{Bromine}}{Br_2(g)}$

VI. $\underset{\text{Phosphorus}}{P_4(s)} + \underset{\text{Chlorine}}{6Cl_2(g)} \text{ ¾ ®} \underset{\substack{\text{Phosphorus chloride}\\\text{(Covalent chloride)}}}{4PCl_3(l)}$

6. On moving from left to right in a period, the metallic character of elements decreases whereas the non-metallic character increases.
On going down in a group of the periodic table, the metallic character of elements increases whereas the non-metallic character of elements decreases.

7. Refer to Activity 2.8 and Activity 2.10 of Student's Book.

8. Differences between Chemical Properties of Metals and Non-metals

Metals	Non-metals
Metals form basic oxides.	Non-metals form acidic oxides or neutral oxides.
Metals displace hydrogen from water (or steam).	Non-metals do not react with water (or steam) and hence, do not displace hydrogen from water (or steam).
Metals displace hydrogen from dilute acids.	Non-metals do not react with dilute acids and hence, do not displace hydrogen from dilute acids.
Metals form ionic chlorides with chlorine.	Non-metals form covalent chlorides with chlorine.
Metals usually do not combine with hydrogen. Only a few reactive metals combine with hydrogen to form ionic metal hydrides.	Non-metals react with hydrogen to form stable, covalent hydrides.

9. Copper does not react with water because in the activity series of metals it is below the hydrogen.

10. ***Sulphur*** is used for making fire crackers, gun powder and sulphuric acid.
Helium is used in balloons.
Argon is used in electrical bulbs and fluorescent tubes.
Oxygen is absolutely essential for the respiration of all living body.

III. Practical-based Questions

(*Refer to the Student's Book*)

1. (*b*) **2.** (*d*) **3.** (*c*) **4.** (*b*) **5.** (*c*)

UNIT 3: WATER POLLUTION

(*Refer to the Student's Book*)

3.1 LEARNING OBJECTIVES

At the end of this unit, the learners would be able to:

Knowledge and Understanding	Skills	Attitudes and Values
• Define water pollution. • Identify the main water pollutants. • Describe the dangers of polluted water. • Suggest the ways of preventing water pollution.	• Develop research skills • Evaluate the ways of minimising pollution.	• Develop awareness of the dangers of polluted water. • Develop a sense of responsibility for caring about the environment.

3.2 LESSONS AND TIME ALLOCATION

Lessons	Periods Required	Total Periods
3.1 Water Pollution	1	**8**
3.2 Main Water Pollutants • Sewage • Nutrient-Rich Waste Water • Chemical Waste • Radioactive Waste • Oil Pollution • Plastic • Alien Species • Other Forms of Pollution	2	

3.3 Dangers of Polluted Water • Eutrophication • Acidification • Health Hazards	2	
3.4 Prevention of Water Pollution • Education • Laws • Economics	1	
3.5 Our Clean Future	1	
Assessment	1	

3.3 CONTENT MAP

Introduction

This unit defines water pollution and discusses the main water pollutants. It describes the dangers of polluted water and suggests the ways of preventing water pollution.

Classroom Organisation

Whole class orientation, individual work and then working in groups

Teaching and Learning Materials

- Paper, Pen, Pencil, Computers, and Internet connection

Teaching Aids

- **Audio-video:** Video showing harmful effect of water pollution
- **Notes: Name of different pollutants**
- **PowerPoint Presentation:** Ways of minimising pollution
- **Visual:** Disease caused by drinking polluted water.

Competences Practised

- Literacy
- Critical thinking
- Research and problem solving
- Numeracy
- Creativity and innovation
- Communication in official languages
- Co-operation, inter-personal relations and life skills

Vocabulary Acquisition

- Career terminology
- Science terminology
- Name of Chemicals

Revision

- Objective type questions are provided at the end of each unit.
- Short answer type questions are provided at the end of each unit.

Assessments

- A formative assessment task of image collection
- A formative assessment of creativity

3.4 SUPPLEMENTARY INFORMATION FOR THE TEACHER

Water pollution is the **contamination** of **water** bodies (e.g. lakes, rivers, oceans, aquifers and groundwater). This form of environmental degradation occurs when **pollutants** are directly or indirectly discharged into **water** bodies without adequate treatment to remove harmful compounds.

There are many types of water pollution because water comes from many sources. Here are a few types of water pollution:

1. **Nutrients Pollution.** Some wastewater, fertilisers and sewage contain high levels of nutrients. If they end up in water bodies, they encourage algae and weed growth in the water. This will make the water undrinkable, and even clog the filters. Too much algae will also use up all the oxygen in the water, and other water organisms in the water will die out of oxygen starvation.
2. **Surface water pollution.** Surface water includes natural water found on the earth's surface, like rivers, lakes, lagoons and oceans. Hazardous substances coming into contact with this surface water, dissolving or mixing physically with the water can be called surface water pollution.
3. **Oxygen Depleting.** Water bodies have micro-organisms. These include aerobic and anaerobic organisms. When to much biodegradable matter (things that easily decay) end up in water, it encourages more micro-organism growth, and they use up more oxygen in the water. If oxygen is depleted, aerobic organisms die, and anaerobic organisms grow more to produce harmful toxins such as ammonia and sulphides.
4. **Ground water pollution.** When humans apply pesticides and chemicals to soils, they are washed deep into the ground by rainwater. This gets to underground water, causing pollution underground.

   This means when we dig wells and bore holes to get water from underground, it needs to be checked for ground water pollution.

5. **Microbiological.** In many communities in the world, people drink untreated water (straight from a river or stream). Sometimes there is natural pollution caused by micro-organisms like viruses, bacteria and protozoa. This natural pollution can cause fishes and other water life to die. They can also cause serious illness to humans who drink from such waters.
6. **Suspended Matter.** Some pollutants (substances, particles and chemicals) do not easily dissolve in water. This kind of material is called particulate matter. Some suspended pollutants later settle under the water body. This can harm and even kill aquatic life that live at the floor of water bodies.
7. **Chemical Water Pollution.** Many industries and farmers work with chemicals that end up in water. This is common with Point-source Pollution. These include chemicals that are used to control weeds, insects and pests. Metals and solvents from industries can pollute water bodies. These are poisonous to many forms of aquatic life and may slow their development, make them infertile and kill them.
8. **Oil Spillage.** Oil spills usually have only a localised effect on wildlife but can spread for miles. The oil can cause the death to many fish and get stuck to the feathers of seabirds causing them to lose their ability to fly.

Effects of Water Pollution

The effects of water pollution are varied and depend on what chemicals are dumped and in which locations.

Many water bodies near urban areas (cities and towns) are highly polluted. This is the result of both garbage dumped by individuals and dangerous chemicals legally or illegally dumped by manufacturing industries, health centres, schools and market places.

- **Death of aquatic (water) animals.** The main problem caused by water pollution is that it kills life that depends on these water bodies. Dead fish, crabs, birds and seagulls, dolphins, and many other animals often wind up on beaches, killed by pollutants in their habitat (living environment).
- **Diseases.** Eventually, humans are affected by this process as well. People can get diseases such as hepatitis by eating seafood that has been poisoned. In many poor nations, there is always outbreak of cholera and diseases as a result of poor drinking water treatment from contaminated waters.
- **Destruction of ecosystems.** Ecosystems (the interaction of living things in a place, depending on each other for life) can be severely changed or destroyed by water pollution. Many areas are now being affected by careless human pollution, and this pollution is coming back to hurt humans in many ways.

Prevention of Water Pollution

Dealing with water pollution is something that everyone (including governments and local councils) needs to get involved with. Here are a few things you can do to help. Learning about the issue (like you are doing) is the greatest and most important step to take. Here are a few more:

You can help

- Never throw rubbish away anyhow. Always look for the correct waste bin. If there is none around, please take it home and put it in your trash can. This includes places like the beach, riverside and water bodies.
- Use water wisely. Do not keep the tap running when not in use. Also, you can reduce the amount of water you use in washing and bathing. If we all do this, we can significantly prevent water shortages and reduce the amount of dirty water that needs treatment.
- Do not throw chemicals, oils, paints and medicines down the sink drain, or the toilet. In many cities, your local environment office can help with the disposal of medicines and chemicals. Check with your local authorities if there is a chemical disposal plan for local residents.
- Buy more environmentally safe cleaning liquids for use at home and other public places. They are less dangerous to the environment.
- If you use chemicals and pesticides for your gardens and farms, be mindful not to overuse pesticides and fertilisers. This will reduce runoffs of the chemical into nearby water sources. Start looking at options of composing and using organic manure instead.

If you live close to a water body, try to plant lots of trees and flowers around your home, so that when it rains, chemicals from your home does not easily drain into the water.

Governments, Local Councils and Laws

Many governments have very strict laws that help minimise water pollution. These laws are usually directed at industries, hospitals, schools and market areas on how to dispose, treat and manage sewage. Do you know the laws in your country? This is the time to find out.

In many developed cities, waste or sewage treatment is very efficient, and designed to minimise pollution of water bodies.

There are also lots of organisations and groups that help educate people on the dangers of water pollution. It is always great to join these groups, because they regularly encourage other members of their communities to have a better attitude towards water.

3.5 FOR MORE INFORMATION VISIT

- http://www.numbeo.com/pollution/country_result.jsp?country=Rwanda
- http://eschooltoday.com/pollution/water-pollution/what-is-water-pollution.html
- http://www.kidsecologycorps.org/our-environment/natural-cycles/water-pollution
- http://www.conserve-energy-future.com/various-water-pollution-facts.php

3.6 ASSESSMENT

1. Name the causes of water pollution?

2. Explain the following briefly:

(*i*) Chemical waste

(*ii*) Radioactive waste

(*iii*) Oil pollution

Answers

1. The causes of water pollution are:

(*i*) Pathogens

(*ii*) Organic wastes

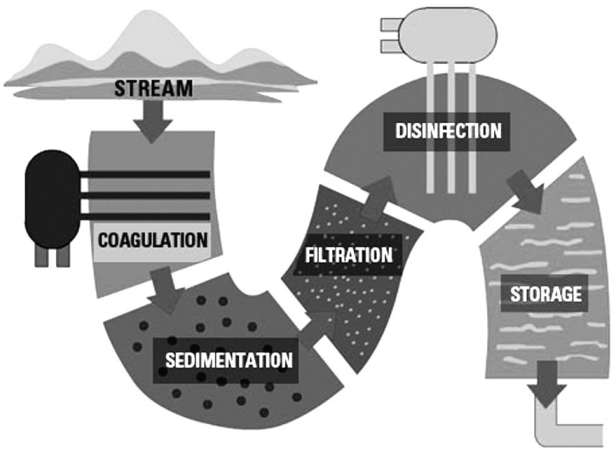
2. (*i*) The waste products produced by industries contain chemicals. These are called chemical wastes.

(*ii*) A waste that contains radioactive substance.

(*iii*) The pollution caused by oil and oil wastes is termed as oil pollution.

3.7 ADDITIONAL ACTIVITY

- Ask the learners to make an album showing main water pollutants.
  {Help the learners in making album}
- Ask the learners to make a model of water treatment plant.



Loading tank: Alum and other chemicals are added to the water at this stage. Suspended particles get stuck to the chemicals to form a loosely clumped mass of fine particles.

Sedimentation stage: As particles get stuck they become heavy and sink to the bottom of the chamber. At this stage, most of the particles are stuck to form sediments, sinking to the bottom. The water is passed onto the filtration chamber.

Filtration stage: As water passes slowly through this chamber, finer particles (sediments) are filtered out over layers of sand, charcoal and gravel.

Disinfection stage: Chlorine or any other kind of disinfection method is applied to kill any bacteria and other living organisms that may be in the water. It is very normal and natural for fresh water to contain living organisms.

Storage stage: The water is then passed into large storage tanks and left for a while for the action of disinfection to be complete. At the tail end of this storage tanks, huge pipes are connected to transport water to our homes and work places.

3.8 TEACHING METHODOLOGY AND LEARNING ACTIVITIES

Lesson 1: Water Pollution (*Refer to the Student's Book*)

- The teacher should introduce the lesson by asking the learners to carry out **Activity 3.1**.

Activity 3.1: Showing awareness about water pollution

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out an activity to investigate the level of awareness about water pollution in their area as per the procedure given in the Student's Book.
- He/She should ask the learners to prepare an illustrative presentation on "water pollution" from the data collected and present it in class.
- After completion of the activity, the teacher should ask the learners to read the text given in the Student's Book regarding causes of water pollution.

Activity 3.2: Illustrating effects of quantities **(***Refer to the Student's Book***)**

- The teacher should guide the learners to carry out the activity as given in the Student's Book to understand the effect of quantity of pollutants on the pollution.
- After completion of activity, ask the learners to do **Exercise 3.1** given on to assess the achievement of objectives.

Lesson 2: Main Water Pollutants (*Refer to the Student's Book*)

- The teacher should ask the learners to carry out **Activity 3.3**.

Activity 3.3: Illustrating major pollutants of water (*Refer to the Student's Book*)

- Guide the learners to visit their nearby water body and collect information on the major pollutants added to the water body.
- After completion of the activity, discuss the different water pollutants.

Activity 3.4: Illustrating disposal of sewage (*Refer to the Student's Book*)

- The teacher should divide the class into small groups and guide them to visit sewage disposal system in their areas to understand how sewage is disposed.
- After completion of the activity, discuss sewage disposal with the learners and then ask them to do **Exercise 3.2** to assess the achievement of objectives.
- The teacher should ask the learners to read the text about other pollutants of water such as nutrient-rich waste water, chemical waste, radioactive waste, oil pollution, plastics, alien species and other forms of pollution given in the Student's Book and ask the learners to do **Exercise 3.3 to 3.8** to assess the achievement of objectives.

Activity 3.5: Showing radioactive waste (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as given in the Student's Book.

Activity 3.6: Say no to plastics (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as given in the Student's Book.

Lesson 3: Dangers of Polluted Water (*Refer to the Student's Book*)

- The teacher should introduce the lesson by asking the learners to carry out **Activity 3.7**.

Activity 3.7: Illustrating effects of polluted water (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as given in the Student's Book to illustrate effects of polluted water.

Activity 3.8: Diseases caused by polluted water (*Refer to the Student's Book*)

- The teacher should guide the learners to design a questionnaire to find out how many students in their class have been affected by the diseases shown in the activity.
- After completion of activity, ask the learners to read the text on the water-borne diseases and their causes and then ask the learners to do **Exercise 3.9** to assess the achievement of objectives.

Lesson 4: Prevention of Water Pollution (*Refer to the Student's Book*)

- The teacher should ask the learners to carry out **Activity 3.9**.

Activity 3.9: Illustrating prevention of water pollution (*Refer to the Student's Book*)

- The teacher should guide the learners to make a poster/PowerPoint presentation on how we can save water as given in the Student's Book.
- After completion of activity, ask the learners to read and discuss the text given in the Student's Book on the importance of education, laws, and economics in preventing pollution.

Lesson 5: Our Clean Future (*Refer to the Student's Book*)

- The teacher should ask the learners to read the text given in the Student's Book regarding the steps we can take to prevent or reduce water pollution.
- After learners read the text, ask them to do **Exercise 3.10** to assess the achievement of objectives.

3.9 ANSWERS TO IN-TEXT EXERCISES

Exercise 3.1 (*Refer to the Student's Book*)

1. Most of the water which we use comes from **rivers** and **lakes**.
2. The contamination of water of rivers, lakes and ponds, etc., with unwanted and harmful substances is called water pollution.
3. *Escherichia coli* and *Streptococcus faecalis* are two pathogens which cause gastrointestinal diseases.
4. True
5. Causes of water pollution are:
   - Municipal and industrial discharge
   - Excessive phytoplankton growth within water
   - Domestic sewage and animal excreta.

Exercise 3.2 (*Refer to the Student's Book*)

1. Sewage generally consists of **faeces**, **urine** and **laundry waste**.
2. False
3. Sewage contains harmful micro-organisms such as bacteria, protozoa, fungi, viruses and parasites.

Exercise 3.3 (*Refer to the Student's Book*)

1. Nutrient-rich waste water causes rapid growth of green plants called **algae** in the water body.

2. Yes, because algae in the nutrient-rich waste water compete with other organisms in the water for dissolved oxygen.
3. Algae is the organism which covers the entire water body like a green sheet.

Exercise 3.4 (*Refer to the Student's Book*)

1. The poisonous chemicals produced by industries as their waste products are called chemical waste.
2. Chemical waste can cause **cancer** and **nervous disorders** in humans.
3. Compounds of harmful metals such as mercury, cadmium, lead, arsenic and nickel are present in chemical waste. These may also include detergents and polychlorinated biphenyls (PCBs).

Exercise 3.5 (*Refer to the Student's Book*)

1. A radioactive substance is a substance that is unstable and produces dangerous kinds of radiation.
2. Radioactive wastes are generated from **nuclear power plants** and **medical and scientific institutions**.
3. Radioactive waste can cause cancer.

Exercise 3.6 (*Refer to the Student's Book*)

1. Oil and oil wastes enter water bodies from different sources such as oil refineries, storage tanks, automobile waste oil, and spillage of oil from ships.
2. The pollution caused by oil and oil wastes is termed **oil pollution**.
3. Oil is insoluble in water; it floats and spreads rapidly into a thin layer. This layer prevents oxygen transfer from atmosphere. As a result of this, less oxygen is available for aquatic life such as animals and plants.

Exercise 3.7 (*Refer to thee Student's Book*)

1. **Polythene** is the most common plastic.
2. False
3. Use of plastics is prohibited because most plastics are not biodegradable (they do not break down naturally in the environment). Once in a water body, they amass in landfills, litter streets, obstruct sewers and hurt aquatic life.

Exercise 3.8 (*Refer to the Student's Book*)

1. Alien species (sometimes known as invasive species) are animals or plants from one region that have been introduced into a different ecosystem where they do not belong.
2. The **water hyacinth** is a major biodiversity problem of the Lake Victoria Basin.
3. Growth of **water hyacinth** can destroy aquatic life.

Exercise 3.9 (*Refer to the Student's Book*)

1. True
2. The pH of pure water is **7**.
3. Water pollution is harmful to **living beings** and **environment**.
4. The dangers of water pollution are eutrophication, acidification and health hazards.
5. Typhoid and Cholera are two water-borne diseases.

Exercise 3.10 (*Refer to the Student's Book*)

1. Different ways to solve water pollution:
   - ¬ Never throw rubbish in water bodies.
   - ¬ Do not throw chemicals, oils, paints and medicines down the sink drain, or the toilet.
   - ¬ Buy more environmentally safe cleaning liquids for use at home and other public places.
   - ¬ Do not overuse pesticides and fertilisers. This will reduce runoffs of the chemical into nearby water sources. Start looking at options of composting and using organic manure instead.
2. Yes, awareness helps to prevent disposal of human waste into waterways.
3. We should conserve water by decreasing our water consumption.
4. The 3Rs to prevent water pollution are:
   REFUSE: Say NO to Water pollution
   RECYCLE: Recycle water
   REDUCE: Minimise use of water
5. (*d*)

3.10 ANSWERS TO UNIT ASSESSMENT

I. Multiple Choice Questions (*Refer to the Student's Book*)

1. (*d*)	**2.** (*d*)	**3.** (*b*)	**4.** (*d*)	**5.** (*a*)
6. (*a*)	**7.** (*b*)	**8.** (*a*)	**9.** (*d*)	**10.** (*c*)

II. Open Ended Questions (*Refer to the Student's Book*)

1. Water pollution is the addition of any foreign substance (organic, inorganic, radioactive or biological) in water which produces harmful effect and decreases the usefulness of water.
2. The substances which cause water pollution *i.e.*, they cause harmful effect in water and decreases its usefulness are known as water pollutants.
   The major pollutants of water include:

(*a*) Sewage, (*b*) Nutrient-rich waste water,
(*c*) Chemical waste, (*d*) Radioactive waste,
(*e*) Oil pollution, (*f*) Plastic,
(*g*) Alien species and (*h*) other forms.

3. Plastic is the most common waste found in water. It is banned in Rwanda because
   (*a*) Plastic is one of the most common materials, used for packaging, and making any kind of manufactured object.
   (*b*) Plastic is light and floats easily so it can travel enormous distances across the oceans.
   (*c*) Most plastics are not biodegradable (they do not break down naturally in the environment). Once in a water body, they amass in landfills, litter streets, obstruct sewers and hurt marine life.

4. Alien species are animals or plants from one region that have been introduced into a different ecosystem where they do not belong. The water hyacinth which was introduced as an ornamental plant has since invaded lakes. Their rampant growth has destroyed native wetlands and waterways, killing native fishes and other wildlife.

5. Addition of pollutants to water changes its physical, chemical and biological properties. Dangers of polluted water include:

Eutrophication: The process of nutrient enrichment of aquatic ecosystems is called eutrophication. It blocks light to reach under water affecting aquatic plants. Thus, resulting in loss of aquatic life.

Acidification: Reduction in the pH of the ocean over an extended period of time, caused primarily by uptake of carbon dioxide (CO_2) from the atmosphere. This is called acidification. This affects corals and the ability of shellfish to form shells.

Health Hazard: Water pollution may not damage our health immediately but can be harmful after long term exposure. These can be responsible for a lot of water borne diseases. The discharge of harmful carcinogens can cause birth defects and cancer.

6. The process of nutrient enrichment of aquatic ecosystems is called eutrophication. It is caused due to the entry of nutrient-rich water into the aquatic body. It results in a thick growth of algae (tiny plant) called algal bloom, and many other weeds. Rapid growth of these plants covers the entire surface of water. The algae use up a lot of oxygen that other aquatic animals die due to lack of it.

It affects the water body by blocking light to reach under water. Eutrophication hence results in loss of aquatic life. Slowly, it results in the death of "lake or river".

7. There are different ways a water body gets polluted. Wastes from industries are discharged into rivers directly. These wastes affect in following ways:
   (*a*) Heavy metals can slow development; result in birth defects and some are carcinogenic, i.e., can cause cancer.

(*b*) Industrial waste can affect immune system, reproductive system or cause poisoning.

(*c*) Microbial pollutants from sewage often result in water-borne diseases that infect aquatic life and terrestrial life through drinking water. They can cause diseases like typhoid, cholera, infectious hepatitis and amoebic dysentery.

8. Education can help people determine their best strategies to avoid contaminating local water sources by

(*a*) Avoiding urinating or defecating in or near the water;

(*b*) Building toilets/sites for waste downhill from wells to reduce risks of contaminating groundwater;

(*c*) Employing household water treatment and safe storage techniques.

Awareness helps to prevent disposal of solid and human waste and chemical and industrial waste into waterways as much as possible. It also includes treating wastes before they go into waterways. Awareness can be spread through education camps, role plays and public involvement.

9. Polluter Pays Principle means that whoever causes pollution should have to pay to clean it up, one way or another. For example the factories that use rivers must have their water inlet pipes downstream of their effluent outflow pipes. If they cause pollution, they themselves are the first people to suffer. Ultimately, the polluter pays principle is designed to stop people from polluting.

10. We can work together to keep the environment clean so the plants, animals, and people who depend on it remain healthy. We can take individual action to help reduce water pollution. These steps are:

- By reducing the amount of water we use, you will reduce the amount of water that flows into sewage treatment systems.
- By using, environmental friendly house-hold products like biodegradable soap and all-natural toiletries.
- By applying natural pesticides and fertilisers in fields.
- By avoiding, littering in rivers, lakes, and oceans.
- By disposing off toxic products with care.
- By following the three Rs to prevent water pollution, *i.e.*, refusing water pollution, recycling water and reducing wastage of water.

III. Practical-based Questions (*Refer to the Student's Book*)

1. (*a*) **2.** (*a*) **3.** (*c*)

3.11 PROJECT (*Refer to the Student's Book*)

The teacher should guide the learners to carry out the project as given in the Student's Book.

UNIT 4: EFFECTIVE WAYS OF WASTE MANAGEMENT

(*Refer to the Student's Book*)

4.1 LEARNING OBJECTIVES

At the end of this unit, the learners would be able to:

Knowledge and Understanding	Skills	Attitudes and Values
• Describe the steps involved in effective waste management. • Explain the importance and benefits of waste recycling. • Discuss the various effects of waste materials and poor waste disposal.	• Make some useful materials from waste.	• Develop a sense of managing natural resources while discussing effective ways of waste management. • Develop teamwork and confidence in group activities and presentations. • Develop a sense of responsibility in minimising waste materials.

4.2 LESSONS AND TIME ALLOCATION

Lessons	Periods Required	Total Periods
4.1 Steps to Effective Waste Management • Prevention • Minimisation • Reuse • Recycle • Energy Recovery • Disposal	4	**12**

4.2 Importance and Benefits of Waste Recycling • Environmental Protection • Conservation of Natural Resources • Energy Saving • Job Creation	4	
4.3 Effects of Waste and Poor Disposal	3	
Assessment	1	

4.3 CONTENT MAP

Introduction

The unit describes the steps involved in effective waste management and the importance and benefits of waste recycling. It also deals with the various effects of waste materials and poor waste disposal.

Classroom Organisation

Whole class orientation, individual work and then working in groups

Teaching and Learning Materials

- Paper, Pen, Pencil, Computers, and Internet connection.

Teaching Aids

- **Audio-video:** Video showing steps involved in waste management
- **Notes:** Benefits of waste recycling
- **PowerPoint Presentation:** Various effects of poor waste disposal
- **Visual:** Harmful effect of poor disposal.

Competences Practised

- Literacy
- Numeracy
- Critical thinking
- Creativity and innovation
- Research and problem solving
- Communication in official languages
- Co-operation, inter-personal relations and life skills

Revision

- Objective type questions are provided at the end of each unit
- Short answer type questions are provided at the end of each unit

Assessments

- A formative assessment task of image collection
- A formative assessment of creativity

4.4 SUPPLEMENTARY INFORMATION FOR THE TEACHER

Effects of waste and poor waste disposal

Imagine we all throw garbage, junk and rubbish away anyhow. Imagine there was no authority to supervise waste management activities from all the sources. Imagine we all just sent our rubbish to the landfill, or just dumped them in a nearby river. What do you think will happen? A disaster!

Environmental Effects

- **Surface water contamination:** The wastes that end up in water bodies negatively change the chemical composition of the water. Technically, this is called water pollution. This will affect all ecosystems existing in the water. It can also cause harm to animals that drink from such polluted water.
- **Soil contamination:** Hazardous chemicals that get into the soil (contaminants) can harm plants when they take up the contamination through their roots. If humans eat plants and animals that have been in contact with such polluted soils, there can be negative impact on their health.
- **Pollution:** Bad waste management practices can result in land and air pollution and can cause respiratory problems and other adverse health effects as contaminants are absorbed from the lungs into other parts of the body.
- **Leachate:** Liquid that forms as water trickles through contaminated areas is called Leachate. It forms very harmful mixture of chemicals that may result in hazardous substances entering surface water, groundwater or soil.

Economic Effects

- **Municipal wellbeing:** Everyone wants to live and visit places that are clean, fresh and healthy. A city with poor sanitation, smelly and with waste matter all over the place do not attract good people, investors and tourists. Such cities tend to have poor living standards.
- **Recycling revenue:** Cities that do not invest in recycling and proper waste control miss out on revenue from recycling. They also miss out on job opportunities that come from recycling, composting and businesses that work with them.

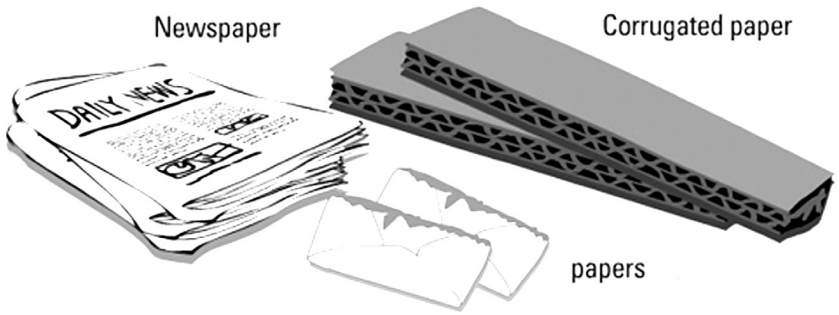
How Paper is Recycled

Collection, transportation and storage

The biggest task for paper recycling companies is probably the collection, transporting and sorting of waste paper.

This is because we always add paper to other waste items and get them contaminated with food, plastics and metals.

Sometimes collected paper is sent back to the landfills because they are too contaminated to use. Try to keep waste paper in separate grades at home or in the office—example, do not mix newspapers and corrugated boxes up.



All paper recovered is sent to the recycling centre, where it is packed, graded, put into bales and sent to the paper mill. At the mill, all the paper is stored in a warehouse until it is needed.

Repulping and Screening (say re-pal-pin and skree-nin): From the storage shelves, they are moved into a big paper-grinding machine called a vat (pulper). Here the paper is chopped into tiny pieces, mixed with water and chemicals and heated up to break it down into organic plant material called fibre. After, it is screened to remove contaminants such as bits of plastic and globs of glue.

Deinking (say dee-in-kin): This involves 'washing' the pulp with chemicals to remove printing ink and glue residue. Sometimes, a process called floatation is applied to further remove stubborn stains and stickies. Floatation involves the use of chemicals and air to create bubbles which absorb the stickies in the pulp.

Refining, Bleaching and Colour Stripping: Refining involves beating the recycled pulp to make them ideal for paper-making. After refining, additional chemicals are added to remove any dyes from the paper. It is then bleached to whiten and brighten it up.

Paper making: At this stage, the pulp is ready to be used for paper. Sometimes new pulp is added to give it extra strength and smoothness. Water is added to the pulp and sprayed onto a large metal screen in continuous mode. The water is drained on the screen and the fibres begin to bond with each other. As it moves through the paper-making machines, press rollers squeeze out more water, heat them dry and coat them up.

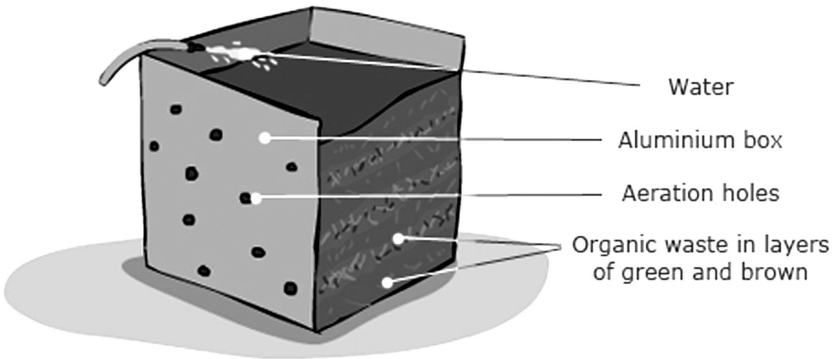
They are then finished into rolls.

How to Prepare Compost

With the right conditions (air and moisture), organic waste such as food and plant materials can be decomposed by bacteria, fungi, worms and organisms. Decayed organic matter is humus. Yard waste such as grass and flower clippings can also be composted.

Composting comes in two kinds: bin/pile composting and worm composting (vermiculture).

Bin/pile composting is easier for many households because one does not have to be too careful with what to put into it. Here is what you need:



- Get an old bin or box (1 cubic yard), or you can buy one from the shop. Ensure that you punch holes around it to help with aeration.
- Prepare your organic waste matter. Make sure you cut them into pieces (about 1 inch in size). Do not throw in big chunks of the waste. Make sure you separate the organic waste into brown and green parts. Brown parts include waste like wood chips, saw-dust, yard waste shreds, straw and hay, dry leaves and shredded paper. Green parts include grass trimmings, fruit and veggie scraps, green leaves and livestock manure.
- Put the waste in the box in layers, 50% green, 50% brown.
- Mix and add some water every seven days.
- In a couple of weeks, the compost will be ready. It will look dark-brown and smell just like soil.

There are other larger composting units used in schools and some restaurants. These have larger cylindrical chambers of about 8–10 feet in length. Waste items are usually layered in the chamber, dry leaves on food waste layers. The content of the cylinders are turned regularly for aeration to speed up the composting. It takes about 2–3 weeks for the composting to complete.

Commercial composting units are a lot more sophisticated, as they are tested for colour, pH, odour, moisture, and other related characteristic that appeal to compost buyers.

4.5 FOR MORE INFORMATION VISIT

- http://www.eschooltoday.com/waste-recycling/childrens-role-in-waste-management.html
- http://www.eschooltoday.com/waste-recycling/waste-management-tips-for-kids.html
- http://kids.niehs.nih.gov/explore/reduce/
- http://www.wikihow.com/Manage-Your-Home-Waste

4.6 ASSESSMENT

1. What are the importance and benefits of waste recycling?
2. What is Waste Recycling?
3. Name the waste items that are usually recycled.

Answers

1. Recycling is beneficial in many ways, including:

   Recycling helps protect the environment: This is because the recyclable waste materials would have been burned or ended up in the landfill. Pollution of the air, land, water and soil is reduced.

   Recycling conserves natural resources: Recycling more waste means that we do not depend too much on raw (natural) resources, which are already massively depleted.

   Recycling saves energy: It takes more energy to produce items with raw materials than from recycling used materials. This means we are more energy efficient and the prices of products can come down.

   Recycling creates jobs: People are employed to collect, sort and work in recycling companies. Others also get jobs with businesses that work with these recycling units. There can be a ripple of jobs in the municipality.
2. Recycling is processing used materials (waste) into new, useful products. This is done to reduce the use of raw materials that would have been used. Recycling also uses less energy and is a great way of controlling air, water and land pollution.

   Effective recycling starts with household (or the place where the waste was created). In many serious countries, the authorities help households with bin bags with labels on them. Households then sort out the waste themselves and place them in the right bags for collection. This makes the work less difficult.
3. *Paper waste*: Paper waste items include books, newspapers, magazines, cardboard boxes and envelopes.

Plastic waste: Items include plastic bags, water bottles, rubber bags and plastic wrappers.

Glass waste: All glass products like broken bottles, beer and wine bottles can be recycled.

4.7 TEACHING METHODOLOGY AND LEARNING ACTIVITIES

Lesson 1: Steps to Effective Waste Management

(*Refer to the Student's Book*)

- The teacher should introduce the lesson by asking learners to carry out **Activity 4.1**.

Activity 4.1: Steps to waste management (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity on their own and then discuss their observations with their classmates. He/She should further brainstorm the learners with the leading questions given in the activity to help them understand their role in creating foul smell and also how they can contribute in reduction of the same.
- After completion of the activity, the teacher should ask the learners to read and discuss about different components of garbage given in the Student's Book.

Activity 4.2: Illustrating waste hierarchy (*Refer to the Student's Book*)

- The teacher should split class into small groups and ask them to observe the diagram given in **Activity 4.2**. Thereafter ask them to discuss the terms given in waste hierarchy to manage waste and make a presentation in class.
- After groups give their presentation, the teacher should give his/her views and suggestions in the class. Tell them that these are the six steps to effective waste management.

Activity 4.3: Illustrating prevention of waste (*Refer to the Student's Book*)

- The teacher should guide the learners to investigate the dustbin of their houses and then to discuss with their families on how to avoid generating waste as given in the Student's Book.
- After completion of the activity, the teacher should discuss the concept of prevention of waste as given in the Student's Book.

Activity 4.4: Showing reuse of waste (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as given in the Student's Book.
- After completion of the activity, the teacher should discuss with learners the concept of reusing things to minimise waste and then ask the learners to make a list of things they can reuse.

Activity 4.5: Illustrating recycling of waste (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the steps given in the Student's Book to make their own recycled paper to illustrate recycling of waste.
- After completion of the activity, the teacher should discuss with the learners the concept of recycling and its importance.
- He/She should further ask the learners to do **Exercise 4.1** to assess the achievement of objectives.

Activity 4.6: To make a biogas generator (*Refer to the Student's Book*)

- The teacher should guide the learners to make a biogas generator by following the steps given in the Student's Book.
- After completion of the activity, the teacher should discuss with the learners the concept of energy recovery from waste as given in the Student's Book.

Activity 4.7: Showing waste disposal system (*Refer to the Student's Book*)

- The teacher should arrange a field trip of the learners to a landfill and an incinerator site.
- He/She should guide the learners to ask people working there about description and details of the processes and then to prepare a report and present in the class.
- After completion of the activity, the teacher should refer the Student's Book and discuss with learners the concept of waste disposal.

Activity 4.8: Preparing compost **(***Refer to the Student's Book***)**

- The teacher should split the class into small groups and then ask them to prepare compost by following the steps given in the activity.

Activity 4.9: Game of waste management (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as given in the Student's Book.

Activity 4.10: Importance of 3Rs (*Refer to the Student's Book*)

- The teacher should refer to the Student's Book and guide the learners to make a table showing wastes which can be reduced, recycled and reused. Ask them to discuss the importance of 3Rs in the class.
- He/She should further ask the learners to do **Exercise 4.2** to assess the achievement of objectives.

Lesson 2: Importance and Benefits of Waste Recycling

(*Refer to the Student's Book*)

- The teacher should begin the lesson by asking the learners to carry out **Activity 4.11**.

Activity 4.11: Practising recycling week (*Refer to the Student's Book*)

- The teacher should guide the learners to practise recycling week in their routine as given in the Student's Book. Discuss the benefits of recycling in the class and present your findings as report.
- After completion of the activity, the teacher should ask the learners to read the text given in the Student's Book on recycling, environmental protection, conservation of natural resources, energy saving and job creation.
- He/She should further ask the learners to do **Exercise 4.3** to assess achievement of objectives.

Lesson 3: Effects of Waste and Poor Disposal

(*Refer to the Student's Book*)

- The teacher should begin the lesson by asking the learners to carry out **Activity 4.12**.

Activity 4.12: Group discussion on poor disposal of garbage

(*Refer to the Student's Book*)

- The teacher should lead a group discussion on poor disposal of garbage as given in the activity.
- After completion of the activity, the teacher should ask the learners to read the text given in the Student's Book on the effects of waste and poor disposal.

Activity 4.13 (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as given in the Student's Book.
- He/She should further ask the learners to do **Exercise 4.4** to assess the achievement of objectives.

4.8 ANSWERS TO IN-TEXT EXERCISES

Exercise 4.1 (*Refer to the Student's Book*)

1. The effective ways of waste management are prevention, minimisation, reuse, recycling and disposal.
2. Prevention means preventing or avoiding of the waste completely.
3. True
4. Sacks, clothed bags, plastic cups, glass bottles can be used for multiple times.
5. The following are components of garbage
   - peels of fruits and vegetables
   - fallen leaves of plants
   - dust, paper, plastics, glass, metals, etc.

Exercise 4.2 (*Refer to the Student's Book*)

1. True
2. Disposal is also known as burying it.
3. Landfills are the most common form of waste disposal and are an important component of an integrated waste management system.
4. Plant and animal waste materials can be converted into manure.
5. Compost is a natural fertiliser.

Exercise 4.3 (*Refer to the Student's Book*)

1. Benefits of recycling are:
   - Reducing energy usage and volume of landfills.
   - Reducing air pollution, water pollution and land pollution.
   - Reducing greenhouse gas emissions and preserving natural resources.
   - Protecting the environment.
2. False; *Explanation:* Recycling helps reduce pollution.
3. Industrial waste releases poisonous gases and chemicals into the environment which cause air pollution.

   When the non-biodegradable wastes are burned, they emit gases. These gases cause air pollution.
4. Recycle waste materials into **new products**.
5. Recycling is more labour-intensive than land-filling or incineration. This means that building the recycling industry is a way to create more jobs.

Exercise 4.4 (*Refer to the Student's Book*)

1. Improper disposal can lead to death of **animals** as well as **humans**.
2. Dysentery and Cholera are caused by poor disposal of wastes.
3. True
4. Effects of poor domestic waste disposal are:
   - It leads to the spread of diseases.
   - It may cause to human injury.
   - It hinders the scenic beauty.
5. When solid wastes are dumped in drainage channels and gutters, they block the flow of the sewage which may cause flood.

4.9 ANSWERS TO UNIT ASSESSMENT

I. Multiple Choice Questions (*Refer to the Student's Book*)

1. (*a*)	**2.** (*b*)	**3.** (*c*)	**4.** (*d*)	**5.** (*d*)
6. (*b*)	**7.** (*a*)	**8.** (*d*)	**9.** (*a*)	**10.** (*c*)

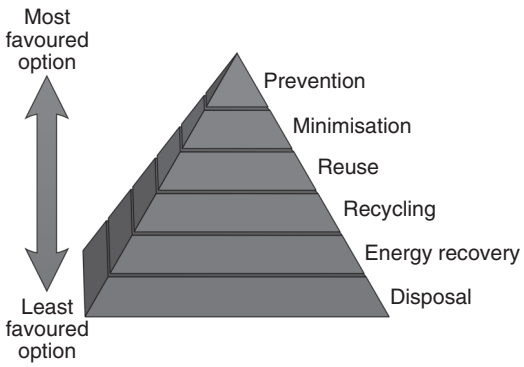
II. Open Ended Questions (*Refer to the Student's Book*)

1. REUSE plastic bottle, chips packet, shirt, mobile phone, polythene
   COMPOST banana peel, shirt
   RECYCLE plastic bottle,
   LANDFILL chips packet, mobile phone
2. Briquetting is one of the ways to turn the wastes into treasure. It is used to densify the loose combustible materials into solid composites. The waste can be made of different shapes and sizes with the presence of pressure and binding agents.
3. Recycling is, processing used materials (waste) into new, useful products. Some of its benefits are discussed below:
   - Recycling includes conservation of natural resources. Less need for the resources that have to be planted, grown and harvested or extracted from ground (ores and minerals).
   - Recycling includes reducing deforestation by reducing the need for raw materials, so that our forests can be preserved.
   - Recycling helps in reducing pollution. The manufacturing process (including the extraction of raw materials from the earth) for many products releases waste that pollutes the environment.

- Recycling aids in reducing land pollution by freeing the land occupied by waste.
- Recycling takes much less energy to make products using recycled materials as compared to making products from raw materials.

4. Waste management includes all the processes of handling waste and reducing it. There are ways to achieve effective waste management. These ways are studied as waste hierarchy. Waste hierarchy focuses more on waste minimisation.

5. The six steps of effective waste management are:



6. The following are some ways by which we can contribute to minimise waste:
- By not leaving heating on constantly
- By closing water running too long
- By boiling a kettle with the right amount of water in it
- By switching off the lights whenever not in use.

7. Energy recovery from waste is the conversion of non-recyclable waste materials into useable heat, electricity, or fuel through a variety of processes, including heating. This process is often called waste-to-energy (WTE). Energy is recovered, approximately ten per cent of the volume remains as ash, which is generally sent to disposal.

For example, bio-mass waste can be burned to produce energy (biogas). Refer Figure 4.4 of Student's Book.

8. Poor waste handling can cause deleterious effects on health of both animals and humans. These include:
- Waste such as sewage can enter in the body through the means of food and water. This can cause various water borne diseases such as cholera in humans.
- The poor disposal of waste in water bodies and near around can lead to death of animals. Animals can consume toxic chemicals and die.

- Wastes like human stool cause diseases when poorly dumped, as the flies will carry the germ from the stool. It can also lead to human injury.
- It also leads to the spread of diseases when wastes like broken bottles are dumped anywhere, they collect water in them (when it rains) and this may become a breeding ground for mosquitoes.

9. Poor Domestic Waste management displays an ugly scenario of the environment. This can affect the tourism industry, as the tourists may not get attracted to visit the country. This can create a bad impression of country as waste is responsible for spreading diseases and also making injury. A tourist might even get victimised of any such circumstance.

10. Examples of energy recovery from recycling include:
- Recycling aluminium can save enough energy to run a TV for 3 hours
- Approximately, one tonne of paper recycled can save 17 trees.

4.10 PROJECT

(*Refer to the Student's Book*)

The teacher should guide the learners to make a presentation as given in the Student's Book.

UNIT 5: CATEGORIES OF CHEMICAL REACTIONS

(*Refer to the Student's Book*)

5.1 LEARNING OBJECTIVES

At the end of this unit, the learners would be able to:

Knowledge and Understanding	Skills	Attitudes and Values
• Explain the difference between a decomposition reaction and combination reaction. • Explain single displacement, double displacement (precipitation and neutralisation) and combustion reactions. • Write and balance ionic equations.	• Apply the rules of balancing equations to write balanced chemical reactions. • Carry out experiments to show precipitation reactions, and to differentiate endothermic and exothermic reactions. • Classify chemical reactions as endothermic and exothermic using simple experiments. • Properly use a thermometer to measure changes in temperature.	• Develop a team spirit, sense of responsibility when performing experiments.

5.2 LESSONS AND TIME ALLOCATION

Lessons	Periods Required	Total Periods
5.1 Types of Reactions • Combination Reactions • Decomposition Reactions • Single Replacement Reactions • Double Displacement Reactions • Combustion Reactions	4	16
5.2 Classification of Chemical Reaction as Endothermic and Exothermic Reactions • Exothermic Reactions • Endothermic Reactions • Explanation for the Energy Changes During Chemical Reactions	4	
5.3 Ionic Equations	4	
5.4 Rules for Writing Ionic Equations	3	
Assessment	1	

5.3 CONTENT MAP

Introduction

The unit explains the difference between a decomposition reaction and combination reaction. It also discusses single displacement, double displacement (precipitation and neutralisation) and combustion reactions. Besides, it describes how to write and balance ionic equations.

Classroom Organisation

Whole class orientation, individual work and then working in groups

Teaching and Learning Materials

- Paper, Pen, Pencil, Computers, and Internet connection

Teaching Aids

- **Audio-video:** Video showing types of reactions
- **Notes:** Examples of different types of reactions
- **PowerPoint Presentation:** How to write and balance ionic equations
- **Visual:** Images showing precipitation and neutralisation

Competences Practised

- Literacy
- Numeracy
- Critical thinking
- Creativity and innovation
- Research and problem solving
- Communication in official languages
- Co-operation, inter-personal relations and life skills

Vocabulary Acquisition

- Name of Chemicals
- Reaction name
- Types of chemical equations

Revision

- Objective type questions are provided at the end of each unit.
- Short answer type questions are provided at the end of each unit.

Assessments

- A formative assessment task of image collection
- A formative assessment of creativity

5.4 SUPPLEMENTARY INFORMATION FOR THE TEACHER

Chemical reactions are processes in which substances change into other substances. You know a chemical reaction takes place if one or more of these occur:

- **Colour changes.** Different combinations of molecules reflect light differently. A colour change indicates a change in molecules.
- **Heat content changes.** In all chemical reactions, the heat content of the reactants and the heat content of the products is **never** the same. Sometimes the difference is great and can be easily detected. At other times, the difference is slight and more difficult to detect.
- **Gas produced.** Whenever a gaseous product forms in a liquid solution, bubbles can be seen. A colourless gas produced in a reaction of solids is much harder to detect.
- **Precipitate forms.** Precipitates are insoluble products formed by a reaction taking place in a liquid solution. This insoluble product will eventually settle to the bottom, but might immediately appear by turning the clear solution cloudy.

Most chemical reactions can be placed into one of the following types:

1. Combination reactions

- Elements are joined together.
- General Form: A + B → AB

2. Decomposition reactions

- A compound breaks into parts.
- General Form: AB → A + B

3. Single displacement reactions

- A single element replaces an element in a compound.
- General Form: A + BC → AC + B

4. Double displacement reactions

- An element from each of two compounds switch places.
- General Form: AB + CD → AD + CB

5. Neutralisation reactions

- Special types of double displacement reactions that involve the reaction between an acid and base to form a salt and water. Heat is usually given off in neutralisation reactions.

6. Precipitation reactions

- Aqueous reactions that involve the formation of a precipitate (solid).

7. Combustion reactions

- The reaction of an element or compound with oxygen.
- Combustion usually releases a lot of heat energy. It is also referred to as *burning*.

5.5 FOR MORE INFORMATION VISIT

- http://www.ducksters.com/science/chemistry/chemical_reactions.php
- http://www2.ucdsb.on.ca/tiss/stretton/CHEM1/stoich2.html
- https://en.wikibooks.org/wiki/General_Chemistry/Types_of_chemical_reactions
- http://www.ric.edu/faculty/ptiskus/reactions/

5.6 ASSESSMENT

Identify the types of chemical reaction and write balanced chemical equation for the following:

1. Potassium chloride + Silver nitrate → Potassium nitrate + Silver chloride
2. Copper carbonate (+ heat) → Copper oxide + Carbon dioxide

3. Aluminium chloride + Sodium hydroxide → Aluminium hydroxide **+ Sodium chloride**
4. Magnesium + Copper sulphate → Magnesium sulphate + Copper
5. Water (+ electric current) → Hydrogen + Oxygen

Answers

1. Double displacement reaction,
$$\mathbf{KCl + AgNO_3} \rightarrow KNO_3 + AgCl$$
2. Decomposition reaction,
$$\mathbf{CuCO_3} \rightarrow CuO + CO_2$$
3. Double displacement reaction,
$$\mathbf{AlCl_3 + 3NaOH} \rightarrow Al(OH)_3 + 3NaCl$$
4. Single displacement or replacement,
$$\mathbf{Mg + CuSO_4} \rightarrow MgSO_4 + Cu$$
5. Decomposition reaction,
$$\mathbf{2H_2O} \rightarrow 2H_2 + O_2$$

5.7 ADDITIONAL ACTIVITY

Determining the Types of Reactions

1. Divide learners into diverse groups. It is usually best for learners to work in pairs on this activity.
2. Distribute the baggies containing the picture cards, reaction type cards, reaction template, and product cards.
3. Learners should place the picture cards face up on their work area.
4. The learners, working in pairs, will match one of the types of reaction to the picture that best defines the reaction type. For example, the construction materials that form the building illustrate decomposition or composition reactions.
5. The teacher will circulate to determine if the groups have correctly matched the type of reaction with the picture.
6. Groups will write a description of each type of reaction and develop a generic reaction for each type using letters A, B, C, and D. An example is A + B → AB is a combination reaction.
7. The teacher can then have six groups explain why the picture illustrated that type of reaction and give their generic reaction for each type. This can be done verbally, on the board, or with an interactive board.
8. Learners will then remove the reaction template and all the reaction type cards from the plastic baggie.

9. The teacher will begin the PowerPoint on reaction types as a loop for learners to view as they match the type of reaction to an actual reaction.
10. Learners will place the reaction card beside the actual reaction on the reaction template that illustrates that type of reaction. For example, the reaction $C_3H_8 + O_2$ is a combustion reaction so the learner would place the combustion reaction type card to the left of these reactants.
11. The learners will also record their answers on the activity sheet and the teacher can circulate quickly to determine if learners are accurately identifying the types of reactions.
12. At this point, the activity can continue with matching the products to the appropriate reactants or direct the learners to the additional practice on identifying the types of reactions.
13. If the activity continues, the learners will remove the product cards from the baggie and predict which products would be formed from the reactants.
14. The teacher can quickly circulate through the groups to determine if the learners are correctly identifying the products. Learners should record their results on the activity sheet.
15. Learners should return all the cards to the plastic baggie.

5.8 TEACHING METHODOLOGY AND LEARNING ACTIVITIES

Activity 5.1: Illustrating chemical reactions (*Refer to the Student's Book*)

- The teacher should guide the learners to think what happens during different situations of our daily life as given in the activity.
- After the learners present their views, the teacher should discuss the fact that in all these situations the nature and the identity of the initial substance have somewhat changed. It means that a chemical reaction has taken place.
- After completion of activity, the teacher should ask the learners to read the text given in the Student's Book regarding characteristics of chemical reactions.

Lesson 1: Types of Reactions (*Refer to the Student's Book*)

- The teacher should discuss with learners the five major categories of chemical reactions as given in the Student's Book.

Activity 5.2: Combination of iron and sulphide (Combination reaction)

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to observe the combination reaction.

- After completion of activity, with the help of examples given in the Student's Book, the teacher should discuss with learners the different types of combination reactions.

Experiment 1 (*Refer to the Student's Book*)

- The teacher should split the learners in small groups and guide them to carry out the experiment in the laboratory to illustrate combination of ammonia and hydrogen chloride as per the procedure given in the Student's Book.
- After learners read and carry out the experiment, the teacher should ask them to do **Exercise 5.1** to assess the achievement of objectives.

Activity 5.3: Decomposition of silver chloride (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to observe decomposition reaction.
- After completion of activity, with the help of examples given in the Student's Book, the teacher should discuss with learners the different types of decomposition reactions.

Activity 5.4: Electrolysis of water (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to observe electrolysis of water.

Activity 5.5: Decomposition of sodium nitrate (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to observe decomposition of sodium nitrate.

Activity 5.6: Heating ferrous sulphate crystals (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to observe decomposition of ferrous sulphate.

Experiment 2 (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to observe decomposition of Hydrated Copper (II) Sulphate.
- After learners read and carry out the experiment, the teacher should ask them to do **Exercise 5.2** to assess the achievement of objectives.

Activity 5.7: Reaction of iron nails with copper sulphate

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to observe single replacement reaction.
- After completion of activity, the teacher should ask the learners to do **Exercise 5.3** to assess the achievement of objectives.

Activity 5.8: Formation of precipitate (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to observe formation of precipitate.

Activity 5.9: Formation of silver iodide (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to observe formation of silver iodide as a result of double displacement reaction.
- After completion of activity, the teacher should discuss with learners the examples of precipitation reaction as given in the Student's Book.

Activity 5.10: Illustrating neutralisation reaction (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to observe neutralisation reaction.
- After completion of activity, the teacher should discuss with learners some applications of neutralisation reaction as given in the Student's Book.
- After discussion, the teacher should ask the learners to do **Exercise 5.4** to assess the achievement of objectives.

Activity 5.11: Burning of magnesium ribbon (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to observe combustion reaction.
- After completion of activity, the teacher should discuss with learners the effect of combustion on elements and compounds referring examples given in the Student's Book.
- Thereafter, the teacher should ask the learners to do **Exercise 5.5** to assess the achievement of objectives.

Lesson 2: Classification of Chemical Reactions as Endothermic and Exothermic Reactions

(*Refer to the Student's Book*)

- The teacher should ask the learners to read the text related to classification of chemical reactions given in the Student's Book.

- After learners read the lesson, discuss with them Endothermic and Exothermic reactions with the examples given in the Student's Book.

Experiment 3 (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the experiment as per the procedure given in the Student's Book to differentiate between exothermic and endothermic reactions.
- After completion of the experiment, ask the learners to do **Exercise 5.6** to assess the achievement of objectives.

Lesson 3: Ionic Equations (*Refer to the Student's Book*)

- The teacher should ask the learners to read the text related to Ionic Equations given in the Student's Book.
- After learners read the lesson, discuss with them the Ionic equations with examples given in the Student's Book.

Lesson 4: Rules for Writing Ionic Equations (*Refer to the Student's Book*)

- The teacher should ask the learners to read the rules of writing equation given in the Student's Book.
- After learners read the lesson, discuss with them the rules of writing equation with examples as given in the Student's Book.
- After discussion, ask the learners to do **Exercise 5.7** to assess the achievement of objectives.

5.9 ANSWERS TO IN-TEXT EXERCISES

Exercise 5.1 (*Refer to the Student's Book*)

1. When iron powder is heated with sulphur, **iron sulphide** is formed. This is an example of **combination reaction**.
2. $\underset{\text{Hydrogen}}{H_2(g)} + \underset{\text{Chlorine}}{Cl_2(g)} \xrightarrow{\text{Combination}} \underset{\substack{\text{Hydrogen}\\ \text{chloride}}}{2HCl(g)}$
3. False; *Explanation:* Calcium oxide reacts with carbon dioxide to form calcium carbonate.
4. When ammonia reacts with hydrogen chloride, the product obtained is ammonium chloride.
5. Hydrogen chloride gas on dissolving in water forms **hydrochloric** acid.

Exercise 5.2 (*Refer to the Student's Book*)

1. When 0.5 grams of lead nitrate is heated, we will observe the evolution of brown fumes.

2. The colour of anhydrous copper sulphate is **white**.
3. **False;** *Explanation*: The digestion of food in the body is an example of decomposition reaction.
4. **(a)** $2AgBr(s) \xrightarrow{\text{Sunlight}} 2Ag(s) + Br_2(g)$

   (b) $\underset{\text{Calcium carbonate}}{CaCO_3} \xrightarrow{\text{Heat}} \underset{\text{Calcium oxide (Quicklime)}}{CaO(s)} + \underset{\text{Carbon dioxide}}{CO_2(g)}$

   (c) $\underset{\text{Water}}{2H_2O(l)} \xrightarrow[\text{Decomposition}]{\text{Electricity}} \underset{\text{Hydrogen}}{2H_2(g)} + \underset{\text{Oxygen}}{O_2(g)}$
5. The rate of decomposition of hydrogen peroxide is increased by the catalyst MnO_2.

Exercise 5.3 (*Refer to the Student's Book*)

1. True
2. When a piece of iron object is placed in copper sulphate solution, the deep blue colour of copper sulphate solution fades due to the formation of iron sulphate.
3. False; *Explanation:* Zinc is more reactive than copper.
4. **(a)** $\underset{\text{Copper oxide}}{CuO(s)} + \underset{\text{Magnesium}}{Mg(s)} \rightarrow \underset{\text{Magnesium oxide}}{MgO(s)} + \underset{\text{Copper}}{Cu(s)}$

   (b) $\underset{\substack{\text{Iron (III) oxide}\\\text{(Ferric oxide)}}}{Fe_2O_3(s)} + \underset{\text{Aluminium}}{2Al(s)} \rightarrow \underset{\text{Aluminium oxide}}{Al_2O_3(s)} + \underset{\substack{\text{(Molten)}\\\text{Iron}}}{2Fe(l)}$
5. When a strip of lead metal is placed in a solution of **copper nitrate**, lead nitrate and **copper** are formed.

Exercise 5.4 (*Refer to the Student's Book*)

1. The insoluble substance formed during a chemical reaction is called **precipitate**.
2. The reaction of an acid and a base is known as a **neutralisation** reaction.
3. True
4. If barium chloride solution is added to copper sulphate solution, a white precipitate of barium sulphate is produced along with copper chloride solution.

   $\underset{\text{Barium chloride}}{BaCl_2(aq)} + \underset{\text{Copper sulphate}}{CuSO_4(aq)} \rightarrow \underset{\substack{\text{Barium sulphate}\\\text{(Whilte ppt.)}}}{BaSO_4(s)} + \underset{\text{Copper chloride}}{CuCl_2(aq)}$
5. $\underset{\text{Copper sulphate}}{CuSO_4(aq)} + \underset{\text{Hydrogen sulphide}}{H_2S(g)} \rightarrow \underset{\substack{\text{Copper sulphide}\\\text{(Black ppt.)}}}{CuS(s)} + \underset{\text{Sulphuric acid}}{H_2SO_4(aq)}$

6. The general equation for a double displacement reaction is

where A and B are positive ions (cations).
X and Y are negative ions (anions).

Exercise 5.5 (*Refer to the Student's Book*)

1. True
2. When glucose reacts with oxygen, products are carbon dioxide and water.
3. When any hydrocarbon burns in insufficient oxygen, the products are **carbon monoxide** and **water**.
4. Combustion reaction referred to as **burning**.
5. $CH_4(g) + 2O_2(g) \longrightarrow CO_2(g) + 2H_2O(l)$ + **Heat**

Exercise 5.6 (*Refer to the Student's Book*)

1. The chemical reactions which proceed with the evolution of heat energy are called **exothermic reactions**.
The chemical reactions which proceed with the absorption of heat energy are called **endothermic reactions**.
2. Energy is absorbed for **breaking** the bonds and released during **formation** of bonds.
3. False; *Explanation:* Decomposition reactions are generally endothermic.
4. $2H_2(g) + O_2(g) \longrightarrow 2H_2O(l)$
5. $NH_2Cl(s) \longrightarrow NH_3(g) + HCl(g)$

Exercise 5.7 (*Refer to the Student's Book*)

1. The reactions which occur in aqueous solution can also be represented by **ionic equations**.
2. If spectator ions are subtracted from both sides of the equation, the remaining equation is known as the **net ionic equation**. [Ions that are in an identical state on both sides of ionic equations are called **spectator ions**.]
3. True
4. *Condensed equation:* $2AgNO_3(aq) + Cu(s) \longrightarrow 2Ag(s) + CuNO_3(aq)$
Ionic equation: $2Ag^+(aq) + 2NO_3^-(aq) + Cu(s) \longrightarrow 2Ag(s) + Cu^{2+}(aq) + 2NO_3^-(aq)$
Net ionic equation: $2Ag^+(aq) + Cu(s) \longrightarrow 2Ag(s) + Cu^{2+}(aq)$
5. The net ionic equation for all reactions of strong acids with strong bases that form salt and water is $\mathbf{H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)}$

5.10 ANSWERS TO UNIT ASSESSMENT

I. Multiple Choice Questions

(*Refer to the Student's Book*)

1. (*d*)	**2.** (*c*)	**3.** (*d*)	**4.** (*b*)	**5.** (*b*)
6. (*c*)	**7.** (*d*)	**8.** (*a*)	**9.** (*c*)	**10.** (*c*)

II. Open Ended Questions

(*Refer to the Student's Book*)

1. (*a*) $\underset{\text{Hydrogen}}{H_2(g)} + \underset{\text{Chlorine}}{Cl_2(g)} \xrightarrow{\text{Combination}} \underset{\text{Hydrogen chloride}}{2HCl(g)}$

(*b*) $\underset{\substack{\text{Calcium oxide}\\\text{(quickline)}}}{CaO(s)} + \underset{\substack{\text{Carbon}\\\text{dioxide}}}{CO_2(g)} \xrightarrow{\text{Combination}} \underset{\substack{\text{Calcium}\\\text{carbonate}}}{CaCO_3\,(s)}$

(*c*) $\underset{\text{Ammonia}}{NH_3\,(g)} + \underset{\substack{\text{Hydrogen}\\\text{chloride}}}{HCl\,(g)} \xrightarrow{\text{Combination}} \underset{\substack{\text{Ammonium}\\\text{chloride}}}{NH_4Cl\,(s)}$

2. (*a*) Combination Reaction

(*b*) Decomposition Reaction

(*c*) Double Displacement: Neutralisation Reaction

3. (*a*) $\underset{\text{Copper sulphate}}{CuSO_4\,(aq)} + \underset{\text{Hydrogen sulphide}}{H_2S\,(g)} \rightarrow \underset{\substack{\text{Copper sulphide}\\\text{(Black ppt.)}}}{CuS\,(s)} + \underset{\text{Sulphuric acid}}{H_2SO_4\,(aq)}$

(b) $\underset{\text{Silver Bromide}}{2AgBr\,(s)} \xrightarrow[\text{Decomposition}]{\text{Light}} \underset{\text{Silver}}{2Ag\,(s)} + \underset{\text{Bromine}}{Br_2(g)}$

(*c*) $\underset{\text{Water}}{2H_2O\,(l)} \xrightarrow[\text{Decomposition}]{\text{Electricity}} \underset{\text{Hydrogen}}{2H_2\,(g)} + \underset{\text{Oxygen}}{O_2\,(g)}$

(*d*) $\underset{\substack{\text{Potassium}\\\text{chloride}}}{2KClO_3} \xrightarrow[\text{Decomposition}]{\text{Heat}} \underset{\substack{\text{Potassium}\\\text{chloride}}}{2KCl\,(s)} + \underset{\text{Oxygen}}{3O_2\,(g)}$

(e) $\underset{\substack{\text{Hydrated copper}\\\text{sulphate (blue)}}}{CuSO_4 \,.\, xH_2O} \rightleftharpoons \underset{\substack{\text{Anhydrous Copper}\\\text{sulphate (White)}}}{CuSO_4(s)} + \underset{\text{Water}}{xH_2O}$

(*f*) $\underset{\substack{\text{Silver nitrate}\\\text{(Colourless solution)}}}{2AgNO_3(aq)} + \underset{\substack{\text{Copper}\\\text{(Red-brown)}}}{Cu(s)} \rightarrow \underset{\substack{\text{Copper}\\\text{(Blue Solution)}}}{Cu(NO_3)_2(aq)} + \underset{\substack{\text{Silver}\\\text{(Greyish white)}}}{2Ag(s)}$

(*g*) $\underset{\substack{\text{Copper sulphate}\\\text{(Blue solution)}}}{CuSO_4(aq)} + \underset{\substack{\text{Magnesium}\\\text{(Silver white)}}}{Mg(s)} \rightarrow \underset{\substack{\text{Magnesium sulphate}\\\text{(Colourless solution)}}}{MgSO_4(aq)} + \underset{\substack{\text{Copper}\\\text{(Red-brown)}}}{Cu(s)}$

(*h*) $AgNO_3(aq) + NaCl(aq) \longrightarrow AgCl(s) + NaNO_3(aq)$

(*i*) $\underset{\text{Base}}{NaOH(aq)} + \underset{\text{Acid}}{HCl(aq)} \text{ ¾ ®} \underset{\text{Salt}}{NaCl(aq)} + \underset{\text{Water}}{H_2O(l)}$

(*j*) $\underset{\text{Base}}{2NaOH(aq)} + \underset{\text{Acid}}{H_2SO_4(aq)} \longrightarrow \underset{\text{Salt}}{Na_2SO_4(aq)} + \underset{\text{Water}}{2H_2O(l)}$

4. The chemical reactions which proceed with the evolution of heat energy are called ***exothermic reactions.***

The chemical reactions which proceed with the absorption of heat energy are called ***endothermic reactions.***

5. X is Copper and black colour compound is copper oxide (CuO).

6. The important use of decomposition reactions are:

- The digestion of food in the body is an example of decomposition reaction.
- Decomposition reaction is used in black and white photography.

7. (*a*) When a piece of iron metal is placed in copper sulphate solution, then iron sulphate solution and copper metal are formed.

(*b*) When a copper strip is placed in a solution of silver nitrate, then copper nitrate solution and silver metal are formed.

(*c*) When copper oxide is heated with magnesium powder, then magnesium oxide and copper are formed.

(*d*) When iron powder is heated with sulphur, iron sulphide is formed.

(*e*) When silver metal is placed in copper sulphate, no reaction takes place.

8. (*a*) Brown fumes are of nitrogen dioxide (NO_2).

(*b*) The yellow compound is Lead Oxide

(*c*) Lead salt is Lead nitrate

9. When sodium reacts with chlorine, sodium chloride is formed. The formation of sodium chloride with sodium and chlorine is a combination reaction and the electrolysis of sodium chloride is a decomposition reaction. So, we can say that a decomposition reaction is the opposite of a combination reaction.

10.

Exothermic Reaction	Endothermic Reaction
An **exothermic** reaction is one in which energy is released from the system into the surroundings.	An **endothermic** reaction occurs when energy is absorbed from the surroundings in the form of heat.
A + B → C + D + *q* (heat energy)	A + B + *q* (heat) → C + D

11. (*a*) $Mg(s) + 2H^+(aq) \longrightarrow Mg^{2+}(aq) + H_2(g)$

(*b*) $Zn(s) + Cu^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Cu(s)$

(*c*) $H^+(aq) + OH^-(aq) \longrightarrow H_2O(l)$

12. The graph shows Exothermic reaction.

III. Practical-based Questions

(*Refer to the Student's Book*)

1. (*c*) **2.** (*a*) **3.** (*c*) **4.** (*b*) **5.** (*b*)

UNIT 6: PREPARATION OF SALTS AND IDENTIFICATION OF IONS

(*Refer to the Student's Book*)

6.1 LEARNING OBJECTIVES

At the end of this unit, the learners would be able to:

Knowledge and Understanding	Skills	Attitudes and Values
• Define solubility. • Describe factors that affect solubility. • Explain the concept of unsaturated, saturated and supersaturated solutions. • Explain the solubility curves of different salt solutions. • Describe different methods of preparing soluble and insoluble salts. • Name the sources and uses of salts in daily life.	• Prepare different soluble and insoluble salts using suitable chemicals. • Interpret solubility curves of different solutions. • Carry out experiments to show the effect of temperature on the solubility of different salts. • Use solubility curves to determine the solubility of different salt solutions at different temperatures. • Perform tests to identify cations and anions.	• Develop a team spirit and sense of responsibility during experiments. • Appreciate the uses of salts in daily life such as sodium chloride as a table salt.

6.2 LESSONS AND TIME ALLOCATION

Lessons	Periods Required	Total Periods
6.1 Saturated and Unsaturated Solutions	1	**28**
6.2 Supersaturated Solutions	1	
6.3 Factors Influencing Solubility of Different Salts	4	
6.4 Solubility Curve	1	
6.5 Calculation of Solubility: Solved Numericals	3	
6.6 Different Ways of Preparing Normal Salts • Preparing Salts from Reaction of Acid with Active Metal • Preparing Salts from Reaction of Acid with Carbonates and Hydrogen Carbonate • Preparation of Salts from Reaction of Acids with Metal Oxide • Preparing Salts from Reaction of Acids with Bases • Preparation of Salt from Metal Oxides and Non-Metal Oxide • Preparing Salt with a Base and Non-Metal Oxide	6	
6.7 Uses and Sources of Salt • Sodium Chloride (NaCl) • Washing Soda ($Na_2CO_3.10H_2O$) • Baking Soda, Sodium Hydrogen-Carbonate ($NaHCO_3$)	6	
6.8 Identification of Ions • Identification of Cations • Identification of Anions • Identification of Gases	5	
Assessment	1	

6.3 CONTENT MAP

Introduction

This unit discusses the solubility and factors that affect solubility. It explains unsaturated, saturated and supersaturated solutions, including the solubility curves of different salt solutions. The unit also describes different methods of preparing soluble and insoluble salts. In addition, it tells the sources and uses of salts in daily life.

Classroom Organisation

Whole class orientation, individual work and then working in groups

Teaching and Learning Materials

- Paper, Pen, Pencil, Computers, and Internet connection

Teaching Aids

- **Audio-video:** Video showing preparation of salts
- **Notes:** List of salts and their uses
- **PowerPoint Presentation:** Showing unsaturated, saturated and supersaturated solutions
- **Visual:** Colour images of salts, solubility curve, unsaturated, saturated and supersaturated solutions

Competences Practised

- Literacy
- Numeracy
- Critical thinking
- Creativity and innovation
- Research and problem solving
- Communication in official languages
- Co-operation, inter-personal relations and life skills

Revision

- Objective type questions are provided at the end of each unit
- Short answer type questions are provided at the end of each unit

Assessments

- A formative assessment task of image collection
- A formative assessment of creativity

6.4 SUPPLEMENTARY INFORMATION FOR THE TEACHER

Differences Between each Solution

Saturated versus unsaturated

- Saturated is when there is a little bit of solute left that hasn't dissolved completely in the solvent. Unsaturated can be if there were more solute to put in an unsaturated solvent it would absorb more solute. Saturated is when there is a little bit of solute left that has not dissolved completely in the solvent.
- Unsaturated can be known also as dilute because there is not much solute in the solvent. If there were more solute to put in an unsaturated solvent, it would absorb more solute. It means that there is a smaller amount of solute in an unsaturated solution than there is in a saturated solution.

Saturated versus supersaturated

- The difference between saturated and supersaturated is that saturated has a little bit of solute that is left sitting at the bottom. Supersaturated is when there is actually a lot of solute sitting at the bottom of a container that can't be absorbed further. So the difference is that supersaturated has more solute sitting at the bottom of a container than a saturated would have.

Unsaturated versus supersaturated

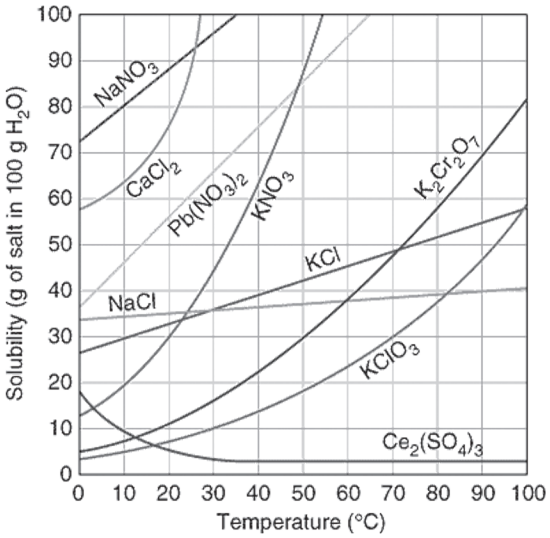
- The difference is that unsaturated solvent still has capacity to absorb the solute. The supersaturated solution is when there is too much solute in the solvent like stack of solute at the bottom of the solvent. Unsaturated has a dilute amount of solute and supersaturated has a concentrated amount of solute. The difference is that unsaturated solvent still has capacity to absorb the solute. The supersaturated solution is when there is too much solute in the solvent, and the solvent can't absorb more solvent. It means that there is a stack of solute at the bottom of the solvent for supersaturated.

6.5 FOR MORE INFORMATION VISIT

- http://www.buzzle.com/articles/unsaturated-solution.html
- http://www.science.uwaterloo.ca/~cchieh/cact/c120/solution.html
- http://www.slideshare.net/sqjafery/unsaturated-saturated-and-supersaturated-solutions
- http://theydiffer.com/difference-between-unsaturated-saturated-and-supersaturated-solutions/

6.6 ASSESSMENT

Look at the following graph and answer the questions that follow:



1. How many grams of Calcium Chloride can be dissolved in 100 g of water at 20°C?
2. How hot would the water have to be in order to get 70 g of $K_2Cr_2O_7$ to dissolve in 100 g of water?
3. If a 60 g crystal of $Pb(NO_3)_2$ was put in 100 g of water at 20°C, how much of the crystal would be left after it dissolved?

Answers

1. 75 g **2.** 90°C **3.** 5 g

6.7 TEACHING METHODOLOGY AND LEARNING ACTIVITIES

Activity 6.1: Demonstrating unsaturated, saturated and supersaturated solutions (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book to demonstrate unsaturated, saturated and supersaturated solutions.
- After completion of activity, the teacher should discuss with learners the definitions of important terms given in the Student's Book.

Lesson 1: Saturated and Unsaturated Solutions

(*Refer to the Student's Book*)

- The teacher should ask the learners to carry out **Activity 6.2**.

Activity 6.2: Testing whether a given solution of a substance is unsaturated, saturated, or supersaturated, at a particular temperature

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book.
- After completion of activity, the teacher should discuss with learners the differences between saturated and unsaturated solutions as given in the Student's Book.
- After discussion, ask the learners to do **Exercise 6.1** to assess the achievement of objectives.

Lesson 2: Supersaturated Solutions

(*Refer to the Student's Book*)

- The teacher should ask the learners to read and then discuss the text given in the Student's Book concerning supersaturated solutions.

Activity 6.3: Identifying dilute and concentrated solution

(*Refer to the Student's Book*)

- The teacher should guide the learners to read and then carry out the activity on their own.
- After completion of activity, ask the learners to do **Exercise 6.2** to assess the achievement of objectives.

Lesson 3: Factors Influencing Solubility of Different Salts

(*Refer to the Student's Book*)

- The teacher should ask the learners to read and then discuss the text given in the Student's Book on the factors influencing solubility of different salts.
- After learners read the lesson, ask them to do **Exercise 6.3** to assess the achievement of objectives.

Lesson 4: Solubility Curve

(*Refer to the Student's Book*)

- The teacher should ask the learners to read the text related to solubility curve given in the Student's Book
- After learners read the lesson, the teacher should discuss with them the information that can be obtained using solubility curve.

Lesson 5: Calculation of Solubility (*Refer to the Student's Book*)

- The teacher should ask the learners to carry out **Activity 6.4**.

Activity 6.4: Determining the solubilities of potassium sulphate, sodium chloride and sodium nitrate at room temperature (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book.
- After completion of activity, the teacher should discuss the examples given in the Student's Book.

Lesson 6: Different ways of Preparing Normal Salts

(*Refer to the Student's Book*)

- The teacher should ask the learners to carry out **Activity 6.5**.

Activity 6.5: Preparation of Zinc Sulphate $ZnSO_4.7H_2O$ (White Vitriol)

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.

Activity 6.6: Preparation of Sodium Chloride (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.

Experiment 1 (*Refer to the Student's Book*)

- The teacher should guide the learners to prepare calcium chloride by the action of an acid on an insoluble carbonate as per the procedure given in the Student's Book.

Activity 6.7: Preparation of copper sulphate $CuSO_4.5H_2O$ (Blue vitriol)

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.

Activity 6.8: Preparation of sodium sulphate (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.

Activity 6.9: Preparation of lead carbonate (*Refer to the Student's Book*)

- The teacher should guide the learners to prepare lead carbonate as per the procedure given in the Student's Book.

Activity 6.10: Preparation of calcium carbonate (*Refer to the Student's Book*)

- The teacher should guide the learners to prepare calcium carbonate as per the directions given in the Student's Book.
- After learners carry out the activities, ask them to do **Exercise 6.4** to assess the achievement of objectives.

Lesson 7: Uses and Sources of Salt (*Refer to the Student's Book*)

- The teacher should ask the learners to read the text related to uses and sources of different salts given in the Student's Book.
- After learners read the lesson, the teacher should discuss the lesson with them and then ask them to do **Exercise 6.5** to assess the achievement of objectives.

Lesson 8: Identification of Ions (*Refer to the Student's Book*)

- The teacher should ask the learners to read the text related to identification of ions given in the Student's Book.
- After learners read the lesson, the teacher should discuss the lesson with them and then ask them to do **Exercise 6.6** and **Exercise 6.7** to assess the achievement of objectives.

6.8 ANSWERS TO IN-TEXT EXERCISES

Exercise 6.1 (*Refer to the Student's Book*)

1. The state of equilibrium (or saturation) can be changed either by adding more water (solvent) to it or by increasing the temperature of solution.
2. True.
3. A solution which is unable to dissolve any more of the solute at a particular temperature is called a saturated solution at that temperature.
4. An unsaturated solution contains **less** solute than it can dissolve at that temperature.

5.

	Unsaturated Solution	Saturated Solution
1.	An unsaturated solution contains as less solute as it can dissolve at that temperature. That is, it can dissolve more.	A saturated solution contains as much solute as it can dissolve at the temperature.
2.	With the increase in temperature, it becomes more unsaturated.	With the increase in temperature it becomes unsaturated.

Exercise 6.2 (*Refer to the Student's Book*)

1. A solution that contains the maximum amount of solute at an elevated temperature is a supersaturated.

2.

Dilute Solution	Concentrated Solution
A solution containing relatively small amount of solute in a fixed amount of solvent or compared to that of the solvent is a dilute solution.	A solution containing relatively more quantity or large amount of solute in the fixed amount of solvent is a concentrated solution.

3. A saturated solution prepared at a higher temperature contains more of a given solute than does a saturated solution prepared at a lower temperature. So, when a saturated solution prepared at a higher temperature is cooled to room temperature, it will tend to throw out the excess of the solid from the solution in the form of crystals.

Exercise 6.3 (*Refer to the Student's Book*)

1. Like dissolves **like**.

2. I_2 and S_8 are not soluble in **water** but they are soluble in CCl_4, CS_2.

3. False; *Explanation*: The solubility of gases always decreases with increase in temperature.

4. The factors that affect solubility are

- **Nature of solute**
- **Temperature**

5. (a); *Explanation*: Solubilities of some substances in water such as calcium sulphate, calcium hydroxide and sodium sulphate decrease with the rise of the temperature.

Exercise 6.4 (*Refer to the Student's Book*)

1. Copper oxide dissolves in dilute sulphuric acid to form **a blue copper sulphate solution**.
2. The molecular formula of
   (a) White Vitriol is $\mathbf{ZnSO_4.7H_2O}$
   (b) Blue Vitriol is $\mathbf{CuSO_4.5H_2O}$
3. True
4. (a) $CaO(s) + SO_3(l) \longrightarrow CaSO_4(s)$
   (b) $MgO(s) + CO_2(g) \longrightarrow MgCO_3(s)$
5. (d); *Explanation*: The salts obtained by reaction of *sulphuric acid* are called *sulphates*.

Exercise 6.5 (*Refer to the Student's Book*)

1. **Uses of Sodium Carbonate**
   - Large quantities of sodium carbonate are used in the manufacture of glass, borax, soap and caustic soda.
   - It is used in the paper, paints and textile industries.
   - It is used for softening hard water. It removes temporary as well as permanent hardness.
   - It is used for washing purposes in the laundry.
   - It is used as an important laboratory reagent both in qualitative and quantitative analysis.
2. The molecular formula of washing soda is $\mathbf{Na_2CO_3.10H_2O}$.
3. The chemical name of baking soda is **Sodium Hydrogencarbonate.**
4. **False;** *Explanation*: Sodium hydrogencarbonate is present as an ingredient in antacids.
5. **False;** *Explanation*: The large crystals of sodium chloride obtained from rocks are generally brown in colour due to impurities present in them.

Exercise 6.6 (*Refer to the Student's Book*)

1. **False**; *Explanation*: NH_4^+ ions do not form a precipitate with both aqueous sodium hydroxide and aqueous ammonia.
2. Fe^{2+} ions form a **green** precipitate with both aqueous sodium hydroxide and aqueous ammonia.
3. Cu^{2+} ions form a *blue* precipitate with both aqueous sodium hydroxide and aqueous ammonia. The precipitate dissolves in excess ammonia to form a dark blue solution.
4. (b); *Explanation*: Al^{3+} ions form a *white* precipitate with both aqueous sodium hydroxide and aqueous ammonia. The precipitate dissolves in excess aqueous sodium hydroxide but not in excess aqueous ammonia.

5. Fe^{3+} ions form a brown precipitate with both **aqueous sodium hydroxide** and **aqueous ammonia.**

Exercise 6.7 (*Refer to the Student's Book*)

1. SO_3^{2-} ion forms white precipitate with both aqueous barium nitrate [$Ba(NO_3)_2$] and aqueous barium chloride ($BaCl_2$). The precipitate dissolves in both dilute hydrochloric acid and dilute nitric acid.
2. I^- ions form **a pale-yellow** precipitate when acidified with dilute nitric acid followed by aqueous lead nitrate [$Pb(NO_3)_2$] or silver nitrate.
3. The common chemical reagents used in the identification of anions are dilute hydrochloric acid (HCl), aqueous barium nitrate ($Ba(NO_3)_2$), aqueous silver nitrate ($AgNO_3$), dilute nitric acid (HNO_3) and dilute ammonia (NH_3) solution. Besides, red litmus is also used.
4. True.
5. CO_3^{2-} ion liberates a colourless, odourless gas (carbondioxide) when reacted with dilute hydrochloric acid. The gas turns lime water milky or forms a white precipitate with calcium hydroxide solution, turns blue litmus paper pink

6.9 ANSWERS TO UNIT ASSESSMENT

I. Multiple Choice Questions (*Refer to the Student's Book*)

1. (*a*)	**2.** (*c*)	**3.** (*a*)	**4.** (*b*)	**5.** (*d*)
6. (*b*)	**7.** (*a*)	**8.** (*c*)	**9.** (*d*)	**10.** (*a*)

II. Open Ended Questions (*Refer to theStudent's Book*)

1. **Saturated solution:** A solution that contains as much solute as can dissolve in the given solvent at a given temperature is a saturated solution.
   Unsaturated solution: A solution that contains less solute that can dissolve at a given temperature is an unsaturated solution.
2. A solution in which more solute is dissolved by increasing the temperature of a saturated solution is called supersaturated solution.
3. When a saturated solution prepared at a higher temperature is cooled to room temperature, it will tend to throw out the excess of the solid from the solution in the form of crystals. It takes, however, sometime for the excess solute to come out. During this interval, solution holds in it more solute than is required to saturate it. Such a solution is called a supersaturated solution.
4. With the increase in temperature saturated solution becomes unsaturated.
5. Refer Activity 6.5 in the Student's Book.
6. The factors that influence the solubility of salts are: nature of solute and temperature.

7. • The solubility curve helps us predict which substance will crystallise out first from a solution containing two or more solutes.
• The solubility curve helps us compare the solubilities of different substances at the same temperature.

8. (*a*) • It is used in the paper, paints and textile industries.
• It is used for softening hard water. It removes temporary as well as permanent hardness.
• It is used for washing purposes in the laundry.

(*b*) • It is used in soda-acid fire extinguishers.
• It is used in as antiseptic and antacids.

9. Ca^{2+} ions form a *white* precipitate with aqueous sodium hydroxide but not with aqueous ammonia. The precipitate does not dissolve in excess sodium hydroxide. Fe^{2+} ions form a dirty green precipitate with both aqueous sodium hydroxide and aqueous ammonia. The precipitate does not dissolve in excess alkali.

10. CO_3^{2-} liberates a colourless, odourless gas (carbondioxide) when reacted with dilute hydrochloric acid. The gas turns lime water milky or forms a white precipitate with calcium hydroxide solution, turns blue litmus paper pink.

III. Numericals

(*Refer to the Student's Book*)

1. Weight of a solute = 80 grams

Solubility at 30°C = 20

Weight of solvent (water) = ?

According to the formula,

$$\text{Solubility} = \frac{\text{Weight of solute (in grams)}}{\text{Weight of solvent (in grams)}} \times 100$$

$$\therefore \quad \text{Weight of solvent (grams)} = \frac{\text{Weight of solute (in grams)}}{\text{Solubility}} \times 100$$

$$= \frac{80}{20} \times 100 = 400 \text{ grams}$$

$\therefore$ 80 grams of solute needs 400 grams of solvent (water) to form saturated solution at 30°C.

2. Given, Mass of solute (sugar) = 14 grams
Mass of solvent (water) = 10 grams
Solubility at 30°C = ?
According to the formula,
Solubility

$$= \frac{\text{Wt. of solute (in grams)}}{\text{Wt. of solvent (in grams)}} \times 100$$

$$= \frac{14 \text{ grams}}{10 \text{ grams}} \times 100$$

$$= 140$$

$\therefore$ The solubility of sugar at 30°C is 140.

IV. Practical-based Questions

(*Refer to the Student's Book*)

1. (*c*) **2. (i)** (c) **(ii)** (d) **(iii)** (c) **(iv)** (a)

6.10 PROJECT

(*Refer to the Student's Book*)

The teacher should guide the learners to carry out the experiment on their own.

UNIT 7: THE MOLE CONCEPT AND GAS LAWS

(*Refer to the Student's Book*)

7.1 LEARNING OBJECTIVES

At the end of this unit, the learners would be able to:

Knowledge and Understanding	Skills	Attitudes and Values
• Explain the mole concept. • Explain the concepts of: relative atomic mass, relative formula mass, relative molecular mass, molar mass limiting reactant empirical and molecular formulae. • State the gas laws: Gay-Lussac, Charles' law, Boyle's law, Ideal gas law, and the Grahams' law of diffusion.	• Experimentally determine the mass composition of a compound using magnesium oxide as an example. • Calculate the molar masses of various substances and weigh out 1 mole of each. • Perform calculations involving empirical and molecular formulae. • Apply the gas laws to calculate the volume, temperature and pressure of gases, and molecular weight of gases.	• Develop a teamwork approach in research, group activities and exercises. • Respect procedures while performing experiments. • Appreciate the work done by different personalities in the formulation of gas laws e.g., Gay-Lussac, Charles, Boyle, and Graham.

7.2 LESSONS AND TIME ALLOCATION

Lessons	Periods Required	Total Periods
7.1 Avogadro Number and the Mole Concept	1	**18**
7.2 Calculation of Number of Moles	2	
7.3 Definition of Relative Atomic Mass	1	
7.4 Definition and Calculation of Relative Molecular Mass	1	
7.5 Definition and Calculation of Relative Formula Mass	1	
7.6 Calculation of Molar Mass	1	
7.7 Relationship Between Number of Moles, Mass and Molar Mass	1	
7.8 Calculation of Mass Per cent Composition of an Element in a Compound	1	
7.9 Empirical Formula and Molecular Formula	1	
7.10 Stoichiometric Calculations	1	
7.11 Limiting Reactants	1	
7.12 The Gaseous State	1	
7.13 The Gas Laws • Gay Lussac Law • Charles' Law • Boyle's Law • Avogadro's Law—Volume Amount Relationship • Ideal Gas Equation • Graham's Law of Diffusion	2	
7.14 Calculation of Molar Gas Volume Under Standard Conditions	2	
Assessment	1	

7.3 CONTENT MAP

Introduction

The unit explains the mole concept, including the concepts of relative atomic mass, relative formula mass, relative molecular mass, molar mass, limiting reactant, empirical and molecular formulae. Besides, it discusses the gas laws: Gay Lussac, Charles' law, Boyle's law, the Ideal gas law and Grahams' law of diffusion.

Classroom Organisation

Whole class orientation, individual work and then working in groups.

Teaching and Learning Materials

- Paper, Pen, Pencil, Computers, and Internet connection.

Teaching Aids

- **Audio-video:** Video showing Gas laws: Gay-Lussac, Charles' law, Boyle's law, the Ideal gas law and Grahams' law of diffusion.
- **Notes:** Molecular formulae, relative atomic mass, relative formula mass, relative molecular mass
- **PowerPoint Presentation:** Stoichiometric calculations and Limiting reactants

Competences Practised

- Literacy
- Numeracy
- Critical thinking
- Creativity and innovation
- Research and problem solving
- Communication in official languages
- Co-operation, inter-personal relations and life skills

Revision

- Objective type questions are provided at the end of each unit
- Short answer type questions are provided at the end of each unit.

Assessments

- The learners should be able to determine the composition of compounds by mass, volume and number of moles.

7.4 SUPPLEMENTARY INFORMATION FOR THE TEACHER

- The **Avogadro constant** 6.022×10^{23} is defined as the number of atoms in exactly 12 g of carbon-12. The **mole** is the amount of substance that contains the same number of particles (atoms/ions/molecules/formula units etc.) as there are atoms in exactly 12 g of carbon-12. Mass of 1 mole of a substance is called its molar mass.
- **Boyle's Law** states that Volume of a given mass of dry gas is inversely proportional to its pressure at a constant temperature.
- **Charle's Law** states that Volume of a given mass of a dry gas is directly proportional to its absolute (kelvin) temperature, if the pressure is kept constant.
- **Gay-Lussac's Law** of combining Volumes states that when gases react, they do so in volumes which bear a simple ratio to one another, and to the volume of gaseous product, provided that all the volumes are measured at the same temperature and pressure.
- **Avogadro's Law** : Equal volumes of all gases under similar conditions of temperature and pressure contain the same number of molecules. We'll enhance our knowledge on atomic mass, evaluation of percentage composition of a compound in a reaction etc. in this module.

7.5 FOR MORE INFORMATION VISIT

- http://www.chemteam.info/Mole/Avogadro-Number-CalcsII.html
- http://www.physchem.co.za/OB11-che/atomic2.htm
- http://www.slideshare.net/JDLongenberger/notes-gas-laws

7.6 ASSESSMENT

1. The largest number of molecules is in:

(*a*) 28 g of CO (*b*) 46 g of C_2H_5OH

(*c*) 36 g of H_2O (*d*) 54 g of N_2O_5

2. The number of molecules in 89.6 litre of a gas at NTP are:

(*a*) 6.022×10^{23} (*b*) $2 \times 6.022\times10^{23}$

(*c*) $3 \times 6.022\times10^{23}$ (*d*) $4 \times 6.022\times10^{23}$

3. The total number of protons in 10 g of calcium carbonate is:

(*a*) 3.0115×10^{24} (*b*) 1.5057×10^{24} (*c*) 2.0478×10^{24} (*d*) 4.0956×10^{24}

4. What is equivalent weight of NaCl?

(*a*) 58.5 (*b*) 12.12 (*c*) 13.45 (*d*) 65.42

Answers

1. (*c*) **2.** (*d*) **3.** (*a*) **4.** (*a*)

7.7 TEACHING METHODOLOGY AND LEARNING ACTIVITIES

Lesson 1: Avogadro Number and the Mole Concept

(*Refer to the Student's Book*)

- The teacher should introduce the lesson by asking the learners to read and carry out **Activity 7.1**.

Activity 7.1: Illustrating link between number of particles and mass of particles
(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book to help them understand the link between number of particles and mass of particles.
- After completion of activity, the teacher should ask the learners to read and discuss the text given in the Student's Book regarding relationship between Avogadro number, mole and mass.
- After learners read the lesson, ask them to do **Exercise 7.1** to assess the achievement of objectives.

Activity 7.2: Illustrating concept of moles **(***Refer to the Student's Book***)**

- The teacher should split the class into small groups and then ask them to discuss the concept of moles as a way of expressing the amount of substance and make a presentation on the same.

Lesson 2: Calculation of the Number of Moles

(*Refer to the Student's Book*)

- Using the examples given in the Student's Book, the teacher should guide the learners to calculate number of moles.
- He/She should ask the learners to solve **Exercise 7.2** to assess the achievement of objectives.

Lesson 3: Definition of Relative Atomic Mass

(*Refer to the Student's Book*)

- The teacher should ask the learners to read the definition and concept of relative atomic mass given in the Student's Book.

Lesson 4: Definition and Calculation of Relative Molecular Mass

(*Refer to the Student's Book*)

- The teacher should ask the learners to read the definition and calculation of relative molecular mass given in the Student's Book.
- He/She should ask the learners to solve **Exercise 7.3** to assess the achievement of objectives.

Lesson 5: Definition and Calculation of Relative Formula Mass

(*Refer to the Student's Book*)

- The teacher should ask the learners to read the lesson on definition and calculation of relative molecular mass given in the Student's Book and then practise calculating Relative Formula Mass with the help of examples given in the Student's Book.
- He/She should ask the learners to solve **Exercise 7.4** to assess the achievement of objectives.

Lesson 6: Calculation of Molar Mass (*Refer to the Student's Book*)

- The teacher should begin the lesson by asking the learners to read and carry out **Activity 7.3**.

Activity 7.3: Understanding molar mass (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.
- He/She should ask the learners to solve **Exercise 7.5** to assess the achievement of objectives.

Lesson 7: Relationship Between Number of Moles, Mass and Molar Mass

(*Refer to the Student's Book*)

The teacher should guide the learners to read the text on relationship between number of moles, mass and molar mass given in the Student's Book and to practise calculating the number of moles in a certain mass of a substance.

Lesson 8: Calculation of Mass Percent Composition of an Element in a Compound

(*Refer to the Student's Book*)

Using the formula and examples given in the Student's Book, the teacher should guide the learners to calculate mass per cent composition of an element in a compound.

Experiment 1 (*Refer to the Student's Book*)

The teacher should guide the learners to perform the experiment to determine the Per cent Composition of a magnesium in magnesium oxide as per the procedure given in the Student's Book.

- After learners perform the experiment, the teacher should ask them to do **Exercise 7.6** to assess the achievement of objectives.

Lesson 9: Empirical Formula and Molecular Formula

(*Refer to the Student's Book*)

- The teacher should ask the learners to read the text on empirical formula and molecular formula given in the Student's Book and with the help of examples discuss with learners the steps for writing empirical and molecular formula.
- After the discussion, the teacher should ask the learners to do **Exercise 7.7** to assess the achievement of objectives.

Lesson 10: Stoichiometric Calculations (*Refer to the Student's Book*)

- The teacher should ask the learners to read the text on stoichiometric calculations given in the Student's Book. Thereafter, using the examples given in the Student's Book, discuss and help the learners understand how to balance chemical equations.
- After the discussion, the teacher should ask the learners to do **Exercise 7.8** to assess the achievement of objectives.

Lesson 11: Limiting Reactants (*Refer to the Student's Book*)

The teacher should begin the lesson by asking the learners to carry out **Activity 7.4**.

Activity 7.4: Illustrating limiting reactants (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book to understand limiting reagents and their importance in stoichiometric calculations.
- With the help of examples given in the Student's Book, the teacher should help the learners in identifying and calculating limiting reactants.
- He/She should further ask the learners to do **Exercise 7.9** to assess the achievement of objectives.

Lesson 12: The Gaseous State (*Refer to the Student's Book*)

- The teacher should ask the learners to read the text on the Gaseous State given in the Student's Book and then discuss the physical properties of the gaseous state with the learners.

Lesson 13: The Gas Laws (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out **Activities 7.5** to **7.8** to illustrate and discuss the gas laws.

Activity 7.5: Illustrating Gay-Lussac's law (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.

Activity 7.6: Illustrating Charles' law (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.

Activity 7.7: Illustrating Boyle's law (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.

Activity 7.8: To Study the diffusion of two gases (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.

Lesson 14: Calculation of Molar Gas Volume Under Standard Conditions

(*Refer to the Student's Book*)

- With the help of solved examples given in the Student's Book, the teacher should guide the learners to calculate molar gas volume under standard conditions.
- After learners practise calculation of molar gas volume, the teacher should ask them to do **Exercise 7.10** to assess the achievement of objectives.

7.8 ANSWERS TO IN-TEXT EXERCISES

Exercise 7.1 (*Refer to the Student's Book*)

1. **True**.
2. A group of 6.022×10^{23} particles (atoms, ions, or molecules) of a substance is called a **mole** of that substance.
3. One mole of CO_2 contains $\mathbf{6.023 \times 10^{23}}$ atoms of carbon.
4. (*b*)
5. Mole is a link between the **mass** of atoms (or molecules) and the **number** of atoms (or molecules).

Exercise 7.2 (*Refer to the Student's Book*)

1. Mass of oxygen gas = 12 g

   Molar mass of oxygen gas = $2 \times 16 = 32$ g mol^{-1}

   $$\text{No. of moles of oxygen gas} = \frac{\text{Mass of oxygen gas}}{\text{Molar mass of oxygen gas}}$$

   $$= \frac{12\,\text{g}}{32\,\text{g mol}^{-1}} = 0.375 \text{ mol.}$$

2. (*i*) 0.5 mole of water molecules = 0.5 mole × molar mass of water
= 0.5 mol × 18 g mol^{-1} = 9.0 g

(*ii*) 0.2 mole of oxygen atoms = 0.2 mole × molar mass of oxygen atoms
= 0.2 mole × 16 g mol^{-1} = 3.2 g

Exercise 7.3 (*Refer to the Student's Book*)

1. (*a*) Molecular mass of phosphorus molecule, P_4
= Mass of P × 4
= 31 × 4 = 124 u.

(*b*) Molecular mass of sulphur molecule, S_8
= Mass of S × 8
= 32 × 8 = 256 u.

Exercise 7.4 (*Refer to the Student's Book*)

1. (*i*) Formula unit mass of ZnO
= atomic mass of Zn + atomic mass of O
65 u + 16 u = 81 u

(*ii*) Formula unit mass of Na_2CO_3
= (atomic mass of Na × 2) + atomic mass of C × 1
+ (atomic mass of O × 3)
= (23 × 2) + (12 × 1) + (16 × 3)
= 46 u + 12 u + 48 u = 106 u

(*iii*) Formula unit mass of $C_6H_{12}O_6$
= (atomic mass of C × 6) + (atomic mass of H × 12)
+ (atomic mass of oxygen × 6)
= (12 × 6) + (1 × 12) + (16 × 6)
= 72 u + 12 u + 96 u = 180 u

Exercise 7.5 (*Refer to the Student's Book*)

1. The molar masses of all these substances will be equal to the respective molecular masses expressed in g/mol. Now:

(*a*) Molar mass of ethyne, C_2H_2
= Mass of C × 2 + Mass of H × 2
= 12 × 2 + 1 × 2
= 24 + 2
= 26 g/mol

(*b*) Molar mass of hydrochloric acid, HCl

= Mass of H + Mass of Cl

= 1 + 35.5

= 36.5 g/mol

(*c*) Molar mass of nitric acid, HNO_3

= Mass of H + Mass of N + Mass of O × 3

= 1 + 14 + 16 × 3

= 15 + 48

= 63 g/mol

Exercise 7.6 (*Refer to the Student's Book*)

1. Molecular mass of water (H_2O)

= 2 × 1 u + 16 u = 18 u

Mass percentage of hydrogen (H) in water

$$= \frac{2u}{18u} \times 100 = 11.11\%$$

Mass percentage of oxygen (O) in water

$$= \frac{16u}{18u} \times 100 = 88.89\%$$

Hence, the composition of water by mass is H = 11.11% and O = 88.89%.

2. Molecular mass of glucose ($C_6H_{12}O_6$)

= 6 × 12 u + 12 × 1 u + 6 × 16 u

= 72 u × 12 u + 96 u = 180 u

Mass percentage of carbon (C) in glucose

$$= \frac{72u}{180u} \times 100 = 40.0\%$$

Mass percentage of hydrogen (H) in glucose

$$= \frac{12u}{180u} \times 100 = 6.67\%$$

Mass percentage of oxygen (O) in glucose

$$= \frac{96u}{180u} \times 100 = 53.33\%$$

Hence, glucose contains 40.0% carbon, 6.67% hydrogen and 53.33% oxygen.

3. Molecular mass of $Na_2CO_3 \cdot 10H_2O$

= 2 × 23 u + 12 u + 3 × 16 u + 10 (2 × 1 u + 1 × 16 u)

= 46 u + 12 u + 48 u + 180 u = 286 u

286 g of washing soda contains 180 g of water of crystallisation.

100 g of washing soda will contain $\frac{180\,u}{286\,u} \times 100\,g$ water of crystallisation = 62.94 g

The amount of water of crystallisation in washing soda = 62.94% by mass.

4. Molecular mass of $KMnO_4$

$= 39 + 55 + 16 \times 4 = 39 + 55 + 64 = 158$ u

Percentage of potassium

$$= \frac{39 \times 100}{158} = 24.68\%$$

Percentage of manganese

$$= \frac{55 \times 100}{158} = 34.81\%$$

Percentage of oxygen

$$= \frac{64 \times 100}{158} = 40.51\%$$

The percentage composition of potassium permanganate is as follows:

Potassium = 24.68%
Manganese = 34.81%
Oxygen = 40.51%

Exercise 7.7 (*Refer to the Student's Book*)

1.

Element	Symbol	Percentage	Atomic mass	Relative no. of moles	Simple ratio of moles	Simplest whole no. of ratio
Carbon	C	40%	12	$\frac{40}{12} = 3.33$	$\frac{3.33}{3.33} = 1$	1
Hydrogen	H	6.67%	1	$\frac{6.67}{1} = 6.67$	$\frac{6.67}{3.33} = 2$	2
Oxygen	O	53.33%	16	$\frac{53.33}{16} = 3.33$	$\frac{3.33}{3.33} = 1$	1

$\therefore$ Empirical formula is CH_2O.

2. For calculating empirical formula

Element	Symbol	Percentage by mass	Atomic mass	% by mass/ atomic mass	Simple ratio	Simplest whole number ratio
Iron	Fe	69.9	55.85	69.9/55.85 = 1.25	1.25/1.25 = 1	2
Oxygen	O	30.1	16.00	30.1/16.00 = 1.88	1.88/1.25 = 1.5	3

So, the empirical formula = Fe_2O_3

3.

Element	%	Atomic mass	Atomic ratio	Simplest ratio	Simplest whole number ratio
C	48.0	12	$\frac{48.0}{12} = 4.0$	$\frac{4.0}{1.0} = 4$	4
H	8.0	1	$\frac{8.0}{1} = 8.0$	$\frac{8.0}{1.0} = 8$	8
N	28.0	14	$\frac{28.0}{14} = 2.0$	$\frac{2.0}{1.0} = 2$	2
O	16.0	16	$\frac{16.0}{16} = 1.0$	$\frac{1.0}{1.0} = 1$	1

The simplest ratio of C : H : N : O is 4 : 8 : 2 : 1

Empirical formula of the compound is $C_4H_8N_2O$.

Exercise 7.8 (*Refer to the Student's Book*)

1. (*a*) $2CO + O_2 \longrightarrow 2CO_2$

(*b*) $2KNO_3 \longrightarrow 2KNO_2 + O_2$

(*c*) $2O_3 \longrightarrow 3O_2$

(*d*) $NH_4NO_3 \longrightarrow N_2O + 2H_2O$

(*e*) $4CH_3NH_2 + 9O_2 \longrightarrow 4CO_2 + 10\ H_2O + 2N_2$

(*f*) $Cr(OH)_3 + 3HClO_4 \longrightarrow Cr(ClO_4)_3 + 3H_2O$

2. (*a*) $CaC_2 + 2H_2O \longrightarrow C_2H_2 + Ca(OH)_2$

(*b*) $2\ KClO_3 \longrightarrow 2\ KCl + 3O_2$

(*c*) $2C_6H_6 + 15O_2 \longrightarrow 12CO_2 + 6H_2O$

(*d*) $2C_5H_{12}O + 15O_2 \longrightarrow 10CO_2 + 12H_2O$

Exercise 7.9 (*Refer to the Student's Book*)

1. You are asked to identify the limiting reactant and mass (in grams) of the excess reactant remaining after the reaction is complete.

You are given the mass of the reactants.

Step 1. Write a balanced chemical equation.

$$2H_2 + O_2 \longrightarrow 2H_2O$$

Step 2. Determine the limiting reactant by comparing the relative amounts of reactants available.

Calculate the amount (in mol) of one of the reactants needed and compare that value to the amount available.

amount of O_2 needed: $8.40\ g\ H_2 \left(\frac{1\ mol\ H_2}{2.016\ g}\right)\left(\frac{1\ mol\ O_2}{2\ mol\ H_2}\right) = 2.08\ mol\ O_2$

amount of O_2 available: $61.0\ g\ O_2 \times \frac{1\ mol\ O_2}{32.00\ g} = 1.91\ mol\ O_2$

More O_2 is needed (2.08 mol) than is available (1.91 mol), so O_2 is the limiting reactant.

2. Step 1. $0.30\ \cancel{mol\ Zn} \times \frac{1\ mol\ H_2}{1\ \cancel{mol\ Zn}} = 0.30\ mol\ H_2$

$$0.52\ 1\ \cancel{mol\ HCl} \times \frac{1\ mol\ H_2}{2\ \cancel{mol\ HCl}} = 0.26\ mol\ H_2$$

You see that hydrochloric acid must be the limiting reactant and that some zinc must be left unconsumed. (Zinc is the excess reactant.)

Step 2. Since HCl is the limiting reactant, the amount of H_2 produced must be **0.26 mol.**

Exercise 7.10 (*Refer to the Student's Book*)

1. The relationship of volume and temperature of a gas is expressed in absolute scale. This is known as **Charles law**.

2. Boyle's law can help to deduce relationship between **density**, and **pressure** of the gas.

3. A gas that follows Boyle's law, Charle's law and Avogadro's law strictly is called ideal gas.
4. True.
5. True.

7.9 ANSWERS TO UNIT ASSESSMENT

I. Multiple Choice Questions

(*Refer to the Student's Book*)

1. (*a*)	**2.** (*a*)	**3.** (*c*)	**4.** (*c*)	**5.** (*c*)
6. (*b*)	**7.** (*a*)	**8.** (*a*)	**9.** (*a*)	

II. Open Ended Questions

(*Refer to the Student's Book*)

1. A mole is the amount of pure substance containing the same number of chemical units as there are atoms in exactly 12 grams of carbon-12 (*i.e.*, 6.023×10^{23}).
2. The **relative atomic mass** (A_r) of an element is the average relative mass of an atom of an element as compared with an atom of $_{12}C$ taken as 12 atomic mass unit.

   The **relative molecular mass** of a compound is the average relative mass of its molecule as compared with the mass of one $_{12}C$ atom taken as 12 u.
3. No. of moles of a substance, $X = \frac{\text{Mass of the substance in grams}}{\text{Molar mass of the substance in grams per mole}}$
4. An **empirical formula** represents the simplest whole number ratio of various atoms present in a compound.
5. The compounds having same empirical and molecular formula are H_2O, Fe_2O_3, NO_2, Na_2CO_3.
6. The **limiting reagent** (or **limiting reactant**) in a chemical reaction is the substance that is totally consumed when the chemical reaction is complete.
7. In textbook, Refer Activity 7.5.
8. **Charles' law** is a relationship between volume and absolute temperature. It states that volume of a fixed amount of gas is directly proportional to its absolute temperature.

   Boyle's law states that under isothermal condition, pressure of a fixed amount of a gas is inversely proportional to its volume.
9. An **ideal gas** equation can be characterised by three state variables: absolute pressure (P), volume (V), and absolute temperature (T). The relationship between all three was first stated by Émile Clapeyron in 1834 as a combination of Boyle's law, Charles' law and Avogadro's law.

   PV = ***n***RT where, n = number of moles, R = universal gas constant.

10. According to Graham's law, *the rates of diffusion of gases are inversely proportional to the square root of their molecular masses.*

Or

According to Graham's law, *the rates of diffusion of gases are inversely proportional to the square roots of their densities.*

Or

Graham found experimentally that *time taken for the diffusion of equal volumes of two gases under similar conditions of temperature and pressure is directly proportional to the square root of their densities or molecular masses.*

III. Numericals

(*Refer to the Student's Book*)

1. Since temperature and amount of gas remains constant, Boyle's law is applicable.

$P_1V_1 = P_2V_2$

$P_1 = 1.2$ bar, $P_2 = ?$

$V_1 = 120$ ml, $V_2 = 180$ ml

$\therefore \quad 1.2 \times 120 = P_2 \times 180$

$\therefore \quad P_2 = \dfrac{1.2 \times 120}{180} = 0.8$ bar

2.

$V_1 = 520$ ml, $V_2 = 26$ ml

$T_1 = 100 + 273 = 373$ K, $T_2 = ?$

Since pressure remains constant, by applying Charle's law:

$$\frac{V_1}{T_1} = \frac{V_2}{T_2}$$

So, $$T_2 = \frac{V_2 \times T_1}{V_1}$$

$$\therefore \quad T_2 = \frac{(260\ \text{ml}) \times (373\ \text{K})}{(520\ \text{ml})} = 186.5\ \text{K}$$

or, $T_2 = 186.5 - 273 = -86.5°C$

3. $pV = nRT$

$$\text{or } p = \frac{m}{V} \cdot \frac{RT}{M} = \frac{dRT}{M}$$

$$d = \frac{pM}{RT}$$

$p = 5$ bar, $T = 273 + 30 = 303$ K, $M = 17$,

$R = 0.083$ bar.dm^{3}mol^{-1}K^{-1}

$$\therefore \quad d = \frac{(5 \text{ bar}) \times (17 \text{ g.mol}^{-1})}{(0.083 \text{ bar.dm}^3\text{mol}^{-1}\text{K}^{-1}) \times (303 \text{ K})}$$

$$= 3.37 \text{ g.dm}^{-3}$$

4. According to ideal gas equation,

$pV = nRT$

$n = \frac{8.8}{44}$ mol, $P = 1$ bar

$T = 273 + 31.1 = 304.1$ K

$V = ?$ $R = 0.083$ bar.dm^{3}K^{-1}mol^{-1}

Now $$V = \frac{nRT}{p}$$

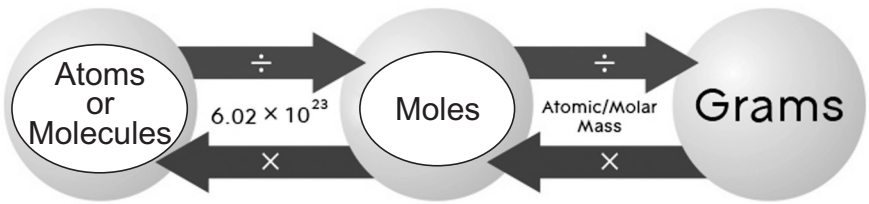
$$= \frac{\left(\frac{8.8}{44} \text{mol}\right) \times (0.083 \text{ bar.dm}^3\text{K}^{-1}\text{mol}^{-1}) \times (304.1\text{K})}{1 \text{ bar}}$$

$$= 5.05 \text{ dm}^3 \text{ or } 5.05 \text{ L}$$

IV. Practical-based Questions

(*Refer to the Student's Book*)

1.



2. The following figure depicts **Boyle's** law.

3. True.

4. The buns, slices of cheese, leaves of lettuce, and 5 pieces of burger meat are all reacting to produce burgers. Assuming you use *one of each to make a burger,* the limiting reagent will be the lettuce leaves.

The "reaction" will produce **3 burgers** – the amount determined by the limiting reagent – and have 1 bun, 3 slices of cheese, and 2 pieces of meat in **excess**.

7.10 PROJECT

(*Refer to the Student's Book*)

The teacher should guide the learners to carry out the experiment on their own.

UNIT 8: PREPARATION AND CLASSIFICATION OF OXIDES

(*Refer to the Student's Book*)

8.1 LEARNING OBJECTIVES

At the end of this unit, the learners would be able to:

Knowledge and Understanding	Skills	Attitudes and Values
• Categorise different oxides. • Explain how different oxides are formed. • State the uses of different oxides. • Describe the reaction of oxides with other substances. • Describe the process of producing slaked lime.	• Experimentally prepare different oxides from elements and compounds. • Test the properties of oxides prepared in the laboratory. • Classify oxides into alkaline, acidic, amphoteric and neutral.	• Develop a team approach and a sense of responsibility in group activities. • Respect for the procedures while performing experiments. • Care about harmful oxides like sulphur dioxide and nitrogen dioxide, during experiments.

8.2 LESSONS AND TIME ALLOCATION

Lessons	Periods Required	Total Periods
8.1 Preparation of Oxides Direct Combination of an Element with Oxygen • Thermal Decomposition of Hydroxide Carbonates and Nitrate • Thermal Decomposition of Hydroxide • Thermal Decomposition of Carbonates • Thermal Decomposition of Nitrates	4	**18**

8.2 Reaction of Oxides with Water	4	
8.3 Reaction of Oxides with Acid and Bases	4	
8.4 Classification of Oxides	4	
8.5 Uses and Production of Slaked Lime (*Ishwagara*)	1	
Assessment	1	

8.3 CONTENT MAP

Introduction

This unit explains how different oxides are formed and discusses categories of different oxides. It also gives the uses of different oxides. Besides the unit, describe the reaction of oxides with other substances and the process of producing slaked lime.

Classroom Organisation

Whole class orientation, individual work and then working in groups

Teaching and Learning Materials

- Paper, Pen, Pencil, Computers, and Internet connection

Teaching Aids

- **Audio-video:** Video showing formation of oxides
- **Notes:** List of acidic oxide, basic oxide, neutral oxide, and amphoteric oxide
- **PowerPoint Presentation:** Process of producing slaked lime

Competences Practised

- Literacy
- Numeracy
- Critical thinking
- Creativity and innovation
- Research and problem solving
- Communication in official languages
- Co-operation, inter-personal relations and life skills

Revision

- Objective type questions are provided at the end of each unit.
- Short answer type questions are provided at the end of each unit.

Assessments

- A formative assessment task of image collection
- A formative assessment of creativity

8.4 FOR MORE INFORMATION VISIT

- http://www.kristallikov.net/page29e.html
- http://www.chemguide.co.uk/inorganic/group2/thermstab.html
- https://en.wikipedia.org/wiki/Thermal_decomposition

8.5 ADDITIONAL ACTIVITY

Formation of Iron Oxide

Take three test tubes A, B, C. Place an iron nail in each. Add water to test tube A. Place fused calcium chloride which absorbs moisture in test tube B. Add boiled water to test tube C, add a layer of oil above the water and plug it with a cork. Let the test tubes stand for a few days. You will notice that the nail in test tube A rusts because it has air and moisture which are the two substances necessary for rusting. In test tube B, the nail does not rust as it has oxygen but the moisture has been absorbed by calcium chloride. In test tube C, the nail does not rust because boiled water was devoid of air. Hence, we can conclude that, atmospheric oxygen and moisture are the two substances essential for rusting.

8.6 TEACHING METHODOLOGY AND LEARNING ACTIVITIES

Activity 8.1: Illustrating types of oxides (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book and record their observations.
- He/She should ask the learners the leading questions given in the activity and then discuss their answers.

Lesson 1: Preparation of Oxides (*Refer to the Student's Book*)

The teacher should ask the learners to read the methods to prepare oxides as given in the Student's Book.

Activity 8.2: Illustrating nature of metal oxide (*Refer to the Student's Book*)

The teacher should guide the learners to repeat **Activity 8.1** with Calcium and make a report on the products obtained from the reaction of metals with oxygen.

- After completion of activity, ask the learners to read the text given in the Student's Book regarding combination of metals with oxygen.
- After the learners read the text, the teacher should ask them to do **Exercise 8.1** to assess the achievement of objectives.

Activity 8.3: Illustrating nature of non-metal oxide (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.
- He/She should guide the learners to note their observations and make a report on the products obtained from the reaction of non-metals with oxygen.
- After completion of the activity, the teacher should ask them to do **Exercise 8.2** to assess the achievement of objectives.

Activity 8.4: Illustrating thermal decomposition (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.

Activity 8.5: Thermal decomposition of copper carbonate
(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.

Activity 8.6: Thermal decomposition of lead nitrate (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.
- After learners perform the activities, the teacher should ask them to do **Exercise 8.3** to assess the achievement of objectives.

Lesson 2: Reaction of Oxides with Water (*Refer to thee Student's Book*)

The teacher should begin the lesson by asking the learners to carry out **Activity 8.7**.

Activity 8.7: Illustrating combination of oxides with water
(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.
- After completion of activity, the teacher should discuss with learners the equations for reaction of metal oxides with water as given in the Student's Book.

Activity 8.8: Non-metal oxides dissolve in water to form acid

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.
- After completion of activity, the teacher should discuss with learners the equations for reaction of non-metal oxides with water to form acids as given in the Student's Book.
- After discussion, the teacher should ask them to do **Exercise 8.4** to assess the achievement of objectives.

Lesson 3: Reaction of Oxides with Acids and Bases

(*Refer to the Student's Book*)

The teacher should begin the lesson by asking the learners to carry out **Activity 8.9**.

Activity 8.9: Illustrating combination of oxides with acid and bases

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.
- After completion of activity, the teacher should discuss with learners the equations for reaction of oxides with acid and bases as given in the Student's Book.
- After discussion, the teacher should ask them to do **Exercise 8.5** to assess the achievement of objectives.

Lesson 4: Classification of Oxides

(*Refer to the Student's Book*)

The teacher should begin the lesson by asking the learners to carry out **Activity 8.10** and **8.11**.

Activity 8.10: Illustrating acidity/basicity of oxides

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.

Activity 8.11: Illustrating chemical properties of MgO

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.

Activity 8.12: Illustrating effect of litmus solution to different oxides

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.

- After completion of activities the teacher should ask them to do **Exercise 8.6** to assess the achievement of objectives.

Lesson 5: Uses and Production of Slaked Lime (*ISHWAGARA*)

(*Refer to the Student's Book*)

- The teacher should guide the learners to read the uses and production of slaked lime as given in the Student's Book and discuss among themselves.
- After learners read and discuss lesson 5, the teacher should ask them to do **Exercise 8.7** to assess the achievement of objectives.

8.7 ANSWERS TO IN-TEXT EXERCISES

Exercise 8.1 (*Refer to the Student's Book*)

1. Metals react with oxygen to produce **metal oxide**.
2. True
3. The molecular formula of iron oxide is $\mathbf{Fe_3O_4}$.
4. Magnesium (Mg) does not react with oxygen at room temperature. It reacts with oxygen on heating to give magnesium oxide (MgO).
5. (*d*); both (*a*) and (*b*) formulae are correct. *Explanation:* Al_2O_3 is aluminium oxide, and Na_2O is sodium oxide.

Exercise 8.2 **(***Refer to the Student's Book***)**

1. The molecular formula of phosphorus pentoxide is $\mathbf{P_2O_5}$.
2. $S(s) + O_2(g) \longrightarrow SO_2(g)$
3. Non-metal oxides are generally **acidic** in nature.
4. **True**; *Explanation:* On reaction with water *s*ulphur oxide forms sulphuric acid and nitrogen oxide forms nitric acid.
5. (*d*); *Explanation:* All options are oxides of non-metals.

Exercise 8.3 (*Refer to the Student's Book*)

1. Metal hydroxide decomposes to form **metal oxide** and **water**.
2. (*i*) $Ca(OH)_2(s) \xrightarrow{\text{Heat}} CaO(s) + H_2O(g)$

   (*ii*) $\underset{\text{Zinc carbonate}}{ZnCO_3(s)} \xrightarrow{\text{Heat}} \underset{\text{Zinc oxide}}{ZnO(s)} + \underset{\text{Carbon dioxide}}{CO_2(s)}$

3. Lithium nitrate decomposes on heating to produce **lithium oxide, nitrogen dioxide** and **oxygen**.
4. Thermal decomposition is a chemical reaction where heat causes one substance to break into two or more different substances.
5. False; *Explanation*: Carbonates of sodium and potassium decompose at very high temperatures. They do not decompose at Bunsen temperature.

Exercise 8.4 (*Refer to the Student's Book*)

1. Calcium oxide reacts vigorously with water to form calcium hydroxide.
2. The molecular formula of magnesium hydroxide is $Mg(OH)_2$.
3. (*d*); All are correct options. *Explanation*: (*a*) H_2SO_4 is sulphuric acid, (*b*) H_2SO_3 is sulphurous acid, and (*c*) H_2CO_3 is carbonic acid.
4. **True**
5. Sodium oxide and potassium oxide are two metal oxides which are soluble in water.

Exercise 8.5 (*Refer to the Student's Book*)

1. (*b*); *Explanation:* The colour of copper oxide is black.
2. Most of the metal oxides are **basic** in nature but some metal oxides show both acidic and basic nature.
3. (*i*) $\underset{\text{Aluminium oxide}}{Al_2O_3(s)} + \underset{\text{Hydrochloric acid}}{6HCl(aq)} \longrightarrow \underset{\text{Aluminium chloride (salt)}}{2AlCl_3(aq)} + \underset{\text{Water}}{3H_2O(l)}$

   (*ii*) $\underset{\text{Zinc oxide}}{ZnO(s)} + \underset{\text{Sodium hydroxide}}{2NaOH(aq)} \longrightarrow \underset{\text{Sodium zincate (salt)}}{Na_2ZnO_2(aq)} + \underset{\text{Water}}{H_2O(l)}$
4. (*i*) Aluminium oxide reacts with sodium hydroxide to form sodium aluminate (salt) and water.

   $\underset{\text{Aluminium oxide}}{Al_2O_3(s)} + \underset{\text{Sodium hydroxide}}{2NaOH(aq)} \longrightarrow \underset{\text{Sodium Aluminate (salt)}}{2NaAlO_2(aq)} + \underset{\text{Water}}{H_2O(l)}$

   (*ii*) Zinc oxide reacts with hydrochloric acid to form zinc chloride (salt) and water.

   $\underset{\text{Zinc oxide}}{ZnO(s)} + \underset{\text{Hydrochloric acid}}{2HCl(aq)} \longrightarrow \underset{\text{Zinc chloride (salt)}}{ZnCl_2(aq)} + \underset{\text{Water}}{H_2O(l)}$

Exercise 8.6 (*Refer to the Student's Book*)

1. Oxides are classified into: acidic oxides, basic oxides, neutral oxides, and amphoteric oxides.
   - *Acidic oxides*: sulphur dioxide, sulphur trioxide, carbon dioxide, phosphorus

pentoxide.

- *Basic oxides*: sodium oxide, magnesium oxide, potassium oxide, copper oxide and calcium oxide.
- *Neutral oxides*: carbon monoxide, nitric oxide, and nitrous oxide.
- *Amphoteric oxides*: aluminium oxide and zinc oxide.

2. (*i*) **Acidic oxides** are oxides of non-metals.

(*ii*) **Basic oxides** are oxides of metals.

(*iii*) Some metals react with oxygen to produce **amphoteric oxides**.

(*iv*) Some non-metals react with oxygen to form **neutral oxides**.

3.

Acidic Oxides	Basic Oxides (Alkaline oxides)	Amphoteric Oxides	Neutral Oxides
• Lead dioxide	• Sodium oxide	• Zinc oxide	• Water
• Chromium trioxide	• Magnesium oxide	• Aluminium oxide	• Carbon monoxide
• Carbon dioxide	• Copper oxide		• Nitrogen oxide
• Sulphur dioxide	• Calcium oxide		
• Sulphur trioxide	• Potassium oxide		
• Silicon dioxide			

Exercise 8.7 (*Refer to the Student's Book*)

1. *Ishwagara* (slaked lime) is used for white washing and formation of calcium carbonate.

2. (*c*); The chemical formula of marble is $CaCO_3$. *Explanation*: $Ca(OH)_2$ is calcium hydroxide, CaO is calcium oxide and $CaCl_2$ is calcium chloride.

3. **False**; *Explanation*: A large amount of heat is released when calcium oxide reacts with water to form calcium hydroxide.

4. Slaked lime is a **white powder**.

5. (*d*); *Explanation*: Solid calcium hydroxide is also known as slaked lime (*ishwagara*).

8.8 ANSWERS TO UNIT ASSESSMENT

I. Multiple Choice Questions

(*Refer to the Student's Book*)

1. (*c*) **2.** (*c*) **3.** (*a*) **4.** (*a*) **5.** (*b*)
6. (*d*) **7.** (*a*) **8.** (*a*) **9.** (*c*) **10.** (*a*)

II. Open Ended Questions

(*Refer to the Student's Book*)

1. Comparison between acidic oxides and basic oxide are:

Acidic Oxide	Basic Oxide
Acidic oxides are oxides of non-metals.	Basic oxides are oxides of metals.
They turn blue litmus solution to red.	They turn red litmus solution into blue.
Most acidic oxides are soluble in water.	Most metal oxides are insoluble in water but some of these dissolve in water to form alkalis.
They react with water to produce an acid.	They react with water to produce a base.
All acidic oxides react with alkali to give salt and water.	All basic oxides react with acid to form salt and water.
Example: Sulphur dioxide, sulphur trioxide, carbon dioxide, phosphorus pentoxide	*Example:* Sodium oxide, magnesium oxide, potassium oxide, copper oxide and calcium oxide.

2. Distinction between amphoteric oxides and neutral oxides are:

Amphoteric Oxide	Neutral Oxide
Some metals react with oxygen to produce amphoteric oxides.	Some non-metals react with oxygen to form neutral oxides.
Amphoteric oxides exhibit both acidic and basic characteristics.	Neutral oxides do not show acidic nor basic characteristics.
These oxides react with acids as well as bases to form salt and water.	Neutral oxides do not react with either acids or bases.
They change red litmus to blue and blue litmus to red.	They have no effect on litmus solution.
Examples: Aluminium oxide and zinc oxide.	*Examples:* carbon monoxide, nitric oxide, and nitrous oxide.

3. Refer to Answers of Questions 1 and 2.

4. All the metal carbonates undergo thermal decomposition to give metal oxide and carbon dioxide. For example,

(*i*) When calcium carbonate is heated, it decomposes (breaks) to give calcium oxide and carbon dioxide.

$$\underset{\text{Calcium carbonate}}{CaCO_3(s)} \xrightarrow{\text{Heat}} \underset{\text{Calcium oxide}}{CaO(s)} + \underset{\text{Carbon dioxide}}{CO_2(g)}$$

(*ii*) Magnesium carbonate decomposes into magnesium oxide and carbon dioxide.

$$\underset{\text{Magnesium carbonate}}{MgCO_3(s)} \xrightarrow{\text{Heat}} \underset{\text{Magnesium oxide}}{MgO(s)} + \underset{\text{Carbon dioxide}}{CO_2(g)}$$

(*iii*) Zinc carbonate decomposes into zinc oxide and carbon dioxide.

$$\underset{\text{Zinc carbonate}}{ZnCO_3(s)} \xrightarrow{\text{Heat}} \underset{\text{Zinc oxide}}{ZnO(s)} + \underset{\text{Carbon dioxide}}{CO_2(g)}$$

(*iv*) Lithium carbonate decomposes into lithium oxide and carbon dioxide

$$\underset{\text{Lithium carbonate}}{Li_2CO_3(s)} \xrightarrow{\text{Heat}} \underset{\text{Lithium oxide}}{Li_2O(s)} + \underset{\text{Carbon dioxide}}{CO_2(g)}$$

5. Properties of acidic oxides

1. Acidic oxides do not react with acids.
2. They react with bases and alkalis to form salt and water.
3. They dissolve in water to form acidic solutions.
4. They are usually gases at room temperature.

Properties of basic oxides

1. Basic oxides do not react with bases.
2. They react with acids to form salt and water.
3. They are usually insoluble in water. Those that dissolve in water form alkaline solutions.

6. (i) Calcium oxide (lime or quicklime) reacts vigorously with water to form calcium hydroxide (slaked lime)

$$\underset{\substack{\text{Calcium oxide}\\\text{(lime or quicklime)}}}{CaO(s)} + \underset{\text{Water}}{H_2O(l)} \xrightarrow{\text{Combination}} \underset{\text{Calcium hydroxide}}{Ca(OH)_2(s)}$$

(*ii*) Magnesium reacts with oxygen on heating to form magnesium oxide. It does not react with oxygen at room temperature.

$$\underset{\text{Magnesium}}{2Mg(s)} + \underset{\text{Oxygen}}{O_2(g)} \rightarrow \underset{\text{Magnesium Oxide}}{2MgO}$$

(*iii*) Sulphur combines with oxygen to give sulphur dioxide.

$$S(s) + O_2 \longrightarrow \underset{\text{(Acidic oxide)}}{SO_2(g)}$$

(*iv*) Lithium carbonate decomposes into lithium oxide and carbon dioxide.

$$\underset{\text{Lithium carbonate}}{Li_2CO_3(s)} \xrightarrow{\text{Heat}} \underset{\text{Lithium oxide}}{Li_2O(s)} + \underset{\text{Carbon dioxide}}{CO_2(g)}$$

(*v*) Carbon dioxide dissolves in water to form carbonic acid.

$$\underset{\text{Carbon dioxide}}{CO} + \underset{\text{Water}}{H_2O(l)} \text{ ¾ ®} \underset{\text{Carbonic acid}}{H_2CO_3(aq)}$$

7. Refer to answer of Question 6.

8.

Acidic Oxides	**Basic Oxides[a] (Alkaline oxides)**
• Carbon dioxide	• Sodium oxide
• Sulphur dioxide	• Magnesium oxide
• Sulphur trioxide	• Copper oxide
• Silicon dioxide	• Calcium oxide
• Phosphorus Pentoxide	• Potassium oxide

9. Refer to Answer of Question 4.

10. In textbook, Refer to Activity 5.11 (Unit 5).

8.9 PROJECT

(*Refer to the Student's Book*)

The teacher should guide the learners to carry out the project as given in the Student's Book.

UNIT 9: ELECTROLYTES AND NON-ELECTROLYTES

(*Refer to the Student's Book*)

9.1 LEARNING OBJECTIVES

At the end of this unit, the learners would be able to:

Knowledge and Understanding	Skills	Attitudes and Values
• Define an electrolyte and a non-electrolyte. • Give examples of weak and strong electrolytes and non-electrolytes. • State applications of electrolytes in daily life.	• Carry out experiment to distinguish between electrolytes and non-electrolytes. • Carry out experiments to classify solutions as strong electrolytes, weak electrolytes or non-electrolytes	• Develop an awareness of safety issues when carrying out experiments. • Appreciate the importance of electrolytes in daily life like sulphuric acid in a car battery.

9.2 LESSONS AND TIME ALLOCATION

Lessons	Periods Required	Total Periods
9.1 Electrolyte and Non-Electrolyte	1	**8**
9.2 Definition of Electrolysis	1	
9.3 Strong Electrolyte	1	
9.4 Weak Electrolyte	1	
9.5 Conductivity of Electricity by Electrolytes	2	
9.6 Application of Electrolytes	1	
Assessment	1	

9.3 CONTENT MAP

Introduction

This unit deals with electrolytes, non-electrolytes and electrolysis. It also discusses the applications of electrolytes in daily life.

Classroom Organisation

Whole class orientation, individual work and then working in groups

Teaching and Learning Materials

- Paper, Pen, Pencil, Computers, and Internet connection

Teaching Aids

- **Audio-video:** Video showing electrical conductivity of electrolytes, non-electrolytes and process of electrolysis
- **Notes:** List of strong and weak electrolytes, and non-electrolytes
- **PowerPoint Presentation:** Applications of electrolytes in daily life.

Competences Practised

- Literacy
- Numeracy
- Critical thinking
- Creativity and innovation
- Research and problem solving
- Communication in official languages
- Co-operation, inter-personal relations and life skills

Revision

- Objective type questions are provided at the end of each unit
- Short answer type questions are provided at the end of each unit.

Assessments

- A formative assessment task of image collection
- A formative assessment of creativity.

9.4 SUPPLEMENTARY INFORMATION FOR THE TEACHER

- Some common strong electrolytes are as follows.

Category	Electrolytes	Chemical Formulae
Strong Acids	Chloric acid	$HClO_3$
	Sulphurous acid	H_2SO_3
	Hydroiodic acid	HI
	Hydrobromic acid	HBr
	Hydrochloric acid	HCl
	Nitric acid	HNO_3
	Periodic acid	HIO_4
	Triflic acid	CF_3SO_3H
Strong Base	Potassium hydroxide	KOH
	Lithium hydroxide	LiOH
	Barium hydroxide	$Ba(OH)_2$
	Sodium hydroxide	NaOH
	Calcium hydroxide	$Ca(OH)_2$
	Magnesium hydroxide	$Mg(OH)_2$
	Sodium amide	$NaNH_2$
	Potassium amide	KNH_2
Salts	Sodium nitrate	$NaNO_3$
	Sodium chloride	NaCl
	Potassium nitrate	KNO_3
	Magnesium chloride	$MgCl_2$
	Copper sulphate	$CuSO_4$
	Sodium carbonate	Na_2CO_3
	Silver nitrate	$AgNO_3$
	Ferric chloride	$FeCl_3$

- Some weak electrolytes are listed in given table.

Weak Electrolytes	Chemical Formulae
Acetic acid	CH_3COOH
Hydrocyanic acid	HCN
Ammonium hydroxide	NH_4OH
Ammonia	NH_3
Hydrofluoric acid	HF
Carbonic acid	H_2CO_3
Mercuric chloride	$HgCl_2$
Chromic acid	H_2CrO_4
Boric acid	H_3BO_3
Nitrous acid	HNO_2
Pyridine	C_5H_5N
Ethylamine	$C_2H_2NH_2$
Dimethylamine	$(CH_3)_2NH$
Glycine	$C_2H_3O_2NH_2$
Trimethylamine	$(CH_3)_3N$
Alanine	$C_3H_5O_2NH_2$
Oxalic acid	$(COOH)_2$
Tap water	H_2O
Phosphoric acid	H_3PO_4
Zinc sulphate	$ZnSO_4$

- Some common non-electrolytes are as follows.

Non-electrolytes	Chemical Formulae
Sucrose	$C_{12}H_{22}O_{11}$
Glucose	$C_6H_{12}O_6$
Ethanol	C_2H_5OH
Methanol	CH_3OH
Carbon tetrachloride	CCl_4
Carbon disulphide	CS_2
Kerosene	Hydrocarbons
Chemically pure water	H_2O
Urea	NH_2CONH_2
Dichloromethane	CH_2Cl_2
Glycerol	$CH_2OH—CHOH—CH_2OH$
Methylsulphonylmethane (MSM)	$(CH_3)_2SO_2$
Carbon dioxide	CO_2
Oxygen	O_2
Sulphur dioxide	SO_2

9.5 FOR MORE INFORMATION VISIT

- http://sciencenotes.org/electrolytes-strong-weak-and-non-electrolytes/
- http://chemistry.tutorvista.com/inorganic-chemistry/list-of-electrolytes.html
- http://www2.volstate.edu/chem/111internet/Solutions/electrolytes.html
- http://encyclopedia.kids.net.au/page/el/Electrolysis

9.6 ASSESSMENT

1. Classify the following into electrolytes and non-electrolytes

Hydrochloric acid, Nitric acid, Sulphuric acid, Acetic acid, Carbonic acid, Lithium hydroxide, Sodium Hydroxide, Potassium Hydroxide, Calcium Hydroxide, Barium Hydroxide

2. Electricity is not conducted by

(*a*) plastic (*b*) non-metals

(*c*) solid ionic substances (*d*) all of these

3. Electrolyte liquid may include

(*a*) solutions (*b*) molten solids (*c*) gases (*d*) both (*a*) and (*b*)

4. In order to conduct electricity, the ionic metals

(*a*) shall be dissolved in water (*b*) shall be finely grinded

(*c*) shall be in molten form (*d*) shall be in ionic lattices

Answers

1. All are electrolytes **2.** (*d*) **3.** (*d*) **4.** (*c*)

9.7 ADDITIONAL ACTIVITY

Can water be Split into Oxygen and Hydrogen?

First you need to gather up all of the materials you will need. Below is a list of the following items needed to conduct this activity:

- A 9-volt battery
- 2 pencils – remove the eraser and metal part on the ends
- Salt
- Thin cardboard
- Electrical wire
- Small glass
- Water

Are you ready? Let's start. Both pencils need to be sharpened on both ends.

Cut a piece of the cardboard to fit over the glass and push both pencils through the cardboard so that the pencils are about an inch apart. Dissolve one teaspoon of salt into the water and let sit for a few minutes. Next, connect one end of one of the wires to the positive terminal of the battery and the other end to the lead of the pencil. Repeat with the other wire attaching it to the negative terminal of the battery. Place the other end of the pencils down into the salt water mixture.

What happened? As the electricity from the battery passes through the pencils, the water splits into hydrogen and chlorine gas which appear as very tiny bubbles on each pencil tip. The reason it splits into hydrogen and chlorine rather than hydrogen and oxygen is because salt was added to the water. The chlorine gas comes from the chloride in the salt. The chlorine gas will collect around the pencil tip connected to the positive terminal of the battery (the anode) and the hydrogen gas will collect around the pencil tip that is connected to the negative terminal of the battery (the cathode).

9.8 TEACHING METHODOLOGY AND LEARNING ACTIVITIES

Lesson 1: Electrolyte and Non-electrolyte (*Refer to the Student's Book*)

The teacher should begin the lesson by asking the learners to carry out **Activity 9.1**.

Activity 9.1: Distinction between electrolyte and non-electrolyte

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.
- After completion of activity, the teacher should discuss with learners their observations and the distinction between electrolyte and a non-electrolyte as given in the Student's Book.
- After discussion, the teacher should ask them to do **Exercise 9.1** to assess the achievement of objectives.

Lesson 2: Definition of Electrolysis (*Refer to the Student's Book*)

- The teacher should discuss the definition of electrolysis with learners as given in the Student's Book.

Lesson 3: Strong Electrolyte (*Refer to the Student's Book*)

- The teacher should ask the learners to read the text on strong electrolyte given in the Student's Book.
- After learners read the lesson, the teacher should ask them to do **Exercise 9.2** to assess the achievement of objectives.

Lesson 4: Weak Electrolyte (*Refer to the Student's Book*)

- The teacher should ask the learners to read the text on strong electrolyte given in the Student's Book.
- After learners read the lesson, the teacher should ask them to do **Exercise 9.3** to assess the achievement of objectives.

Lesson 5: Conductivity of Electricity by Electrolytes

(*Refer to the Student's Book*)

- The teacher should begin the lesson by asking the learners to carry out **Activity 9.2**.

Activity 9.2: Identifying the conductivity of electricity by electrolytes

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book.

Lesson 6: Application of Electrolytes (*Refer to the Student's Book*)

- The teacher should begin the lesson by asking the learners to carry out **Activity 9.3**.

Activity 9.3 (*Refer to the Student's Book*)

- The teacher should guide the learners to research and make presentations about the applications of electrolytes in daily life.
- After learners make their presentations, the teacher should ask them to read and the discuss the applications of electrolytes as given in the Student's Book.
- After discussion, the teacher should ask them to do **Exercise 9.4** to assess the achievement of objectives.

9.9 ANSWERS TO IN-TEXT EXERCISES

Exercise 9.1 (*Refer to the Student's Book*)

1. Pure water and sugar solution do not contain **ions**.
2. Non-electrolytes are **covalent** compounds.
3. **Non-electrolytes:** Sugar, urea, benzene, ethanol, chloroform, ether, etc.
4. An **electrolyte** is a substance that produces an electrically conducting solution when dissolved in water.
5. True

Exercise 9.2 (*Refer to the Student's Book*)

1. An electrolyte which is completely ionised in water and thus produces a large amount of ions is called **strong electrolyte**.
2. **Hydrochloric acid, sulphuric acid** and **nitric acid** are also called mineral acids.
3. Strong electrolytes: Sodium hydroxide, potassium hydroxide, hydrochloric acid, nitric acid and sulphuric acid.
4. The safety measures to use sulphuric acid are:
(*i*) Handle them very carefully.
(*ii*) Always wear protective goggles, gloves and a lab coat.
(*iii*) When diluting H_2SO_4, add small volumes of the acid to large volumes of water.
(*iv*) Work near a running supply of water. If the acid contacts the skin, it must be washed off rapidly with tap water.
(*v*) Store the acids in smaller, easier to handle bottles. These are never stored in metal containers.

5. False; *Explanation*: In laboratory, dilute acids are stored in containers made up of glass.

Exercise 9.3 (*Refer to the Student's Book*)

1. Weak electrolytes are those electrolytes which do not fully dissociate into ions in water and only partially ionise in water.

2. Weak electrolytes: Acetic acid, carbonic acid, sulphurous acid, ammonium hydroxide, calcium hydroxide and magnesium hydroxide.

3. The acids present in fruits are called **organic acids**.

4. (*a*) Lactic acid is found primarily in sour milk products, yogurt, and some cottage cheeses. The casein in fermented milk is coagulated (curdled) by **lactic acid. Lactic acid** is also responsible for the sour flavour of sour dough bread

(*b*) The acid present in lemon is **citric acid.**

5. Weak electrolytes have low electrical conductivity because of low concentration of ions in the solution.

Exercise 9.4 (*Refer to the Student's Book*)

1. Fill in the blanks.

(*a*) Nitric acid (HNO_3) is a **corrosive acid**.

(*b*) Sodium hydroxide is used in the making of **detergents, soaps, and drain cleaners.**

(*c*) **Sulphuric acid (H_2SO_4)** is used in car batteries for electricity.

(*d*) **Ammonium chloride (NH_4Cl)** is a main component of dry cell.

(*e*) Magnesium hydroxide ($Mg(OH)_2$) is also known as **milk of magnesia**.

9.10 ANSWERS TO UNIT ASSESSMENT

I. Multiple Choice Questions (*Refer to the Student's Book*)

1. (*c*)	**2.** (*c*)	**3.** (*c*)	**4.** (*a*)	**5.** (*d*)
6. (*b*)	**7.** (*d*)	**8.** (*d*)	**9.** (*d*)	**10.** (*a*)

II. Open Ended Questions (*Refer to the Student's Book*)

1. Strong electrolytes: Hydrochloric acid, nitric acid and sulphuric acid, sodium hydroxide and potassium hydroxide.

Weak electrolytes: Acetic acid, carbonic acid, sulphurous acid, organic acid, ammonium hydroxide, calcium hydroxide and magnesium hydroxide.

None-electrolytes: Sugar and urea

2. Comparison between strong and weak electrolytes are:

Strong electrolytes	Weak electrolytes
An electrolyte which is completely ionised in water and thus produces a large amount of ions is called strong electrolyte.	An electrolyte which is partially ionised in water and thus produces a small amount of ions is called weak electrolyte.
These electrolytes have high electrical conductivity.	These electrolytes have low electrical conductivity
These electrolytes react very rapidly with metals, metal carbonates and metal hydrogen carbonates.	These electrolytes react quite slowly with metals, metal carbonates, and metal hydrogen carbonates.
Examples: Hydrochloric acid, sulphuric acid and nitric acid.	**Examples:** Acetic acid, carbonic acid, citric acid, lactic acid, oxalic acid

3. **Non-electrolytes** are covalent compounds that do not dissociate into ions when they are dissolved in water. They dissolve in water as molecules. Sugar and urea are good examples of non-electrolytes.

4. The acids prepared from the minerals of the earth are called **mineral acid**. The acids present in fruits are called **organic acids**.

5. In laboratory, the strong acids are stored in containers made up of glass. These are never stored in metal containers. Before storing they are mixed with water to dilute them.

6. Refer to Activity 9.2.

7. (*a*) The electrolyte used in car batteries is sulphuric acid (H_2SO_4).
(*b*) The electrolyte used in Fertiliser is nitric acid (HNO_3)
(*c*) The electrolyte used in Table salt is sodium chloride (NaCl)
(*d*) The electrolyte used in Detergents is sodium hydroxide (NaOH)

8.
- Ammonium chloride (NH_4Cl) is a main component of dry cell. Dry cell is commonly known as Leclanché cell. The other electrolyte used in dry cell is manganese dioxide (MnO_2).
- Sodium acetate (CH_3COONa) used to seal concrete so that it is protected against bad weather. It is also used as an ingredient in potato chips.
- Potassium nitrate (KNO_3) is used as a food additive.
- Sodium hydroxide (NaOH) is an important ingredient in many detergents, soaps, and drain cleaners.

III. Practical-based Questions

(Refer to the Student's Book)

1. (*b*) **2.** (*c*) **3.** (*a*) **4.** (*c*) **5.** (*d*)

UNIT 10: PROPERTIES OF ORGANIC COMPOUNDS AND USES OF ALKANES

(*Refer to the Student's Book*)

10.1 LEARNING OBJECTIVES

At the end of this unit, the learners would be able to:

Knowledge and Understanding	Skills	Attitudes and Values
• Identify organic compounds and their origin. • Describe the physical and chemical properties of alkanes (methane). • State the uses of methane and some other alkanes. • Explain structural isomerism	• Use simple experiments to classify compounds into organic and inorganic. • Prepare methane gas in the laboratory. • Apply IUPAC rules to the nomenclature of alkanes.	• Develop a team approach and sense of responsibility in group discussions and experiments. • Appreciate the economic importance of alkanes in daily life such as fuels.

10.2 LESSONS AND TIME ALLOCATION

Lessons	Periods Required	Total Periods
10.1 Definition of Organic Chemistry	1	**18**
10.2 Difference Between Organic and Inorganic Chemistry	2	
10.3 Occurrence of Organic Compounds	1	
10.4 Homologous Series	1	
10.5 General Formulae of Alkanes	1	
10.6 Nomenclature of Alkanes	2	
10.7 Structural Isomerism	2	
10.8 Physical Properties of Alkanes	2	
10.9 Chemical Properties of Alkanes	2	
10.10 Laboratory Preparation of Methane	2	
10.11 Uses of Alkanes	1	
Assessment	1	

10.3 CONTENT MAP

Introduction

This unit discusses organic compounds and their origin. It describes the physical and chemical properties of alkanes (methane), including uses of methane and some other alkanes. In addition, it explains structural isomerism and laboratory preparation of methane.

Classroom Organisation

Whole class orientation, individual work and then working in groups.

Teaching and Learning Materials

- Paper, Pen, Pencil, Computers, and Internet connection

Teaching Aids

- **Audio-video:** Laboratory preparation of methane
- **Notes:** List of organic compounds
- **PowerPoint Presentation:** Uses of alkanes
- **Visual:** Structure of first 10 alkanes.

Competences Practised

- Literacy
- Numeracy
- Critical thinking
- Creativity and innovation
- Research and problem solving
- Communication in official languages
- Co-operation, inter-personal relations and life skills

Revision

- Objective type questions are provided at the end of each unit.
- Short answer type questions are provided at the end of each unit.

Assessments

- A formative assessment task of image collection
- A formative assessment of creativity

10.4 SUPPLEMENTARY INFORMATION FOR THE TEACHER

Introduction to Organic Chemistry

Organic chemistry is the study of "living" things—not in the same way that biology is the study of life. Rather, organic chemistry takes a look at what composes the living things, and how they're structured. Organic chemistry breaks down living things not only into organs seen in organisms, but also goes a step further to break down those organs into atoms and molecules. It focuses mainly on carbon, which is highly essential to maintaining life, and particularly zeroes in on the hydrocarbon, which is a molecule composed of hydrogen and carbon. Hydrocarbons not only compose what we're made of, but also what we consume, including carbohydrates, proteins, steroids, fats, and more! As a matter of fact, you may be surprised to know that everyday things, such as caffeine, plastic, and paint are all composed of hydrocarbons!

Occurrence

The most important sources for alkanes are oil and natural gas. Oil is a mixture of liquid alkanes and other hydrocarbons. Higher alkanes (which are solid) occur as residues from oil distillation ("tar"). One of the largest natural deposits of solid alkanes is in an asphalt lake known as the Pitch Lake. Besides, alkanes also appear in the universe. They are found in the atmosphere of other planets such as Jupiter, Saturn, and Uranus. Methane and ethane have also been detected in the north region of Titan—a satellite of Saturn.

Isomerism

Alkanes with more than three carbon atoms can be arranged in various ways, forming structural isomers. The simplest isomer of an alkane is the one in which the carbon atoms are arranged in a single chain with no branches. This isomer is sometimes called the *n*-isomer (*n* for "normal", although it is not necessarily the most common). However, the chain of carbon atoms may also be branched at one or more points. The number of possible isomers increases rapidly with the number of carbon atoms. For example:

- C_1: methane only
- C_2: ethane only
- C_3: propane only
- C_4: 2 isomers: *n*-butane and isobutane
- C_5: 3 isomers: pentane, isopentane, and neopentane
- C_6: 5 isomers:
- C_{12}: 355 isomers

Alkanes: Usage

Alkanes are hydrocarbons and consist only of carbon and hydrogen. The number of carbon atoms within an alkane determines its use. Propane, butane and methane, for example, are cooking and heating fuels, and are also used to generate electricity in some countries. Butane is used in disposable cigarette lighters. Under relatively low pressure, butane and propane can be liquefied, and are then known as LPG, or liquid petroleum gas. These two alkanes are also used in aerosol sprays as propellants. Some alkanes with a higher number of atoms form the greater part of aviation and diesel fuel. These alkanes, however, possess higher melting points, which can cause the fuels to become too thick to use in cold climates such as the polar regions. Kerosene and gasoline are made from combinations of alkanes.

Larger alkanes work well as lubricating oils. Their hydrophobic nature prevents water from reaching the surface of metal parts, and they also have anti-corrosive properties. Polypropylene and polyethylene, synthetic polymers with numerous applications, are alkanes containing extremely long chains of carbon atoms.

10.5 FOR MORE INFORMATION VISIT

- http://encyclopedia.kids.net.au/page/al/Alkane
- http://www.kidzsearch.com/wiki/Alkane
- http://www.gcsescience.com/o8.htm

10.6 ASSESSMENT

1. Two isomeric forms of a saturated hydrocarbon
   (*a*) have the same structure
   (*b*) have different compositions of elements
   (*c*) have the same molecular formula
   (*d*) have a different content of the isotopes of hydrogen

2. Which of the following hydrocarbons does **not** have isomers?
   (*a*) C_7H_{16} (*b*) C_5H_{10} (*c*) C_4H_8 (*d*) C_3H_8

3. What is the general formula of alkane?

4. Give three uses of alkanes.

Answers

1. (*c*) **2.** (*d*) **3.** C_nH_{2n+2}

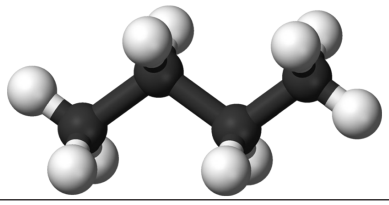
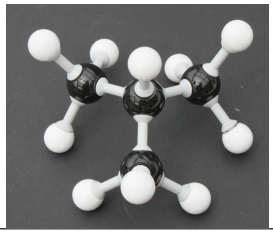
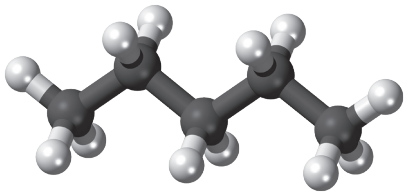
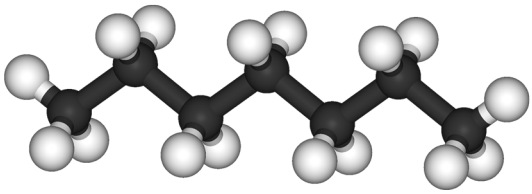
4. Refer Alkanes: Usage (**SUPPLEMENTARY INFORMATION FOR THE TEACHER in teacher's guide**) or Lesson 10.11 in the Student's Book.

10.7 ADDITIONAL ACTIVITY

Make a ball and stick model of the following:

1. butane 2. iso-butane 3. pentane 4. heptane

Hint.

	
Butane	iso-butane
	
Pentane	Heptane

10.8 TEACHING METHODOLOGY AND LEARNING ACTIVITIES

Activity 10.1: Distinguishing daily use things as organic or inorganic

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the directions given in the Student's Book.

Lesson 1: Organic Chemistry

(*Refer to the Student's Book*)

- The teacher should ask the learners to read and discuss the text on Organic Chemistry given in the Student's Book.

Lesson 2: Difference between Organic and Inorganic Chemistry

(*Refer to the Student's Book*)

- The teacher should ask the learners to carry out **Activity 10.2**.

Activity 10.2: Distinction between organic and inorganic compounds

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book.

Lesson 3: Occurrence of Organic Compounds

(*Refer to the Student's Book*)

- The teacher should ask the learners to read and discuss the text on Occurrence of Organic Compounds given in the Student's Book.

Lesson 4: Homologous Series (*Refer to the Student's Book*)

- The teacher should ask the learners to read and discuss the text on Homologous Series given in the Student's Book.

Lesson 5: General Formulae of Alkanes (*Refer to the Student's Book*)

- The teacher should ask the learners to read and discuss the text on General Formulae of Alkanes given in the Student's Book.

Lesson 6: Nomenclature of Alkanes (*Refer to the Student's Book*)

- The teacher should ask the learners to read and discuss the text on Nomenclature of Alkanes given in the Student's Book.

Lesson 7: Structural Isomerism (*Refer to the Student's Book*)

- The teacher should ask the learners to read and discuss the text on Structural Isomerism given in the Student's Book.

Lesson 8: Physical Properties of Alkanes (*Refer to the Student's Book*)

- The teacher should begin the lesson by asking the learners to carry out **Activity 10.3**.

Activity 10.3: Illustrating physical properties of alkanes

(*Refer to the Student's Book*)

- The teacher should split the class in small groups and ask them to discuss the physical properties of alkanes.
- After completion of activity, the teacher should ask the learners to read and discuss the text on physical properties of alkanes given in the Student's Book.
- After learners read the text, the teacher should ask them to do **Exercise 10.1** to assess the achievement of objectives.

Lesson 9: Chemical Properties of Alkanes (*Refer to the Student's Book*)

- The teacher should begin the lesson by asking the learners to carry out **Activity 10.4**.

Activity 10.4: Illustrating chemical properties of alkanes

(*Refer to the Student's Book*)

- The teacher should guide the learners to carry out the activity as per the procedure given in the Student's Book.
- After completion of the activity, the teacher should ask them to do **Exercise 10.2** to assess the achievement of objectives.

Lesson 10: Laboratory preparation of methane

(*Refer to the Student's Book*)

- The teacher should ask the learners to read and discuss the text on Laboratory Preparation of Methane given in the Student's Book.
- After learners read the text, the teacher should ask them to do **Exercise 10.3** to assess the achievement of objectives.
- The teacher should ask the learners to carry out **Activity 10.5**.

Activity 10.5: Illustrating extraction of methane (*Refer to the Student's Book*)

- The teacher should guide the learners to carry out research and make a presentation on how methane gas is naturally formed. (A field visit may be necessary to a biogas plant).

Lesson 11: Uses of Alkanes (*Refer to the Student's Book*)

- The teacher should ask learners to read and discuss the text on Uses of Alkanes given in the Student's Book.
- After learners read the text, the teacher should ask them to do **Exercise 10.4** to assess the achievement of objectives.

10.9 ANSWERS TO IN-TEXT EXERCISES

Exercise 10.1 (*Refer to the Student's Book*)

1. Alkanes contain only **C—C** and **C—H** bonds.
2. False; *Explanation:* The first four members of alkanes (C_1 to C_4) are gases; the next thirteen members, (C_5 to C_{17}) are liquids while the higher members are waxy solids.
3. (*b*); less than water. *Explanation:* The densities of alkanes increase with increasing molecular masses but become constant at about 0.8 g cm^{-3}. This shows that the density of alkanes is less than water. (The density of water is 1 g/cm^3).

4. (*d*); All options are **not** alkanes. *Explanation:* The general formula of homologous series of alkanes is C_nH_{2n+2}, where *n* is a positive integer.
5. True

Exercise 10.2 (*Refer to the Student's Book*)

1. Alkanes are known as paraffins.
2. Alkanes on burning in air or oxygen get completely oxidised to **carbon dioxide** and **water.**
3. **(a)** $CH_4 + Cl_2 \xrightarrow[\text{or Heat}]{\text{Diffused sunlight}} \underset{\text{Chloromethane}}{CH_3Cl} + HCl$

(b)

$$C_{10}H_{22} \xrightarrow[550^0C]{\text{Heat}} \underset{\text{Alkane}}{C_6H_{14}} + \underset{\text{Alkene}}{C_4H_8}$$

$$C_{10}H_{22} \longrightarrow \underset{\text{Alkane}}{C_8H_{18}} + \underset{\text{Alkene}}{C_2H_4}$$

$$C_{10}H_{22} \longrightarrow \underset{\text{Alkane}}{C_5H_{12}} + \underset{\text{Alkene}}{C_3H_6} + \underset{\text{Alkene}}{C_2H_4}$$

$$C_{10}H_{22} \longrightarrow \underset{\text{Akene}}{C_{10}H_{20}} + \underset{\text{Hydrogen gas}}{H_2}$$

4. Breaking down large molecules of alkanes by heating at high temperature and pressure is termed **thermal cracking.**
5. **Carbon black** is used in the manufacture of printer ink and black pigments.

Exercise 10.3 (*Refer to the Student's Book*)

1. Methane can be prepared in the laboratory by heating a mixture of **anhydrous sodium ethanoate** and **soda-lime**.
2. False; *Explanation:* As methane gas is collected over water which shows that *methane is insoluble in water.*
3. In laboratory, methane gas is collected in a gas jar by the **downward displacement** of water.
4. Soda-lime is a mixture of sodium hydroxide (NaOH) and calcium oxide (CaO) in the ratio 3 : 1.

5. True

Exercise 10.4 (*Refer to the Student's Book*)

1. **Petroleum** is largely a mixture of different alkanes.

2. Products obtained on refining of petroleum are gasoline, kerosene, diesel, furnace oil and wax.

3. (*i*) Full form of LPG is **L**iquefied **P**etroleum **G**as
(*ii*) Full form of CNG is **C**ompressed **N**atural **G**as

4. **Carbon black** is a finely divided substance produced by the incomplete combustion of heavy petroleum products.

5. True

10.10 ANSWERS TO UNIT ASSESSMENT

I. Multiple Choice Questions (*Refer to the Student's Book*)

1. (*a*)	**2.** (*c*)	**3.** (*d*)	**4.** (*c*)	**5.** (*a*)
6. (*b*)	**7.** (*b*)	**8.** (*c*)	**9.** (*c*)	**10.** (*a*)

II. Open Ended Questions (*Refer to the Student's Book*)

1.

Organic Chemistry	Inorganic Chemistry
Organic chemistry focuses on all compounds that contain the element carbon, usually in the form of carbon and hydrogen bonds.	Inorganic chemistry deals with the compounds that do not have carbon, though there are some exceptions.
Many of the organic compounds are classified as hydrocarbons.	Many of the inorganic compounds are classified as salts.
Example: Methane, Ethane, Acetic acid, ethyl alcohol	Example: Sodium bicarbonate, Sodium carbonate, Water

2. In textbook, refer Table 10.1

3. Hydrocarbons with related structures and properties are usually separated into "families" known as homologous series.

4. The IUPAC names of first ten alkanes are:

Methane	Ethane	Propane	Butane	Pentane
Hexane	Heptane	Octane	Nonane	Decane

5. Physical properties of alkanes are:

Alkanes are colourless. The first four members of alkanes (C_1 to C_4) are gases; the next thirteen members, (C_5 to C_{17}) are liquids while the higher members are waxy solids. The boiling points and melting points of alkanes directly correspond to the size of the molecule. The melting and boiling points of the shorter chain alkanes are low, but the melting and boiling points of alkanes increase as the number of carbon atoms in the carbon chain increases.

Alkanes are insoluble in water but soluble in ether. The densities of alkanes increase with increasing molecular masses but become constant at about 0.8 g cm^{-3}. Alkanes are less dense than water (alkanes float on top of water).

Chemical properties of alkanes are:

Alkanes react rapidly with oxygen, releasing energy, which makes alkanes useful as fuels. Alkanes react with halogens, such as chlorine gas and bromine water in the presence of ultraviolet light.

Cracking of alkanes is a thermal decomposition that involves the breaking of carbon-carbon bonds to form smaller molecules of hydrocarbons.

6. In the Student's Book, Refer lesson 10.10 (Unit 10)

7.
- Some higher alkanes are used as lubricating oils and as vaseline.
- Alkanes are used as chloroform.
- Alkanes are also used as a source of heat.
- Alkanes are also used in rubber industry.

III. Practical-based Questions

(*Refer to the Student's Book*)

1. (*d*) **2.** (*b*) **3.** (*b*) **4.** (*d*) **5.** (*a*)

10.11 PROJECT

(*Refer to the Student's Book*)

The teacher should guide the learners to carryout the project on their own.