REPUBLIC OF RWANDA

MINISTRY OF EDUCATION
NATIONAL CURRICULUM DEVELOPMENT CENTRE (NCDC)

P.O.BOX, 608 KIGALI

www.ncdc.gov.rw

ADVANCED LEVEL CHEMISTRY CURRICULUM FOR SCIENCE COMBINATIONS

- MCB (Mathematics-Chemistry-Biology);
- PCB (Physics- Chemistry-Biology);
- PCM (Physics-Chemistry-Mathematics).

Kigali, June 2010

LIST OF PARTICIPANTS

1. GAHIMA Charles, Director General, NCDC; Coordinator
2. RUTAKAMIZE Joseph, Director of science and Artistic Unit, NCDC; Supervisor
3. NIYIBIZI Alain: Chemistry Curriculum Developer, NCDC ;Team leader
4. TUSIIME Angelique : Chemistry Curriculum Developer, NCDC ;Vice Team leader and Secretary
5. NYIRANDAGIJIMANA Anathalie: Curriculum Developer in charge of Pedagogical Norms , NCDC
6. RUSHARAZA Innocent: Inspector of Biology and Chemistry- GIE
7. NTAGANDA Innocent: Chemistry Specialist - RNEC
8. GASOMA Jean Baptiste: Deputy- Head Teacher in Charge of Studies – Collège S^{t} André
9. NGABIRANO Hannington: Chemistry Teacher – Nyagatare Secondary School
10. UTAZIRUBANDA JMV: Chemistry Teacher – Lycée Notre Dame d'Afrique- Nyundo
11. NIYONSABA Straton: Chemistry Teacher – APAPEB Byumba

TABLE OF CONTENTS

I. INTRODUCTION

Rwanda intends to build a knowledge based economy, with particular emphasis on science and technology as an engine of development. In this regard, the Ministry of education undertook the 2009 education system reform in which the system of combinations at advanced level was introduced. In this context, the NCDC found it wise to review chemistry curriculum, the 1999 edition. In this revision, the emphasis was put on the structure of the curriculum, content and methodology in order to equip learners with enough and appropriate knowledge, skills and attitudes.

To meet this pedagogical orientation/need, the curriculum is presented in a three column table. The content suggested in the second column of the curriculum, has specific objectives to be attained in the first column as well as a methodological note in the third column which suggests the appropriate teaching/ learning activities to be done.

Chemistry is a science subject and directly linked to our everyday life activities thus its mastery requires scientific research and experiments. The curriculum strongly emphasises on the student practical work (laboratory experiments), project work (research work) as well as study tours. All these learning activities should give learners the opportunity to apply Chemistry in different contexts, and appreciate the relevance of Chemistry in our daily life.

This curriculum also helps learners to use ICT (Information and Communication Technology) tools to support the mastery and achievement of the desired learning objectives. Technology used in the teaching and learning of Chemistry, for example simulation on computer, is to be regarded as a tool to enhance the teaching and learning process and not to replace teachers.

At the end of detailed content of each grade, there is a proposal of lesson distribution to be taught per term.

II. GENERAL OBJECTIVES TO BE ACHIEVED BY THE END OF A' LEVEL

After the completion of Chemistry course in Advanced Level Secondary Education, the learner should be able to:

a) Apply acquired knowledge, skills and attitudes in daily life problem solving;

b) Express him/herself fluently in teaching language: written and spoken;

c) Analyze situations scientifically;

d) Analyze, explain facts and practical applications of phenomena relating to daily life;

e) Identify scientific problems;

f) Collect, evaluate and interpret scientific data;

g) Present results and draw appropriate conclusions;

h) Possess knowledge and skills that would enable him /her to access studies in chemistry and related courses in universities and higher institutions of learning;

III. LEARNER'S SKILLS TO BE ENHANCED

Here is a list of some of suggested learner's skills to be improved. While teaching, the teacher should make sure that the skills listed below are developed through teaching and learning activities.

Skills	**Suggested learning methods activities**
1. ICT skills as tools for learning	• Using computers and projectors in presenting individual or group activities • Doing research on internet • Simulation (internet) • Using calculators in operations
2. Communication skills	• Discussion in group, oral and writing presentations of findings (results) • Using fluently Chemistry formulae in presenting and solving problems • Debate • Brainstorming
3. Individual skills	• Individual research (in the library) in a given time • Individual activities (exercises, homework, test,…) in a given time

4. Social skills	• Working in groups • Discussion • Debate
5. Work constructively in teams/ group learning skills	• Group activities
6. Critical and logical thinking skills	• Using formulae and laws to solve problems • Relating the solution of a problem to the real world • Debate • Brainstorming
7. Critical and interpretation skills	• Collecting data, analyzing data, synthesizing data, interpreting data and presenting data by using tables, charts, diagrams, graphs… • Case study
8. Creative and innovation skills (knowledge transfer)	• Activities of demonstration and generalization • Hands-on activities • Project work
9. Problem solving skills	• Activities related to daily events • Case study
10. Motivation and self confidence skills	• Activities related to the use of Chemistry in real life
11. Observation skills	• Hands-on activities • Field work (eg :visit industries)
12. Practical skills	• Hands- on activities
13. Environment conservation	• Hands- on activities • Field work • Case study • Debate • Project work
14. Precision skills	• Hands- on activities (Measuring)
15. Laboratory management skills	• Hands- on activities • Field work • Project work
16. Time management	• Activities in limited duration (practical and mental work).

IV. METHODOLOGICAL NOTES

The use of teaching resources is crucial in enabling learners to understand chemistry concepts.
Teachers should encourage learner's hands–on activities using real or concrete materials to help them gain experience, construct abstract ideas, obtain scientific findings, build self confidence, be independent and inculcate the spirit of cooperation.

In order to assist learners in having positive attitudes towards chemistry, confidence and thinking systematically, students have to be involved into the teaching and learning process. Good moral values can be cultivated through suitable contexts. Learning in groups should be emphasized to help learners to develop social skills, encourage cooperation and build self confidence. Environment awareness and conservation skills should also be developed through the teaching and learning process in the classroom by using examples, and showing positive and negative impact of chemicals on the environment by using Chemical reactions and equations, case studies experiments and project work.

Various teaching strategies and approaches such as direct instruction, discovery learning, investigation, guided research or other methods must be incorporated**.** Among the approaches that should be taken into consideration, we can say:

- Learner-centered learning;
- Different learning abilities and styles of learners (individualization);
- Use of relevant, suitable and effective teaching materials;
- Formative evaluation to determine the effectiveness of teaching and learning process.

The choice of a suitable approach will stimulate the teaching and learning environment inside or outside the classroom. The considered suitable approaches include the following:

- Cooperative learning;
- Contextual learning;
- Mastery learning;
- Constructivism.

In this curriculum, suggested various exercises in all chapters may be done in groups or individually.

V. EVALUATION APPROACH

Evaluation or assessment has to be planned and carried out as a part of the classroom activities. Different methods of assessment can be conducted. These may be in the form of assignments, oral questioning and answering, observations and interviews. Based on the given responses, teacher can rectify learners' misconceptions and weaknesses and also improve his/her own teaching skills. Teacher can then take subsequent effective measures in conducting remedial and enrichment activities in upgrading learners' performances.

The teacher should organise practical tests to verify whether students have indeed acquired the basic skills suggested in this curriculum: He/she should set standards of passing these tests. It is not recommended to evaluate students on the basis of technical terms; it is the student's reasoning that matters.

SENIOR FOUR DETAILED CURRICULUM

GENERAL OBJECTIVES BY THE END OF SENIOR FOUR

At the end of senior four, students should be able to:

1. Describe atomic structure.
2. Explain the concept of isotopes.
3. Explain the variation trends of physical properties in the periodic table.
4. Establish the electronic configuration of elements using s, p, d and f orbitals.
5. Explain the formation of various types of bonds.
6. Describe the different molecular shapes.
7. Describe the physical and chemical properties of elements in the periodic table**.**
8. Explain the preparation and uses of some elements and their compounds.
9. Define oxidation and reduction in terms of loss or gain of oxygen or hydrogen and in terms of loss or gain of electrons**.**
10. Identify the substances that are oxidized and those that are reduced in a redox reaction.
11. Distinguish between oxidizing agent and reducing agent in a redox reaction.
12. Describe the chemical diversity shown by the transition elements.
13. Explain the properties of some transition elements and their compounds.
14. Identify experimentally anions and cations from their various solutions and compounds.

CHAPTER 1: ATOMIC STRUCTURE

GENERAL OBJECTIVES

At the end of this chapter, students should be able to:
a). Describe atomic structure.
b). Explain the concept of isotopes.

SPECIFIC OBJECTIVES	CONTENTS 1. ATOMIC STRUCTURE	SUGGESTED TEACHING/ LEARNING ACTIVITIES
-Define an atom -Describe the structure of an atom.	**1.1**. The particles which constitute an atom i.e. protons, neutrons, electrons and their properties.	The teacher should show the existence of charged particles by rubbing a ball point pen in hair and immediately use it to pick small pieces of paper.
	1.2. Simple outline on their discovery.	Do an assignment about the discovery of atomic particles; emphasis should be put on the names of the discoverers.
-Distinguish between relative atomic mass and isotopic mass of an atom.	**1.3.** Atomic number, mass number, isotopic mass compared with relative atomic mass.	
-Calculate the relative atomic mass using isotopic masses and relative abundance.	**1.4**. Calculations of relative atomic masses given isotopic masses and relative abundance e.g. ^{35}Cl 75%, ^{37}Cl 25%.	Do calculations involving relative atomic mass
-State the functions of each part of a mass spectrometer.	**1.5.** Simple description of mass spectrometer and its uses.	
-Explain how the mass spectra are obtained -Interpret a mass spectrum.	**1.6.** Simple interpretation of mass spectrum e.g. $C1_2$, H_2, I_2, Br_2.	Do exercises about mass spectrum

CHAPTER 2: PERIODIC TABLE

GENERAL OBJECTIVE

At the end of this chapter, students should be able to:
Explain the variation trends of physical properties in the periodic table

SPECIFIC OBJECTIVES	**CONTENTS** **2. PERIODIC TABLE**	**TEACHING/ LEARNING ACTIVITIES**
-Briefly, explain the historical background of the periodic table. -Explain the arrangement of elements in a periodic table according to their atomic number. -Explain the variation in conductivity, melting and boiling point, atomic radius, electronegativity, electropositivity, ionization energy and metallic character down each group and across each period in the periodic table.	**2.1**. Historical back ground. **2.2.** Classification of elements in the periodic table according to MENDELEEV and the modern periodic table **2.3**. - Variation of physical properties in groups and periods i.e. conductivity, melting and boiling point, atomic radius, electronegativity and electropositivity, ionization energy, metallic character.	Use periodic table charts The teacher will mention the MENDELEEV`s periodic law

CHAPTER 3: ELECTRONIC STRUCTURE

GENERAL OBJECTIVE

At the end of this chapter, students should be able to:
Establish the electronic configuration of elements using s, p, d and f orbitals

SPECIFIC OBJECTIVES	**CONTENTS** **3. ELECTRONIC STRUCTURE**	**TEACHING/ LEARNING ACTIVITIES**
-Explain Bohr's model of an atom Interpret atomic spectra	**3.1.** Bohr's model of an atom **3.2.** Atomic spectra: -Absorption spectrum -Emission spectrum	Show some spectral representations in text book
-Explain hydrogen spectrum and spectral series	**3.3**. Hydrogen spectrum and spectral series e.g.: Lyman, Balmer Series. **3.4.** Energy levels, sub-energy levels and orbitals.	
-State the rules that govern electronic configuration.	**3.5.** Rules governing electronic configuration • Aufbau principle • Pauli's principle • Hund's rule	Use orbital models to show s,p and d orbitals
-Write electronic configuration of elements. -Interpret a graph of ionization potential against the number of electrons.	**3.6.** Electronic configuration of elements using s,p,d and f orbitals. **3.7**. Graphical interpretation of ionization potential against the number of electrons removed.	Do many exercises about electronic configuration using s,p,d and f orbitals should be done

CHAPTER 4: BONDING

GENERAL OBJECTIVES

At the end of this chapter, students should be able to:

a) Explain the formation of various types of bonds
b) Describe the different molecular shapes

SPECIFIC OBJECTIVES	**CONTENTS** **4. BONDING**	**TEACHING/ LEARNING ACTIVITIES**
-Describe the formation of ionic bonds -State the properties of ionic compounds	**4.1. Ionic bonding** Ionic bond, ionic compounds and their properties.	The teacher will give examples of structure of ionic compounds face centred cubic (NaCl), Body centred cubic (CsCl).
-Describe the formation of covalent bonds -State the properties of covalent compounds -Interpret hybridization of atomic orbitals -Explain the formation of sigma and pi bonds in the single, double and triple bonds.	**4.2. Covalent bonding** • Covalent bond, covalent compounds and their properties, • Polar and non-polar compounds. • Dative and coordinate bond. • Hybridization of atomic orbitals. • Formation of sigma and Pi bonds.	Compare the properties of ionic and covalent compounds Give examples of coordinate bonds: $A1_2C1_6$, NH_4^+, H_30^+…
-Explain the shapes of molecules basing on VSEPR theory and the existence of different bond angles.	• Shapes of molecules based on valence shell electron pair repulsion theory and bond angles leading to double and triple bonds.	Examples should include; Linear shape, planar shape, tetrahedral pyramidal, bent, octahedral and bipyramidal.
-Describe the formation of metallic bond -State the physical properties of metals and metallic compounds in reference to free	**4.3. Metallic bonding** • Metallic bond • Physical properties of metals e.g.	Mention the presence of electron cloud (sea) in metals.

(delocalized) electrons	conductivity, malleability, ductility, shininess, density, boiling and melting points.	
-Describe the formation of inter- and intramolecular forces. -State the properties of compounds having inter- and intramolecular forces.	**4.4. Inter- and intramolecular forces** • Hydrogen bond • Van der Waals forces.	Give examples of molecules having inter- and intramolecular forces. Compare the effect of intermolecular forces on some physical properties of some compounds e.g. H_2O and H_2S, …

CHAPTER 5: COMPARATIVE STUDY OF CHEMICAL REACTIONS OF ELEMENTS IN THE PERIODIC TABLE

GENERAL OBJECTIVES

At the end of this chapter, students should be able to:
a) Describe the physical and chemical properties of elements in the periodic table**.**
b) Explain the preparation and uses of some elements and their compounds.

SPECIFIC OBJECTIVES	**CONTENTS** **5. COMPARATIVE STUDY OF CHEMICAL REACTIONS OF ELEMENTS IN THE PERIODIC TABLE**	**TEACHING/ LEARNING ACTIVITIES**
-State the physical properties of group I and II elements. -Explain the preparation methods of the monoxides and peroxides of group I and II elements.	**5.1. Chemistry of group I and II elements.** • Physical properties • Preparation method (monoxides and peroxides). • Solubility and nature of resultant solutions. • Action of heat on group I and II compounds: carbonates, nitrates and sulphates. • Uses of some elements and compounds	Carry out experiments on preparation, solubility and action of heat on compounds of group I and II elements. Research on the uses of group I and group II elements and their compounds basing on their respective properties.
-State the physical properties of boron and aluminium -Explain the reaction of different elements with selected reagents	**5.2. Study of group III elements:** • Physical properties of Boron and Aluminium • Reactions of elements of group III (Boron and Aluminium) with: Oxygen, Water, Halides, Dilute	

	acids, Sodium hydroxide.	
-State the preparation methods of the oxides, hydroxides and chlorides of boron and aluminium. -Describe the chemical properties of the oxides, hydroxides and chlorides of boron and aluminium.	• Study of group III compounds: Oxides, hydroxides and chlorides of Boron and Aluminium. - Preparation - Solubility and nature of resultant solutions. - Amphoteric character of aluminium (III) oxide and hydroxide [$Al(OH)_3$]	Carry out reactions of : -NaOH solution on $Al3^+$ -Use NaOH in excess.
-Mention the uses of boron and aluminium.	- Uses of boron and aluminium.	Emphasize on the amphoteric character of Al_2O_3 and $Al(OH)_3$
	5.3. Group IV.	
-Compare the physical properties of group IV elements. -Distinguish between the allotropes of carbon (physical properties). -State the uses of the allotropes of carbon.	• Comparative study of physical properties of group IV elements. • Allotropes of carbon and uses	Discuss the unique properties of Carbon
-Mention the uses of group IV elements.	• Uses of group IV elements	
-Explain the chemical properties of group IV elements.	• Reaction of C, Sn, Pb, Si with: Oxygen, Hydrogen, Chlorine, Hydroxides, Dilute acids	Carry out test for Pb^{2+} Emphasize on the amphoteric nature of PbO
-Compare the chemical reactions of the oxides and chlorides of group IV elements with water, acids and strong alkaline solutions. -Discuss the chemistry of the hydrides of group IV elements. -Explain the variation of oxidation states and its effect on the stability of their	• Comparative study of compounds of group IV elements: oxides, chlorides • Hydrides of group IV elements • Variation of oxidation states and the stability of their compounds	

compounds. -Define diagonal relationship. -Describe the similarities and differences among the elements of group I, II, III and IV due to diagonal relationship.	• Diagonal relationship of group I, II, III and IV: Similarities and differences	
-Explain the physical properties of group V elements -Mention the physical properties of the allotropes of Phosphorus. -Distinguish between the chemical properties of nitrogen and phosphorus. -Describe the preparation of nitrogen. -Explain the chemical reactions of nitrogen. -Discuss the chemical reactions of nitrogen compounds.	**5.4. Group V elements** • Physical properties: physical state, Metallic character. • Allotropes of Phosphorus • Chemical properties of Nitrogen and phosphorus • Preparation of Nitrogen • Reaction of Nitrogen with: Oxygen, Hydrogen, Metals (e.g Mg) • Chemical properties of Nitrogen compounds: - NH_3: oxidation (preparation of HNO_3) - Reaction with acids - N_2O: decomposition - NO_2: reaction with water (preparation of HNO_3 and HNO_2) - Dimerisation of NO_2 - N_2O_3: reaction with bases (alkalis) : preparation of NO_2^-	Show that metallic character increase down the group Discuss suitable conditions for synthesis of Ammonia You can also prepare NO_2 using HNO_3
-Explain the reactions of HNO_3 with metals, non metals and bases	HNO_3: - Reaction with metal (Mg, Zn, Pb), Cu (concentrated nitric acid) - Exception (Ag, Au, Pt, Hg) - Neutralisation (reaction with bases)	Carry out the following experiment: reaction of HNO_3 with metals.

	- Reaction with non-metals (S,C, P, I) - Oxidizing power NO_3^-: - action of heat - reaction with H_2SO_4	Carry out the following experiment: reaction of HNO_3 with non-metals.
-State the uses of nitrogen and its compounds. -Explain the reactions of phosphorus with oxygen, chlorine and water. -Describe the chemical properties of phosphorus compounds. . -State the uses of phosphorus and its compounds -Mention the physical properties of group VI elements. -Explain the reactions between Sulphur and oxygen. -Explain the reactions of group VI with hydrogen and metals. -Compare the acidity and volatility of H_2S and H_2O.	• Uses of Nitrogen and its compounds • Reaction of Phosphorus with: Oxygen, Chlorine, Water • Chemical properties of Phosphorous compounds: - P_2O_3 with water - P_2O_5 with water - PCl_3 with ethanol, water, oxygen, chlorine - PCl_5 with, water, carboxylic acids, ethanol - H_3PO_4: with metals and bases - Reaction of phosphates with H_2SO_4. • Uses of Phosphorus and its compounds **5.5. Group VI elements** • Physical properties: - physical state - Metallic character - Allotropes of Sulphur • Reaction between S and O • Reaction of Oxygen and Sulphur with H_2 and metals. • Comparison of acidity and volatility of H_2S and H_2O	Carry out the following experiments: reaction of H_3PO_4 with metals, NaOH and reaction of phosphates with H_2SO_4. Burn Sulfur with Oxygen Burn sulfur (powder) with iron (fillings) Emphasize on the presence of hydrogen bonds between molecules of H_2O

-Explain the trends of physical and chemical properties down the group VII elements.	**5.6. Group VII** • Comparative study of physical properties of halogens: - Physical state, - Volatility, - Colour. • Comparative study of chemical properties of halogens: - Reactions with oxygen, water, sodium hydroxide (both dilute and cold or hot concentrated). - Displacement reactions down the group - Behaviour of hydrides of halogens with regard to: acid strength, volatility and their reducing power.	-Discuss physical states, volatility and colour of group VII elements down the group. -Stress the difference in products obtained when: halogens react with dilute and cold sodium hydroxide or hot concentrated sodium hydroxide. -Prepare HCl gas.
-Explain the trends in strength of acidity of hydrides of halogens -State the uses of halogens and their compounds. -Explain the chemistry of chlorates, iodates, perchlorates and periodates and their uses.	• Uses of halogens and their compounds • Chlorates and iodates e.g. $KClO_3$, KIO_3 and perchlorates, periodates and their uses.	
-State the physical properties of group VIII elements. -Explain the reactivity of group VIII elements. -Mention the uses of group VIII elements (explain why elements of group VIII are important even if their reactivity is very limited).	**5.7. Group VIII elements** -Physical properties -Reactivity - Uses	

	5.8. Period III elements	
-Compare the physical properties of period III elements.	- Physical properties e.g. melting and boiling points, atomic radius, physical state, polarisability, ionization energy, conductivity, electronegativity, metallic character, density .	Discuss the variation of physical properties across period III of the periodic table.
-Describe the nature of the oxides of group III elements and the type of bonding in their chlorides.	- Alkalinity and acidity of their oxides, bonding in chlorides.	Stress the decrease of alkalinity of oxides across the period.

CHAPTER 6: CLASSIFICATION OF REACTIONS

GENERAL OBJECTIVES

At the end of this chapter, students should be able to:
a) Define oxidation and reduction in terms of loss or gain of oxygen or hydrogen and in terms of loss or gain of electrons**.**
b) Identify the substances that are oxidized and those that are reduced in a redox reaction.
c) Distinguish between oxidizing agent and reducing agent in a redox reaction.

SPECIFIC OBJECTIVES	**CONTENTS** **6.CLASSIFICATION OF REACTIONS**	**TEACHING/ LEARNING ACTIVITIES**
-Define oxidation number. -Explain how oxidation number is obtained. -Define oxidation and reduction	**6.1** Oxidation number -Definition -Assigning oxidation number	
-Discuss reactions in which oxidation numbers do not change.	**6.2** Reactions in which oxidation state does not change: -Neutralization - Double decomposition.	The teacher will give many examples on each of the above reactions. Identifying direct combination or decomposition and the conditions suitable for each. Distinguish a redox reaction from a metathesis reaction.
-Explain redox reactions. -State common reducing and oxidizing agents and their behaviour in half and overall redox equations.	**6.3**. Redox reaction -Half redox equations -Reducing and oxidizing agents -Balancing redox equations using half equations.	Illustrate a redox reaction by carrying out an experiment using Fe and Cu. Eg: $CuSO_4$ +Fe , $FeSO_4$+Zn

CHAPTER 7: TRANSITION ELEMENTS (FIRST SERIES)

GENERAL OBJECTIVES

At the end of this chapter, students should be able to:
a) Describe the chemical diversity shown by the transition elements.
b) Explain the properties of some transition elements and their compounds.

SPECIFIC OBJECTIVES	**CONTENTS** **7.TRANSITION ELEMENTS (FIRST SERIES)**	**TEACHING/ LEARNING ACTIVITIES**
-Give simple explanation of the general characteristics of transition elements	**7.1.** General characteristics a.Variable oxidation states. b. Catalytic ability. c. Formation of colours in solids or solutions. d. Magnetic properties (paramagnetism and diamagnetism). e. Formation of alloys. f. Formation of complex alloys.	The teacher will explain why Zinc is not considered as a transition element.
-Establish the structure, names of complex ions. -State the applications of complex ions.	**7.2**.Structure, rules of naming and applications of complex ions Rules of naming. Applications of complex ions (Medicine, agriculture biological substances).	
-Explain the chemical reactions of transition elements. -Describe the properties of oxides, hydroxides and oxo-anions of transition elements.	**7.3.**Chemical reactions of Cr, Mn,, Co, Fe, Cu and Zn with: Water, HCl, HNO_3, H_2SO_4 **7.3**.Properties of oxides, hydroxides and oxo-anions.	Carry out experiments involving the concerned metals with water and acids.

CHAPTER 8: IDENTIFICATION OF IONS

GENERAL OBJECTIVES

At the end of this chapter, students should be able to:
a) Identify experimentally anions and cations from their various solutions and compounds.
b) Specify confirmatory tests for each ion.

SPECIFIC OBJECTIVES	**CONTENTS** **8. IDENTIFICATION OF IONS**	**TEACHING/ LEARNING ACTIVITIES**
Identify experimentally anions and cations.	Identification of Na^{+}, K^{+}, Mg^{2+}, Cu^{2+}, Ba^{2+}, Al^{3+}, Pb^{2+}, Fe^{2+}, Fe^{3+}, Cr^{3+}, Mn^{2+}, Mn^{7+}, Cu^{+}, Zn^{2+}, NH_4^{+}, CO_3^{2-}, NO_3^{-}, SO_4^{2-} Cl^{-}, I^{-}.	Carry out flame tests. Observe the effects of sodium hydroxide and ammonium hydroxide on various cations. Identify confirmatory tests for each ion

PROPOSAL OF LESSON DISTRIBUTION FOR SENIOR 4

First term

Weeks	**Topics**	**Number of periods**
1-4	Atomic structure	28
5-6	Periodic table	14
7-10	Electronic structure	28
11-12	Revision and Exams	14
Total:12 weeks		**84**

Second term

Weeks	**Topics**	**Number of periods**
1-3	Bonding	21
4-10	Comparative study of chemical reactions of elements in the periodic table	49
11-12	Revision and Exams	14
Total:12 weeks		**84**

Third term

Weeks	**Topics**	**Number of periods**
1-3	Classification of reactions	21
4-5	Transition elements (first series)	14
6-10	Identification of ions	35
11-12	Revision and Exams	14
Total: 12 weeks		**84**

SENIOR FIVE DETAILED CURRICULUM

GENERAL OBJECTIVES BY THE END OF SENIOR FIVE

At the end of senior five, students should be able to:

1. Classify basic organic compounds according to the functional groups they contain.
2. Explain physical and chemical properties of each class of basic organic compounds.
3. Recognize the importance of organic chemistry and its applications in daily life.
4. Express the concentration of solutions in different units.
5. Carry out simple acid-base, redox and back-titration reactions
6. Establish the formula of some compounds.
7. Determine the enthalpy of chemical reactions.
8. Predict the feasibility of a chemical reaction at normal temperature and pressure.

CHAPTER 1. ORGANIC CHEMISTRY

GENERAL OBJECTIVES

At the end of this chapter, students should be able to:
a) Classify basic organic compounds according to the functional groups they contain.
b) Explain physical and chemical properties of each class of basic organic compounds.
c) Recognize the importance of organic chemistry and its applications in daily life.

SPECIFIC OBJECTIVES	**CONTENTS** **1. ORGANIC CHEMISTRY**	**TEACHING/ LEARNING ACTIVITIES**
-State three places in which peat (Nyiramugengeri) occurs naturally and give its applications.	**1.1. Occurrence of carbon** -coal and wood -composition and uses of coal -Making of charcoal from wood.	• Mention some places where peat is found
-State unique properties of carbon.	**1.2**.Unique properties of carbon	• Emphasize on the ability of carbon to form stable multiple bonds, chains and rings.
-Name the first 20 alkanes -State physical properties of alkanes -State sources of alkanes -Describe the preparation of alkanes -Write structures of Alkanes -Explain chemical reactions of alkanes with chlorine and oxygen.	**1.3. Functional groups** **1.3. 1 Alkanes** - Nomenclature of alkanes up to the 20^{th} - Physical properties: • Physical state • Solubility -Occurrence: • Natural gas • Petroleum -Laboratory preparation of alkanes - Structures and isomers -Chemical properties of alkanes: • reactions with chlorine (substitution)	• Learner should mention where methane gas is found in Rwanda (lake Kivu)

-State uses of alkanes	and mechanisms of reaction: homolytic fission of the bond • reactions with oxygen **(**combustion); - Uses of alkanes: fuel, petroleum chemistry industry **1.3.2 Alkenes.**	• Emphasize on the steps of radical chain mechanism • Show that the importance of the reaction is energy production. • Mention risks of pollution
-State natural sources of alkenes -Name alkenes -Show structures of Alkenes -Prepare alkenes in laboratory -Explain physical properties of alkenes -Explain chemical reactions of alkenes -State uses of alkenes	- Occurrence: Crude oil. - Nomenclature of alkenes. - Structure and positional isomerism. -Laboratory preparation methods - Physical properties. • Physical state • solubility - Chemical properties: • Addition reactions (H_2, Br_2, Cl_2, HCl, H_2SO_4 and H_2O) and the mechanisms involved. • Combustion reactions: (O_2) • Oxidation: (O_2, O_3). - Uses of alkenes	• Prepare ethene using ethanol and concentrated sulphuric acid • Practice writing mechanisms • Test for unsaturation: (bromine water and potassium permanganate)
-Give structures of alkynes -Name alkynes -Explain physical properties of alkynes -Explain the preparation of alkynes -Explain chemical properties of alkynes.	**1.3.2 Alkynes.** - Structure and positional isomerism. -Nomenclature of alkynes - Physical properties. • Physical state • solubility -Laboratory preparation methods - Chemical properties: • Addition reaction (H_2, Br_2, Cl_2, HCI, H_2SO_4 and H_2O) and the mechanisms involved.	• Test for unsaturation • Distinguish between terminal and non-terminal triple bonds

	1.3.4 Alkyl halides	
-Name alkyl halides -Show structures of alkyl halides -Explain physical properties of alkyl halides	- Nomenclature - Structure and isomers - Physical properties	
-Describe the preparation of alkyl halides in laboratory	- Preparation methods	
-Explain chemical reactions of alkyl halides	- Chemical reactions with H_2O, NaOH, NH_3, KCN, alcohol, Na, CH_3COOAg and mechanism of reaction showing SN_1, SN_2 nucleophilic substitution. - Elimination reactions to produce alkenes and alkynes.	• The teacher should show that alkyl halides are used as intermediate compounds in the synthesis of various organic compounds.
-State uses of alkyl halides	- Uses of alkyl halides: CCl_4, $CHCl_3$, CFCs (chlorofluorocarbons)	• Point out the role of CFCs in pollution (or give a homework to learners to do research on this topic)
	1.3.5 Alcohols (alkanols)	
-Name and classify Alcohols	- Nomenclature, structure and classification of alcohols.	
-Explain physical properties of alcohols.	- Physical properties Physical state Solubility Volatility	• Mention the existence of polyalcohols • Distinguish between classes of alcohols using $ZnCl_2$/Conc.HCl
-Describe methods of preparing alcohols	-Preparation methods	• Emphasize on the importance of hydrogen bonds.
-Explain chemical properties of alcohols.	- Chemical properties: reaction with Na, HCl, PCl_5, $SOCl_2$, CH_3COCl , CH_3COOH, and mechanisms Dehydration and etherification (mechanism of reaction). - Oxidation of alcohols: (MnO_2, CrO_2Cl_2, $KMnO_4$, $K_2Cr_2O_7$)	• Carry out **carefully** the chemical reaction of alcohols with Na • Dehydration of ethanol using concentrated H_2SO_4 • Use acidified $KMnO_4$ and $K_2Cr_2O_7$ to test for alcohol
-Describe essential preparation methods of ethanol.	- Study of ethanol: Preparation methods	• Carry out an experiment of alcoholic

-State uses of ethanol	Uses of ethanol	fermentation and distillation
	1.3.6 Ethers	
-Describe essential properties of ethoxyethane as an example of ethers.	Nomenclature structure, physical properties, Preparation, and uses.	• Emphasize on the inert property of ethers and their importance in preservation of reactive metals
	1.3.7 Aldehydes (Alkanals) and Ketones (Alkanones).	
-Name aldehydes and ketones	- Nomenclature and structure	
-Explain the physical properties of aldehydes and ketones	- Physical properties	
-Prepare aldehydes and ketones	- Preparation	
-Describe comparatively the chemical properties of aldehydes and ketones.	- Chemical properties. • Reactions with HCN and mechanism, NH_3, NH_2OH, NH_2-NH_2, C_6H_5NH-NH_2 and 2, 4 - dinitrophenyl hydrazine.	• Emphasize on the importance of the reactions with 2, 4 - dinitrophenylhydrazine, Fehling's solution and Tollens` reagent, $Cr_20_7^{2-}$, $Mn0_4^-$, Fuchsin to distinguish between aldehydes and ketones.
-Interpret chemical reactions with Fehling`s and Tollens' reagent.	• Oxidation by Fehling's solution and Tollens' reagent, $Cr_2O_7^{2-}$, MnO_4^-, Fuchsin.	• Carry out experiments
-Distinguish between aldehydes and ketones	• Reduction to alcohols. • Reaction with PCl_5. • Reaction with Grignard reagent and mechanism.	
-State uses of aldehydes and ketones.	- Uses of methanal and acetone.	
	1.3.8 Carboxylic acids (Alkanoic acids).	
-Name carboxylic acids	- Nomenclature, Structure and existence of polyacids	
-Explain physical properties of carboxylic acids	-Physical properties	• Mention dimerisation of carboxylic acids to explain volatility

-Describe general methods of preparing carboxylic acids	-Preparation methods	
-Describe chemical properties of carboxylic acids	- Chemical properties: • Reactions with Na, Na_2CO_3, NaOH, PCl_5, C_2H_5OH, Cl_2. • Reduction with $LiAlH_4$.	• Carry out experiment about esterification
-State uses of carboxylic acids.	- Uses of carboxylic acids.	
-Name and classify amines -Explain physical properties of amines.	**1.3.9. Amines.** Nomenclature, structure and classification of amines. - Physical properties Physical state Solubility Volatility	Distinguish between classes of amines using $NaNO_2$/concentrated HCl
-Describe methods of preparing amines -Explain chemical properties of amines.	-Preparation methods -Chemical properties • Basicity • Reaction with HCl, HNO_2, carboxylic acids, acid derivatives and Grignard reagent.	• Compare the basicity of amines
-Prepare acid derivatives -Identify the structures of acid derivatives and name them. -Describe physical and chemical properties of acid derivatives.	**1.3.10. Acid Derivatives: Esters, Acyl chlorides, acid anhydrides, amides, nitriles.** - Preparation methods, - Structure and nomenclature, -Physical properties -Chemical properties • Reactions with H_20, NH_3, ROH,	

-Identify the formula and uses of urea	RNH_2, • Saponification of esters. • Reduction of Amides and Nitriles. - Formula and uses of urea	
-Classify lipids	**1.4. Higher molecular weight esters- Lipids** **1.4.1 Glycerides (fats and oils).** -Classes of different Lipids basing on: • Physical state; • Saturation and unsaturation • Length of molecules.	
-Describe the extraction of fats and oils	- Extraction of fats and oils from nuts and soya beans.	• Carry out the extraction of fats and oils by pressure and solvent extraction
-Explain hydrolysis of glycerides to give glycerol and soap.	**1.4.2 Waxes :**Beeswax as an example **1.4.3** Glycerides and saponification.	• Carry out the experiment about saponification
-Explain the importance of fats and oils	- Importance of fats and oils	
-Define and classify carbohydrates	**1.5 - Carbohydrates.** - Definition, general structures. - Classes and examples: • monosaccharide: glucose and fructose • disaccharides: sucrose, lactose and maltose • Polysaccharides: starch, glycogen and cellulose	• Carry out an experiment to test for starch using iodine.
-State properties of carbohydrates	- Properties of monosaccharide, disaccharides and polysaccharides • Reducing and non-reducing sugars • Hydrolysis and condensation. of carbohydrates	• Mention the reducing and non reducing properties of carbohydrates • Carry out the experiments to test for

-Explain the importance of carbohydrates	• Solubility - Importance of carbohydrates	reducing sugars. • Teacher should mention energy production among others.
-Illustrate the general structure of amino acids	**1.6 - Amino Acids and Proteins.** - Structure of amino acids	• Give at least three examples of amino acids • Homework: let students look for the 20 amino acids.
-Show the properties of Amino acids and peptide linkage in formation of proteins.	- Properties of amino acids: • basicity • acidity and • Formation of Zwitterions. • Peptide linkage to form proteins. -Examples of proteins: • Albumin, hemoglobin, keratin, myosin….	• Carry out experiments to test for proteins
-Explain hydrolysis of proteins -State the importance of proteins	-Hydrolysis of proteins. -Importance of proteins	• Give exercises on hydrolysis of peptides
-Differentiate types of isomerism	**1.7. Isomerism** - Structural isomerism: • Positional; • Functional • Chain isomerism. - Stereo isomerism: • Geometrical; • Optical isomerism.	• Give many exercises on isomerism

CHAPTER 2. MOLE CONCEPT

GENERAL OBJECTIVES

At the end of this chapter, students should be able to:
4. Express the concentration of solutions in different units.
5. Carry out simple acid-base, redox and back-titration reactions
6. Establish the formula of some compounds.

SPECIFIC OBJECTIVES	**CONTENTS** **2. MOLE CONCEPT**	**TEACHING/ LEARNING ACTIVITIES**
-Define a mole -Calculate molar volume -Express concentration with different units -Prepare solutions of known molarities -Perform acid-base titrations with accuracy -Determine the composition of a mixture by titration	**2.1.**Mole and Avogadro's number **2.2.**Molar volume at s.t.p and r.t.p **2.3.**Units of concentration: • Mass per volume • Molarity • Normality • Percentage **2.4.**Preparation of solutions **2.5.**Simple acid- base titrations using methyl orange and phenolphthalein **2.6.**Determining the percentage composition of Na_2CO_3 and NaCl solution by titrating with HCl solutions	• Exercises involving calculations should be given. • Give exercises about conversions of different units of concentration • Carry out experiments about: - Preparation of solutions - Acid-base titrations - Titration on redox reactions - Back titrations

-Perform titrations on redox reactions	**2.7.** Titrations involving redox reactions e.g. MnO^-_4 and Fe^{2+}, $Cr_2O_7^{2-}$ and Fe^{2+}, $S_2O_3^{2-}$ and I^-, MnO^-_4 and $C_2O_4^{2-}$ and so on. **2.8.** Back titrations and the calculations involved. **2.9.** Determination of the atomic masses and number of moles of water of crystallisation	Give exercises involving calculations of number of moles of water of crystallization

CHAPTER 3. CHEMICAL ENERGETICS/ THERMODYNAMICS

GENERAL OBJECTIVES

At the end of this chapter, students should be able to:
a) Determine the enthalpy of chemical reactions.
b) Predict the feasibility of a chemical reaction at normal temperature and pressure.

SPECIFIC OBJECTIVES	**CONTENTS** **3. CHEMICAL ENERGETICS/ THERMODYNAMICS**	**TEACHING/ LEARNING ACTIVITIES**
-Explain thermodynamics -Distinguish between a system and its surrounding -Explain internal energy and heat of reaction of a system	**3.1**. Explanation of the term "thermodynamics". - Difference between a system and its surroundings. **3.2**. Internal energy of a system. - Heat of reaction Examples of reactions in which heat is released or absorbed: exothermic and endothermic reactions **3.3.** Heat of reaction and enthalpy • Exothermic reactions (ΔH = negative) • Endothermic reactions (ΔH = positive) - Energy profile for a chemical reaction using simple energy diagrams. - Different enthalpies of reactions: • Combustion, • neutralization, • formation, • displacement, • solution,	• Carry out simple experiments on heat of combustion and heat of neutralization.

-State Hess's law and apply it to thermochemical calculations. -Explain the enthalpy of reaction and state its applications.	**3.4**. Hess's law and its applications (calculations). **3.5.** Applications of ΔH or enthalpy change of reactions i.e. feasibility of a reaction. - Bond energies: • Calculations • Applications. - Born-Haber cycle -Hydration and lattice energy for ionic compounds. - Simple experiment on heat of combustion and heat of neutralization.	• Do exercises on thermochemical calculations • Discuss the feasibility of chemical reactions. • Carry out simple experiments on quantitative determination of enthalpy changes • Do exercises involving calculations on bond –energies • Calculate lattice energy using Born-Haber cycle

PROPOSAL OF LESSON DISTRIBUTION FOR SENIOR 5

First term

Weeks	Topics	Number of periods
1	Alkanes	7
2-3	Alkenes.	14
4-5	Alkynes	14
6	Alkyl halides	7
7-8	Alcohols (alkanols)	14
9-10	Aldehydes (Alkanals) and Ketones (Alkanones)	14
11-12	Revision and Exams	14
Total: 12 weeks		**84**

Second term

Weeks	Topics	Number of periods
1	Carboxylic acids (Alkanoic acids).	7
2	Amines.	7
3-4	Acid Derivatives: Esters, Acyl chlorides, acid anhydrides, amides, nitriles	14
5-6	Lipids (fats and oils)	14
7-8	Carbohydrates	14
9-10	Amino Acids and Proteins	14
11-12	Revision and Exams	14
Total: 12 weeks		**84**

Third term

Weeks	Topics	Number of periods
1-2	Isomerism	14
3-5	Mole concept	21
6-10	Chemical energetics	35
11-12	Revision and Exams	14
Total: 12 weeks		**84**

SENIOR SIX DETAILED CURRICULUM

GENERAL OBJECTIVES BY THE END OF SENIOR SIX

At the end of senior six, students should be able to:

1. Describe the concept of chemical equilibrium.
2. Write the equilibrium constant expression for a reaction and calculate its value from experimental data.
3. Apply Le chatelier's principle on chemical equilibria of industrial processes.
4. Explain and apply Raoult's law.
5. Explain colligative properties.
6. Perform calculations involving colligative properties.
7. Determine a relative molecular mass of chemical substances.
8. Calculate pH and pOH of strong and weak acid, strong and weak bases as well as salts.
9. Describe buffer solutions and their uses.
10. Compare cation and anion hydrolysis
11. Explain the application of indicators.
12. Calculate the solubility product constant of a slightly soluble salt.
13. Describe how chemical reactions produce electrical energy and how electrical energy induces chemical reaction.
14. Explain the reactivity of benzene ring.
15. Write mechanisms of reactions of benzene ring and its derivatives with various reagents.
16. Describe the preparation and importance of polymers.
17. Discuss the basis of chemical kinetics: collision, collision in proper orientation and activation energy.
18. Determine the order of reaction using experimental data.
19. Explain the effects of different factors on the rate of reaction.
20. Explain the usefulness and hazards of nuclear reactions.
21. Relate the original amount of substance to the remaining amount of the substance after time, t.
22. Describe industrial methods of preparing some useful chemical products.
23. Describe methods of extracting certain metals from their ores.
24. Describe fractional distillation of crude oil.

CHAPTER 1. CHEMICAL EQUILIBRIUM

GENERAL OBJECTIVES

At the end of this chapter, students should be able to:
a) Describe the concept of chemical equilibrium.
b) Write the equilibrium constant expression for a reaction and calculate its value from experimental data.
c) Apply Le chatelier's principle on chemical equilibria of industrial processes .

SPECIFIC OBJECTIVES	**CONTENTS** **1. CHEMICAL EQUILIBRIUM**	**TEACHING/ LEARNING ACTIVITIES**
-Explain the concept of chemical equilibrium and factors that affect the position of equilibrium.	**1.1.** Explanation of chemical equilibrium: -Examples of reversible reactions. -Concentration equilibrium constant (K_c).	• The teacher will mention that the rate of forward reaction is equal to the rate of backward reaction.
-Explain and apply the Le Chatelier's principle and apply it to dynamic equilibrium.	**1.2**. Factors affecting the position of equilibrium in accordance with the Le Chatelier's principle: -Concentration: equilibrium law and its derivation. -Pressure: equilibrium law in terms of partial pressures of gases. -Temperature -Catalysts	• Exercises involving calculations on: -concentration equilibrium constant (K_c) -pressure equilibrium constant (K_p)
-Derive K_c and K_p -Compare concentration equilibrium constant and pressure equilibrium constant (K_c, K_p).	**1.3.** Comparison between K_c and K_p	
-Show the importance of equilibrium constant factors on industrial processes	**1.4.** Applications of factors on industrial processes: -Contact process -Haber process.	• Details not required

CHAPTER 2. PHASE EQUILIBRIUM

GENERAL OBJECTIVES

At the end of this chapter, students should be able to:
a) Explain and apply Raoult's law.
b) Explain colligative properties.
c) Perform calculations involving colligative properties.
d) Determine a relative molecular mass of chemical substances.

SPECIFIC OBJECTIVES	**CONTENTS** **2. PHASE EQUILIBRIUM**	**TEACHING/ LEARNING ACTIVITIES**
-Explain phase equilibrium -Interpret phase diagram -State Raoult's law -Calculate molecular mass -Explain effects of a solute on the boiling and freezing point of a solvent	**2.1.** Explanation of phase equilibrium **2.2.** Phase diagram for water **2.3.** Partition coefficient and solvent extraction **2.4.** Raoult's law and its application on: • Miscible mixtures • Fractional distillation. **2.5.** Colligative properties: Boiling point elevation Freezing point depression Osmotic pressure	The teacher should emphasize on triple point and critical temperature. The teacher should mention partition coefficient as means of separation of mixtures

CHAPTER 3. IONIC EQUILIBRIUM

GENERAL OBJECTIVES

At the end of this chapter, students should be able to:
a) Calculate pH and pOH of strong and weak acid, strong and weak bases as well as salts.
b) Describe buffer solutions and their uses.
c) Compare cation and anion hydrolysis
d) Explain the application of indicators.

SPECIFIC OBJECTIVES	**CONTENTS** **3. IONIC EQUILIBRIUM**	**TEACHING/ LEARNING ACTIVITIES**
-Differentiate strong and weak electrolytes. -Define the degree of ionization (alpha α)	**3.1.** Strong and weak electrolytes and the degree of ionization (alpha α).	The teacher should mention examples of strong and weak electrolytes The teacher and learners should discuss the dissociation of (strong and weak) acids and bases.
-Explain the ionic equilibrium -Establish the relationship between the degree of ionization and equilibrium constant.	**3.2**. Explanation of ionic equilibrium and equilibrium constant of weak acids and bases.	
-Explain ionic product of water.	**3.3.** Ionic equilibrium of water and its ionic product (K_w).	
-Define an acid and a base in terms of Brönsted and Lewis theory.	**3.4.** Alkalinity and acidity on Brönsted/ Lowry and Lewis with examples.	The teacher should give examples of Brönsted/ Lowry and Lewis acids and bases.
-Calculate the pH of a solution, given $[H_3O^+]$ or $[OH^-]$ for strong and weak acids or bases.	**3.5.** Dissociation of weak acids–degree of dissociation and dissociation constant. Calculations involved.	
-Calculate the concentration of a solution given pH.	**3.6**. Dissociation of weak bases. **3.7**. pH and pOH: definitions and	Do exercises on applications of ionic

-Calculate the pH of a buffer solution and state the applications of buffer solutions.	relationship at 25°C. **3.8**. Calculations involved in pH of strong and weak acids as well as bases. **3.9.** Buffer solution: - Definition, explanation and examples. - Calculating the pH of buffer solutions and applications.	equilibrium constant. Applications of buffer solutions (human blood, stomach…) Do exercises on buffer solutions
-Explain hydrolysis of salts and determine the pH of resultant solutions.	**3.10.** Qualitative study of the hydrolysis of salts.	Do calculations on salt hydrolysis and pH of a resultant solution.
-Identify colours of different indicators in acids and in bases. -Make a choice of appropriate indicators in acid-base titrations. -Explain pH titration curves.	**3.11**. How an indicator works, choice of indicators and pH titration curves.	The teacher should mention some indicators and the range for colour changes. -Carry out experiments about titration and determine titration curves

CHAPTER 4. SOLUBILITY AND SOLUBILITY PRODUCT

GENERAL OBJECTIVE

At the end of this chapter, students should be able to:
Calculate the solubility product constant of a slightly soluble salt.

SPECIFIC OBJECTIVES	**CONTENTS** **4. SOLUBILITY AND SOLUBILITY PRODUCT**	**TEACHING/ LEARNING ACTIVITIES**
-Define solubility. -Derive solubility product -Calculate the solubility product (K_s) -Predict if the formation of precipitate occurs.	**4.1.** Sparingly soluble solids**,** - Solubility **4.2**. Solubility product (K_{sp}) and calculations involved. **4.3**. Relationship between solubility and solubility product**.** - Comparison between ionic product and solubility. **4.4**. Common ion effect. - Solubility and complex ion formation.	• Do exercises on solubility and solubility product. • Carry out experiments about precipitation due to common ion effect. • Do exercises/ experiments to determine whether precipitation occurs or not. • Do exercises/ experiments to determine on complex ion formation

CHAPTER 5. ELECTROCHEMISTRY

GENERAL OBJECTIVE

At the end of this chapter, students should be able to:
Describe how chemical reactions produce electrical energy and how electrical energy induces chemical reaction.

SPECIFIC OBJECTIVES	CONTENTS 5. ELECTROCHEMISTRY	TEACHING/ LEARNING ACTIVITIES
-Define electrolytes, conductors, conductance and conductivity. -Explain the variation of molar conductivity and concentration -Apply Kohlrausch's law of molar conductivity. -Write and balance half cell equations. -Explain cell diagrams. -Use half cells to generate electricity. -Calculate cell voltage.	**5.1. Conductance and conductivity** 5.1.1. Electrolytes and non electrolytes 5. 1.2. Conductors and non conductors 5.1.3. Conductance and conductivity of electrolytes. 5.1.4. Ionic mobility and ionic interference. 5.1.5. Molar conductivity in dilute solutions. 5.1.6. Molar conductivity at infinite dilution (independent migration of ions). **5.2. Electrochemical cells**. 5.2.1. Half cells and measuring of electrode potential using hydrogen electrode. 5.2.2. Half cell equations and overall cell equation. 5.2.3. Cell diagrams, cell representation and calculations for cell voltage. 5.2.4. Nernst's law and calculation for cell voltage (e.m.f).	• Carry out experiments using sugar and salts solution demonstrating conductivity. • Do exercises • Carry out experiment showing an arrangement of a cell.

-Explain the functioning of specific dry cells.	5.2.5. Daniell and Leclanché dry cells.	• Dismantle a dry cell and observe its components. • The teacher should mention the sacrificial protection against corrosion.
-Explain the concept of electrolysis and use Faraday's laws in calculations.	**5.3. Electrolysis** 5.3.1. Faraday's laws. 5.3.2. Relationship between Avogadro's constant and Faraday's constant and calculations involved.	
-State the factors that affect electrolysis.	5.3.3. Factors affecting electrolysis: • Nature of electrodes • Position in the electrochemical series • Concentration	• Electrolysis of copper sulphate solution using copper electrodes or Platinum (or graphite) electrodes.
-Interpret different applications of electrolysis.	5.3.4. Uses and applications e.g. electroplating, production of NaOH, Cl_2, copper refinery and Aluminium extraction.	
-Explain the functioning of lead acid accumulator	**5.4. Lead acid accumulator** 5.4.1. Charge 5.4.2. Discharge	• Explanation of how the lead acid accumulator functions as an electro-chemical cell and as an electrolytic cell. • Observe the construction of acid accumulator.

CHAPTER 6. AROMATIC COMPOUNDS

GENERAL OBJECTIVES

At the end of this chapter students should be able:

a) Explain the reactivity of benzene ring.

b) Write mechanisms of reactions of benzene ring and its derivatives with various reagents**.**

SPECIFIC OBJECTIVES	CONTENTS 6. AROMATIC COMPOUNDS	TEACHING/ LEARNING ACTIVITIES
-Explain the structure of benzene -State physical properties of benzene -Interpret chemical properties of benzene	**6.1. BENZENE** - Kekule's structure of benzene - Source of benzene - Physical properties - Chemical properties: Addition reaction with H_2 and Cl_2. Electrophilic substitution: halogenation, alkylation, acylation, nitration, sulphonation and their mechanisms.	• Emphasize on naming reactants and products.
-Explain chemical properties of derivatives of benzene.	**6.2. Derivatives of benzene** **6.2.1**. **Methylbenzene** - Sources - Physical properties. - Chemical properties in the same way as in benzene. - Reaction with Cl_2 (free radical substitution) - Oxidation using MnO_4^-, MnO_2	• The teacher should give some examples of derivatives of benzene including the ones obtained above • The teacher should mention that products of the reaction of Methylbenzene with Cl_2 depend on conditions. • Oxidize Methylbenzene by using $KMnO_4$ solution. (Experiment to be carry out in a fume chamber).

-Prepare and state chemical properties of phenols	**6.2.2**. **Alkanols and phenols** - **Alcohols:** Phenyl methanol: Preparation, Chemical properties: electrophilic substitution and side chain reactions. -**Phenol:** Preparation Physical properties Chemical properties: (electrophilic substitution) Acid properties Uses.	• Compare the reactivity of alkanols (containing benzene ring or not) and phenol. • Give other derivatives of phenol. • Emphasize on testing for phenol
-State chemical properties of Aromatic aldehydes and Ketones	**6.2.3**. **Aromatic aldehydes and Ketones** Electrophilic substitutiona Acid properties Uses.	
-State physical and Chemical properties of aromatic acids	**6.2.4. Aromatic acids** Physical properties, Chemical properties (electrophilic substitution**)**	
-Describe the preparation of aniline using nitrobenzene. -State Physical and Chemical properties of aniline	**6.2.5**. **Nitrobenzene and phenylamine** Preparation of aniline using nitrobenzene. Physical properties Chemical properties of aniline: -Diazotization. -Coupling reaction with phenol and aniline**.**	Give equation only

CHAPTER 7. POLYMERISATION

GENERAL OBJECTIVE

At the end of this chapter students should be able:
Describe the preparation and importance of polymers.

SPECIFIC OBJECTIVES	CONTENTS 7. POLYMERISATION	TEACHING/ LEARNING ACTIVITIES
-Define polymerization	**7.1**. Definition of monomer, polymer and polymerization	
-Differentiate between addition and condensation polymers -Interpret the relationship between the structures and properties of polymers	**7.2**. Types of polymers, their preparation, properties and uses: Addition polymers: polyethene, polypropene, polychloroethene (P.V.C.), polyphenylethene (polystyrene). Condensation polymers: Polyester e.g. terylene, polyamide (Nylon 66), Bakelite.	• The teacher should give their methods of formation and applications. • Discuss the effects of some polymers on the environment.
-Differentiate thermosoftening and thermosetting polymers.	Thermosoftening and thermosetting or thermohardening polymers.	• Discuss recycling of polymers: biodegradable and non-biodegradable polymers.
-Explain the importance of copolymerization.	**7.3**. Copolymers: styrene with isoprene	
-Give examples of natural polymers	**7.4**. Natural polymers - Examples are natural rubber, silk, cotton wool and cellulose. -Vulcanization of rubber.	

CHAPTER 8. CHEMICAL KINETICS

GENERAL OBJECTIVES

At the end of this chapter students should be able:

a) Discuss the basis of chemical kinetics: collision, collision in proper orientation and activation energy.
b) Determine the order of reaction using experimental data.
c) Explain the effects of different factors on the rate of reaction.

SPECIFIC OBJECTIVES	**CONTENTS** **8. CHEMICAL KINETICS**	**TEACHING/ LEARNING ACTIVITIES**
-Explain the concept of chemical kinetics -Define rate of reaction -Write the mathematical expression of rate law -Determine molecularity of reaction -Define orders of reaction with respect to the reactants and overall order of reaction -Determine the order of reaction -Explain the effects of different factors on the rate of reaction	**8.1.** The concept of chemical kinetics -Definition of the rate of reaction. Mathematical rate law expression which is experimentally determined (Rate=k{A}^{n}) -Molecularity of a reaction. -Order of reaction: zero order, first order and second order. -Half-life for first order and second order reactions. -Deducing orders of reactions from experimental data. -Determination of rate constant and its units -Graphical representation of orders of reactions **8.2**.Factors that affect the rate of reaction: a) Concentration: expressed in terms of the collision of molecules and the rate expression.	• The teacher should give examples of fast and slow reactions **Note:** Molecularity is not necessarily equal to the order of reaction depending on simplicity or complexity of the reaction. • Use calculations and graphs to determine half-life. • Do some calculations involving orders of reactions • Simple experiments using clock reactions to determine the order of reaction e.g. H_2O_2 and I^- or $S_2O_3^{2-}$ and H^+ and the graphical representation.

	b) Temperature: effect on the rate of reaction in terms of the collision of molecules and the activation energy. c) Catalyst: effect on the rate of reaction in terms of lowering the activation energy. Properties of catalysts and the types of catalysis e.g. heterogeneous and homogeneous and the theory of catalysis. d) Pressure: effect on the collision of molecules. e) Light: effect and examples of photochemical reactions. f) Physical state: effect of the change of state.	Use Arrhenius` equation to calculate the ratio of rate constant and activation energy with change in temperature. Mention positive catalysts (promoters) and poisoning catalysts (inhibitors).

CHAPTER 9. RADIOACTIVITY

GENERAL OBJECTIVES

At the end of this chapter students should be able:

a) Explain the usefulness and hazards of nuclear reactions.
b) Relate the original amount of substance to the remaining amount of the substance after time, t.

SPECIFIC OBJECTIVES	CONTENTS **9. RADIOACTIVITY**	TEACHING/ LEARNING ACTIVITIES
- Define radioactivity - Name some common radio isotopes - Explain the properties of alpha, Beta and Gamma rays. -Write and balance nuclear reaction equations. - Define and calculate half life. - Explain the application of radioactive substances	**9.1.** Definition of radioactivity. **9.2**. Radio isotopes. Origin of instability of nuclei of radioactive substance. **9.3**. Radioactive emissions: - alpha, Beta and Gamma rays and their properties. Health hazards of radioactive substances. **9.4.** Nuclear equations and radioactive decay series -Artificial transmutation. -Fission and Fusion and their applications: Hydrogen bomb, Atomic bomb and production of electricity. **9.5**. Rate of decay of radioactive substances expressed in form of rate of decay equation. -Half life of radioactive substances and calculations involved. -Apparatus used to measure rate of decay of radioactive substances e.g. counter Geiger Muller and cloud chamber **9.6**. Uses of some radio isotopes e.g. ^{14}C, ^{32}P, ^{60}Co, ^{131}I	• Give an assignment about the discovery of radioactivity. **Note:** The radioactive decay of substances is first order reaction. • Discuss the importance of radioactive substances

CHAPTER 10. APPLIED CHEMISTRY

GENERAL OBJECTIVES

At the end of this chapter students should be able:
a) Describe industrial methods of preparing some useful chemical products.
b) Describe methods of extracting certain metals from their ores.
c) Describe fractional distillation of crude oil.

SPECIFIC OBJECTIVES	CONTENTS 10. APPLIED CHEMISTRY	TEACHING/ LEARNING ACTIVITIES
-Explain industrial manufacture of ammonia, nitric acid and sulfuric acid and state their uses.	**10.1**.-Manufacture of ammonia using Haber process -Industrial manufacture of nitric acid by catalytic oxidation of ammonia. -Contact process for sulfuric acid.	• Mention raw materials, their sources, suitable conditions and applicability of -Le Chatelier's principle. -Discuss the uses of ammonia -Emphasize on the steps and necessary conditions for the manufacture of nitric acid. -Show scheme of contact process and give uses of sulfuric acid.
-State major constituents of fertilizers -State the chemical reactions involved in the manufacture of fertilizers -Briefly explain the manufacture of fertilizers -Interpret the labels on fertilizer containers	**10.2.** The manufacture of fertilizers e.g. ammonium sulphate, potassium sulphate and phosphate fertilizers: -Raw materials used -Chemical reactions involved	• Learners should do research on some elements present in commonly used fertilizers. e.g. N.P.K in varying ratios.
-Explain the extraction and purification of metals Explain how cassiterite is extracted in Rwanda	**10.3.** Extraction of metals: Aluminium, Zinc, Iron, Copper and Tin from their ores	• Name metals, their main ores, and methods of extraction, purification and uses. • Emphasize on how Tin is extracted in Rwanda

		• Visit mining sites
-Explain fractional distillation of petroleum -State uses of petroleum products -Explain the importance of cracking and reforming	**10.4**. Oil refining, distillation and cracking of petroleum	• Show the distillation column and components obtained at each level and their uses. • Mention the removal of sulfur from iron sulfide (an impurity in petroleum) and the necessity of cracking and reforming.
-Explain fermentation process -Give the importance of fermentation	**10.5.** Alcoholic fermentation process (breweries).	• Enzyme catalysis should be mentioned but not treated in details. • Explain the steps involved • It's better to visit breweries industries
-Explain the preparation of soap -Prepare soap -Explain the action of soap on dirt -Distinguish between soap and detergents -Give different forms of soap -Explain the effects of soaps and detergents on environment.	**10.6.** Soap and detergents production Raw materials used. Steps involved in soap preparation Action of soap on dirt. Differences between soap and detergents. Effects of soap and detergents in the environment	• Prepare soap in the laboratory • Visit industries and local cooperatives that produce soap and detergents. • Mention different forms of soap (solid, liquid and powder soaps)

PROPOSAL OF LESSON DISTRIBUTION FOR SENIOR 6

First term

Weeks	**Topics**	**Number of periods**
1-4	Chemical equilibrium	28
5-6	Phase equilibrium	14
7-10	Ionic equilibrium	28
11-12	Revision and Exams	14
Total: 12 weeks		**84**

Second term

Weeks	**Topics**	**Number of periods**
1-4	Solubility and solubility product	21
5-8	Electrochemistry	28
9-10	Aromatic compounds	21
11-12	Revision and Exams	14
Total: 12 weeks		**84**

Third term

Weeks	**Topics**	**Number of periods**
1	Polymerisation	7
2-3	Chemical kinetics	21
4-7	Radioactivity	14
8-10	Applied chemistry	28
11-12	Revision and Exams	14
Total: 12 weeks		**84**

VI. LIST OF CHEMICALS AND LABORATORY APPARATUS

CHEMICALS			
N°	**Item**	**N°**	**Item**
1	Aniline (Aminobenzene)	86	Lead (IV) oxide
2	Acetic acid (Ethanoic acid)	87	Lead (II) (IV) oxide
3	Acetone (propanone)	88	Lead (II) iodide
4	Acetaldehyde (Ethanal)	89	Magnesium (ribbon, powder and turnings)
5	Acetamide (Ethanamide)	90	Magnesium salts (chloride, sulphate, nitrate and carbonate)
6	Aluminium (foil and powder)	91	Magnesium oxide
7	Aluminium oxide	92	Manganese
8	Aluminium salts (nitrate, sulphate and chloride)	93	Manganese(IV) oxide
9	Aluminium potassium sulphate	94	Manganese (II) salts (chloride, sulphate and carbonate)
10	Alizarin	95	Mercury chloride
11	Ammonia solution	96	Methanoic acid (formic acid)
12	Ammonium ethanedioate (oxalate)	97	Methanol
13	Ammonium acetate (ethanoate)	98	Methylated spirit
14	Ammonium salts (chloride, sulphate and carbonate	99	Methyl orange indicator
15	Ammonium dihydrogen phosphate	100	Millions' reagent
16	Ammonium iron (II) sulphate	101	D-camphor
17	Ammonium iron (III) sulphate	102	Naphtalene
18	Ammonium dihydrogen carbonate	103	Nickel
19	Ammonium thiocyanate	104	Nickel Aluminium alloy powder
20	Barium salts (nitrate, chloride and carbonates)	105	Nickel salts (carbonate, sulphate, nitrate and chloride)
21	Barium chromate	106	Nitric acid (concentrated)
22	Barium peroxide	107	Nitrobenzene
23	Barium diphenylamine sulfonate	108	4-Nitrophenol
24	Benzaldehyde	99	Orthophosphoric acid

25	Benzene	110	Paraffin wax
26	Benzoic acid	111	Parafin oil
27	Bicarbonate indicator	112	PH buffers (tablets/capsules)
28	Borax (di-sodium tetraborate (III)-10 water)	113	Phenol detached crystals
29	Bromine	114	Phenolphtalein indicator solid
30	1-Bromobutane	115	Phosphorus red stick
31	1-Bromotymol blue (water-solution)	116	Phosphorus pentachloride
32	Brady's Reagent (2,4-dinitrophenyl hydrazine)	117	Platinum wire
33	Calcium metal	118	Potassium metal
34	Calcium carbonate powder and marbre chips	119	Potassium bromide
35	Calcium salts (nitrtate, chloride and sulphate)	120	Potassium salts (chloride, sulphate, nitrate and carbonate)
36	Calcium oxide	121	Potassium chlorate
37	Calcium hydroxide	122	Potassium chromate
38	Calcium hypochlorite	123	Potassium dichromate
39	Carbon rods (graphite)	124	Potassium ferricyanide
40	Carbon powder	125	Potassium ferrous cyanide
41	Carbon tetra chloride (tetra chloromethane)	126	Potassium hydrogen sulphate
42	Chloro acetic acid	127	Potassium hydrogen posphate
43	Chloroform (Trichloromethane)	128	Potassium hydroxide
44	Chromium potassium sulphate (chrome alum)	129	Potassium iodate
45	Chromium trioxide	130	Potassium iodide
46	Cinnamic acid	131	Potassium ethanedioate (oxalate)
47	Cobalt(II) chloride (crystals and paper)	132	Potassium manganate (VII) (permanganate)
48	Copper (foil, powder and turnings)	133	Potassium persulphate
49	Copper (II) sulphate (anhydrous and hydrated)	134	Potassium tiocyanate
50	Copper salts (II)(chloride, nitrate and carbonate)	135	Schiff's reagent
51	Copper (II)oxide	136	Silica gel (for chromatography)
52	Copper (I) chloride and oxide	137	Silver nitrate
53	Cyclohexane	138	Sodalime
54	Dichloroacetic acid	139	Sodium metal
55	Dimethylglyoxime	140	Sodium ethanoate (acetate)

56	Diethyl ether (Ethoxyethane)	141	Sodium benzoate
57	Diphenylamine (redox indicator)	142	Sodium bismuthate
58	Devardas alloy	143	Sodium salts (chloride, nitrate and sulphate)
59	Di-potassium hydrogen phosphate	144	Sodium carbonate (anhydrous and hydrated)
60	Di-sodium hydrogen phosphate	145	Sodium chromate
61	Ethanol	146	Sodium dichromate
62	Fehling's solutions (N°1 and N°2)	147	Sodium hydrogen carbonate (sodium bicarbonate)
63	Formaldehyde (methanal)	1489	Sodium hydrogen sulphate
64	Glass wool	149	Sodium hydrogen sulphite
65	Glycerol	150	Sodium phosphate
66	Glycérine	151	Sodium citrate
67	Hexane	152	Sodium hydroxide pellets
68	Hydrochloric acid (concentrated)	153	Sodium peroxide
69	Hydrogen peroxide (20 vol and 100 vol)	154	Sodium sulphite
70	Iron nails and fillings)	155	Sodium thiosulphate
71	Iron (II) salts (chloride, sulphate and carbonate)	156	Sodium nitrite
72	Iron (III) chloride (anhydrous) and hydrated	157	Starch (soluble)
73	Iron (III) sulphate, nitrate and oxide	158	Succinic acid (Butanedioic acid)
74	Iodine solution and resublimated	159	Sulphur (powder and rolls)
75	Ketones (aromatic et aliphatic	160	Sulphuric acid (concentrated)
76	Lithium (carbonate and nitrate)	161	Trichloroacetic acid
77	Litmus indicator paper-red	162	Universal indicator (solution and pH chart 1.0-14)
78	Litmus indicator paper-blue	163	Urea
79	Litmus (solution and solid)	164	Vanadium pentoxide
80	Litmus indicator Neutral	165	Xylene
81	Lead metal (foil and shots	166	Zinc (granulated and powder)
82	Lead (II) ethanoate (acetate)	167	Zinc bromide
83	Lead (II) salts (nitrate, chloride, sulphate and carbonate)	168	Zinc chloride (anhydrous)
84	Nessler's reagent	169	Zinc salts (nitrate, sulphate and carbonate)
85	Lead (II) oxide	170	Zinc oxide

Laboratory Apparatus			
N°	**Item**	**N°**	**Item**
1	Burettes (50ml)	19	Spatulas
2	Stops cloks	20	Glass rods
3	Weighing balances	21	Measuring cylinders (5ml, 10ml, 25ml, 50ml, 100ml, 250ml
4	Pipettes (10ml and 25 ml)	22	Test tubes holders
5	Filter funnels	23	Weighing bottles
6	Filter papers	24	Motars and pestles
7	Retor stands and clamps	25	Tripod stands
8	Conical flasks	26	Round bottom flasks (250ml and 500ml
9	Glass beakers (50ml, 100ml, 150ml and 600ml)	27	Volumetric flasks (250ml, 1000ml, and 2000ml) for teachers'use
10	Plastic flasks (250ml)	28	Glass beakers 1000ml (for teachers' use)
11	Test tubes and test tube racks	29	Measuring cylinders 1000 ml (for teachers'use)
12	Heating apparatus (Bunsen burner, kerosene stove or gas stove)	30	Droppers
13	Crucibles and lids	31	Separating funnels
14	Boiling tubes	32	Watch glasses
15	Cocks (Assorted sizes)	33	Wire gauze and pipe clay triangles
16	Gas delivery tubes (Assorted sizes)	34	Reagent bottles
17	Thermometers (-10-110°C)	35	White tiles
18	Volumetrics flasks (250ml)	36	Rubber bungs

VII. BIBLIOGRAPHY

1. Direction des Programmes de l'Enseignement Secondaire, Chimie 6ème Année, Manuel de l'élève 2ème Partie, Avril 1990, Février 1991.
2. Gene A. Davis, ph.D., Organic Chemistry made ridiculously simple, MedMaster inc., Miami 2003.
3. Graham Hill and John Holman, Chemistry in Context, Fifth edition, May 2000.
4. John Hollman and Phil Stone, Chemistry, 2nd Edition, 2001.
5. J.V. Narlikar and All, Chemistry part I, Text book for Class XI, New Delhi, National council of education research and training, December 2005.
6. Paul Arnaud, Cours de Chimie Physique, 14ème Edition, 1998.
7. Paul Arnaud, Cours de Chimie organique, 15ème Edition, 1995.
8. National Curriculum Development Center (NCDC), Advanced level Mathematics curriculum for science combinations, Kigali, March 2010
9. National Curriculum Development Center (NCDC), Chemistry programme Advanced level, Kigali, November 1999.
10. Davis, Modern chemistry, 1999.
11. Wilbraham, Chemistry, 2000.
12. John S. Phillips, Chemistry, Concepts and Applications, 2000.