CHEMISTRY PROGRAMME ADVANCED LEVEL

Section: Biology – Chemistry

ADVANCED LEVEL CHEMISTRY PROGRAMME

FOR BTOLOGY-CHEMISTRY SECTION

INTRODUCTION

The programme in this section is intended to give the student sufficient knowledge that will anable him to pursue further studies be it in universities or any other institutions of higher learning.
The student who has followed this section is able to fit in fields related to Chemistry, Biology, Pharmacy, Agriculture, Medicine and any other related scientific courses. In addition he/she will be able to integrate himselfl herself in everyday life activities be it cultural, social, political or economical in Rwanda. This Chemistry is also intended to be the base for one to work in different scientific production units such as laboratories, industries, and other research centres.

GENERAL ORIENTATION

The student who has followed Chemistry and Biology as his main subjects like any other citizen or cadre, should not confine himself/herself to this field only but his mid should be open to other related social, political and economic fields in .Rwanda and the world in general.

GENERAL OBJECTIVES

At the end of this course, the student should be able to:
a) Apply the knowledge acquired step by step analytically in experimenting, observing and making conclusions which c help him/her in arriving at solutions of some problems.
b) Analyse situations scientifically.
c) Identify scientific problems.
d) Carry out scientific research on a situation.
e) Determine means of verifying a scientific problem.
f) Draw appropriate conclusion)
g) Make a general report on the researched situation.
h) Apply knowledge and transfer it to other situations.

SENIOR FOUR
SPECIFIC OBJECTIVES

At the end 4th year, the student will he able to:
1. Describe the structure of an atom.
2. Distinguish relative atomic mass.
3. Calculate the relative atomic mass.
4. Interpret the propetries of alpha. Beta and Gamma rays.
5. Write and balance nuclear reactions.
6. Define Half life.
7. Interpret a graph of ionisation potentiai agains! the nuniber ofelectrons.
8. Write the electronic configuration for thefirst 30 elenients using S,P,d, f orbitais.
9. Describe the di ferent types of bonds and properties ofcompounds.
10. ExpIa in the formation ofsigma and pi bonds in the double and triple bonds**.**
11. Interpret hvbridization of atornic orbitais.
12. Show the variation in atoniic radius. electronegativity. ionisation energy e.t.c. down the groups and a cross theperiods.
13. Idenlify experimentally anions and cations.
14. Expiain the reaction ofdifferent elements with selected reagents.

1.0. ATOMIC STRUCTURE
1.10. The particles which constitute an atom je. protons, neutrons, electrons and their properties.
1.20. Simple out une on their discovery.
1.30. Atomic number, mass number, isotopic mass compared with relative atomic mass.
1.40. Calculations of relative atomic masses given isotopic masses and abundancy e.g: 35C1 75%, CI 25%
1.50. SimpLe description of mass spectrometer and its uses.
1.60. Simple interpretation of mass spectrum e.g. : C12,H2, 12, Br2
1.70. Emission of alpha, Beta and Gamma rays, their properties and healthy hazards.
1.80. Nuclear equations including artificial transmutation.
1.90. Fission anci Fusion and applications; hydrogen bomb, atomic bomb and production of electricity.
1.91.. HaIf life and simple caiculations.
1.92. Uses of radio isotopes e.g.: ‘4C, 32p, 60Co, H
2.0. ELECTRONIC STRUCTURE
2.10. Hydrogen spectrum and spectral series e.g. : Lyman, Balmer Series.
2.20. Bohr’s model of an atom. Energy leveis and sub-leveis.
2.30. Graphical interpretation of ionisation potential against the number ofelectrons removed.
2.40. Pauli’s exclusion principle.
2.50. Electronic confugiration for at least the first 30 eiements using s,p,d and f orbitais.

3.0. BOND1NG
3.10. Tonic bond, ionic compounds anci their properties.
Examples of structure of ionic compounds face centred cubic (NaC1), body centred cubic (CsCI).
3.20. Covalent bond, covàlent compounds and their properties, polar and non-polar compounds.
3.3 0. Dative and coordinate bond e.g.: A12C16, NH, H304
3.40. Metallic bond and physical properties ofmetals e.g. conductivity, malleabulity, ductility, shineness.
3.50. Hydrogen bond and Van der Waal's Forces.
3.60. Formation of sigma and Pi bonds leading to double and Tripple bonds.
3.70. Hybridization of atomic orbital's, shapes of molecules based on electronic theory repulsion.
3.80. Linear shape, planar shape, tetrahedral, pyramidal, bent, octahedral, bipyramidal.
3.90. Comparing bond angles.
4.0. PERIODIC TABLE
4.10. Historical background.
4.20. Classification ofelements in the periodic table according to MENDELEIEV.
4.30. Variation of Physical properties in groups and periods le conductivity, melting and boiling point, atomic radius, electronegativity, electropositivity, ionisation, ellergy, and metallic character.
4.40. Comparative study oftheir chemical reactions.
4.50. Reactions of groups and 11 with:
a) Oxygen
b) Water
c) Halogens
d) Dilute acids.

3.0. BONDING
3.10. Ionic bond, ionic compounds and their properties.
Examples of structure of ionic compounds face centred cubic (NaCI), body centred cubic (CsCI).
3.20. Covalent bond, covalent compounds and their properties, polar and non-polar compounds.
3.30. Dative and coordinate bond e.g.: A12C16, NH, H30
3.40. Metallic bond and physical properties of metals e.g. conductivity, malleability, ductility, shineness.
3.50. Hydrogen bond and Van der WaaI's Forces.
3.60. Formation of sigma and Pi bonds leading to double and Tripple bonds.
3.70. Hybridization ofatomic orbital's, shapes ofmolecules based on electronic theory repulsion.
3.80. Linear shape, planar shape, tetrahedral, pyramidal, bent, octahedral, bipyramidal.
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4.40. Comparative study oftheir chemical reactions.
4.50. Reactions of groups I and 11 with:
a) Oxygen
b) Water
c) Halogens
d) Dilute acids.

4.60. Compounds of groups I and II
a) Oxides
b) Hydroxides
c) Ha1ides
d) Nitrates
e) Suiphates
f) Carbonates and hydrogen carbonates.
Extraction of sodium and calcium.
Uses of some compounds e.g. : MgSO4, NaHC0, NaCI, NaOH, KOH, etc
4.70. Group III
Reactions ofelements of group III (Boron and Aluminium) with
a) Oxygen
b) Water
c) Halides
d) Dilute acids
Sodium hydroxide
Study of group III compounds
a) Oxides
b) Hydroxides
e) Chlorides
Extraction of Aluminium and its uses

4.80. Group 1V.
- Comparative study ofphysical properties of group 1V elements.
- Study ofchemical properties ofelements carbon, silicon, tin, lead,
their compounds and uses .Refer to fuel gases eg natural gas ,water gas,
producer gas and also Si02, PbO, Pb304, Pb02., SnO,
4.90. Group V
The study ofphysical and chemical properties ofnitrogen and phosphorous.
Preparàtion ofnitrogen,study of its cornpounds and uses; NH3, N20, N02,N,0-, HNO3, N03
A Study ofphosphorus compounds and their uses i.e. P203, P706, PCI3, PCI5. H3P04, and P04
4.91: Group VI
- A Study ofphysical and chemical properties ofoxygen and suiphur.
- Extraction ofsulphur and the study of its cornpounds e.g. H2S, S02, S042, H2S04 Compare volatility and acidity of H2S and H,0.
4.92. Groupe VII
- Comparative study ofphysical and cheniical properties ofhalogens. i.e. physical state, volatility and colour.
- Reactions with oxygen, water, sodium, hydroxide.
- The study of main compounds of group VII and their uses.
.a) Acids-preparation, strength, volatility and their reducing power.
b) Chlorates and iodates e.g. KCIO3, Kb3 perchlorates and periodates and their uses.

4.93. Group VIII
- Study oftheir general properties and uses.
4.94. Period III
- Simple comparative study ofelements in period 111.
a) Physical properties e.g. melting and boiling points, atomic radius, physical state.
b) Basicity and acidity oftheir oxides, bonding in chlorides.
4.95. Transition elements (First Series).
- General characteristics:
a) Variation valency or oxidation state.
b) Catalytic ability.
c) Formation ofcolours in solids or solutions.
d) Magnetic properties.
e) Formation ofalloys.
f) Formation ofcomplex ions,
N.B. : Simple explanations ofeach ofthe above are required for complex ions, structures, naines and applications.
- Chemical properties ofCr, Mn, Fe, Cu ... and their conipounds. Reactions ofelernents with H20, HCI, HNO3 and H,S04. Propertiesofoxides, hydroxides and 0x0-anions.
- Extraction ofiron and copper and their uses.
- Identification ofNa. K. Mg2. CU2,Ba2. A13. Pb2 Fe2, Cr3, Mn24. Mn7. Cu2, Zn24, NH4. CO. NOV, SO.2, cl. r.

SENIOR FIVE
SfiçfljC OBJECTIVES

Al flic end of5 vear, the student should be ahle 10:
1. State three places in whicli peat (Nviraniugengeri) occuir naturally and give its applications.
2. Write structures ofAikanes, interpret its physical and chemical reactions with oxygen and chlorine.
3. Show structures ofAikanes and(nterpret theirphysical and chernical reactions with chlorine. water, hydroch/oric oci and azone.
4. Explain the preparation of ethyne and general chemical properties of ail aikynes.
5. Desci-ibe physical and chemical properties ofethyne and ifs uses.
6. Recognise organic substances iii terni offunctionai groups.
7. Classfy Aikanols and explain theirphysical and chemicaiproperties.
8. Describe methods ofpreparing ethanol and give ils physicai and chemical properties.
9. Describe the essentiai properties o! ethoxyethane as an exainpie of ethers.
10 Describe cornparatively ihe properiies ofaldehydes and ketones.
11. Interpret the chemical reactions with Fehlings and Toilen ‘s solutions.
12. Describe general methods ofpreparing ethanoic acid, give its physical, cheinicai properties and uses.
13, Describe methods of preparing ethanoic acids and give ils uses.
14 Identify the structures ofacid derivatii’e.s and give ifs chemical properties.
/ 5 Describe û simple method ofpreparing soap starting ii’ith stei:r.
16. Expia in physical and cheniical properties oaniines.
1 7. Describe the extraction of fats and oi/sfroni nuts and animais.
18. Show the properties of glucose. tarch and cellulose.
19. Show the structure ofAmino acids and explain the chemicai properties.
20. Show the peptide linkage in theforniatio,i 0f proteins and interp-et hydrlysis ofproteins.
21 Dfferentiate redox reactions and ihose tuai don “ show change in oxidation s tate.

22. Differentiate reversible and irreversible reactions.
23. Establish a matheniatical expression ,showing the rate ofreaction.
24. Define the order ofreaction.
25. Give using exaniples the difference /etween rate of reaction and concentration and explainfactors influencing the rate ofreaction.
26. Define heat ofreaction, interna! energv ofa system.
27. State Hess ‘s Law and app!y it to therinochernical calculations.
28. Exp!ain the enthalpy ofreaction and .state its applications.
29. Explain fermentation ofalcohol and saponification of esters e.g. in Sakirwa and Sulfo.
30. Explain the genera! procedures ofpreparing colo ured substances.

5.0. ORGANIC CHEM1STRY
5.10. Occurrence ofcarbon - coal and wood
- composition and uses ofcoal
- Making ofcharcoal from wood
5.20. Alkanes. Occurence - Petroleum; cracking and fractional distillation.
- Nomenclature ofup to the 20g',
- Physical properties.
- Structures and Chemical properties e.g. reactions with chlorine (substitution, oxygen, combustion) and mechanisms in the reactions with chlorine.
- Hornolytic fission ofthe bond and uses ofalkanes - fuel, petrol-chemical indus y.
5.30. Alkenes - Occurrence.
- Preparation methods.
- Nomenclature ofalkenes.
- Structure and positional isomerism.
- Physical properties and Chemical properties - Additions reactions (Cl7, HCI, H20) and the mechanisrns involved.
- Oxidation reactions (02, 03).
- Uses ofalkenes (ethene and propene).
5.40. Alkynes.
- Preparation, Nomenclature ofalkynes, structure and physical properties. Chemical properties (Addition reaction with Cl7, Hcl)
- A study ofethyne - Test for unsaturatjon.

5.50. AIkyl halides.
- Preparations, structure, nomenclature; physical properties and chemical properties.
- Reactions with H,O, NaOH, NH3, KCN, alcohol, CH3COOAg
- Mechanisrn of reactions showing SN2, SN, Heterolytic substitution.
- Elimination reaction to produce aikenes.
- Uses ofaikyl halides e.g. CCI4, CHCI3,
5.60. Alkanols.
- Preparation, structure, nomenclature and classes ofalcohols.
- Physical properties (importance of hydrogen bonds).
- Chemical properties, reactions with Na, PCl, CH3COOH, Dehydration and etherification (mechanism of reaction).
- Oxidation ofalcohols.
- Study ofethanol, its preparation, properties and uses. Tests for alcohols. Existance of POH alcohols
e.g. HO-C-C-0H
5.70. Esters - preparation, physical properties, structure, nomenclature and uses.
5.80. Aldehydes (Alkanals), Ketones (Aikanone).
- Preparation, structure, nomenclature and physical properties.
- Chemical properties reactions with HCN and the mechanisms NaHSO3, NI-I3, C6H5NHNI-12, 2,4 - dinitrophenyl hvdrazine. Oxidation liv rehling's solution and Tollen's reagent, Cr2O72, MNOE4, Fuchsin. Reduction ofalcohos. Reaction with PCI5. Reaction with Grignard reagent. Uses ofmethanal and acetone.

5.90. Aikanoic acids.
- Preparation, structure, nomenclature and physical properties.
- Chcmical pfoperties. Reactions with Na, Na7CO3, NaOH, PCI5, C,H5OH, CI2.
- Reduction wjth LiALH4.
00
- Existance of Polyacids e.g. HO - C - C - OH,
OHO
H-O-C-C-C-O-H
H
- Uses ofethanoic acid.
5.91. Acid derivatives.
Esters, acid chlorides, anhydrides, amides, nitriles.
PreparatiOnS, nomenclature, physical and chemical properties.
ReactionS with H20, NH3, ROH, RNH2, reducation of amides and Nitriles.
Mentioning of urea and saponification of esters but no details are required.
5.92. AmineS.
- Preparat on, structure, nomenclature and classsification into prirnary, secondary and tertially.
- Physical properties.
- Chemical properties-Basicity. Reaction with HCI, HN02. Acid derivatives and Grignard reagent.

5.93. - High molecular weight esters e.g. fats and oils (Lipids).
- Classes ofdifferent Lipids. i.e. Length of moiecule, existance of double bond and difference in phyi state.
- Extraction of fats and oils from nuts and soya beans, animais.
- Glycirides and saponification.
5.94. - Carbohydrates.
- Definition, general structures.
- Examples ofmonosaccaride and polysaccaride.
- Properties of glucose, starch, glycogene and cellulose. Their hydrolysis and condensation.
5.95. - Amino acids and proteins.
- Structure and properties ofarnino acids i.e. hasicity, acidity and formation ofZwitter ions.
- Peptide linkage to form proteins.
- Hydrolysis ofproteins.

6.0. CLASSIFICATION 0F REAUTIONS
6.10. Reactions in which oxidation state does not clange rieutralization. double decomposition.
6.20. - Redox reaction - balancing redox equations using halfredox equations.
- Many examples on each ofthe ahove reactions should be given. Identifying direct combination or decomposition and thc conditions suitable for each.
7.0. CI-IEMICAL KINETICS
7.10. - Defining the rate ofa reaction. rnathernatical rate expression which is experirnentally deterrnined (Rate K[A jfl)
- Differentiating order and mokcularity ofa reaction.
7.20. Factors that affect the rate ofreaction.
a) Concentration : expressed in terms of the collision ofniolecules and the rate expression. Examples on orders ofreactions and cleducirig orders from experimental data.
b) Temperature : effect on the rate ofreaction in terrns of collision ofrnolecules and the activation energy.
c) Catalyst: effect on the rate ofreaction in ternis of Iowering the activation energy. Properties ofcatalysts and the types ofcatalysis e.g. heterogeneous and homogeneous and the theory ofcatalysis.
cl) Pressure: effect on the collision of molecules.
e) Light: effect and examples of photochernical reactions,
f) Physicai state : effect of change ofstates.
Simple experiments using dock reactions to determinethe order ofreaction e.g. H202 and f or S2032
and H and the graphical representation.

SENIOR SIX

At the end ofthe 6ih form, the studeni ii'ill be able 10:

1. Define o mole.
2. Prepare solutions qfknou'n molarities.
3. Perform acid-base titrations with accuracv.
4. Deterniine the composition ofa mixture bi' titration.
5. Perform titrations on redox reactions.
7. Explain the concept ofchemical equilibrium andfactors that affect the position ofequilibrium.
8. Explain and apply the chatelier principle and apply it b dnaniic equilibrium.
9. Dfferentiate concentration equilibri uni constant and pressure equilibri uni constant (Ko, K,,).
10. Define degree of ionisation (alpha -
11. Djfferentiate strong and ii'eak electrolytes.
12. Establish the relationship hetween the degree of ionisation and equilibriuni constant.
13. Explain what ionicproduct ofwater is.
14. Define an acid and a base in terms of Brônsted and Lewis theorv.
15. calculate the pH ofa solution, given [H3 0 J or [OH .1 for a strong and weak acids or bases.
16. calculate the solubilily product (Kv).
17. Calculate the concentration of a solution given pH.
18. Calculate the pH ofa buffer solution and state the applications ofa buffer solutions.
19. Explain the concept ofelectrolysis and use Faradv s laws in calculations.
20. Interpret djfferent applications 0f electi-ol sis.
21. Ide,iti6' aromatic conipounds.
22. Interpret chemical reactions of Benzene and give the essential properties ofderivatives ofBenzene.
23. ExpIa in electrophilic substitution reactions of benzene and its derivatives.

8.0. CHEMICAL ENERGETICS!THERMODYNAMICS
8.10. - Definition of thermodynamics.
- Difference between a syslcm and its surroundings.
- Explaining the internai energy ofa system.
Examples on the energy ofreactants and products and the H (enthalpy or heat ofreaction).
8.20. - Exothermic (iH negative) and endothermic (H = positive) reactions.
- Energy profile for a chernical reaction using simple energy diagrams.
- Different enthalpies ofreaction: combustion, formation, neutralization, solution, hydration and lattice energy for ionic compounds.
• - Hess'law - definition and applications (calculations).
- Applications oftH or enthalpy ofreactions i.e. feasibility ofa reaction.
N.B. A reaction being feasible thermodynarnicaliy when in pratice it is impossible due to kinetic factors.
8.30. - Bond energies - Calculations and applications.
- Simple experiment on heat of combustion and heat ofneutralization.

24. Give examples of addition and condensation pot viners. their methods of formation and applications.
25. Dfferentiate types of isomerism.
26. Describe industrial rnethods ofpreparing some useful chemical coinpounds and state their uses e.g. NH3, NHO3. . H, S04, . Fertizers like P04 aiid S04 -
27. Describe methods ofextracting certain metals fi-oin their ores (Al. Fe. Zn, Cii, Sn).
28. Describefractional distillation of crude ou.

9.0. MOLE CONCEPT.
9.10. - Review of the definition ofa mole in terms ofAvogadro's number.
- Review of the definition ofrnolarity and concentration ofa solution.
- How to make solutions of known molarities by weighing and dissolving in 250 ml volumetric flask.
- Simple acid-base titrations using Methyl orange and phenolphthalein indicators.
- Determining the atomic masses and moles ofwater ofcrystalization in XOH (X = Na or K), H2C204.XH2O (X = 2) by titrating Na,C0;. X H-,0 (X = 10) with I-12S04, NaOH and HCI respectively.
9.20. Determining the percentage composition ofNa2CO3 mixed with NaCI solution and titrating with HCI solutions. Calculations on moles in general and many acid-base titration ?r0)1em5.
9.30. Titrations involving redox reactions e.g. MnOE4 and Fe2, Cr20{ and Fe2 , S2032 and f , Mn04 and C2042 and so on.
9.40. Back titrations and the calculations involved.
10.0. CHEMICAL EQUILIBRIUM.
10.10.- Definition ofequilibrium and examples on reversible reactions.
- Position ofequilibrium and factors in accordance with the chatelier principle.
10.20. Factors
- Concentration : equilibrium law and it derivation. Calculations involving equil i bri um constant.
- Pressure equilibrium law in terms of partial pressures ofgases. Calculations involving equi li bri um constant.
lO.30.Applications offactors on industrial processes i.e. contact process andHaber process.

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11.0. IONIC EQUILIBRIA
11 . 10. Alkalinity and Acidity on Lewis and Brnsted/Lowry with examples.
11.20. Ionic equilibrium ofwater E iOflC product. [H4] being equivalent to [0H]
11.30. Dissociation ofweak acids - degree of dissociation and dissociation constant. Calculations involved.
11.40. Dissociation ofweak bases. Sparingly soluble solids solubility product (K0) and calculations involved. Common ion effect..
11.50. pH and pOH : definition and relationship at 25°C and calculations involved. pH ofstrong and weak acids and bases.
11.60. Buffer solution calculating the pH of buffer solution and applications.
11.70. Theory of indicators choice of indicators and pH titration curves.
11.80. Qualitative study ofthe hydrolysis ofsalts.
12.0. ELECTROCHEMISTRY
12.10. - Conductance and conductance ofelectrolytes.
- Molar conductance at infinite dilution. lonic mobility and ionic interference.
12.20. Electrolysis
- Faraday's laws and caiculations.
- Relation ship with avogadro's constant and calculations.
- Uses and applications e.g. electroplating, production ofNaOH, Cl2, copper refinery and Aluminium purification.
12.30. Electrochernical cell. Halfcells and measuring of electrode potential using hydrogen electrode.
- Celi diagrams' celi rcprcsentation and calculations for celI voltage.
- Study ofspecific cell dry ccli and lead acid accumulator.

13.0. AROMATIC COMPOUND
13.10.- KeIuIe's Structure ofBeiizene - Source ofbenzene.
- Chemical properties Addition reaction with H2 and Cl2.
- Electrophilic substitution - Halogenation, aikylation, Acylation, Nitration, Sulphonation.
- Mechanism ofreaction ofhalogenation, nitration and suiphonation.
- Naming ofthe products.
13.20.Derivatives ofbenzene - Methylbenzene - Source and physical state.
- Chemical properties like in benzene and also
Its reaction with C12 (Addition) and oxidation ùsing Mn04
13.30.Alkanols and phenols - Alcohols - Phenyl methanol
- Preparation, chemical properties, electrophilic substitution and side chain reactions.
- Phenol - Preparation, Physical and chemical properties (electrophilic substitution)., its acid properties and uses.
13.40 .Arornatic aldehydes and Ketones - electrophi lic substitutions.
I 3.50.Aromatic acids - Physical properties, chemical properties (electrophilic substitution) and derivatives ofaromatic acids.
13.60.NitrobeflZefle and phenylamine - Preparation ofaniline using nitrobenzene. Physical and chemical properties of aniline - diazotization.
- Coupling reaction with phenol and aniline.

I 3.70.POLYMERISATION

- Additional polymers: - Preparation ofpolyethene, polypropene, polychioroethene (P.V.C.) properties and uses.

- Condensation polymers : - Polyester e.g. Telylene, polyamide (Nylon 6,6).

- Preparation, properties and uses.

- Examples ofthermosoftening and thermosetting or thermohardening polymers.

- Natural polymers: - examples rubber and cellulose.

I 3.80.ISOMERISM

— Structural isomcrism : — Positional, lunctional. chain isomerism.

— Stereo isomerism : — Geometrical and optical isomensm.

14.0. APPLIED CHEMISTRY

- Manufacture ofammonia using Haher process.

- Industrial manufacture ofniiric acid h' the caialvtic oxidation ofammonia.

- Contact process for sulphuric acid.

- The manufacture offertilizers e.g. ammonium suiphate, potasium suiphate and phosphate fertilizers.

- Extraction metals. Aluminium. Zinc. copper from their ores and the tin ore in Rwanda.

— 011 refining, distillation and cracking of petrolcum.

- Fermentation processes (enzyme catalysis should he mentioned but not treated in details).

- Soap production including local production ofdetergents (Sakirwa and Sulfo).

- Production ofdye stuffs.

M ETH000LOGY

Student Background

The student entering this section will have al ready acquired a good background oftheoretical aiid practical chernistry. He wilI have also acquired a good experience n handling of rnost ofthe laboratory equipments.

How the teacher will organise the class

For the proper teaching ofchemistry students may work in groups or individually in order to acquire enough knowledge, and skills.

The senior six student will have reached a stage where he is capable of sowing practical and theoratical prôblems on bis own. That is he will be able to carry out experiments in the laboratory make observations and inferences and make a report about his findings.

E VALUATION

In this section the student will be evaluated according to bis ability and skills in handiing laboratory materials and in sowing scientific problems by use of accurate observations and inferences.

The usual method of oral test and examination questions should be continuous.

The daily accessrnent of the student must he followed strictly and the student sli ve(1 be corrected and shown bis weakness and strengtl.

At the end of six years a student should do a chemislry national examination for ail the work covered which wili show that the stucient is capable of going for further studies.

PARTI CULAR FACTORS

It is highly recornmended that two periods per week should be allocated strictly to practical work, because ofemphasis put on experimenting which makes the student understand the subject better.

The chemistry commission recommends that schools offering this combination should have laboratories, sufficient laboratory materials and chemicals for the proper teaching ofthe subject.

Wc also recommend that science and mathematics teachers should have regular seminars and workshops to harmonise the teaching ofthese subjects; to share scientific information and to learn new techniques.

Finally the chemistry commission recommends the setting up ofa chemistry inspection on a national level and a national examination board which will organise a chemistry national examination at the end of six years the results ofwhich wilI be major contributor for the entrence to the university.

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7. Cheniistry in context.
8. inorganic Chemistry by LTPTROT.
9. Chemistry by Ramsden.
0. Worked examples by Lambert and Holderness.
il. Organic Chemistry by Brown.