REPUBLIC OF RWANDA

MINISTRY OF EDUCATION

Rwanda Education Board

CURRICULUM FOR SUSTAINABLE DEVELOPMENT

DIGNITY AND NATIONAL IDENTITY

Advanced Level Chemistry Syllabus

Kigali, 2015

Advanced Level Chemistry syllabus

Kigali, 2015

FOREWORD

The Rwanda Education Board is honoured to avail the syllabuses which serve as the official documents and a guide to competence-based teaching and learning, in order to ensure consistency and coherence in the delivery of a quality education across all levels of general education in the Rwandan schools.

The Rwandan education philosophy is to ensure that young people at every level of education achieve their full potential in terms of relevant knowledge, skills and appropriate attitudes that prepare them to be well integrated in the society and exploit employment opportunities.

In line with efforts to improve the quality of education, the government of Rwanda emphasises the importance of aligning the syllabus, teaching and learning and assessment approaches in order to ensure that the system is producing the kind of citizens the country needs. Many factors influence what children are taught, how well they learn and the competencies they acquire, among them the relevance of the syllabus, the quality of teachers' pedagogical approaches, the assessment strategies and the instructional materials available. The ambition to develop a knowledge-based society and the growth of the regional and global competition in the jobs market has necessitated the shift to a competence-based syllabus. With the help of the teachers, whose role is central to the success of the syllabus, the learners will gain appropriate skills and be able to apply what they have learned in the real life situations. Hence they will make a difference not only to their own lives but also to the success of the nation.

I wish to sincerely extend my appreciation to the people who contributed towards the development of this document, particularly REB and its staff, who organised the whole process from its inception. Special appreciation goes to the development partners who supported the exercise throughout.

Any comment and contribution would be welcome for the improvement of this curriculum.

GASANA I . Janvier
Director General REB

ACKNOWLEDGEMENT

I wish to sincerely extend my special appreciation to the people who played a major role in the development of this syllabus. It would not have been successful without the participation of different education stakeholders, and financial support from different donors, that I would like to express my deep gratitude.

My thanks first goes to the Rwanda Education Board leadership who supervised the curriculum review process and Rwanda Education Board staff who were involved in the conception and syllabus writing. I wish to extend my appreciation to teachers from pre-primary to university level whose efforts during the conception were much valuable.

I owe gratitude to different education partners such as UNICEF, UNFPA, DFID and Access to Finance Rwanda for their financial and technical support. We also value the contribution of other education partner organisations such as CNLG, AEGIS Trust, Itorero ry'Igihugu, Center for Gender Studies, Gender Monitoring Office, National Unit and Reconciliation Commission, RBS, REMA, Handicap International, Wellspring Foundation, Right to Play, MEDISAR, EDC/L3, EDC/Akazi Kanoze, Save the Children, Faith Based Organisations, WDA, MINECOFIN and local and international consultants. Their respective initiative, co-operation and support were basically responsible for the successful production of this syllabus by Curriculum and Pedagogical Material Production Department (CPMD).

Dr. Joyce MUSABE
Head of CPMD

The list of participants who were involved in the elaboration of the syllabus

Rwanda Education Board Staff

- Dr. MUSABE Joyce, Head of CPMD, as a Facilitator
- RUTAKAMIZE Joseph, Director Science Unit
- NYIRANDAGIJIMANA Anathalie, Pedagogical norms Specialist
- TUSIIME Angelique, Chemistry curriculum specialist, Team leader
- NIYIBIZI Alain, Syllabus specifications officer

Teachers and Lecturers

- IYAMUREMYE Daniel, Chemistry lecturer at UR College of Education
- MUJUNI Patrick, Chemistry teacher at FAWE Girl's School,
- MUSONERA Jean Damascene, Chemistry teacher at Kagarama Secondary School
- GASOMA Jean Baptist, Chemistry teacher at College Saint. Andre
- MUSHUMBA Alex, Chemistry teacher at Martyr's Secondary School
- OCHIENG Robert, Chemistry teacher at Son Rise Secondary School

Other Resource Persons

- MUREKERAHO Joseph, local consultant
- MPORANZI Samuel, RBS
- ISHIMO Yvette, REMA

Quality Assurer

- Dr. Derek McMONAGLE

TABLE OF CONTENT

1. INTRODUCTION

1.1 Background to curriculum review

The rationale behind the chemistry syllabus review process was to ensure that the syllabus is responsive to the needs of the learner, and to shift from objective and knowledge based learning to competency based learning. Emphasis in the review has been, building more on skills and competencies and streamlining the coherence within the existing content by benchmarking with syllabi elsewhere with best practices.

The new chemistry syllabus guides the interaction between the teacher and the learner in the learning processes and highlights the essential practical skills and competencies a learner should acquire during and at the end of each unit of learning.

1.2 Rationale of teaching and learning of chemistry

1.2.1 Chemistry and society

Chemistry, one of the natural science subjects, is an important discipline that has contributed significantly to the global socio economic transformation through discoveries on the part of the chemists. This has led to new technologies in the production of small scale and industrial products that are beneficial to the people and the environment.

Application of the knowledge of chemistry is evident in medicine, pharmaceutical, textile, petrochemical and food processing industries. Chemistry has played a role in the harmonisation of man's needs with the conservation of nature and environment in particular.

Chemistry plays a role in the Rwandan ambition to develop a knowledge-based society and to promote science and technology competitiveness in regional and global job market, and to address the issues of lack of appropriate skills in Rwandan education system.

1.2.2 Chemistry and learners

Chemistry is a worthwhile subject because it prepares students for the real world of work through career pathways 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 the natural phenomenon and manage the people and the environment.

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

1.2.3 Competences

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

Generic competences

- **Critical and problem solving skills:** The acquisition of such skills will help the learners to think imaginatively, innovatively and broadly to evaluate and find solutions to the problems encountered in our surrounding.

- **Creativity and innovation**: The acquisition of such skills will help the learners to take initiatives and use imagination beyond knowledge provided in the classroom to generate new ideas and construct new concepts.

- **Research:** This will help the learners to find answers to questions based on existing information and concepts, and use it in explaining phenomena from the gathered information.

- **Communication:** The teachers, irrespective of being language teachers, will ensure the proper use of the language of instruction by the learners. The teachers should communicate clearly and confidently, and convey ideas effectively through spoken and written, by applying appropriate language and relevant vocabulary.

- **Co-operation, inter personal management and life skills:** This will help the learner to co-operate as a team in whatever task assigned and to practice positive ethical moral values while respecting the rights, feelings and views of others. Perform practical activities related to the environmental conservation and protection. 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 to update knowledge and skills with minimum external support. The learners will be able to cope with evolution of knowledge advances for personal fulfilment in the areas that are relevant to their improvement and development.

Broad Chemistry competences

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

- Analyse and explain the scientific phenomena relating to real life experience.
- Use and experiment with a range of scientific and technological tools and equipment and draw appropriate conclusions.
- Demonstrate curiosity, research skills and creativity.
- Observe, analyse, evaluate and interpret without prejudice and make reasonable decisions.
- Make record and interpret observations, measurements and estimates.
- Use principles of scientific methods and experimental techniques to solve specific problems in daily life.
- Develop attitudes on which the scientific investigations depend, such as honesty, persistence, critical thinking and tolerance of uncertainty.
- Appreciate the scientific, social, economic, environmental and technological implications of Chemistry.
- Acquire sufficient understanding and knowledge to become confident citizens in a technological world.
- Provide a foundation in the Chemistry subject matter that would enable the learner to develop attitudes relevant to science such as accuracy, precision and objectivity.

Chemistry and developing the competences

The national policy documents based on national aspirations, identify some **"Basic Competences"** alongside the **"Generic Competences"** that will develop high order thinking skills which will help subject learning and application of what has been learnt in real life situation.

Through experimentation, observations and presentation of information during the learning process, the learner develops not only deductive and inductive skills but also communication, critical thinking and problem solving skills in trying to make inferences and conclusions.

The manipulation of numerical and other data and doing practical experiments, and undertaking project assignment involves not only analytical and problem solving skills but also innovation, creativity and research.

Group work and co-operative learning of chemistry promotes interpersonal relations and teamwork. Learning chemistry prepares responsible citizens who are aware of the power, impact and influence which chemistry has in a modern scientific world. The syllabus emphasises the development of values and positive attitudes, so that what the learner learns is used for the good of the society and for the preservation of the environment.

2. PEDAGOGICAL APPROACH

The learners learn best when they are actively involved in the learning process through a high degree of participation, contribution and production. At the same time, each learner is an individual with their own needs, pace of learning, experiences and abilities. Teaching strategies must therefore be varied but flexible within well-structured sequences of lessons. The learner-centred education does not mean that the teacher no longer has the responsibility of facilitating and guiding so that the learning takes place.

2.1 Role of the learner

The activities of the learner are indicated against each learning unit and they all reflect appropriate engagement of the learner in the learning process. The learning processes will be tailored towards creating a learner friendly environment based on the capabilities, needs, experiences and the interests.

The learning activities will be organised in a way that encourages the learners to construct the knowledge either individually or in groups in an active way. The learners work on one competency at a time in form of concrete units with specific learning outcomes broken down into knowledge, skills and attitude. In practical lessons, the learners will work in groups or individually depending on the nature, intended objective of the activity and the availability of the apparatus. However, the learners are encouraged to do simple project work individually.

2.2 Role of the teacher

The change to a competency-based curriculum is about transforming learning, ensuring that learning is deep, enjoyable and habit-forming. Therefore, lessons should be engaging and should stimulate students' curiosity, critical thinking and problem solving.

The teachers ought to shift from the traditional method of instruction and play the role of a facilitator in order to value the learners' individual needs and expectations. The teacher must identify the needs of each individual learner, the nature of the learning to be done, and the means to shape learning experiences accordingly.

The teacher's role is to organise the learners in the classroom or outside and engage them through participatory and interactive methods through the learning processes as individuals, in pairs or in groups. This ensures that the learning is personalised, active, participative and cooperative.

The teacher will design and introduce the tasks to the class to perform or for immediate discussion. The role of the teacher will be to guide the learners in constructing their own knowledge. The learners are taught how to use the textbooks and other resource materials in different ways: to search for and make use of information in writing their own notes.

The teacher must select and develop appropriate materials like teaching models and charts for the learners to use in their work. In practical lessons, the teacher first demonstrates the handling of the apparatus, and the way the experiment should be carried out, before exposing to the learners the task that can be dangerous. The teacher ought to demonstrate how to mix the reagents in the correct proportions before leaving the learners to do it on their own.

The teacher must devise remedial strategies in and outside the classroom, to address the issue of low achievers and those with learning difficulties, to ensure they keep pace with the rest in acquiring the required competencies.

To make learning relevant, real life examples should be given to make connections between chemistry and their environment. In addition to emphasising on the application of the scientific concepts and principles and minimising memorisation, the teacher should also facilitate students' learning accuracy and unbiased information that will contribute to a more scientifically literate citizen that is capable of making educated decisions regarding the world in which we live.

2.3 Special needs education and inclusive approach

All Rwandans have the right to access education regardless of their different needs. The underpinnings of this provision would naturally hold that all citizens benefit from the same menu of educational programs. 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 or 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 to the needs of these learners. Detailed guidance for each category of the learners with special education needs is provided in the guidance for teachers.

3. ASSESSMENT APPROACH

Assessment is the process of evaluating the teaching and learning processes through collecting and interpreting evidence of an 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 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 has learned.

Assessment will be organised at the following levels: School-based assessment, District examinations, National assessment (LARS) and National examinations.

3.1 Types of assessment

3.1.1. 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 a lesson, he/she should establish 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 competencies based on the stated criteria , before going to the next unit. The teacher will assess how well each learner masters both the subject and the generic competencies described in the syllabus, and from this, the teacher will gain a picture of the all-round progress of the learner. The teacher will use one or a combination of the following: (a) observation (b) pen and paper (c) oral questioning.

3.1.2. 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 the learners, for deciding on progression, for selection into the next level of education and for the certification. This assessment should have an integrative aspect whereby a student must be able to show mastery in all the competencies.

It can be an internal school based assessment or external assessment in the form of national examinations. School based summative assessment should take place once at the end of each term and once at the end of the year. School summative assessment average scores

for each subject will be weighted and included in the final national examination's grade. School based assessment average grade will contribute a certain percentage, as the teachers gain more experience and confidence in assessment techniques, and in the third year of the implementation of the new curriculum it will contribute 10% of the final grade, and will progressively increase. The districts will be supported to continue their initiative to organise a common test per class for all the schools, to evaluate the performance and the achievement level of the learners in individual schools. External summative assessment will be done at the end of the Senior Six.

3.2 Record keeping

This is gathering facts and evidence from the assessment instruments, and using them to judge the student's performance by assigning an indicator against the set criteria or standard. Whatever assessment procedures used, shall generate data in the form of scores, which will be carefully recorded and stored in a portfolio. This will contribute for remedial actions, for alternative instructional strategy and feed back to the learner and to the parents to check the learning progress, and to advice accordingly on 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 on the strengths and weaknesses of his/her work. Portfolios reflect not only work produced (such as papers and assignments), but also it is a record of the activities undertaken over time as part of student's learning. The portfolio output (formative assessment) will be considered for a maximum of three years of Advanced level. Besides, it will serve as a verification tool for each learner, that, he/she attended the whole learning, before he/she undergoes the summative assessment for the subject.

3.3 Item writing in summative assessment

Before developing a question paper, a plan or specification of what is to be tested or examined must be elaborated to show 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 competency based curriculum, questions from higher levels of Bloom's taxonomy should be given more weight than those from the knowledge and comprehension level.

Before developing a question paper, the item writer must ensure that the test or examination questions are tailored towards competency 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 testing broad competencies as stated in the syllabus.

Structure and format of the examination

There will be three papers in chemistry subject at advanced level. Paper 1: measures knowledge and understanding, paper 2 measures skills from higher levels of Bloom's taxonomy and paper 3 will measure practical/experimental skills. Time will depend on the paper's items, weight of the paper and learner's special education needs.

Paper	Component	Weight
Paper 1	The paper will measure both knowledge of the subject matter and acquisition of competences. The paper will assess the first two (low) levels of Bloom's taxonomy, which is Knowledge and understanding.	30%
Paper 2	The paper will assess skills, it will consist questions from higher levels of Bloom's taxonomy (application, analysis, evaluation and synthesis).	40
Paper 3	Practical skills: The paper to measure practical/experimental skills (Observation, Recording & report writing, Manipulation, Measurement, Planning & designing) The experiments should be drawn from different topic areas of the syllabus.	30%

3.4 Reporting to parents

The wider range of learning in the new curriculum means, that it is necessary to think again about how to share learners progress with the parents. A single mark is not sufficient to convey the different expectations of learning, which are in the learning objectives. The most helpful reporting is to share where the 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 the knowledge/understanding the subject skills and the competences in a subject, will convey more than a single mark. For the school based assessments, these scores do not need to be added up.

4. RESOURCES

4.1 Material resources

Teaching and learning of chemistry, necessitates practical activities and experiments for better understanding of the facts. The successful implementation of this curriculum requires a chemistry laboratory, textbooks, charts and ICT tools like computers and projectors. However, there are some chemistry concepts that cannot be easily explained and some experiments that cannot be done in our school laboratories due to safety reasons. Thus, the use of ICT in teaching and learning is vital. With ICT, these concepts can be concretised by the use of animations and simulations. Similarly both, the teachers and the learners are encouraged to use internet for research as well as the other ICT tools for teaching and learning purposes.

4.2 Human resource

The effective implementation of this curriculum needs a joint collaboration of educators at all levels. Given the material requirements, the teachers are expected to accomplish their noble role as stated above. The following are some of the skills required for the teacher: engage the students in a variety of learning activities; use multiple teaching and assessment methods; adjust instructions to the level of the learner;, creativity and innovation; make connections/relations with other subjects; should have a high level of knowledge of the content; effective discipline skills; good classroom management skills; good communicator; a guide and a counsellor and have passion for children in teaching and learning.

In addition, school head teachers and directors of studies are requested to follow-up and assess the teaching and learning of this subject due to its important contribution to the profile, future careers and lives of the learners as well as the development of the country.

5. SYLLABUS UNITS

5.1 Presentation of Syllabus units

Chemistry is taught and learned in lower secondary education as a core subject, i.e. in S1, S2 and S3 respectively. At every grade, the syllabus is structured in Topic areas, Sub-topic areas where applicable and then further broken down into Units. The units have the following elements:

- Unit is aligned with the Number of lessons.
- Each Unit has a Key Unit Competency whose achievement is pursued by all teaching and learning activities undertaken by both the teacher and the learners.
- Each Unit Key Competency is broken into three types of Learning Objectives as follows:
    a) ***Type I:*** Learning Objectives related to Knowledge and Understanding (also known as Lower Order Thinking Skills or LOTS).
    b) ***Type II a***nd ***Type III:*** These Learning Objectives relate to acquisition of Skills, Attitudes and Values (also known as Higher Order Thinking Skills or HOTS). These Learning Objectives are actually considered to be the ones targeted by the present reviewed curriculum.
- Each Unit has a Content, which indicates the scope of coverage of what a teacher should teach and the learner should learn in line with stated learning objectives.
- Each Unit suggests Learning Activities that are expected to engage the learners in an interactive learning process as much as possible (learner-centred and participatory approach).
- Finally, each Unit is linked to Other Subjects, its Assessment Criteria and the Materials (or Resources) that are expected to be used in the teaching and learning process.

In all, the syllabus of chemistry for ordinary level has got 9 Topic areas (Atomic and electronic structure, structure and bonding, the Periodic Table, organic chemistry, equilibrium, solutions and solubility, electrochemistry, chemical energetic and reaction kinetics). As for the units, there are 18 in S4, 15 in S5 and 15 in S6.

5.2 Senior four

5.2.1. Key competences at the end of Senior Four

- Interpret simple mass spectrum and use them to calculate R.A.M of different elements.
- Relate Bohr's model of atom with hydrogen spectrum and energy levels, practice writing electronic configurations using s, p, d, f orbitals and interpret graphical information in relation to the ionization energy.
- Demonstrate how properties of ionic compounds and metals are related to their nature of bonding.
- Demonstrate how the nature of bonding is related to the properties of covalent compounds and molecular structures.
- Use valence electrons and atomic orbitals to explain the trends in the physical properties of the elements.
- Compare and contrast the properties of elements in relation to their position in the Periodic table.
- Compare and contrast the properties of period 3 elements and their compounds in relation to their electronic configuration/charge.
- Deduce how concentration, pressure, catalyst and temperature affect chemical processes in the industry.
- Explain the acid-base theories (Arrhenius acid Bronsted-Lowry and Lewis theory).
- Explain the concept of reduction and oxidation reactions and balance the redox reaction.
- Explain the concept of energy changes and energy profile diagrams for exothermic and endothermic reactions.

5.2.2. Senior Four units

TOPIC AREA: ATOMIC AND ELECTRONIC STRUCTURE	**SUB-TOPIC AREA: ATOMIC STRUCTURE**	
S4 Chemistry	**Unit 1:** Structure of an atom and mass spectrum	**No. of periods:** 18
Key unit competency: The learner should be able to interpret simple mass spectra and use them to calculate R.A.M. of different elements.		

Learning objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		

- Outline the discovery of the sub-atomic particles.
- Compare the properties of sub-atomic particles.
- Explain the fundamental processes that occur in the functioning of a mass spectrometer.
- State the uses of the mass spectrometer.
	- Interpret different mass spectra.
	- Draw and label the mass spectrometer.
	- Calculate the relative atomic mass of an element, given isotopic masses and abundances.
		- Develop the approach of team work in the research and group activities.
		- Appreciate the contribution of different scientists to the discovery of the sub-atomic particles.
			- The constituents of an atom, their properties and the outline of their discovery.
			- Concept of atomic number, mass number, isotopic mass and relative atomic mass.
			- Calculations involving relative atomic mass.
			- Mass spectrometer:
			  o Description of the mass spectrometer and functions of each component of the spectrometer.
			  o Interpretation of mass spectra.
			  o Uses of the mass
				- Research work: carry out research and make presentations on the history of the discovery of the atom and its constituent particles and their properties.
				- Watch a video about the discovery of sub-atomic particles and write a report.
				- Watch videos clips on the structure of an atom and its constituent particles and make a report.
				- Group work: the learners do research about the steps involved

			spectrometer. - Calculations of the relative atomic masses of elements.	in the functioning of a mass spectrometer and present the findings. A labelled diagram of the mass spectrometer is required. - Watch video on the functioning of mass spectrometer and make a report. - Individual work: each learner interprets different mass spectra and does various exercises of calculations of the relative atomic mass for different elements.
Link to other subjects: *Physics (atomic physics).*				
Assessment criteria: *The learners can analyse different mass spectra and use them to determine the RAM.*				
Materials: *Computer, projector, internet..*				

TOPIC AREA: ATOMIC AND ELECTRONIC STRUCTURE		SUB-TOPIC AREA: ELECTRONIC STRUCTURE		
S4 Chemistry		**Unit 2:** Electron configurations of atoms and ions		**No. of periods:** 18
Key unit competency: The learner should be able to relate Bohr's model of the atom with hydrogen spectrum and energy levels, practice writing electronic configurations using s, p, d, f orbitals and interpret graphical information in relation to ionization energy of elements.				
Learning objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Explain how the data from emission spectra provide evidence for discrete energy levels within the atom. - Describe the atomic orbitals. - Determine the electronic configurations of the atoms and ions in terms of s, p, d and f orbitals. - Derive the electronic configuration of an element from data on successive ionization energies.	- Simple interpretation of spectral line series of hydrogen atom. - Relate information of ionization energies to electronic configurations of the elements. - Interpret the graphs of first ionization energies against the atomic number. - Determine the electronic configuration of elements and ions in terms of s, p, and d orbitals.	- Recognise the value of analysis when interpreting the graphs. - Appreciate the contributions of other scientists such as Bohr and Rutherford in the description of atomic structure, Lyman and Balmer in atomic spectra, Pauli and Hund in writing electronic configurations.	- Bohr's atomic model: concept of energy levels. - Absorption and emission of spectra and energy associated, $\Delta E = h\nu$. - Hydrogen spectrum and spectral line series (Lyman and Balmers series: Line spectra as evidence for discrete energy levels). - Quantum theory of the atom. - Include quantum numbers to explain energy levels, sub-energy levels and orbitals. - Number and shape of 's'	- Research and make presentations about the atomic models, according to Rutherford, Bohr and quantum theory. - Watch video clips on Rutherford, Bohr's model of atom and quantum theory. Make a report. - Research and make a presentation on atomic spectra and spectral series. - Watch a video clip on atomic spectra and spectral series and make

- Describe the factors which influence the first ionization energy of the elements.	- Derive the electronic configuration of an element from data on successive ionization energies.		and 'p' orbitals. - Rules governing the electronic configurations: Aufbau principle, Pauli Exclusion Principle and Hund's rule. - Electronic configuration and stability (half and completely filled orbital configurations are stable) - The graphs of ionization energy versus the number of electrons removed. - Interpretation of a graph of first ionization energy versus the atomic numbers of elements. - Factors influencing the magnitude of ionization energy (atomic radii, nuclear charge, shielding effect).	a report. - Exercises in groups of writing electronic configurations for elements and ions in terms of s, p, d. - Watch video clips on quantum numbers and shapes of orbitals. - Discussions about the graphs of ionization energies versus the number of electrons removed from the same atom and present the information obtained from the interpretation of the graphs. - Watch a video clip on Aufbau principle, Pauli Exclusion Principle and Hund's rules' of filling orbitals. - Group activity to interpret the graphs which show the changes of the first ionization energy against the atomic number of elements. The learners should present their conclusions.

				- Research and make a group discussion about the factors influencing the magnitude of ionization energy (atomic radii, nuclear charge, shielding effect) and present your findings.
Link to other subjects: *Physics (atomic physics).*				
Assessment criteria: *The learners can relate Bohr's model of atom with hydrogen spectrum and energy levels/orbitals, practice writing electronic configuration using s, p, d and f orbitals and interpret the graphical information in relation to the ionization energy of the elements.*				
Materials: *Computer, projector, internet*.				

TOPIC AREA: STRUCTURE AND BONDING		**SUB-TOPIC AREA: IONIC AND METALLIC BONDING**
S4 Chemistry	**Unit 3:** Formation of ionic and metallic bonds	**No. of periods:** 7

Key unit competency: The learner should be able to describe how properties of ionic compounds and metals are related to the nature of their bonding.

Learning objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Explain the mechanisms by which atoms of different elements attain stability. - Explain the formation of ionic bonds. - Describe the properties of ionic compounds. - State the factors that influence the magnitude of lattice energy. - Describe the formation of metallic bonds. - State that the forces of attraction hold atoms together.	- Predict whether bonding between specified elements will be primarily ionic or not. - Relate physical properties of matter to differences in strength of forces of attraction between the particles. - Relate the lattice structure of metals to their physical properties. - Represent ionic bonding by dot and cross diagrams. - Perform experiments to show properties of	- Show respect for other's opinion during discussions and research. - Develop a culture of working in a team. - Respect of procedure in experiment to determine electrical and thermal conductivity and solubility. - Appreciate that solubility alone is not conclusive evidence that a compound is ionic.	- Explanations of why atoms of elements form bonds. - Gain of stability by losing and gaining electrons to acquire octet or doublet of electrons in the outer energy level. - The concept of ionic bonding as the electrostatic forces of attraction between oppositely charged ions. - Formation of ions in the ionic bonding process. - The concept of lattice energy and the factors that influence the magnitude of the lattice energy.	- Group discussion on how the atoms of elements can gain their stabilities by either loosing or gaining electron(s) on the valence shells and make a presentation. - Group work: draw diagrams to illustrate the formation of ionic compounds (e.g. in sodium chloride, magnesium oxide, magnesium chloride, sodium peroxide, iron (III) chloride and sodium sulphide) and make a presentation. - Carry out experiments to show properties of ionic

	ionic compounds.		- Physical properties of ionic compounds: (melting and boiling points, solubility in polar and non- polar solvents, conductivity of electricity, brittleness of the ionic lattice structures). - Formation of metallic bonding. - Sea of electrons and the relationship between metallic bonding and physical properties of metals: o Conductivity of electricity and heat. o Malleability. o Ductility. o Shininess.	compounds (e.g. solubility of sodium chloride, potassium chloride in water, electrical conductivity of aqueous solution of sodium chloride, brittleness of ionic compound) and prepare an appropriate scientific report. - Research in groups and discuss the factors that influence the magnitude of lattice energy and make a presentation. - Groups discussion on the formation of metallic bond and physical properties of metals and make a presentation.
Link to other subjects: *Physics (electricity).*				
Assessment criteria: *The learners can demonstrate how the properties of ionic compounds and metals are related to the nature of their bonding.*				
Materials: *Molecular models of some ionic compounds, computers, projectors*.				

TOPIC AREA: STRUCTURE AND BONDING			**SUB-TOPIC AREA: COVALENT BONDING - INTER-MOLECULAR AND INTRA-MOLECULAR FORCES**	
S4 Chemistry		**Unit 4:** Covalent bond and molecular structures		**No. of periods:** 28
Key unit competency: The learner should be able to demonstrate how the nature of the bonding is related to the properties of covalent compounds and molecular structures.				
Learning objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Define octet rule as applied to covalent compounds. - Explain the formation of covalent bonds and describe the properties of covalent compounds. - Describe how the properties of covalent compounds depend on their bonding. - Explain the VSEPR theory. - Describe simple and giant covalent molecular structures. - Explain the formation of dative covalent bonds in different molecules.	- Apply octet rule to draw Lewis structures of different compounds. - Make structures of molecules using models. - Apply the VSEPR theory to predict the shapes of different molecules/ions. - Predict whether the bonding between specified elements will be primarily covalent or ionic. - Relate the shapes of molecules to the type of hybridisation. - Relate the structure of simple and giant	- Develop culture of working in groups during research and discussion sessions. - Appreciate the importance of Lewis structures in chemical reactivity of elements. - Develop orderliness in research and data presentation. - Respect of procedure in experiment.	- Overlap of atomic orbitals to form covalent bonds. - Lewis structures using octet rule (dot and cross structures). - Lewis structures of unusual compounds that do not obey octet rule. - Coordinate or dative covalent bond (e.g. hydroxonium ion, ammonium ion, aluminium chloride and the combination of boron trifluoride and ammonia). - The concept of valence bond theory and formation of (σ) and (π) bonds. - Types of hybridisation(sp,sp^2 sp^3,	- Group discussion and presentation about the overlapping of atomic orbitals to form covalent bond. - Group exercises to write Lewis structure of different compounds (e.g. water, hydrogen chloride, methane, nitrate ion, sulphate ion, carbon dioxide, ammonia, phosphorus trichloride, boron trifluoride, sulphur hexafluride) and make a presentation. - Watch video clips on the formation of dative covalent bonds compared to the normal

- Describe the concept of valence bond theory. - Describe the origin of inter-molecular forces. - Describe the effect of inter and intra molecular forces on the physical properties of certain molecules. - Describe the effect of hydrogen bonding in the biological molecules.	molecular covalent compounds to their properties. - Differentiate sigma from pi bonds in terms of orbital overlap and formation. - Write structures of some compounds that do not obey octet rule. - Compare the formation of dative covalent to normal covalent bonding. - Relate the physical properties to type of inter and intra molecular forces in molecules. - Compare inter and intra molecular forces of attraction in different molecules.		sp^3d, sp^3d^2). - VSEPR theory to explain the formation of shapes of covalent molecules (geometry) and bond angles (linear, trigonal planar, tetrahedral, ,trigonal bipyramidal, octahedral). - Polarity of the covalent bond in relation to difference in electronegativity. - Physical properties of covalent structures: simple molecular structure (e.g. carbon dioxide, carbon sulphide, phosphine) and giant structures (e.g. diamond, graphite silicon dioxide), (Melting and boiling points, solubility in polar and non-polar solvents and conductivity of electricity). - Intra molecular forces: o Definition. o Types and origin of intermolecular (van der Waals forces/London	covalent bond and make a report. - Group work: illustrate how atomic orbitals overlap to form sigma and pi bonds in multiple bonds. - In groups, design a project to demonstrate how atomic orbitals overlap to form single and multiple bonds and display the models made in the class. - Discuss in groups to explain hybridisation of atomic orbitals, types of hybridisation and shapes of molecules, do a display of molecular models and make a presentation. - Carry out experiments to investigate whether unknown compounds are ionic or covalent, write an appropriate scientific report. - Research in groups to explain how electronegativity of elements affect the

			dispersion forces, dipole-dipole interactions and hydrogen bonding). ○ Effect of inter and intra molecular forces on physical properties of certain molecules (e.g. biological molecules DNA, water, proteins).	polarity of molecules and make a presentation. - Research; do a group discussion and make a presentation on the physical properties of simple and giant covalent molecules. - Research in groups and make a presentation about effects of inter and intra molecular forces on certain molecules and their origin in different molecules.
Link to other subjects: *Physics (electricity), Biology (genetics and cell division), Mathematical (Geometry).*				
Assessment criteria: *The learners can demonstrate how the properties of covalent compounds and intermolecular forces are related to the nature of the bond.*				
Materials: *Projector, computer, atomic models*.				

TOPIC AREA: THE PERIODIC TABLE	**SUB-TOPIC: PERIODICITY OF PROPERTIES OF ELEMENTS**	
S4 Chemistry	**Unit 5:** Variation in trends of the physical properties	**No. of periods:** 14

Key unit competency: The learner should be able to use atomic structure and electronic configuration to explain the trends in the physical properties of the elements.

Learning objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Outline the historical back ground of the Periodic Table. - Explain the trends in the physical properties of the elements across a period and down a group.	- Classify the elements into respective groups and periods using electronic configuration. - Relate trends in physical properties of the elements to their electronic configuration. - Classify the elements into blocks (s, p, d, f-block).	- Show respect for other's opinion during group discussions. - Appreciate the contributions of scientists to the classification of the elements in the Periodic Table such as Mendeleev, Dobereiner, Newlands, Moseley and Bohr. - Appreciate the aspect of orderliness in the classification of the elements in the Periodic Table.	- Historical background of the Periodic Table. - Comparison of Mendeleev's table with the modern Periodic Table. - Location of the elements in the Periodic Table based on the electronic configuration: valence electrons (group), number of energy levels (period), last sub-energy levels (block). - Classification of the elements into blocks (s, p, d, f-block). - Factors that influence the change of each physical property of the elements across a period and down	- Research work: research and make a presentation on the historical back ground of the modern Periodic Table. - Activity to arrange elements in increasing order of their relative atomic masses and compare that arrangement to the modern Periodic Table. Take note of the differences. - Group exercises: to classify the elements in groups, periods and blocks from their electronic configurations. - Group discussion about

			a group. - Variation of the physical properties down the group and across the period: Atomic radius, electronegativity, electro-positivity, ionization energy, electron affinity, boiling and melting points, density, electrical and the thermal conductivity and metallic character.	the factors that influence the physical properties of the elements and draw appropriate conclusions. - Group discussions about the trends of the physical properties across the Periodic Table (i.e. trends across a period and down a group) and draw appropriate conclusions.
Link to other subjects: *Physics (electrical conductivity, density).*				
Assessment criteria: *The learners can use valence electrons to determine the position of elements in the Periodic Table and trends in their properties using atomic orbitals (s, p, d and f).*				
Materials: *Periodic table, computer, projector, internet.*				

TOPIC AREA: THE PERIODIC TABLE		SUB-TOPIC: PERIODICITY OF PROPERTIES OF ELEMENTS		
S4 Chemistry	**Unit 6:** Trends in chemical properties of Group 1 elements and their compounds			**No. of periods:** 14
Key unit competency: The leaner should be able to compare and contrast the chemical properties of the Group 1 elements and their compounds in relation to their position in the Periodic Table.				
Learning objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Describe and explain the physical properties of Group 1 elements in terms of metallic character and strength of metallic bond. - Describe and explain the reactivity of the Group 1 elements with oxygen, water and the halogens. - State and explain the properties of Group 1 oxides and hydroxides. - Explain the trends in the solubility of Group 1 compounds. - State the uses of	- Compare the reactivity of Group 1 elements. - Interpret the trends in the thermal decomposition of Group 1 carbonates and nitrates. - Perform experiments to test the alkalinity of Group 1 hydroxides. - Carry out the flame tests for the presence of Group 1 metal cat ions in solution.	- Develop care when dealing with extremely reactive Group 1 elements. - Appreciate the uses of Group 1 elements and their compounds in our daily life.	- Occurrence and physical properties of Group 1 elements: physical state, metallic character, physical appearance and melting point. - Reactivity of Group 1 elements with: oxygen (formation of monoxides, peroxides and superoxides), water and the halogens. - Properties of Group 1 oxides and hydroxides. - Effect of heat on Group 1 carbonates and nitrates. - Solubility of Group 1 compounds. - Flame tests for Na^+, K^+. - Uses of Group1 elements	- The learners research and make presentation on the occurrence of Group 1 elements and their physical properties. - Carry out an experiment to compare the reactivity of sodium and potassium with water and report the observations or watch video clips on the reactions of Group 1 elements with water and explain the trend in their reactivity down the group. - Do experiments to show the alkaline character of sodium oxide and the alkalinity of Group 1

Group 1 elements and their compounds.			and their compounds e.g. manufacture of soaps, detergents and bleaching agents (sodium hydroxide, potassium hydroxide), manufacture of lithium batteries, common table salt, production of photoelectric cells , baking powder, etc.	hydroxides and take note of the observations made. - Heat Group 1 carbonates and nitrates. Identify the products formed using appropriate reagent (e.g. carbon dioxide using lime water) - Carry out experiments on the solubility of Group 1 compounds. - Carry out experiments to identify Group 1 cat ions, write an appropriate report and make conclusions. - Research and make presentation on the uses of Group 1 elements and their compounds based on their properties.
Link to other subjects:				
Assessment criteria: *The leaners can compare and contrast the properties of Group 1 elements and their compounds in relation to their position in the Periodic Table.*				
Materials: *Weighing balance, appropriate chemicals and apparatus, computer, projector.*				

TOPIC AREA: THE PERIODIC TABLE		SUB-TOPIC: PERIODICITY OF PROPERTIES OF ELEMENTS		
S4 Chemistry	**Unit 7:** Trends in chemical properties of Group 2 elements and their compounds			**No. of periods:** 19
Key unit competency: The learner should be able to compare and contrast the properties of the Group 2 elements and their compounds in relation to their position in the Periodic Table.				
Learning objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Describe the physical properties of Group 2 elements. - Describe the properties of Group2 oxides and hydroxides. - Explain the trends in the thermal decomposition of Group 2 carbonates, and nitrates. - Explain the trends in the solubility of Group 2 compounds. - State the uses of Group 2 elements and their compounds. - Describe industrial manufacture of the cement.	- Perform experiments to compare and contrast the reactivity of Group 2 elements. - Write balanced equations of the reactions of Group 2 elements, different elements and the compounds. - Illustrate practically the trends in solubility and thermal decomposition of Group 2 compounds. - Test the alkaline character of Group 2 hydroxides. - Be aware that the compounds of beryllium are	- Appreciate the logic underlying the position of elements in the Periodic Table, their electronic structure and the properties. - Appreciate the importance of qualitative analysis in assuring the quality of different industrial products. - Appreciate the application of the chemistry of Group 2 elements and their compounds in the social economic development. - Develop the	- Occurrence and physical properties of Group 2 elements (physical state, metallic character and physical appearance). - Reactivity of Group 2 elements with oxygen, water, halogens and dilute acids. - Properties of Group 2 compounds: o Ionic and covalent character of oxides and halides o Alkaline nature of oxides and hydroxides o Trends in thermal stability of: carbonates, , hydroxides and nitrates.	- Research and presentation on the occurrence and physical properties of the Group 2 elements. - Carry out experiments to compare the reactions of magnesium and calcium with water and with dilute acids (e.g. dilute HCl) and make reports. - Perform experiments to explain the alkaline character of Group 2 oxides and hydroxides and take note of the observations made. - Practical activity: heat Group 2 carbonates, nitrates and identify the products formed using

- Discuss the environmental and health issues associated with the manufacturing of the cement.	different from the compounds of the other Group 2 elements. Perform chemical test for the presence of Group 2 cat ions in solution. - Suggest preventive measures for environmental and health issues associated with the manufacture of the cement.	teamwork approach while performing experiments and writing field – study reports. - Develop the attitude of sustainable exploitation of natural resources. - Stimulate the culture of entrepreneurship in the area of chemistry.	○ Trends in solubility of hydroxides, carbonates, hydrogen-carbonates and sulphates. - Anomalous properties of beryllerium compounds. - Identification test for Ba^{2+} ions in aqueous solutions - Uses of Group 2 elements and their compounds: ○ magnesium metal: flash light of cameras ○ Magnesium hydroxide : Ant-acids - Uses of calcium carbonate: ○ Extraction of iron. ○ Manufacture of tiles, plates, laboratory mortar and pestle. ○ Use in agriculture to reduce the acidity of soil: process of making slake lime *"ishwagara"* from limestone. ○ Manufacture of cement: raw materials, manufacturing process, types and	appropriate reagents. - Carry out experiments and make report about the solubility of Group 2 compounds. - Practical activities to chemically test Group 2 cat ions in solution and report the observations made. - Research and make presentation on the uses of Group 2 elements and their compounds based on their properties. - Field visit: ○ Visit tiles factory in Nyagatare district ○ Visit the nearby factories of slake lime *"ishwagara".* ○ Visit nearby cement industry and see how cement is manufactured (e.g. Bugarama in Rusizi and Ruyenzi in Kamonyi districts). Then make appropriate field report.

			environmental and health issues related its manufacturing.	
Link to other subjects:				
Assessment criteria: *The learners can compare and contrast the chemical properties of Group 2 elements and their compounds in relation to their position in the Periodic Table.*				
Materials: *Appropriate materials and chemicals.*				

TOPIC AREA: THE PERIODIC TABLE		SUB-TOPIC: PERIODICITY OF PROPERTIES OF ELEMENTS		
S4 Chemistry	**Unit 8:** Trends of chemical properties of Group 13 elements and their compounds			**No. of periods:** 10
Key unit competency: The learner should be able to compare and contrast the chemical properties of the Group 13 elements and their compounds in relation to their position in the Periodic Table.				
Learning objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- State the physical properties of Group13 elements. - Explain the reactivity of Group 13 elements with oxygen, water, halogens, dilute acids and sodium hydroxide. - Describe the properties of oxides, hydroxides and chlorides of Group 13 elements. - State the uses of Group 13 elements and their compounds.	- Compare and contrast the reactivity of Group 13 elements with oxygen, water, halogens, dilute acids and sodium hydroxide. - Perform experiments to show the solubility of Group 13 compounds. - Practically illustrate the amphoteric properties of aluminium oxides and hydroxides. - Identify the anomalous properties of boron	- Develop attitude of orderliness when performing experiments. - Develop a team approach and respect diverse opinions during group discussions and practical activities. - Appreciate the uses of Group 13 elements in daily life.	- Physical properties of Group 13 elements (physical state, metallic character, physical appearance). - Reactions of group 13 elements with oxygen, water, halogens, dilute acids and sodium hydroxide. - Amphoteric character of aluminium and gallium oxides and hydroxides. - Anomalous properties of boron and its compounds - Identification of Al^{3+} ion in aqueous solution. - Uses of Group 13 elements and their compounds:	- Make a group discussion on the physical properties of Group 13 elements and present the results. - Carry out experiment of the reaction between aluminium with different acids and sodium hydroxide and report observations made. - Perform experiments on the reaction of aluminium oxide and hydroxide with acids and bases and report the conclusion. - Carry out chemical test for the presence of

	and its compounds. - Perform chemical tests for the presence of aluminium ion in the solution.		○ Boron: making electronic devices. ○ Aluminium: electric cables, kitchen utensils, construction, packaging.	Al^{3+} ion in the solutions. - Research work on the uses of Group 13 elements and their compounds and make presentation of the findings.
Link to other subjects: *Physics (electricity).*				
Assessment criteria: *The learners can compare and contrast the chemical properties of Group 13 elements and their compounds in relation to their position in the Periodic Table.*				
Materials: *Appropriate chemicals / apparatus.*				

TOPIC AREA: THE PERIODIC TABLE		SUB-TOPIC: PERIODICITY OF PROPERTIES OF ELEMENTS		
S4 Chemistry	**Unit 9:** Trends in chemical properties of Group 14 elements and their compounds			**No. of periods:** 15
Key unit competency: The learner should be able to compare and contrast the chemical properties of the Group 14 elements and their compounds in relation to their position in the Periodic Table.				
Learning objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- State physical properties of Group 14 elements. - State the chemical properties of Group 14 elements. - Distinguish between the chemical reactions of the oxides and chlorides of Group 14 elements. - Explain the trends in thermal stability of the oxide, halides and hydrides of Group 14 elements. - Explain the variation in stability of oxidation state of +2 and +4 down the	- Compare and contrast the physical properties of Group 14 elements. - Compare the relative stabilities of the higher and lower oxidation states in oxides. - Illustrate practically the reactivity of Group14 oxides and chlorides. - Perform chemical test for the presence of Sn^{2+}, Pb^{2+} and hydrogen-carbonate (HCO_3^-) carbonate (CO_3^{2-}) ions in the solutions.	- Respect of procedures during experiments. - Develop a team approach and respect diverse opinions during group discussions and practical activities. - Appreciate the uses of Group 14 elements in daily life.	- Comparative study of physical properties of the Group 14 elements: physical state, metallic character, electrical conductivity. - Reactions of C, Sn, Pb, Si with oxygen, hydrogen, chlorine, dilute acids/concentrated acids and hydroxides. - Comparative study of compounds of Group 14 elements: o Reaction of oxides, chlorides with water, acids and strong alkaline solutions. o Thermal stability of oxides, halides and	- Students do research and make presentation on the physical properties of Group 14 elements. - Carry out experiments of the reaction of carbon, tin, lead with oxygen, dilute acids/concentrated acids and hydroxides and interpret results. - Perform experiments to explain the reactions of Group 14 oxides and chlorides with water, acids and bases and analyse the results with appropriate report. - Perform chemical tests

Group 14 elements. - Mention the uses of Group 14 elements. - Define diagonal relationship.	- Analyse the similarities and differences among the elements of Group 1, 2, 13 and 14 due to diagonal relationship.		hydroxides. ○ SiO_2 as a giant structured covalent compound. - Chemical tests for the presence of Sn^{2+}, Pb^{2+}, $HCO_3^-CO_3^{2-}$ ions in the solutions. - Trends in stability of oxidation states: +2 and +4 as a result of inert pair effect. - Uses of Group 14 elements. - Diagonal relationship of Groups 1, 2, 13 and 14: similarities and differences.	for Sn^{2+}, Pb^{2+}, HCO_3^- and CO_3^{2-} ions and report the results appropriately. - The learners will do research and make a report about the extraction process of tin metal from its oxide. - Research work: research and make a presentation on the diagonal relationship among elements and compounds of Groups 1, 2, 13 and 14 of the Periodic Table.
Link to other subjects:				
Assessment criteria: The *learners can compare and contrast the chemical properties of Group 14 elements and their compounds in relation to their position in the Periodic Table.*				
Materials:				

TOPIC AREA: THE PERIODIC TABLE		SUB-TOPIC: PERIODICITY OF PROPERTIES OF ELEMENTS		
S4 Chemistry	**Unit 10:** Trends in chemical properties of Group 15 elements and their compounds			**No. of periods:** 12
Key unit competency: The leaner should be able to compare and contrast the properties of the Group 15 elements and their compounds in relation to their position in the Periodic Table.				
Learning objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		

- Describe the physical properties of the Group 15 elements.
- Describe the variation in the metallic and non-metallic character of the Group 15 elements.
- Recall the physical properties of the allotropes of phosphorus.
- Describe the chemical reactions of nitrogen compounds.
- Be aware of the increasing oxidizing power of nitric acid
	- Show the acidic character of nitrogen and phosphorus oxides.
	- Distinguish between the chemical properties of nitrogen and phosphorus.
	- Compare the reactions of nitric acid and phosphoric acid with the metals.
	- Prepare ammonia in the laboratory.
	- Perform an experiment on the reaction of phosphates with sulphuric acid.
	- Identify experimentally phosphate and nitrate
		- Develop self confidence in presenting reports and in handling chemicals and the apparatus.
		- Appreciate the dangers caused by nitrogen compounds to the environment.
		- Appreciate the contribution of Haber and Oswald's processes to the social economic development.
			- Physical properties of the Group 15 elements: physical state, metallic character.
			- The relative inertness of nitrogen.
			- Reactions of the Group 15 elements with oxygen, water, chlorine, hydrogen, and metals (e.g. magnesium).
			- Ammonia and nitric acid:
			  o Laboratory preparation of ammonia and nitric acid.
			  o Industrial production of ammonia (Haber process) and of nitric
				- The learners do research and make presentations on the variation of physical properties of the Group15 elements.
				- Carry out the experiments in groups on the reactions of phosphorus with oxygen, water and write a scientific a report.
				- Research in groups the environmental issues of nitrogen oxides and suggest adequate solutions and make a presentation.

with the concentration. - Describe the impact of nitrogen oxides to the environment. - Describe the industrial preparation of ammonia and nitric acid. - Explain the reactions of nitric acid with metals and non-metals. - Describe the chemical properties of phosphorus compounds. - State the uses of the group 15 elements and its compounds	ions in solution. - Develop observation, interpretation, reporting skills and draw valid conclusions.		acid (Ostwald's' process). ○ Environmental impact of their industrial production (effects of nitrogen oxides on the ozone layer and production of acid rain). ○ Uses of ammonia and nitric acid at large scale. ○ Properties of nitric acid: ▪ Reaction with metals (magnesium, zinc, lead, copper) (dilute and concentrated nitric acid). ▪ Reaction with non-metals (carbon, sulphur, phosphorus, iodine) ▪ Oxidizing power. - Allotropes of phosphorus. - Chemical properties of Phosphorous	- The learners research and make presentation on industrial preparation of ammonia gas and nitric acid. - Perform experiments on the reaction of nitric acid with metals (e.g. magnesium, lead, copper, aluminium) and non-metals (e.g. carbon, sulphur, iodine), make report of the findings. - Group discussion on the properties of allotropes of phosphorus. - Perform experiment on the reaction of phosphorus oxides and chlorides with water and make an appropriate scientific report. - Perform experiments on the reactions of phosphoric acid with metals: (magnesium, lead, copper and aluminium) and bases

			compounds: ○ P_2O_3 with water. ○ P_2O_5 with water. ○ PCl_3 with water, oxygen, chlorine. ○ H_3PO_4: with metals and bases. - Laboratory preparation of the phosphoric acid. - Identification of PO_4^{3-} and NO_3^- ions. - Uses of the group 15 elements and compounds: ○ Phosphorus. ○ Nitrogen and its compounds (fertilizers, explosives, textile industry, pharmaceuticals). ○ Arsenic: electronic devices.	and compare the reactivity of phosphoric acid with that of nitric acid and make an appropriate an scientific report. - Perform an experiment in groups on the reaction of phosphates with sulphuric acid and write an appropriate scientific report. - Perform an identification test for phosphate and nitrate ions and write an appropriate scientific report. - Discuss the uses of phosphorus and its compounds and make presentations.
Link to other subjects:				
Assessment criteria: *The learners can compare and contrast the properties of the Group 15 elements and their compounds in relation to their position in the Periodic Table,*				
Materials: *Appropriate chemicals, apparatus.*				

TOPIC AREA: THE PERIODIC TABLE		SUB-TOPIC: PERIODICITY OF PROPERTIES OF ELEMENTS
S4 Chemistry	**Unit 11:** Trends of chemical properties of Group 16 elements and their compounds	**No. of periods:** 12

Key unit competency: The leaner should be able to compare and contrast the chemical properties of the Group 16 elements and their compounds in relation to their position in the Periodic Table.

Learning objectives			Content	Learning Activities
Knowledge and Understanding	**Skills**	**Attitudes and values**		

- Describe the physical properties of the Group 16 elements.
- Describe the reactions between sulphur and oxygen.
- Describe the steps and conditions applied in the industrial preparations of sulphuric acid.
- Describe the chemical properties of sulphuric acid.
- Describe the properties of oxoanions.
- State uses of the Group 16 elements and compounds.
	- Compare the acidity and volatility of hydrogen sulphide and water.
	- Show experimentally the dehydrating and oxidising properties of sulphuric acid.
	- Perform experiments to show how sulphuric acid reacts with metals and non-metals.
	- Identify sulphite and sulphate ions in solutions.
		- Develop carefulness and patience in performing the experiments.
		- Appreciate the use of oxygen in everyday life and uses of sulphur in manufacture of antibiotics, skin lotions and vulcanization of rubber.
		- Appreciate the impact of contact process to socio-economic development.
			- Physical properties of the Group 16 elements (physical state, metallic character) and allotropes of oxygen and sulphur.
			- Comparison of acidity and volatility of the Group 16 hydrides. Emphasis on hydrogen bonds between water molecules.
			- Sulphuric acid:
			  o Industrial preparation (contact process) and its environmental impact.
			  o Properties: oxidising and dehydrating agent, reaction with metals (zinc, copper, iron and magnesium) and non- metals
				- Research in groups and present on the physical properties of the Group 16 elements.
				- Research work and make presentation about the industrial preparation of sulphuric acid.
				- Discuss in groups to explain the volatility and acidity of hydrides of the Group 16 elements and make presentation.
				- Carry out experiments on the reaction of concentrated sulphuric acid with sugar and potassium bromide; make an interpretation and present results appropriately.

			(carbon, sulphur, phosphorous). - Oxoanion: reducing action of $S_2O_3^{2-}$, reaction of SO_3^{2-} with acids, action of heat on sulphates (SO_4^{2-}). - Identification of sulphite and sulphate ions. - Uses of the Group 16 elements and compounds.	- Carry out experiments to show: ○ How sulphuric acid react with metals and non-metals. ○ How sulphite ions react with dilute acids. ○ Action of heat on certain sulphate (e.g. hydrated copper (II) sulphate, hydrated iron (II) sulphate; make an appropriate report. - Perform experiments on the reactions of sulphur oxoanions (reduction of iodine by $S_2O_3^{2-}$, reaction of SO_3^{2-} with hydrochloric acid) and make reports. - Carry out identification tests for sulphite and sulphate ions and make an appropriate report.
Link to other subjects: *Mathematics (statistics).*				
Assessment criteria: *The leaners can compare and contrast the properties of the Group 16 elements and their compounds in relation to their position in the Periodic Table.*				
Materials: *Pipette or burette, volumetric flask.*				

TOPIC AREA: THE PERIODIC TABLE		SUB-TOPIC: PERIODICITY OF PROPERTIES OF ELEMENT
S4 Chemistry	**Unit 12:** Trends of chemical properties of Group 17 elements and their compounds	**No. of periods:** 14

Key unit competency: The learner should be able to compare and contrast the chemical properties of the Group 17 elements and their compounds in relation to their position in the Periodic Table.

Learning objectives			Content	Learning Activities
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- State the natural occurrence of halogens. - Describe the extraction methods of halogens. - Explain the trends of physical and chemical properties of the Group 17 elements down the group. - Describe the trends in strength acidity, volatility and reducing power of halogen hydrides. - Describe the chemical properties of chlorates, iodates,	- Prepare and test halogens. - Relate the oxidising power of the Group17 elements to their reactivity. - Relate the acidity strength of oxoacids to the number of oxygen atoms combined with the halogen. - Test for the presence of halide ions in aqueous solution. - Compare the reactions of the halogens with cold dilute sodium	- Develop carefulness in handling harmful halogen gases. - Appreciate the uses of halogens in the manufacture of insecticides, bleaching reagents and organic solvents. - Develop the culture of protecting the environment from harmful halogen compounds.	- Natural occurrence and extraction of halogens. - Comparative study of the physical properties of halogens: physical state, volatility, and colour. - Laboratory preparation and test of halogens. - Comparative study of the chemical properties of halogens: o Reactions with oxygen, water, sodium hydroxide (both dilute and cold or hot concentrated).	- Research and make presentation on the extraction and physical properties of halogens. - Perform experiments to prepare and test chlorine, bromine and iodine. Make an appropriate report. - Experiment to show the displacement of the iodide ion by chlorine and bromine, and the bromide ion by chlorine and make an appropriate report. - Carry out reactions of chloride, bromide

perchlorates and periodates. - State the uses of halogens and their compounds.	hydroxide and hot concentrated sodium hydroxide solutions.		○ Tends in oxidising power down the group (displacement reactions). ○ Reaction with metals and non-metals. - Preparation and behaviour of hydrides of halogens with regard to: acid strength, volatility and their reducing power. - Tests for halide ions aqueous solution. - Properties of oxoacids (variation of the acidity strength of $HClO$, $HClO_2$, $HClO_3$, $HClO_4$) - Properties of chlorates and iodates, perchlorates and periodates. - Uses and hazards of halogens and their compounds.	and iodide ions with concentrated sulphuric acid and make an appropriate report. - Discuss in groups the reaction of halogens with sodium hydroxides and make a presentation. - Research work: in groups research and make presentation about the trends in acid strength, volatility and reducing power of hydrogen halides. - Carry out an experiment to test for halide ions in given solutions and make an appropriate report. - Group discussion: discuss the variation of the acidity strength of oxoacids in accordance of the number of oxygen atoms and suggest a valid explanation.

				- Group discussion: discuss in groups and present about the oxidising/ reducing power and thermal stability of chlorates and iodates, perchlorates and periodates. - Research work: in groups research and make presentations on the uses of halogens and their derivatives.
Link to other subjects:				
Assessment criteria: *The learners can compare and contrast the properties of Group 17 elements and their compounds in relation to their position in the Periodic Table*.				
Materials: *Appropriate chemicals, apparatus.*				

<table>
<tr><td colspan="3">TOPIC AREA: THE PERIODIC TABLE</td><td colspan="2">SUB-TOPIC: PERIODICITY OF PROPERTIES OF ELEMENTS</td></tr>
<tr><td>S4 Chemistry</td><td colspan="3">Unit 13: Properties and uses of Group 18 elements</td><td>No. of periods: 2</td></tr>
<tr><td colspan="5">Key unit competency: The leaner should be able to compare and contrast the properties of the Group 18 elements in relation to their position in the Periodic Table</td></tr>
<tr><td colspan="3">Learning objectives</td><td rowspan="2">Content</td><td rowspan="2">Learning Activities</td></tr>
<tr><td>Knowledge and Understanding</td><td>Skills</td><td>Attitudes and Values</td></tr>
<tr><td>- State the physical properties of the Group 18 elements.
- Explain the lack of reactivity of the Group 18 elements.
- State the uses of the Group18 elements.</td><td>- Associate chemical inertia of the Group 18 elements to their full valence shell.</td><td>- Recognise importance of noble gases or Group 18 elements in the daily life.</td><td>- Noble gases.
- Occurrence.
- Physical properties.
- Reactivity: inertness which decreases down the group (e.g: reaction of xenon).
- Brief mention of the discovery of first compound in 1962.
- Uses.</td><td>- Research and make presentation of the discovery and isolation of the Group18 elements.
- In groups, the learners should explain why elements of the Group 18 are important even if their reactivity is very limited.</td></tr>
<tr><td colspan="5">Link to other subjects:</td></tr>
<tr><td colspan="5">Assessment criteria: The learners can compare and contrast the properties of Group 18 elements in relation to their position in the Periodic Table.</td></tr>
<tr><td colspan="5">Materials: Computer, projector, internet.</td></tr>
</table>

TOPIC AREA: THE PERIODIC TABLE		**SUB-TOPIC: PERIODICITY OF PROPERTIES OF ELEMENTS**
S4 Chemistry	**Unit 14:** Trends in chemical properties of Period 3 elements and their compounds	**No. of periods:** 9

Key unit competency: The learner should be able to compare and contrast the properties of the Period 3 elements and their compounds in relation to their positions in the Periodic Table.

Learning objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Compare the physical properties of the Period 3 elements. - Describe the nature of the oxides of the Period 3 elements and the type of bonding in their chlorides, oxides and hydrides.	- Relate the physical properties of the Period 3 elements to their position in Periodic Table. - Relate the physical properties of compounds of the Period 3 elements to their nature of bonds across the period.	- Develop the sense of analysis while comparing the properties of elements and compounds across the period. - Develop the culture of a team work during discussion sessions and presentations.	- Properties of the Period 3 elements: - Physical properties e.g. melting and boiling points, atomic radius, physical state, polarisability, ionization energy, conductivity, electronegativity and metallic character. - Chemical properties: - reaction with hydrogen. - trends in oxidising/reducing power across the period. - Properties of the Period 3 compounds: - Alkalinity and acidity of oxides. - Ionic and covalent character of the compounds (chlorides, hydrides and	- Group work: discuss the variation of physical properties across Period 3 and suggest convincing explanations. - Discuss and make presentation about the reducing/oxidising power, alkalinity and acidity of their oxides and bonding in halides of the Period 3 elements. - Discuss the influence of nature of bonding on the physical properties of compounds of the Period 3 elements and make presentation.

			oxides).	
Link to other subjects:				
Assessment criteria: *The learners can compare and contrast the chemical properties of the Period 3 elements and their compounds in relation to their positions in the Periodic Table.*				
Materials: *Appropriate chemicals, apparatus, computer, projector.*				

TOPIC AREA: EQUILIBRIUM			**SUB-TOPIC: CHEMICAL EQUILIBRIUM**	
S4 Chemistry		**Unit15:** Factors that affect chemical equilibrium		**No. of periods:** 10
Key unit competency: The learner should be able to deduce how concentration, pressure, catalyst and temperature affect the chemical processes in industry.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Distinguish between complete and reversible reactions. - Explain dynamic equilibrium. - State the characteristics of dynamic equilibrium.	- Apply Le Chatelier's principle to explain the effects of changes in the temperature, concentration and pressure on a system in equilibrium. - Compare and contrast	- Develop the culture of working as a team, mutual help and care while performing the experiments. - Appreciate the importance of Le	- Difference between complete and reversible reactions. - The concept equilibrium (dynamic equilibrium). - Characteristics of a system in dynamic equilibrium.	- Carry out experiments to show that some chemical reactions are reversible e.g. o Addition of acid to chromate (IV)$^{-}$solution (forward reaction), Warming cobalt(II) chloride solution

- Explain the factors that affect the position of the equilibrium in a reversible reaction.	theoretical and actual optimal conditions in the industrial processes. - Relate the effect of concentration, temperature, pressure and catalyst to the amount of products in the manufacturing industries.	Chatelier's principle in Haber and Contact processes. - Respect of procedure in the experiments.	- Factors that affect equilibrium position (concentration, temperature, pressure and catalyst). Use Le Chatelier's principle. - Application of those factors on industrial processes (contact process and Haber process)	(forward reaction), then cooling the solution favours the backward reaction. ○ Addition of hydroxide to dichromate (VII) solution (backward reaction) and then present the findings. - Discuss in groups and make presentation about the effect of concentration, pressure, temperature and catalyst on equilibrium position. Include their applications to Haber and contact processes. - Research in groups and make presentation about the effect of different conditions on the yield of product in industries.
Links to other subjects: *Economics (finance).*				
Assessment criteria: *The learners can deduce how concentration, pressure, catalyst and temperature affect chemical processes in the industry.*				
Materials: *Computers, projectors, appropriate chemicals, apparatus.*				

TOPIC AREA: EQUILIBRIUM		**SUB-TOPIC: IONIC EQUILIBRIUM**		
S4 Chemistry		**Unit 16:** Acids and bases		**No. of periods:** 3
Key unit competency: The learner should be able to explain the acid-base theories (Arrhenius, Bronsted–Lowry, Lewis).				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Explain the acids and bases using different theories. - Explain the differences in behaviour of strong and weak acids and bases using Bronsted-Lowry theory.	- Classify the acids and bases as strong and weak, depending on their dissociation in aqueous solutions. - Distinguish between Lewis and Bronsted-Lowry theory of acids. - Write the dissociation of acids and bases and identify acid-base conjugate pairs.	- Develop the culture of team work; develop self-confidence during group discussions and presentations of the findings.	- Acids and bases (Arrhenius-Ostwald theory, Bronsted-Lowry theory and Lewis theory). - Differences between strong and weak acids and bases. - Explanation of acid-base conjugate pairs using Bronsted-Lowry theory.	- Research and make presentations on acid-base theories. Equations to support the explanations are required. - Discussions and presentations of the findings about the dissociation of strong and weak acids and bases. Include the acid-base conjugate pairs.
Links to other subjects: *Biology (digestion, enzymes).*				
Assessment criteria: *The learners can explain acids and bases according to different theories.*				
Materials: *Computers, projector, internet.*				

TOPIC AREA: ELECTROCHEMISTRY		**SUB-TOPIC: ELECTROLYSIS AND ELECTROCHEMICAL CELLS**		
S4 Chemistry		**Unit17:** Reduction and oxidation reactions		**No. of periods:** 22
Key unit competency: The learner should be able to explain the concept of reduction and oxidation and balance equations for redox reactions.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Explain the redox reactions in terms of electron transfer and changes in oxidation state (number). - Explain the concept of disproportionation. - Differentiate the reducing agent from the oxidising agent in a redox reaction.	- Work out the oxidation numbers of elements in the compounds. - Perform simple displacement reactions to order elements in terms of oxidising or reducing ability. - Apply half-reaction method to balance redox reactions. - Deduce balanced equations for redox reactions from relevant half equations.	- Develop the culture of inquiring in order to continue the search for new concepts of redox reactions. - Respect of procedure during the experiment. - Appreciate the reactivity of elements in daily lives in terms of chemical phenomenon.	- Definition of electrochemistry. - Relationship between electrochemistry and redox reactions. - Definitions of reduction and oxidation reactions. - Rules used to determine oxidation number of elements. - Determination of the oxidation numbers of elements in the compounds. - Oxidation – reduction reactions (reduction half reaction and oxidation half reaction). - Explanation of oxidising and reducing agents.	- Group activities to work out the oxidation numbers of element in the compounds and balancing various oxidation-reduction reactions and make a presentation. - Experiments to show that oxidation-reduction reactions have taken place and they are followed by change in oxidation numbers (e.g.: reduction of acidified potassium dichromate (VII) and potassium magnate (VII) by sulphur dioxide or ethanol), addition of zinc metal to a solution of copper (II) sulphate).

			- Disproportionation reactions. - Balancing oxidation-reduction reactions. - Reactivity series of metals.	Write an appropriate report. - Practical activities that will help the learners to arrange elements in order of oxidising and reducing ability (e.g.: displacement reactions of halogens, different metals and acids).
Links to other subjects: *Operations in mathematics (linear algebra).*				
Assessment criteria: *The learners can explain the concept of reduction and oxidation reaction and balance the equations for redox reactions.*				
Materials: *Appropriate chemicals, apparatus, computers, projector.*				

TOPIC AREA: CHEMICAL ENERGETICS		**SUB-TOPIC AREA: ENTHALPY CHANGE OF CHEMICAL REACTIONS**	
S4 Chemistry		**Unit 18:** Energy changes and energy profile diagrams for chemical reactions	**No. of periods:** 15
Key unit competency: The learner should be able to explain the concept of energy changes and energy profile diagrams for the exothermic and endothermic reactions.			
Learning Objectives			**Content** / **Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**	
- Define the term thermochemistry. - State the first law of thermodynamics - Define standard enthalpy of reactions (formation, combustion, neutralisation, and atomisation). - Explain the differences between exothermic and endothermic reactions using energy profile diagrams.	- Interpret experimental results about energy changes during chemical reactions. - Relate the energy changes: the bond breaking and bond making. - Relate the type of reaction to its energy profile diagrams.	- Carefully deal with reactions that can produce a lot of heat energy. - Appreciate the use of chemical energy in daily life like combustion of fuels. - Develop the culture of working in a team during the experiments. - Respect of procedure during the experiments.	**Content:** - Definition of thermochemistry. - The concept of system. - Types of systems (open, closed and isolated systems). - Heat energy and temperature. - Internal energy of a chemical compound (kinetic + potential energy). - First law of thermodynamics. - Standard enthalpy change of chemical reactions (enthalpy of formation, combustion, neutralization, atomization.). **Learning Activities:** - Perform group discussions about the characteristics of different types of systems and heat transfer (examples of flask, calorimeter, boiling water in an open container and cooling water in closed container may be used). Present the findings. - Experiments to verify energy changes during a chemical reaction e.g.: o Displacement reaction using zinc and copper (II) sulphate solution. o Burning ethanol). o Presentation of the observations is required.

			- Exothermic and endothermic reactions. - Energy profile diagrams (for both exothermic and endothermic reactions).	- Interpretation of the energy profile diagrams for exothermic and endothermic reactions.
Links to other subjects: *Physics (heat), Mathematics (linear functions) , Biology (homeostasis).*				
Assessment criteria: *The learners can explain the concept of energy changes and energy profile diagrams for exothermic and endothermic reactions.*				
Materials: *Appropriate chemicals, apparatus, computer, projector.*				

5.3 Senior five

5.3.1. Key competences by the end of Senior Five

- Apply IUPAC rules to name the organic compounds and explain the types of isomers for organic compounds.
- Relate the physical and chemical properties of alkanes for the preparation methods, uses and isomerism in organic compounds.
- Relate the physical and chemical properties of alkenes and alkynes to their reactivity and uses.
- Relate the physical and chemical properties of halogenoalkanes to their reactivity and uses.
- Compare the physical and chemical properties of alcohols and ethers to their preparation methods, reactivity and uses.
- Compare the chemical nature of carbonyl compounds to their reactivity and uses, the chemical nature of carboxylic acids and acid halides to their reactivity.
- Relate the functional groups of esters, acid anhydrides, amides and nitriles to their reactivity, preparation methods and uses.
- Relate the chemical nature of amines and amino acids to their properties, uses and reactivity.
- Interpret phase diagrams for different compounds.
- Prepare standard solutions and use them to determine concentration of other solutions by titration.
- Explain the effect of different factors on the molar conductivity of different electrolytes and the applications of conductivity measurements.
- Predict the products of given electrolytes during electrolysis and work out quantitatively to determine how much is liberated at a given electrode using Faraday's law.
- Design an experimental procedure to verify the enthalpy changes of chemical reactions.
- Deduce how Hess's law is applied to Born-Haber cycle.
- Predict the feasibility of chemical reactions.

5.3.2. Senior Five units

<table>
<tr><td colspan="3">TOPIC AREA: ORGANIC CHEMISTRY</td><td colspan="2">SUB-TOPIC AREA: ALIPHATIC COMPOUNDS</td></tr>
<tr><td>S5 Chemistry</td><td colspan="2">Unit 1: Introduction to organic chemistry</td><td colspan="2">No. of periods: 7</td></tr>
<tr><td colspan="5">Key unit competency: The learner should be able to apply IUPAC rules to name organic compounds and explain the types of isomers for organic compounds.</td></tr>
<tr><td colspan="3">Learning Objectives</td><td rowspan="2">Content</td><td rowspan="2">Learning Activities</td></tr>
<tr><td>Knowledge and Understanding</td><td>Skills</td><td>Attitudes and Values</td></tr>
<tr><td>- Name organic compounds.
- Describe the isomers of organic compounds.</td><td>- Use IUPAC rules to name different organic compounds.
- Classify organic compounds as aliphatic, alicyclic and aromatic.
- Determine different formulae for given organic compounds.</td><td>- Develop a sense team approach and self-confidence in group discussions and presentations of the findings.</td><td>- Classification of organic compounds as aliphatic, alicyclic and aromatic.
- Types of formulae for organic compounds (empirical, molecular, structural, displayed and skeletal formulae).
- General rules of nomenclature of organic compounds according to IUPAC.
- Isomerism in organic compounds (structural isomers, stereoisomers).
- Functional group and homologous series.</td><td>- Make a group discussion to classify compounds as aliphatic, alicyclic or aromatic) and make a presentation.
- Do exercises to determine different formulae of organic compounds.
- Do exercises in groups to name some organic compounds using IUPAC rules and make a presentation.
- Research, discuss and present about different types of isomerism and write the isomers of different compounds.</td></tr>
<tr><td colspan="5">Links to other subjects: Biology (chemicals of life).</td></tr>
<tr><td colspan="5">Assessment criteria: The learners can relate the physical and chemical properties of alkanes to preparation methods, uses and</td></tr>
</table>

isomerism in organic compounds.
Materials: *Atomic models, computer, projector.*

TOPIC AREA: ORGANIC CHEMISTRY		**SUB-TOPIC AREA: ALIPHATIC COMPOUNDS**
S5 Chemistry	**Unit 2:** Alkanes	**No. of periods:** 10

Key unit competency: The learner should be able to relate the physical and chemical properties of the alkanes to the preparation methods, uses and isomerism.

Learning Objectives			**Content**	**Learning Activities**
Knowledge and Undemanding	**Skills**	**Attitudes and Values**		
- Name straight chain alkanes up to carbon -20. - Define homologous series. - Be aware of the dangers associated with combustion reactions of the alkanes. - Describe and explain the trend in physical properties of homologous series of alkanes.	- Write the structural formula of the alkanes. - Scientific report writing skills in the practical experiments. - Prepare, collect and test methane gas. - Write reaction mechanisms for a photochemical reaction. - Use IUPAC system to name straight and branched alkanes. - Develop practical skills and interpreting results	- Appreciate the importance of the alkanes in daily life. - Appreciate the dangers caused by the alkanes to the environment as major sources of air contaminants. - Develop orderliness and confidence in presentation. - Respect of procedure in experiment to carry out preparation of	- Nomenclature of straight chain hydrocarbon alkanes (up to carbon-20) and branched hydrocarbons using IUPAC system. - Definition of homologous series. - Homologous series of the alkanes. - Physical properties of straight and branched alkanes (e.g. physical state, solubility in water, boiling and melting	- Exercise in groups to name straight chain alkanes up to carbon-20 and make a presentation. - Do a research in groups to recognise alkanes and make a presentation. - Do exercises in groups to name some branched alkanes using IUPAC system and make a presentation. - Carry out experiment to prepare alkanes (methane gas or ethane

- Describe a photo-chemical reaction and free radical mechanism. - Describe the preparation methods of the alkanes. - State the physical properties and uses of the alkanes. - State the chemical properties of the alkanes.	in making appropriate deductions.	methane or propane.	points). - Preparation of the alkanes (e.g. methane, ethane and propane) decarboxylation and other methods. - Uses of the alkanes as source of: fuel, organic products in daily life (e.g. cosmetics, soap-less detergents and derivatives of food preservatives). - Chemical properties of the alkanes (e.g. combustion, halogenations (photochemical reaction).	gas), interpret and make an appropriate scientific report. - Do a research and make a presentation on properties of alkanes both physical and chemical (e.g. melting and boiling points, solubility in water, physical state, combustion halogenation).
Links to other subjects: *Biology (chemicals of life).*				
Assessment criteria: *The learners can relate the physical and chemical properties of the alkanes to preparation methods, uses and isomerism.*				
Materials: *Atomic models, flip charts, computer, projector.*				

TOPIC AREA: ORGANIC CHEMISTRY		**SUB-TOPIC AREA: ALIPHATIC COMPOUNDS**	
S5 Chemistry	**Unit 3:** Alkenes and alkynes	**No. of periods:** 22	
Key unit competency: The learner should be able to relate the physical and chemical properties of the alkenes and alkynes to their reactivity and uses.			
Learning Objectives			**Content** / **Learning Activities**
Knowledge and Undemanding	**Skills**	**Attitudes and Values**	
- Explain the reactivity of alkenes in comparison to alkanes. - Explain the existence of geometrical isomerism in the alkenes. - Describe the industrial process of preparing the alkenes and alkynes.	- Apply IUPAC rules to name alkenes and alkynes. - Carry out an experiment to prepare and test ethane gas. Outline the mechanisms for electrophilic addition reactions for the alkenes and alkynes. - Write the structural formulae of straight chain alkenes and alkynes. - Apply Markovnikov's rule to predict the product of hydrohalogenation of the alkenes. - Classify the alkynes as terminal and non-	- Appreciate the combustion reaction as source of fuels. - Appreciate the uses and dangers of addition polymers (polythene used for polythene bags, polypropene for plastic bottles etc.). - Develop a team approach and confidence in group activities and presentations.	- Definition of alkenes and homologous series. - Nomenclature and structure of the alkenes: straight and branched (C_5-C_{10}). - Structural and geometrical isomerism in the alkenes. - Preparation methods of the alkenes. - Laboratory preparation of ethane. - Testing for unsaturation using (bromine water, potassium manganite (VII) solution or potassium dichromate (VII) solution). - Physical properties and uses of the alkenes. - Chemical reactions of the alkenes (addition	- Make a group discussion and do an exercise on writing the structural formulae of isomers of the alkenes and their names. Exchange work sheets for marking. - Carry out an experiment to prepare and test ethane gas from dehydration of ethanol and make a report. - Research in groups and make a presentation about physical properties of alkenes and alkynes and their uses. - Research in groups and make a presentation about the reactions of the alkenes and alkynes.

	terminal alkynes using their different structures.		reactions, combustion reaction, oxidation of alkenes, ozonolysis in alkenes, hydroformylation, addition polymerization). - Definition of the alkyne and homologous series. - Structure and nomenclature of straight and branched chain alkynes (C_5- C_{10}). - Physical properties and uses of the alkynes. - Industrial preparation method of the alkynes. - Chemical properties of the alkynes (electrophilic addition reactions and reactions of terminal and non-terminal alkynes with metals or metal salts).	Outline their reaction mechanisms. - Research in groups and make a presentation about the industrial preparation process of the alkenes and alkynes and their uses. - Do exercises in groups to identify whether the alkyne is terminal or non-terminal and exchange work sheets for marking.
Links to other subjects: *Biology (endocrinology, chemicals of life)*				
Assessment criteria: *The leaners can relate the physical and chemical properties of the alkenes and alkynes to their reactivity and uses.*				
Materials: *Appropriate chemicals, apparatus, computer, projector.*				

TOPIC AREA: ORGANIC CHEMISTRY		**SUB-TOPIC AREA: ALIPHATIC COMPOUNDS**	
S5 Chemistry	**Unit 4:** Halogenoalkanes (alkyl halides)		**No. of periods:** 17
Key unit competency: The learner should be able to relate the physical and chemical properties of halogenoalkanes to their reactivity and uses.			

Learning Objectives			**Content**	**Learning Activities**
Knowledge and Undemanding	**Skills**	**Attitudes and Values**		
- Define halogenoalkanes and the homologous series. - Explain the reactivity of halogenoalkanes. - Explain the physical properties of halogenoalkanes. - Describe the preparation methods for halogenoalkanes. - Explain different mechanisms in halogenoalkane. - Explain the uses and dangers associated with halogenoalkanes.	- Draw the displayed structural formulae of halogenoalkanes and give names using IUPAC system. - Classify halogenoalkanes according to a developed formula as primary, secondary and tertiary. - Write reaction mechanisms of halogenoalkanes as SN_1, SN_2, E_1 and E_2. - Test for the presence of halogenoalkanes in a given sample organic compound.	- Appreciate the uses and dangers of halogenoalkanes in everyday life. - Develop awareness in protecting the environment. - Develop a team work approach and confidence in group activities and presentation sessions.	Definition of halogenoalkane and homologous series. Nomenclature of halogenoalkanes, isomerism and classification (as primary, secondary and tertiary halogenoalkanes). - Physical properties of halogenoalkanes (solubility, smell, volatility). - Preparation of halogenoalkanes. - Chemical reactions of halogenoalkanes (substitution reactions and elimination reactions). - Uses of halogenoalkanes (e.g. chlorofluorocarbons	- Make a group discussion and a presentation on nomenclature, classification, physical properties and reactivity of halogenoalkanes. - Do exercises on writing and naming halogenoalkanes. - Make a group discussion on preparations of halogenoalkanes and test for their presence using silver nitrate solution in ethanol. Write an appropriate report. - Discuss in groups and make presentations on the structural isomers in halogenoalkanes. - Discuss in groups the SN_1

			(CFCs) in fluids in the refrigerator and aerosol sprays, as solvents for organic substances, as fire extinguishers). - Dangers associated with CFCs on destruction of ozone layer and increasing the global warming.	and SN_2, E_1 and E_2 mechanisms for primary, secondary and tertiary halogenoalkanes and factors considered for a particular compound to undergo SN_1 and SN_2, E_1 and E_2 mechanisms and make a presentation. - Research and make presentations on the uses and dangers of halogenoalkanes and their derivatives (put emphasis on chlorofluorocarbons on the environmental pollution).
Links to other subjects: *Biology (ecology), Geography (people and the environment), General studies (environment).*				
Assessment criteria: *The learners can relate the physical and chemical properties of halogenoalkanes to their reactivity and uses.*				
Materials: *Appropriate chemicals, apparatus, computer, projector.*				

TOPIC AREA: ORGANIC CHEMISTRY		**SUB-TOPIC AREA: ALIPHATIC COMPOUNDS**		
S5 Chemistry		**Unit 5:** Alcohols and Ethers		**No. of periods:** 22
Key unit competency: The learner should be able to compare the physical and chemical properties of alcohols and ethers to their preparation methods, reactivity and uses.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Undemanding	**Skills**	**Attitudes and Values**		
- Explain isomers in alcohols from C-4 to C-6. - Describe the physical properties and uses of alcohols. - Explain the mechanism of dehydration of alcohols and the reaction with hydrogen chloride. - Recall the steps involved in fermentation process. - Describe the physical and chemical properties and preparation methods of ethers.	- Write and name alcohols according to IUPAC system. - Classify alcohols as primary, secondary and tertiary. - Carry out an experiment to compare the oxidation reactions of primary, secondary and tertiary alcohol. - Perform iodoform test to distinguish between the methyl and non- methyl alcohols. - Carry out experiments to distinguish between primary, secondary and tertiary alcohols. - Prepare ethanol at school.	- Appreciate the uses and dangers of alcohols to the society. - Develop a culture of working as a team during group activities. - Appreciate the uses ethers as non-polar solvents.	- Definition of alcohols and the homologous series. - Nomenclature, isomerism and the classification of alcohols. - Physical properties of alcohols (boiling point, volatility, solubility and state at room temperature). - Uses of alcohols as drinks, solvents and motor fuels. - Preparations of alcohols (e.g. ethanol). - Local preparation of ethanol by fermentation (urwagwa. ikigage).	- Make group discussion to do exercises on naming and writing isomers for different alcohols. Exchange work sheets for marking. - Make group discussion to explain the physical properties of alcohols and make a presentation. - Carry out an experiment to compare the oxidation reactions of primary, secondary and tertiary alcohols and write an appropriate report. - Do more exercises on writing and naming alcohols and ethers. - Visit breweries to assess the industrial production of alcohol by fermentation and

- State the uses of ethers. - Describe the local process of making alcohol. - Explain the effect of oxidation on urwagwa when it overstays. (urwagwa rushaje).			- Chemical properties of alcohols (e.g. oxidation, esterification, reaction with sodium metal, reaction with sodium hydroxide , reaction with concentrated sulphuric acid at different temperatures). - Nomenclature, physical properties, isomers and uses of ethers as non-polar solvents - Preparation reactions and chemical properties of ethers.	write an appropriate field report. - Carry out experiments to distinguish between primary, secondary and tertiary alcohols. (Lucas test) and write an an appropriate report. - Perform an experiment to distinguish between the methyl and non- methyl alcohols (iodoform test) and write an appropriate report. - Debate the uses of alcohols and dangers associated with unsafe use of different types of alcohols on our health, family and society. - Carry out a research and make presentations on the physical properties, chemical properties, uses and preparation reactions of ethers.
Links to other subjects: *Biology (chemicals of life).*				
Assessment criteria: *The learners can deduce the physical and chemical properties of alcohols and ethers to their preparation methods, reactivity and uses.*				
Materials: *Appropriate chemicals, apparatus, computer, projector.*				

TOPIC AREA: ORGANIC CHEMISTRY		SUB-TOPIC AREA: ALIPHATIC COMPOUNDS		
S5 Chemistry		**Unit 6:** Carbonyl compounds		**No. of periods:** 22
Key unit competency: The learner should be able to compare the chemical nature of carbonyl compounds to their reactivity and uses.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Undemanding	**Skills**	**Attitudes and Values**		
- Describe the reactivity of carbonyl compounds. - State the physical properties of aldehydes and ketones. - Describe the preparation reactions of ketones and aldehydes. - Explain the mechanisms of nucleophilic addition reactions of carbonyl compounds.	- Prepare ketones from secondary alcohols by oxidation reaction. - Compare aldehydes and ketones by using Fehling's solution and Tollens' reagent. - Write and name carbonyl compounds and isomers of ketones and aldehydes. - Write equations for the reactions of carbonyl compounds with other substances. - Compare the physical properties of carbonyl compounds to those of alcohols and alkenes. - Differentiate the methyl	- Appreciate the importance and dangers associated with carbonyl compounds in daily life. - Develop a culture of working in groups, develop self-confidence in making presentation. - Respect of procedure in performing an experiment on distinguishing carbonyl compounds from other organic compounds.	- Nomenclature and isomerism in carbonyl compounds. - Physical properties of aldehydes and ketones (volatility, solubility and boiling point). - Uses of carbonyl compounds. - Preparation methods of ketones and aldehydes. - Chemical reactions of carbonyl compounds (nucleophilic addition, oxidation, iodoform reactions, and chemical test).	- Do exercises on naming and drawing isomers of carbonyl compounds and exchange work sheets for marking. - In groups, the learners discuss and make presentations on the reactivity and mechanisms of nucleophilic, addition of carbonyl compounds. - Group discussion and presentation about the physical properties and uses of aldehydes and ketones. - Carry out experiment to distinguish between carbonyl compounds and

	ketones from other ketones by using the iodoform test. - Carry out an experiment to distinguish between carbonyl compounds and other organic compounds. - Carry out an experiment to distinguish between ketones and aldehydes. - Carry out an experiment to prepare ethanol and propan-2-one.			other organic compounds by using 2, 4-dinitrophyneylhydrazine and write an appropriate report. - Carry out an experiment to prepare ethanol and acetone by oxidising ethanol and propan-2-ol under controlled conditions and report the findings. - Carry out an experiment to distinguish between ketones and aldehydes using Fehling's solution and Tollens' reagent and write an appropriate report. - Carry out iodoform test to distinguish methyl ketones from aldehydes and other ketones and write an appropriate report.
Links to other subjects: *Biology (chemicals of life).*				
Assessment criteria: *The learners can deduce the chemical nature of carbonyl compounds to their reactivity and uses.*				
Materials: *Appropriate chemicals, apparatus, computer, projector.*				

TOPIC AREA: ORGANIC CHEMISTRY			**SUB-TOPIC AREA: ALIPHATIC COMPOUNDS**	
S5 Chemistry		**Unit 7:** Carboxylic acids and acyl halides		**No. of periods:** 17
Key unit competency: The learner should be able to compare the chemical nature of the carboxylic acids and acid halides to their reactivity.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Undemanding	**Skills**	**Attitudes and Values**		
- Explain the physical properties and uses of the carboxylic acids and acyl chlorides. - Describe the inductive effect on the acidity of the carboxylic acids. - Explain the reactions of the carboxylic acids and acyl chlorides.	- Apply the IUPAC rules to name different carboxylic acids acyl chlorides. - Write the structural formula and isomers of the carboxylic acids. - Distinguish between the carboxylic acids from other organic compounds using appropriate chemical test. - Prepare carboxylic acids from oxidation of aldehydes or primary alcohols. - Compare the physical properties of the carboxylic acids to those of alcohols.	- Develop a culture of working as a team in group activities and develop self-confidence in making presentation. - Appreciate the uses of the carboxylic acids as the intermediate compounds in the industrial processes such as aspirin, vinegar and perfumes.	- Nomenclature and isomers. - Physical properties and uses of carboxylic acids. - Acidity of carboxylic acids. - Preparation methods of the carboxylic acids and acyl halides. - Reactions of the carboxylic acids (with metals, sodium hydroxide, sodium carbonate/hydrogencarbonate, phosphorus pentachloride/ thionyl chloride, esterification, reduction reactions, reaction with halogens). - Nomenclature and physical properties of acyl chlorides. - Reactions of acyl chlorides	- Make a group discussion on naming the carboxylic acids; write the structures and their isomers. Exchange work sheets for marking. - Do exercises of writing and naming the carbonyl compounds and make a report. - Research and make presentations on physical properties of the carboxylic acids, acyl chlorides and their uses. - Discuss in groups, the preparation reactions of the carboxylic acids and acyl halides and make a presentation. - Research and make a

	- Outline the mechanisms of esterification and those of reaction of acyl chlorides with ammonia, amines and alcohols.		with water, strong base, Grignard reagents, alcohols, ammonia and amines, salts of the carboxylic acid and reduction of acyl halides.	presentation on the chemical reactions of carboxylic acids and acyl chlorides. - Carry out an experiment to distinguish the carboxylic acids from other organic compounds using sodium carbonate/hydrogencarbonate and write an appropriate report. - Carry out an experiment to prepare a carboxylic acid by oxidation of an aldehydes or a primary alcohol using acidified potassium manganite (VII) and write an appropriate report.
Links to other subjects: *Biology (chemicals of life).*				
Assessment criteria: *The learners can deduce the chemical nature of the carboxylic acids and acyl halides to their reactivity.*				
Materials: *Appropriate chemical, apparatus, computer, projector.*				

TOPIC AREA: ORGANIC CHEMISTRY		SUB-TOPIC: ALIPHATIC CHEMISTRY		
S5 Chemistry		**Unit 8:** Esters, acid anhydrides, amides and nitriles		**No. of periods:** 22
Key unit competency: The learner should be able to relate the functional groups of esters, acid anhydrides, amides and nitriles to their reactivity, preparation methods and uses.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Undemanding	**Skills**	**Attitudes and Values**		
- Describe the chemical properties of esters, acid anhydrides, amides and nitriles. - Describe the process of urea manufacture and its uses. - Describe the formation of the detergents.	- Apply IUPAC rules to name esters, acid anhydrides, amides and nitriles. - Compare the physical properties of esters to those of alcohols and carboxylic acids. - Make a soap and compare its properties with those of soapless detergents. - Compare the reactivity of acid anhydrides with those of acyl chlorides. - Prepare aspirin from appropriate reagents.	- Appreciate the importance of esters in the manufacture of soap. - Appreciate the importance of esters and amides as intermediate compounds in the manufacture of polyesters and polyamides such as terylene and nylon in the textile industries. - Appreciate the importance of acid anhydrides in the manufacture of drugs such as aspirin and paracetamol.	- Nomenclature and structure of esters. - Physical properties of esters and its uses. - Chemical properties of esters. - Saponification and the detergents. - Structure and nomenclature of acid anhydrides. - Preparations of acid anhydrides. - Chemical properties of acid anhydrides. - Uses of acid anhydrides. - Structure and nomenclature of amides. - Physical properties of amides.	- Research and group discussions to write the structures and names of esters, acid anhydrides, amides and nitriles. Exchange work sheets for marking. - Do exercises on wiring and naming esters, acid anhydrides, amides and nitriles. - Research in groups and discuss the properties of acid anhydrides, amides and nitriles. - In groups, discuss the chemical reactions of esters, acid anhydrides, amides and nitriles. Make presentations.

		- Appreciate the importance of urea as a fertiliser in agriculture. - Appreciate the importance of the detergents in comparison to soaps.	- Preparations of amides - Chemical properties of amides (reduction reaction, reaction with water /acid, Hoffman degradation reaction and reaction with nitrous acid, dehydration reaction and alcohols). - Uses of amides like urea in the chemical industry, medicine, niche, agriculture. - Structures and nomenclature of some nitriles. - Physical properties and the preparation methods of nitriles. - Reactions of nitriles (hydrolysis and reduction).	- Carry out a field study at a nearby soap and detergent making factory to observe the process of saponification and write an appropriate report. - Carry out an experiment to make soap in the laboratory and write an appropriate report. - Carry out an experiment to prepare aspirin using acetic anhydride and salicylic acid and write an appropriate report. - Research in groups and make a presentation about the industrial manufacture of urea and its uses.
Links to other subjects: *Agriculture (fertilizers), Biology (homeostasis).*				
Assessment criteria: *The learners can relate the functional groups of esters, acid anhydrides, amides and nitriles to their reactivity, preparation methods and its use.*				
Materials: *Appropriate chemicals, apparatus, computer, projector.*				

TOPIC AREA: ORGANIC CHEMISTRY		**SUB-TOPIC AREA: ALIPHATIC CHEMISTRY**		
S5 Chemistry		**Unit 9:** Amines and amino acids		**No. of periods:** 11
Key unit competency: The learner should be able to relate the chemical nature of the amines and amino acids to their properties, uses and reactivity.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Undemanding	**Skills**	**Attitudes and Values**		
- Explain the zwitterion forms in the solution of different pH. - Explain the isoelectric point in amino acids. - Describe the physical properties and uses of amines. - Describe the preparation methods of the amines. - Describe the reactions of amino acids and amines with other substances.	- Apply IUPAC rules to name the amines and amino acids. - Classify amines as primary, secondary and tertiary amines. - Write the optical isomers of zwitterion forms of the amino acids. - Compare and contrast the physical properties of the amino acids to those of the carboxylic acids and amines. - Test the presence of amines and amino acid in the solution.	- Appreciate the importance of the amines as intermediate compounds in making polyamides in the textile, drugs and dyes industries. - Appreciate the importance of amino acids as the building blocks for proteins in our bodies. - Develop a team approach and self - confidence in group activities and presentations.	- Name and classify amines. - Physical properties, natural occurrence and uses of the amines. - Preparation reactions of the amines (reduction of amides, Hoffman degradation reaction, reduction of nitriles, alkylation of ammonia, reduction of nitro compounds). - Chemical reactions of the amines with: dilute acids, nitrous acid, derivatives of carboxylic acids, Grignard reagents, alkyl halides. - General structure of amino acids and some common examples. - Comparison of the	- Discuss in groups to classify the amines as primary, secondary tertiary and name some amines. Then compare the classification of amines to that of alcohols. - Do exercises on writing, naming and classifying the amines. - In groups, discuss the physical properties of the amines and those of amino acids then make a presentation. - Research and discuss on the natural occurrence, solubility of amines in water and behaviour as bases in comparison with ammonia. Make an

			physical properties of amino acids to those of the carboxylic acids and amines. - Chemical properties of the amino acids (reaction with hydrochloric acid, nitrous acid, sodium hydroxide and sodium carbonate). - Optical isomers of the amino acids. - Peptides and polypeptides: o Formation and structure. o Uses of amino acids as building blocks of proteins.	appropriate report. - Do a group discussion and make a presentation, to compare and contrast the physical properties of amino acids to those of the carboxylic acids and amines. - Research in groups and make a presentation about the preparation methods of the amines and their chemical reactions with substances. - Carry out an experiment to test the presence of the amines in a solution and write an appropriate report. - Carry out an experiment to test for the presence of amino acid in a solution and write an appropriate report. - Do a research, discuss in groups and make a presentation on how amino acids react with: hydrochloric acid, sodium hydroxide and sodium

				carbonate. - Research in groups on the uses of amino acids and make a presentation.
Links to other subjects: *Biology (nutrition in animals, cytology)*				
Assessment criteria: *The learner can deduce the chemical nature of the amines and amino acids to their properties, uses and reactivity.*				
Materials: *Appropriate chemicals, apparatus, computer, projector.*				

TOPIC AREA: EQUILIBRIUM			**SUB-TOPIC AREA: PHYSICAL EQUILIBRIUM**	
S5 Chemistry		**Unit 10:** Phase diagrams		**No. of periods:** 11
Key unit competency: The learner should be able to interpret the phase diagrams for different compounds.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Define a phase. - Explain the term phase equilibrium. - Explain the effect of change of state on changing pressure and temperature. - Define heterogeneous and homogeneous equilibria. - Define triple point, critical point, normal boiling and melting points of substances.	- Relate the physical properties of compounds to their phase diagrams. - Locate triple point, critical point, normal boiling and melting points on the phase diagrams. - Compare the phase diagrams of water with the carbon dioxide.	- Develop analysis skills, team work, and attentiveness in interpreting the phase diagrams and in practical activities.	- Definition of a phase. - Explanation of the concept of the phase equilibrium. - Heterogeneous and homogeneous equilibria. - The phase diagrams (water and carbon dioxide). - Explanations of triple point, critical point, normal boiling and melting points. - Comparison of the phase diagrams for substances which expand on freezing and those that contract on freezing. - Applied aspects of the phase diagrams. - Conditions under which substances states are	- Group discussion about interpretations of the phase diagrams (for water and carbon dioxide) using charts and present their observations. - Practical activities and examples to discuss in groups that [water expands on freezing (e.g. glass breaks when water in it freezes and ice floats on water, carbon dioxide contracts on freezing]. Present the findings for every activity.

			stable. e.g.: carbon dioxide in fire extinguishers is kept at high pressure. - Explanation of why ice floats on liquid water.	
Links to other subjects: *Mathematics (function and graphs), Physics (heat).*				
Assessment criteria: *The learners can interpret the phase diagrams of water and carbon dioxide.*				
Materials: *Charts, refrigerator, fire extinguisher, computers.*				

TOPIC AREA: SOLUTIONS AND SOLUBILITY		**SUB-TOPIC AREA: DETERMINATION OF CONCENTRATION OF SOLUTIONS**	
S5 Chemistry	**Unit11:** Solutions and titration		**No. of periods:** 28
Key unit competency: The learner should be able to prepare standard solutions and use them to determine concentration of other solutions by titration.			
Learning Objectives			**Content** / **Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and values**	
- Define the terms standard solution and primary standard solution.	- Prepare solutions with different concentrations. - Properly use the burettes, pipettes during titration.	- Develop a team approach and a sense of responsibility in performing the	- Definition of standard solution and primary standard solution. - Properties of a primary - Carry out practical activities to prepare solutions of different

- Explain the properties of a standard primary solution. - Explain the titration process, emphasising the need for precise measurements.	- Interpret the experimental data obtained by titration and report. - Carry out acid-base, redox base titrations and do calculations involved.	experiments of titration. - Respect of procedure in practical experiment. - Develop a culture of orderliness in performing practical experiments. - Appreciate the use of appropriate measurements in daily life.	standard solution. - Preparation of standard solutions with different concentrations (e.g.: 0.5M, 1M, 2M). - Acid–base titrations (e.g. hydrochloric acid and sodium hydroxide solution, hydrochloric acid and sodium carbonate solution). - Redox titrations (e.g. potassium manganite(VII) solution and Fe^{2+} ions, potassium manganite(VII) solution and oxalic acid). - Back titrations (e.g. hydrochloric acid and sodium hydroxide solution hydrochloric acid and calcium carbonate, aqueous ammonia, hydrochloric acid and sodium hydroxide solution). - Applications of titration to determine concentrations of a solution whose concentration is not known, number of water crystallisation, percentage	concentrations (e.g.: 0.5M of sodium carbonate solution, 1M of sulphuric acid.). The presentation of results is required. - Carry out experiments of titration to determine the concentration of solution, number of water crystallization, percentage of purity of an impure sample and relative atomic mass of an element, find the percentage by mass of potassium hydroxide in a given sample of banana peel an appropriate report of findings is required. - Do calculation exercises related to acid–base titrations, redox titrations and back titrations.

			purity of impure sample and relative atomic mass of elements.	
Links to other subjects: *Mathematics (statistics: data analysis and interpretation).*				
Assessment criteria: *The learners can prepare standard solution and use them to determine the concentration of other solutions by titration.*				
Materials: *Appropriate chemicals, apparatus, computers, projector, internet.*				

TOPIC AREA: ELECTROCHEMISTRY			**SUB-TOPIC AREA: CONDUCTANCE AND CONDUCTIVITY**	
S5 Chemistry		**Unit12:** Conductivity of solutions		**No. of periods:** 11
Key unit competency: The learner should be able to explain the effect of different factors on the molar conductivity of different electrolytes and the applications of conductivity measurements.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Explain the conductivity of solutions. - State and explain the factors that affect molar conductivity of solutions.	- Use Kohlrausch's law to calculate the molar conductivity of an electrolyte. - Interpret a graph of molar conductivity against concentration for both weak and strong	- Develop a team approach and responsibility in performing experiments. - Appreciate the contributions of other scientists like	- Conductance of electrolytic solutions. - Measurement of conductivity of solutions. - Specific conductivity of solutions. - Molar conductivity of solutions (molar	- In groups, discuss the working of conductivity cell (use a labelled diagram) and make a presentation. - Research in groups and make presentations about the factors that affect

- State Kohlrausch's law of individual molar conductivity. - Explain the use of molar conductivity in the acid-base titration.	electrolytes. - Compare and contrast metallic conductivity and electrolytic conductivity.	Kohlrausch's law in calculation of molar conductivity of solutions. - Respect the procedure in performing experiments.	conductivity of strong and weak electrolytes). - Factors that affect molar conductivity of solutions (temperature, concentration, type of electrolytes, ionic charge and size). - Kohlrausch's law of individual molar conductivity. - Relation between molar conductivity, degree of ionisation and ionisation constant. - Use of conductivity measurement in titration and solubility product. - Difference between metallic conductivity and electrolytic conductivity.	molar conductivity. - Carry out an experiment to verify the conductivity of solutions (e.g. sugar and salts). Write a report about the observations made. - With the help of examples, do exercises of calculations using Kohlrausch's law of individual molar conductivity and exchange work sheets for marking. - Carry out an experiment to compare the electrolytic conductivity and metallic conductivity and make an appropriate report.
Links to other subjects: *Physics (electricity).*				
Assessment criteria: *The learners can explain the effect of concentration, temperature, viscosity of the solvent, ionic charge and size on the molar conductivity of different electrolytes and the applications of conductivity measurements.*				
Materials: *Appropriate chemicals, apparatus, computers, projectors, internet.*				

TOPIC AREA: ELECTROCHEMISTRY		SUB-TOPIC AREA: ELECTROLYSIS AND ELECTROCHEMICAL CELLS		
S5 Chemistry		**Unit13:** Electrolysis		**No. of periods:** 16
Key unit competency: The learner should be able to predict the products of given electrolytes during electrolysis and work out quantitatively to determine how much is liberated at a given electrode using Faraday's law.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Define electrolysis, cathode and anode. - Explain the electrolysis of different substances. - State Faraday's law and define Faraday's constant. - Describe the industrial applications of the electrolysis.	- Develop practical experimental skills related to electrolysis, interpret results and draw valid conclusions. - Carry out a practical activity to explain the phenomenon of electrolysis. - Compare the electrolysis of dilute solutions and concentrated solutions. - Calculate the masses and volumes of substances liberated during electrolysis.	- Develop a team approach, sense of responsibility and self-confidence in performing experiments. - Respect other's opinion during group discussions. - Appreciate the work of Faraday. - Respect of procedure during an experiment.	- Definition of electrolysis. - Description of electrolytic cells. - Electrolysis of concentrated and dilute sodium chloride solution, water, copper (II) sulphate solution. - Use Faraday's law of electrolysis to calculate the mass and volume of substances liberated at electrodes. - Factors affecting electrolysis [nature of electrodes (inert and active electrodes), concentration (concentrated and dilute	- Carry out a practical activity to explain the phenomenon of electrolysis (concentrated and dilute sodium chloride solution, water and copper (II) sulphate) solution. A report of the observations is required. - With the help of examples, do exercises of calculations using Faraday's law to determine the mass and volume of substances liberated at different electrodes. - Research and discuss in groups, and make presentations about the

	- Relate the nature of electrode, reactivity of metal ion in solution, to the products of electrolysis. - Perform electroplating of graphite by copper metal.		solutions), position in the electrochemical series]. - Applications of electrolysis: ○ Extraction and refining of metals. ○ Electroplating. ○ Preparations of chemicals (e.g. sodium hydroxide, chlorine, hydrogen).	factors that affect electrolysis. - Research and make a presentation about the industrial applications of electrolysis. - Carry out electroplating of graphite by copper and report the observation.
Links to other subjects: *Physics (electricity).*				
Assessment criteria: *The learners can predict the products of given electrolytes during electrolysis and work out quantitatively to determine how much is liberated at a given electrode using Faraday's law.*				
Materials: *Computers, projecto , internet, appropriate chemicals and apparatus for electrolysis.*				

TOPIC AREA: CHEMICAL ENERGETICS	**SUB-TOPIC AREA: ENTHALPY CHANGE OF CHEMICAL REACTIONS**	
S5 Chemistry	**Unit 14:** Enthalpy change of reactions	**No. of periods:** 25
Key unit competency: The learner should be able to design an experimental procedure to verify the enthalpy changes in a chemical reaction.		

Learning Objectives			**Content**	**Learning Activities**
Knowledge and Undemanding	**Skills**	**Attitudes and Values**		
- Define heat of reaction, standard enthalpy change of combustion, enthalpy of neutralisation, enthalpy of solution, enthalpy of hydration and lattice enthalpy. - Describe an experimental procedure in determination of heat of combustion. - Explain the relationship between quantity of heat produced and mass of substance in a combustion reaction. - State Hess' law of	- Develop practical experimental skills about enthalpy changes of reactions, interpreting results and drawing valid conclusions. - Carry out practical activities to determine enthalpy change of reactions (enthalpy change of combustion of ethanol, enthalpy change of neutralisation). - Calculate the enthalpy change of combustion, neutralisation and dissolution from experimental data.	- Develop a team approach and sense of responsibility in performing the experiments. - Have confidence in handling the chemicals and the apparatus during practical activities. - Respect of procedure during experiments of combustion and neutralisation. - Respect of other's opinion during group discussions. - Appreciate the contributions of other scientists such as	- Definition of standard enthalpy of reaction (enthalpy change of combustion, enthalpy change of neutralisation, enthalpy change of solution, enthalpy of hydration and lattice enthalpy). - Relationship between temperature and heat: $Q = mc\Delta T$ - Experimental methods for finding the standard enthalpy of reaction (enthalpy change of combustion, enthalpy change of neutralisation, enthalpy change of dissolution).	- Carry out practical activities to determine enthalpy change of reactions (enthalpy change of combustion of ethanol, enthalpy change of neutralisation of hydrochloric acid with sodium hydroxide solution and enthalpy of dissolution of sodium hydroxide in water). Presentation of the observations is required. - In groups, do exercises of calculations about enthalpy change of reactions (e.g. combustion and neutralisation). - With the help Hess' law,

constant heat summation. - State and explain the factors that affect the magnitude of lattice energy. - Describe the bond breaking as endothermic and the bond making as exothermic.	- Deduce how Hess's law is applied to Born-Haber cycle. - Construct Hess's energy cycles and Born-Haber cycles from the data obtained experimentally or been provided. - Calculate the enthalpy changes of reactions using Hess's law. - Use the standard bond energy to determine the standard enthalpy of reactions. - Relate the heat of hydration and lattice energy to heat of solution.	Hess, Born and Haber's work.	- Hess's law. - Applications of Hess's law to calculate standard enthalpy changes of reactions. - Hydration and lattice energies (factors affecting the magnitude of the lattice energy). - Born-Haber cycle. - Calculations of the average standard bond enthalpy.	do exercises about calculations of enthalpy changes of reactions and exchange work sheets for marking. - With the help of examples, do exercises of calculations about Born Haber cycles, standard average bond energy using data obtained experimentally or been provided. - In groups, discuss and present about the factors affecting the hydration energy and lattice energy.
Links to other subjects: *Physics (thermodynamics), Mathematics (vectors).*				
Assessment criteria: *The learners can design an experimental procedure to verify the enthalpy changes in a chemical reaction.*				
Materials: *Appropriate chemicals, apparatus.*				

TOPIC AREA: CHEMICAL ENERGETIC			**SUB-TOPIC AREA: SPONTANEITY OF CHEMICAL REACTIONS**	
S5 Chemistry		**Unit15:** Entropy and free energy		**No. of periods:** 11
Key unit competency: The learner should be able to predict the feasibility of chemical reactions.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Explain the term entropy. - State the second law of thermodynamics. - State, if the value of free energy for a reaction will be positive or negative.	- Relate the entropy changes to the changes in degree of disorder. - Predict the spontaneity of reactions using the Gibbs free energy values.	- Develop a team approach, responsibility and self-confidence in group activities and presentations. - Respect of other's opinion during group discussions.	- Definition of entropy. - Change in entropy. - Second law of thermodynamics. - Free energy, the deciding factor: $\Delta G^0 = \Delta H^0 - T\Delta S^0$. - Feasibility of chemical reactions.	- Discuss in groups, if the entropy of the reaction will be positive or negative. Then present the conclusions. - Group activities for the learners to decide whether given reactions are thermodynamically possible or not. Then present the conclusions.
Links to other subjects: *Physics (thermodynamics), Mathematics (functions).*				
Assessment criteria: *The learners can predict the feasibility of chemical reactions.*				
Materials: *Computer, projector, internet.*				

5.4 Senior six

5.4.1 Key competences by the end of Senior Six

- Explain the properties and uses of transition metals.
- Relate the properties of metals to their methods of extraction and uses, and suggest preventive measures to dangers associated with their extraction.
- Analyse the components of quality fertilizers and their benefits, effects of misuse and dangers associated with the substandard fertilizers,
- Relate the chemistry and uses of benzene and its derivatives to their nature and the structures.
- Relate the types of polymers to their structural properties and the uses
- Apply partition and Raoult's law to separate the mixtures and determine the molecular and formula mass of compounds, using colligative properties..
- Write expressions and calculate the values of equilibrium constant, interpret the values of Kc in relation to the yield of the products in the reversible reactions
- Prepare solutions, measure their pH and calculate the pH of acidic and alkaline solutions.
- Explain the concept of buffer solution, hydrolysis of salts and discuss its applications in manufacturing industry and biological processes.
- Relate titration curves to the type of acid and base titrated, properly choose and use indicators in acid-base titrations.
- Calculate the solubility product, constant of sparingly soluble salts and deduce the applications of common ion effect in the industry
- Explain the working and the industrial applications of electrochemical and electrolytic cells.
- Measure the rates of reaction and formulate simple rate equations using experimental results.
- Explain the factors that affect the rate of chemical reaction and use Arrhenius equation to calculate the ratio of rate constant and activation energy with the change in temperature.
- Explain the importance and dangers of radioisotopes in everyday life.

5.4.2. Senior Six units

TOPIC AREA: THE PERIODIC TABLE			**SUB-TOPIC AREA: TRANSITION METALS**	
S6 Chemistry		**Unit1:** Properties and uses of transition metals		**No. of periods:** 22
Key unit competency: The learner should be able to explain the properties and uses of transition metals.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Discuss qualitatively the properties of transition elements when compared to those of calcium as a typical s-block metal. - Explain the principle of ligand exchange. - State the rules of naming complex ions and stereo isomerism. - Describe reactions of transition metals. - State the uses of transition metals.	- Relate the electronic configurations to special properties of the transition metals. - Relate the electronic configuration to the definition of a transition metal/element as d-block elements. - Compare the physical properties of transition metals to those of s-block and p-block elements. - Explain why scandium and zinc	- Show respect for other's opinion during group discussion. - Develop a team work in group discussion. - Respect procedure in experiments. - Appreciate the use of transition metals in biological processes.	- Definition of transition metal. - Electronic configuration of transition metals (1^{st} series). - Properties of the transition metals (melting and boiling points, metallic and ionic radii, ionization energy, variable oxidation states, complex formation, formation of coloured compounds, catalytic properties of transition metals and magnetic properties).	- Do exercises in groups and exchange work sheets for marking about writing the electronic configuration of the elements from scandium to zinc. - Discuss in groups, the properties of transition metals and make a presentation. - Group discussion: discuss about the nomenclature, isomerism and shapes of complex ions (octahedral, tetrahedral and square planar) and make a presentation by displaying the models. - Perform experiments to

	are not considered as true transition metals. - Predict the shape of the complex compounds of transition metal cat ions. - Observe the colours of transition metal solutions. - Perform the confirmatory tests for transition metal ions. - Apply the rules in naming the complex ions.		- The anomalous properties of Zn and Sc. - Naming of complex ions and isomerism in compounds of transition elements (stereoisomerism). - The chemistry of individual metals (scandium, titanium, vanadium, chromium, manganese, iron, cobalt, nickel, copper and zinc): o Reactions. o Uses. - Identification of transition metal ions in the aqueous solutions.	demonstrate ligand exchange and write an appropriate scientific report (e.g. addition of ammonia solution to a solution of copper (II) ions or concentrated hydrochloric acid and vice-versa). - Research and do a group discussion and make a presentation about the reactions of individual transition elements (with other substances and their uses. - Carry out the experiments in groups for the preliminary and confirmatory tests for transition metal ions (Ni^{2+}, Fe^{2+}, Fe^{3+}, Mn^{2+}, Cr^{3+}, Zn^{2+}, Co^{2+}, Cu^{2+}) and write an appropriate report.
Link to other subjects: *Biology (respiration, blood circulation).*				
Assessment criteria: *The learner can explain the properties and uses of transition metals.*				
Materials: *Appropriate chemicals, apparatus, computer, projector.*				

TOPIC AREA: THE PERIODIC TABLE			**SUB-TOPIC AREA: TRANSITION METALS**	
S6 chemistry		**Unit 2:** Extraction of metals		**No. of periods:** 14
Key unit competency: The learner should be able to relate the properties of metals to their methods of extraction and uses, and suggest preventive measures to the dangers associated with their extraction.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Describe the extraction of copper, iron, sodium, tantalum, zinc, wolfram, aluminium and tantalum. - Outline and explain the uses copper, iron, tantalum, zinc, wolfram, tin ore (cassiterite). - Explain the issues associated with the extraction of metals and preventive measures.	- Relate the properties of metals to their methods of extraction.	- Appreciate the use of transitional metals. - Appreciate the cost or difficulties related to the extraction of copper, iron, tantalum, zinc, wolfram. - Develop orderliness in work to present. - Develop culture of working in groups. - Appreciate the dangers associated with the extraction of different metals.	- Methods of extraction of copper, iron, sodium aluminium, tin, tantalum, zinc, wolfram (tungsten). - Uses of copper, iron, tantalum, zinc, tin, wolfram. - Dangers associated with the extraction of metals (e.g. pollution). - Preventive measures associated with metal extraction.	- In groups, discuss on extraction of copper, iron, sodium, aluminium, tantalum, zinc, wolfram and write a report. - Research in groups and present about the uses of copper, zinc, iron, tantalum and wolfram. - Visit the nearby mining sites of tantalum and wolfram and make a field report. - Research and make a presentation on the measures to minimise dangers associated with the metal extraction.
Links to other subjects: *Physics (electricity) ,Geography (mining), Biology (nutrition), Environmental Science (pollution).*				
Assessment criteria: *The learners can relate the properties of metals to their methods of extraction and uses and suggest preventive measures to dangers associated with their extraction.*				
Materials: *Wall charts illustrating metal extraction processes.*				

TOPIC AREA: THE PERIODIC TABLE		**SUB-TOPIC AREA: PERIODICITY OF PROPERTIES OF ELEMENTS**		
S6 Chemistry		**Unit 3**: NPK as components of fertilizers		**No. of periods:** 7
Key unit competency: The learner should be able to analyse the components of quality fertilizers and their benefits, effects of misuse and dangers associated with the substandard fertilizers.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- State the major constituents of the fertilizers. - Identify the characteristics of a good fertilizer. - State the chemical reactions involved in the manufacture of the fertilizers. - Briefly describe the manufacture of the fertilizers. - State the advantages or disadvantages of using the fertilizers. - Identify the effects of misuse of the fertilizers and the dangers of substandard fertilizers.	- Interpret the labels on the fertilizer containers. - Classify the fertilizers in terms of composition.	- Develop sense of responsibility in using the fertilizers. - Choose the effective ways of applying the fertilizers. - Appreciate the use of the fertilizers in increasing the crop production.	- Types of fertilizers. - Components of a fertilizer. - Characteristics of a good fertilizer. - The manufacture of the fertilizers e.g. ammonium sulphate, potassium sulphate, ammonium nitrate, urea and phosphate fertilizers: raw materials used and chemical reactions involved. - Advantages/disadvantages of the use of an organic and inorganic fertilizers. - Dangers of the use of the substandard fertilizers.	- The learners do research and make presentation to identify types of fertilizers, their components in their correct ratios and the standard quality requirements. - Discuss the advantages and disadvantages of the use of organic and inorganic fertilizers and make an appropriate report. - Design a project of making compost manure and test it impacts using a control experiment and write a report. - Using a case study, the learners debate on the environmental issues of the misuse of fertilizers and

				suggest suitable solutions and then make a presentation.
Links to other subjects: *Agriculture (fertilization).*				
Assessment criteria: *The learners can analyse the components of quality fertilizers and their benefits, effects of misuse and dangers associated with the substandard fertilizers.*				
Materials: *Appropriate chemicals, apparatus.*				

TOPIC AREA: ORGANIC CHEMISTRY			**SUB-TOPIC AREA: AROMATIC COMPOUNDS**	
S6 Chemistry		**Unit 4:** Benzene		**No. of periods:** 14
Key unit competency: The learner should be able to relate the chemistry and uses of benzene to its nature and structure.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- State the physical properties of benzene. - Describe the uses of benzene. - Outline the preparations of benzene. - Describe the	- Relate the conditions for reactions of benzene to its chemical stability. - Illustrate the mechanism of electrophilic substitutions on benzene.	- Appreciate the uses of benzene in the industries and in daily life. - Develop a team work approach, self-confidence in group activities and presentations.	- Structure of benzene. - Physical properties, uses and toxicity of benzene. - Preparation of benzene. - Chemical stability of benzene: o Π-bond delocalisation in benzene ring. o Stabilisation energy.	- Do a research and make a presentation about the structure, chemical stability and uses of benzene. - Discuss the mechanisms involved in the electrophilic substitution reactions of benzene and

chemical properties of benzene (include mechanisms involved in electrophilic substitution reactions). - State the conditions required for different reactions.		- Develop carefulness while handling toxic chemicals like benzene.	- Reactions of benzene: o Combustion reaction, o Electrophilic addition reactions (addition of chlorine and hydrogenation). o Electrophilic substitution reactions and their mechanisms (chlorination, bromination, nitration, sulphonation, acylation and alkylation). - Nomenclature and positional isomerism in the derivatives of benzene.	name of the product formed in each case. - Group discussion to compare the electrophilic addition in benzene to electrophilic addition in unsaturated aliphatic compounds.
Link to other subjects:				
Assessment criteria: *The learners can relate the chemistry and uses of benzene to its nature and structure.*				
Materials: *Iron (III) chloride solution, sodium hydroxide solution.*				

TOPIC AREA: ORGANIC CHEMISTRY		SUB-TOPIC AREA: AROMATIC COMPOUNDS	
S6 Chemistry	**Unit 5:** Derivatives of benzene		**No. of periods:** 21
Key unit competency: The learner should be able to relate aromatic ketones, aldehydes, carboxylic acids and amines to their chemical activity.			

Learning Objectives			Content	Learning Activities
Knowledge and Undemanding	**Skills**	**Attitudes and Values**		

- Explain the effects of substituent groups on the benzene ring.
- Give systematic names of aromatic compounds.
- Describe the preparation and reactions of phenol, benzoic acid, benzaldehyde, phenyl ethanone and phenylamine.
- State the uses of phenols.
- Describe the reaction of phenol, aromatic carbonyl compounds and carboxylic acids.
- Describe the
	- Test and compare the acidity of phenol with alcohols and carboxylic acids.
	- Test for the presence of phenol in a given solution.
	- Compare and contrast the alkalinity of phenylamines with aliphatic amines and ammonia.
	- Test and compare the alkalinity of phenylamine, ammonia and aliphatic amines.
	- Perform experiments on the reactions of phenol and phenyl
		- Develop team work approach and self-confidence in group discussions and presentations.
		- Appreciate the uses of phenols as analgesics, antiseptics, opium-based painkiller and in photography.
		- Appreciate the use of salts of aromatic carboxylic acids in the food preservatives.
		- Appreciate the importance of aromatic amines as the starting material in the manufacture of azo-dyes and
			- Effect of substituent groups on the benzene ring:
			  ○ Deactivating and activating the substituent.
			  ○ Directing the incoming substituent at ortho, meta and para positions.
			- Phenol:
			  ○ Sources and preparations of phenol.
			  ○ Reactions of phenols (breaking of O-H bond):
			  • Acidity of phenols compared to alcohols and carboxylic acids.
			  • Reaction of phenol with sodium hydroxide, ethanoyl chloride, acid anhydrides and
				- Group discussions and presentations on why some substituent activate while others deactivate the benzene ring and why some direct at ortho/para while others direct at meta positions.
				- Group research work on the importance and sources of phenols.
				- Practical activity to test the acidity of phenol in comparison to alcohols and carboxylic acids.
				- Carry out an experiment to test for the presence of phenol in a given solution.

chemical properties of phenylamines. - Explain the azo-coupling reactions of phenylamine in manufacture of dyes and indicators.	amine.	indicators. - Appreciate the use of diazonium salts as intermediate compounds in the preparation of other organic compounds.	phosphorous pentachloride. - Reactions of phenol electrophilic substitutions: nitration, sulphonation, halogenation, reduction, ethylation and hydrogenation. - Test and uses of phenol (e.g. antiseptics, analgesics, some opium-based killers and photography). - Aromatic hydrocarbons, carbonyl compounds, carboxylic acids and amines. - Structure and nomenclature of aromatic alkanes, alkenes, alcohols, ketones, aldehydes, carboxylic acids and amines. - Reactions of alkylbenzene: o Oxidation of the side chain. o Radical substitution on alkylbenzene (chlorination). - Preparations and reactions of aromatic carbonyl compounds and carboxylic acids. - Preparation methods of phenylamine and the uses of	- State the observations made and write a report. - Experiments on the reactions of phenol with bromine, sodium hydroxide. - Research about the uses of phenol and its derivatives and present the findings. - Exercises on naming aromatic hydrocarbons alcohols, ketones, aldehydes, carboxylic acids and amines. - Practical activity to test and compare alkalinity of phenyl amines, aliphatic amines and ammonia. - Experiments on reaction of phenyl amines with water, hydrochloric acid and phenol. Make appropriate report. - Group discussion about the formation of azo-dyes (azo-coupling reaction) as sources of dyes and indicators. Make presentations.

			its derivatives. - Alkalinity of phenylamine compared to aliphatic amines and ammonia. - Reactions of phenylamine with water, hydrochloric acid, nitrous acid, ethanoyl chloride/ benzoyl chloride, phenol, halogenations and acid anhydrides. - Reactions of diazonium salts as an intermediate compound in the preparation of the other substances and formation of azo-dyes (azo-coupling).	
Links to other subjects:				
Assessment criteria: *The learner can relate the structure of aromatic carbonyl compounds, carboxylic acids and amines to their chemical reactivity.*				
Materials: *Phenylamine, aliphatic amines, benzoic acid, other appropriate chemicals, apparatus.*				

TOPIC AREA: ORGANIC CHEMISTRY		SUB-TOPIC AREA: POLYMERISATION		
S6 chemistry		**Unit 6:** Polymers and polymerisation		**No. of periods:** 14
Key unit competency: The learner should be able to relate the types of polymers to their structural properties and uses.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Define the terms monomer, polymer and polymerisation. - Describe the formation of polymers. - Describe addition and condensation of polymerisation. - Explain the terms thermosetting and thermo-softening of the plastics. - Discuss the advantages and disadvantages of both natural and synthetic polymers. - Explain the biodegradability property of polymers	- Use equations to distinguish between condensation and addition polymerisation. - Write equations to show how nylon-6, 6, polyester, Dacron, Kevlar, natural rubber, PVC and Bakelite are formed. - Prepare phenol-methanol polymer (Bakelite). - Relate the structure and properties of polymers to their uses in the plastic and textile industries. - Reduce polymer wastes by reusing,	- Develop the culture of working in groups. - Develop orderliness in the presentation of research work. - Respect others' opinions during debate, discussions and presentations. - Appreciate the socio-economic importance of polymers. - Develop the sense of responsibility to protect the environment against the hazards of plastics.	- Definition of monomer, polymer and polymerisation. - Types of polymerisation: - Addition polymerisation (e.g. polythene, PVC, rubber) - Condensation polymerisation (e.g. nylons, terylene, polyethene, Kevlar polymer, proteins, cellulose, Bakelite and its preparation) - Classes of polymers: o Natural polymers (e.g. cellulose, proteins, cotton, silk, natural rubber). o Synthetic polymers (e.g. polythene, nylons,	- Research and make a presentation about the polymers, their properties and their uses in daily life. - Carry out an experiment to prepare phenol-methanol polymer (Bakelite) using (phenol, formalin 37% solution of methanol in water) ,concentrated ethanoic acid, aluminium foil and concentrated sulphuric acid. - The learners debate on the use of plastics versus metals in daily life. - A field visit to any nearby plastic industries, textile industries and plastic recycling plant to study about the processes

based on their chemical structure.	recycling and appropriate disposal. - Develop observation, research and report writing skills during the field visits and survey.		terylene, polystyrene, PVC). - Types of polymers (rubbers, fibres and plastics). - Properties of polymers: o Thermosetting and thermosoftening polymers o Biodegradable and non-biodegradable polymers - Importance of vulcanisation in rubber processing. - Uses of polymers and their effect on the environment. - Management of old polymer materials (reuse, recycling and disposal).	involved (e.g. Rwanda plastic industry, SONATUBE, recycling plant in Mageragere, Nyarugenge district). - Discussion on the advantages and disadvantages of using natural and synthetic polymers.
Links to other subjects: *Geography (environment), General studies (environment).*				
Assessment criteria: *The learners can relate the types of polymers to their properties and uses.*				
Materials: *Flip charts, makers, computer, internet.*				

TOPIC AREA: EQUILIBRIUM		**SUB-TOPIC AREA: PHYSICAL EQUILIBRIUM**	
S6 Chemistry		**Unit 7:** Solvent extraction and colligative properties	**No. of periods:** 21
Key unit competency: The learner should be able toapply partition and Raoult's law to separate mixtures and determine the molecular and formula masses of compounds using colligative properties.			
Learning Objectives			**Content** / **Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**	
- Define partition coefficient (distribution law) and solvent extraction. - State the Raoult's law. - State and explain the advantages of carrying out distillation processes under reduced pressures. - Discuss the chemical principles upon which simple distillation, fractional distillation and steam distillation are	- Carry out simple separation experiments based on the solute partitioning between two immiscible solvents. - Calculate the amount of the solute extracted from the solvent. - Interpret boiling point and vapour pressure composition curves of both ideal and non-ideal mixtures.	- Develop a culture of working in a team during experiment. - Respect of procedure in experiments. - Appreciate the importance of partition coefficient in solvent extraction as a separation technique. - Appreciate the importance of fractional distillation in separation of miscible liquids. - Appreciate the importance of colligative properties in determination of molecular masses of the polymers.	- Definition of partition coefficient (distribution law) and solvent extraction. - Raoult's law and ideal solutions. - Solutions that do not obey Raoult's law (positive deviation and negative deviation). - Applications of Raoult's law (fractional distillation of miscible liquids). - Definition of steam distillation and its application. - Definition of colligative properties (vapour pressure lowering, boiling point elevation, freezing	- Perform experiments on the solvent extraction (e.g: extraction of ammonia from water by ethoxyethane) and then make an appropriate report. - Referring to the examples, do exercises involving partition coefficient (K_D) calculations and exchange work sheets for marking. - The learners do calculations to apply Raoult's law to determine the vapour pressure and mole fraction of ideal solutions and exchange their work sheets for correction.

based. - State examples of the applications of the distillation methods used in various industries. - Describe the effect of the solute on vapour pressure, boiling and freezing points of the solvent. - Explain colligative properties.	- Calculate the molecular mass of substances using steam distillation. - Calculate molecular mass of polymers using colligative properties and steam distillation. - Interpret the boiling point composition curves of azeotropic mixtures. - Apply Raoult's law to calculate vapour pressure of given solutions and mole fractions. - Carry out experiments to explain colligative properties. - Apply colligative properties to		point depression and osmotic pressure). - Applications of colligative properties to determining molecular mass and molecular formula of the solute.	- Discuss and make presentations on curves for ideal solutions (obey Raoult's law) and non-ideal solutions (show deviations from Raoult's law). - The learners do exercises on the determination of relative molecular mass using steam distillation. - Carry out the experiments to explain colligative properties and make a valid report. - Referring to the examples, do exercises of calculations related to colligative properties and present the solutions to the exercises.

	determine the molecular mass of the solute in a solution.			
Links to other subjects: *Biology (osmosis), Mathematics (functions, algebra).*				
Assessment criteria: *The learners can explain and apply Raoult's law in calculations, determine the molecular mass of solute using colligative properties, interpret curves for ideal and non- ideal solutions.*				
Materials: *Computers, projector, appropriate chemicals, apparatus.*				

TOPIC AREA: EQUILIBRIUM			**SUB TOPIC AREA: CHEMICAL EQUILIBRIUM**	
S6 Chemistry		**Unit 8:** Quantitative chemical equilibrium		**No. of periods:** 14
Key unit competency: The learner should be able to write expressions and calculate the values of equilibrium constant, interpret the values of Kc in relation to the yield of the products in reversible reactions.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Explain how the temperature affects the magnitude of equilibrium constant Kc. - Derive the relationship between Kc and Kp.	- Derive equilibrium constant Kc. - Interpret the Kc values in relation to the yield of the reversible reactions. - Compare the Kc value with Qc value and	- Develop a culture of working in a team while discussing and presenting. - Appreciate the values of Kc in relation to the completion of different reactions.	- Definition of equilibrium constant $K_{c.}$ - Deriving equilibrium constant K_c (from thermodynamic approach and kinetic approach). - Mass action law and equilibrium constant	- In group, discuss and derive the equilibrium constant expression K_c and make a presentation. - Using examples do exercises of writing expressions for equilibrium constants in terms of

- Write expression for Kc and Kp.	predict if a reaction is at equilibrium or not. - Compare and interpret the values of Kc and Kp of different reactions. - Perform calculations involving equilibrium constants in terms of concentration (Kc) and partial pressure, (Kp).		expression. - Definition of equilibrium constant in terms of partial pressures $K_{p.}$ - Derivation of the relationship between K_c and $K_{p.}$ - Calculations on K_c and K_p. - Comparison between reaction quotient Q_c and equilibrium constant K_c.	concentrations and partial pressures of different reversible reactions and exchange work sheets for marking. - The learners do exercises to determine the relationship between K_c and K_p and exchange work sheets for corrections. - Perform different exercises on calculations of equilibrium concentrations and equilibrium constant values and exchange work sheets for marking. - The learners do exercises to compare the values of K_c and Q_c .exchange work sheets for correction.
Links to other subjects: *Mathematics (quadratic equations).*				
Assessment criteria: *The learners can write expressions and calculate the values of equilibrium constant, interpret the values of Kc in relation to the yield of products in the reversible reactions.*				
Materials: *Computers, projectors.*				

TOPIC AREA: EQUILIBRIUM		SUB-TOPIC AREA: IONIC EQUILIBRIUM		
S6 Chemistry		**Unit 9:** pH of acidic and alkaline solutions		**No. of periods:** 28
Key unit competency: The learner should be able to prepare solutions, measure their pH and calculate the pH of acidic and alkaline solutions. Explain the concept of buffer solution, hydrolysis of salts and discuss its applications in manufacturing industry and biological processes.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Define the degree of ionization (α). - Define the terms Ka, pH, pKa, Kb, pKb and Kw. - Write equations for salt hydrolysis reactions and the expression for the hydrolysis constant. - Define the term buffer solution. - Explain how buffer solutions control pH. - Explain the buffer capacity in relation to buffer range. - Describe the applications of buffer solution in domains such as biological processes,	- Perform calculations involving pH, Ka, pKa, Kw, Kb and pKb. - Interpret the values of Ka and Kb in relation to the strength of acids and bases. - Interpret results, draw valid conclusions and report about the preparation of solutions with different pH. - Prepare different solutions and appropriately use pH-meter to measure their pH.	- Develop a culture of working in a team and self-confidence while discussing exercises, performing experiments and presenting the findings. - Care about corrosive chemicals like concentrated strong acids and alkalis. - Respect the procedure of experiments. - Appreciate the achievements of Henderson and Hasselbalch in calculation of the pH	- Degree of ionisation in relation to the strength of acids and bases (α_a and α_b). - Explanation of acid and base dissociation constants (Ka and Kb). - The relationship between Ka and Kb. - Use Ka or pKa and Kb or pKb to explain the strength of the acids and bases. - Explanation of ionic product of water (Kw). - Definition and calculations of pH and pOH of acidic and alkaline solutions. - Definition of salt	- With the help of examples, do exercises on calculations of the degree of ionisation. Use α-values to predict the strength of the acids and base. - Do calculations on acid and base dissociation constants and use the values to compare the strength of acids and bases. - Carry out experiments to prepare different solutions and measure their pH, present the report of the findings. - Discuss and make

agriculture, natural system (e.g. lakes) and industrial manufacture of cosmetics and drugs.	- Compare the strength of acids and bases of the same concentration, using the values of Ka and Kb. - Relate the values of pH and pOH. - Calculate the pH and hydrolysis constant of aqueous solutions of salts. - Perform experiments to show that hydrolysis of some salts results in neutral, acidic and alkaline solutions. - Prepare buffer solutions of different pH values. - Derive Henderson – Hasselbalch relation and use it to calculate the pH of buffer solution.	of buffer solution. - Appreciate the importance of buffer solutions in pharmaceutical industries, agriculture and biological processes.	hydrolysis. - Salt hydrolysis (hydrolysis of salts that yield acidic and alkaline solutions). - Definition of buffer solution. - pH of buffer solution (include the derivation of Henderson-Hasselbalch's relation). - Preparation of buffer solutions of different pH. - Explanation of the working of buffer solutions. - Definition of buffer capacity and buffer range. - Applications of buffer solutions in biological processes, agriculture natural system (e.g. lakes) and in industrial manufacture of cosmetics and drugs.	presentation on the pH scale in relation to the concentration in H^+ and OH^- ions. - Do exercises on the calculations of pH of acidic and alkaline solutions. - Perform experiments to show that hydrolysis of some salts results in acidic and alkaline solutions (sodium chloride, ammonium chloride, sodium ethanoate). Report of the findings is required. - Perform experiments to prepare and demonstrate the properties of a buffer solution. Then present the results. - In groups, do exercises on the calculations of pH for buffer solutions. Exchange worksheets for marking. - With the help of examples, discuss the working of a buffer

				solution when acids or bases are added and make conclusions. - Research in groups and make presentations about the applications of buffer solution.
Links to other subjects: *Mathematics (logarithm, operations), Biology (transport in animals), Agriculture (soil).*				
Assessment criteria: *The learners can prepare solutions and measure their pH, calculate the pH of acidic and alkaline solutions, can explain the concept of buffer solution, hydrolysis of salts and discuss its applications in the manufacturing industry and biological processes.*				
Materials: *Appropriate chemicals, apparatus, computers, projectors.*				

TOPIC AREA: SOLUTIONS AND SOLUBILITY		SUB-TOPIC AREA: DETERMINATION OF CONCENTRATION OF SOLUTIONS		
S6 Chemistry		**Unit 10:** Indicators and titration curves		**No. of periods:** 7
Key unit competency: The learner should be able to relate titration curves to the type of acid and base titrated, properly choose and use indicators in acid-base titrations.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Define the term indicator. - Explain how the indicators work. - Explain what is meant by the pH range of indicator. - State the criteria for the selection of acid-base indicator for the use in titrations. - Describe the changes in pH during acid/base titrations.	- Perform experiments to show that the effectiveness of different indicators is related to the pH changes which occur during titration. - Draw and interpret titration curves for various acid-base titrations. - Match the titration curve to the type of acid and base titrated. - Interpret pH curves of different titration reactions.	- Develop a culture of working in groups, develop self-confidence while discussing and performing experiments of titration.	- Definition of acid-base indicator. - Explanation of the working of indicators, the pH range of indicators and choice of indicators in titration. - Acid–base titration curves (titration of strong base into strong acid, titration of strong base into a weak acid, titration of weak base into strong acid and titration of weak base into weak acid).	- Perform experiments to show that the effectiveness of different indicators is related to the pH changes which occur during titration and report the findings. - Discuss the working and appropriate choice of indicators during acid-base titration (table of indicators and the pH range can be used). Draw valid conclusions. - Group activities to plot and interpret different titration curves from the experimental results and then present the information obtained.
Links to other subjects: *Mathematics (functions).*				

Assessment criteria: *The learners can relate titration curve to the type of acid and base titrated, properly choose and use indicators in titrations.*
Materials: *Computers, projectors, indicators, charts of titration curves, appropriate chemicals, apparatus.*

TOPIC AREA: SOLUTIONS AND SOLUBILITY		**SUB-TOPIC AREA: SOLUBILITY AND SOLUBILITY PRODUCT**
S6 Chemistry	**Unit 11:** Solubility and solubility product for sparingly soluble salts	**No. of periods:** 18

Key unit competency: The learner should be able to calculate the solubility product, constant of sparingly soluble salts, and deduce the applications of common ion effect in the industry.

Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Define the term solubility product Ksp. - State and explain the factors that affect solubility of sparingly soluble salts. - State and explain the applications of solubility product.	- Perform a simple experiment to determine the solubility product of a sparingly soluble salt. - Write the equations of dissociation and Ksp expression for sparingly soluble salts. - Calculate the molar	- Develop a culture of working in a team and self-confidence while discussing in groups, performing practical activities and presentations of	- Definition of solubility and molar solubility. - Unsaturated, saturated and super saturated solutions. - Equations of the dissociation of sparingly soluble salts in water. - Definition of the solubility product Ksp and writing expressions for Ksp.	- Perform a simple experiment to determine the solubility product of a sparingly soluble salt (e.g. magnesium hydroxide) - In groups, do exercises of writing the equations of dissociation for sparingly soluble salts and do calculations involving

- Explain common ion effect on the solubility of sparingly soluble salts. - Explain the effect of pH on the solubility of sparingly soluble salt. - Explain the relationship between kidney stone formation and solubility and the solubility product. Explain the applications of the solubility product and the common ion effect.	concentration of ions and Ksp values for the sparingly soluble salts. - Relate the solubility product principle to the selective precipitation of substances. - Use the values of Ksp and Qc to predict if a mixture of solutions will form a precipitate or not. - Relate the common ion effect to the solubility of sparingly soluble salt.	findings. - Appreciate the importance of solubility and solubility products in the manufacturing industries and analysis of some ions in solution.	- Relationship between solubility and solubility product Ksp. - Calculations, involving solubility product. - Definition and calculation of ionic product (Qc). - Predicting precipitation reactions using Qc and Ksp values. - Separation of ions by fractional precipitation. - Common ion effects and solubility. - pH change and solubility. - Complex ion formation and solubility. - Applications of solubility product (inorganic qualitative analysis, purification of sodium chloride, salting out the soap, manufacture of baking soda, quantitative analysis of salts, kidney stone formation).	solubility and solubility product Ksp. - Based on calculations, predict whether the mixture of solutions leads to formation of a precipitate or not. - Practical activities to discuss the common ion, complex formation and pH change effect on the solubility of sparingly soluble salts. Then report the findings. - Research and make presentations about the applications of solubility product (inorganic qualitative analysis, purification of sodium chloride, salting out the soap, manufacture of baking soda, quantitative analysis of salts).
Links to other subjects: *Biology (physiology-urinary system).*				
Assessment criteria: *The learners can carry out the calculations related to the solubility product; apply the knowledge of solubility and solubility product to other domain.*				
Materials: *Computer, projector, appropriate chemicals, apparatus.*				

TOPIC AREA: ELECTROCHEMISTRY			SUB-TOPIC AREA: ELECTROLYSIS AND ELECTROCHEMICAL CELLS
S6 Chemistry	**Unit 12:** Electrochemical cell and applications		**No. of periods:** 24
Key unit competency: The learner should be able to explain the working and industrial applications of electrochemical and electrolytic cells.			
Learning Objectives			**Content** / **Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**	
- Define the term electrochemical. - Describe the standard hydrogen electrode. - Explain the working of galvanic cells using the fully labelled diagram. - Describe industrial applications of electrochemical cells.	- Construct a simple galvanic cell. - Use the e.m.f. of the galvanic cell to predict if the cell will generate current or not. - Record the results of a measurement, accurately using a voltmeter. - Calculate the standard cell potentials from standard electrode potentials of two half cells. - Properly use electrolytic cell to carry out electroplating of the graphite by copper.	- Develop a culture of team work, sense of responsibility in group activities and experiments. - Appreciate contributions of electrochemistry to the social and economic development of the society.	- Definition of electrochemical cell. - Description of standard hydrogen electrode as used to determine the standard electrode potentials. - Description of electrochemical cells. Include the cell reactions and e.m.f. of the galvanic cells. - Prediction of spontaneity of redox reactions. - Explanation of the effect of concentration on e.m.f. of the cell (use Nernst equation). - Explanation of corrosion and its effects on metallic	- Carry out practical activities to discuss the working of the galvanic cell (e.g. with copper and zinc electrodes) and make a presentation. - In groups, do exercises involving calculations about the galvanic cells (e.g. using standard electrode potentials and Nernst equation). Report the information obtained. - Research in groups and make presentations about the applications of electrochemistry (e.g. observe dry cells, car battery, telephone

	- Use the standard electrode potentials of cells to determine the direction of electron flow and feasibility of a reaction. - Predict how the value of an electrode potential varies with the concentration using Le Chatelier's Principle. - Apply the principles of redox processes to energy storage devices. - Compare electrochemical cell with electrolytic cell.		objects. - Applications of electrochemical cell: batteries (dry cells, storage batteries and fuel cells). - Comparison between the electrochemical cell and the electrolytic cell.	batteries). - In groups, differentiate between he electrochemical cell and electrolytic cell and present the findings.
Links to other subjects: *Physics (electricity), Mathematics (operations and logarithmic functions).*				
Assessment criteria: *The learners can construct and explain the working of galvanic cells, appreciate the applications of electrochemistry.*				
Materials: *Computer, projector, internet, appropriate chemicals, apparatus.*				

TOPIC AREA: REACTION KINETICS		SUB-TOPIC AREA: RATE EQUATIONS, ORDERS AND MOLECULARITY
S6 Chemistry	**Unit 13:** Factors that affect the rate of reactions	**No. of periods:** 7

Key unit competency: The learner should be able to explain the factors that affect the rate of chemical reaction and use Arrhenius equation to calculate the ratio of rate constant and activation energy with change in the temperature.

Learning Objectives			Content	Learning Activities
Knowledge and understanding	**Skills**	**Attitudes and values**		
- Explain the concept of reaction kinetics. - Explain the effect of different conditions on the rate of reaction.	- Carry out experiments to show how different factors affect the rate of chemical reactions. Predict the effect of changing conditions on the rate of reactions.	- Appreciate the importance of reaction kinetics. - Appreciate the importance of different conditions on the reaction rates.	- Concept of reaction kinetic - Factors that change the rates of reactions (temperature, concentration, surface area, catalyst, pressure and light). - Explanation of effect of change of factors on reaction rates.	- Perform practical activities to show how different reactions have different rates (e.g. burning ethanol and rusting of iron). Then report the findings. - Carry out experiments to show how different factors (concentration, temperature, particle size and catalyst) affect the rate of chemical reactions. Write valid report.

Contribution to literacy: *Reaction kinetics, activation energy, activated complex, collision frequency.*

Assessment criteria: *The learners can explain the factors that affect the rate of chemical reaction and use Arrhenius equation to calculate the ratio of rate constant and activation energy with change in temperature.*

Materials: *Appropriate chemicals, apparatus, computer, projector.*

TOPIC AREA: REACTION KINETICS		**SUB-TOPIC AREA: FACTORS THAT AFFECT THE RATE OF REACTION**
S6 Chemistry	**Unit 14:** Rate laws and measurements	**No. of periods:** 23
Key unit competency: The learner should be able to measure the rates of reaction and formulate simple rate equations using the experimental results.		

Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- State and explain kinetic conditions for a chemical reaction to take place. - Explain the effect of the temperature and catalysts on the rate of the reaction using Boltzmann distribution of energies (and of collision frequency). - Differentiate between SN_1 and SN_2 mechanisms. - State and explain the rate determining the steps for multi-step reactions.	- Deduce the order of reaction from appropriate experimental data. - Calculate the initial rates and the rate constants of reactions from the experimental data. - Perform practical activities to show how different reactions have different rates. - Interpret the graphs which show the change in activation energy with the catalyst. - Calculate the half-life of chemical reaction. - Perform practical	- Develop a spirit of team work, analysis, and self-confidence while discussing exercises and performing the experiments. - Appreciate the contributions of Arrhenius and Boltzmann on the effect temperature and activation energy of different substances and number of molecules.	- Theories of reaction rates (collision theory and transition state theory). Include the energy profiles' diagrams and Arrhenius' equation. - Measuring the rates of reaction by observing the mass changes, colour changes and volume changes. - Experimental determination of orders of reactions and rate laws (Rate = $k\{A\}^n$). - Relation between reactant concentrations and time for zero order reaction, first order reaction (half-life of reaction) and	- Research, discuss in groups and make presentations about theories of reaction rates (collision theory and transition state theory). - Perform practical activities to measure the rates of reaction by observing the colour changes (reaction between sodium thiosulphate and hydrochloric acid), volume changes (reaction of hydrochloric acid with marble chips) and mass changes (marble chips

	activities to measure the rates of reaction by observing the changes in physical quantities (e.g. volume, mass and colour change). - Use collision theory to predict if the reaction will go faster or slower. - Construct rate equations of the form (Rate = k $[A]^n[B]^m$) limited to simple cases involving zero, first and second order reactions. - Interpret graphs of concentration against time and those of concentration against rate for zero and first order reactions.		second order reaction. - Difference between order of reaction and molecularity. - Reaction mechanisms and kinetics. Include the rate determining step for multi-step reactions, SN_1 and SN_2 mechanisms.	and hydrochloric acid). The report of the findings is required. - Do exercises of calculations about writing rate equations, rate constant and half-life of reactions. Exchange the worksheets for marking. - Discuss and present a report about collision theories (simple treatment only), catalysis and reaction mechanisms. Include interpretations of the related graphs.
Links to other subjects: *Biology (enzymatic catalysis).*				
Assessment criteria: *The learner can measure the rates of reaction and formulate simple rate equations.*				
Materials:				

TOPIC AREA: ATOMIC AND ELECTRONIC STRUCTURE			**SUB-TOPIC AREA: ATOMIC STRUCTURE**	
S6 Chemistry		**Unit 15:** Radioactivity		**No. of periods:** 18
Key unit competency: The learner should be able to explain the importance and dangers of radioisotopes in everyday life.				
Learning Objectives			**Content**	**Learning Activities**
Knowledge and Understanding	**Skills**	**Attitudes and Values**		
- Explain the process of radioactivity. - Explain the properties of alpha, beta and gamma rays. - Explain half-lives of radioactive radioisotopes. - Explain the applications of radioisotopes in medicine, agriculture and industries.	- Compare and contrast chemical and nuclear reactions. - Write and balance nuclear reaction equations. - Perform calculations involving the half- life of radioactive substances. - Apply the calculations of half-life to determine the age of the fossils.	- Develop awareness of the dangers of radioactive substances and the nuclear weapons. - Appreciate the importance of radioactivity in the electricity production, diagnosis and treatment of diseases.	- Define radioisotopes and radioactivity. - Stability and instability of nuclei of atoms. - Emission of alpha, beta and gamma rays and their properties (relative mass, relative charge, speed, energy, penetrating power and their effect on photographic plate). - Effect of electric and magnetic fields on the radioactive rays. - Health hazards of the radioactive substances. - Nuclear equations and radioactive decay series. - Fission and fusion and their applications	- Research on the historical background of the discovery of radioactivity and yhe types of radioactivity. Present the findings. - Discuss the hazards of the radioactive substances and suggest preventive measures. - Do exercises to write the equations for the nuclear reactions. Exchange the worksheets for marking. - Do research and make a presentation on the applications of the radio isotopes.

			(production of electricity, hydrogen and atomic bombs). - Comparison between the chemical and nuclear reactions. - Rate of decay of radioactive substances. - Half-life of radioactive substances and calculations involved. - Uses of some radioisotopes e.g. ^{14}C, ^{32}P, ^{60}Co, ^{131}I.	- Research and make presentations on the applications of nuclear fission and fusion. Also discuss the probable health and environmental hazards that they may cause. - Discuss and make a presentation on the differences and similarities between the chemical and nuclear reactions. - Determine the half-life of some elements by calculations and show how the calculated values can be used for the age determination of the fossils.
Links to other subjects: *Mathematics (logarithms), Physics (nuclear physics).*				
Assessment criteria: *The learners can explain the importance and dangers of radioisotopes in everyday life.*				
Materials: *Computer, projector.*				

6. REFERENCES

Addison- wesley chemistry. (2000). *Addison - wesley chemistry Fifith edition.* New York: Prentice Hall,inc.

NCDC. (2013). *Uganda advanced certificate of education teaching syllabi biology, chemistry, agriculture Volume 1*. Kampala: NCDC

Arthur Atikson and All. (2004). *New chemistry s1 s2 s3.* Longman.

Brown L Theodore, LeMay Eugene H, Busten E Bruce and Murphy Catherine. (2009). *Chemistry The central science.* Upper sandle river: Pearson Education.

Cambridge International Examinations. (2013). *Syllabus Cambridge As A level 9701 chemistry for examination in 2015*, England: Cambridge International Examinations

Daniel Iyamuremye and Mutumoy Riziki. (2013). *Senior secondary certificate chemistry for Rwanda.* Nairobi: East African educational publishers Ltd.

Jim Clark and Ray Oliver. (2007). *Longman chemistry for IDCSE.* England: Pearson Education Limited.

Martin, S. S. (2003). *Chemistry The moleculas nature and change Third edition.* New York: McGraw-Hill Higher Education.

Mathews, P. (2003). *Advanced chemistry.* Cambridge university.

Peter Cann and Peter Hughes. (2002). *Chemistry for advanced level.* Manchester: Film setting Ltd.

Ramsden, E. (2000). *A- Level chemistry fourtth edition.* Delta Place: Nelthone thornes.

Republic of Rwanda. (1998). Advanced level chemistry curriculum for Rwandan secondary schools, Kigali: National Curriculum Development Centre (NCDC).

Republic of Rwanda. (2010). Advanced level chemistry curriculum for science combinations, Kigali: National Curriculum Development Centre (NCDC).

7. APPENDIX: SUBJECTS AND WEEKLY TIME ALOCATION FOR A'LEVEL

Subjects in Secondary 4-6		**Number of periods per week (1 period = 40 min.)**		
Core subjects		**S4**	**S5**	**S6**
1. Mathematics		7	7	7
2. Physics		7	7	7
3. Computer Science		7	7	7
4. Chemistry		7	7	7
5. Biology		7	7	7
6. Geography		7	7	7
7. History		7	7	7
8. Economics		7	7	7
9. Literature in English		7	7	7
10. Kinyarwanda major		7	7	7
11. Kiswahili major		7	7	7
12. French major		7	7	7
13. Religion major		7	7	7
14. Entrepreneurship		6	6	6
15. General Studies and Communication Skills		3	3	3
16. Subsidiary Mathematics		3	3	3
Electives Subjects	17. English minor	4	4	4
	18. French minor	4	4	4
	19. Kinyarwanda minor	4	4	4
	20. Kiswahili minor	4	4	4
Co-curricular Activities	Religious activities	2	2	2
	Sports/ Clubs	2	2	2
	Computer/library	2	2	2