CHEMISTRY
—
SYLLABUS

INTERIM JOINT MATRICULATION BOARD

INTERIM JOINT MATRICULATION BOARD EXAMINATION (IJMBE) CHEMISTRY SYLLABUS (REVISED 2012)

1.0 Introduction
1.1 Preamble

The IJMB syllabus prepares candidates for A-level examination and the Chemistry syllabus is designed to lay a solid and broad-based foundation on the advanced principles of the subject matter. The organization of the syllabus is as far as possible in a logical teaching order (within any given section) but the experienced teacher may well wish to vary the order of presentation of topics. The basic and advanced principles of Chemistry are best understood by investigating them in the laboratory, therefore the Chemistry course should be firmly based on practical work. The theoretical and practical aspects of the subject should form an integrated whole. It is intended that most areas of the syllabus will be illustrated by references to Applications of Chemistry.

The assumptions that are made while drawing this syllabus includes

i. that candidates must have covered and passed at credit level, the Chemistry and Mathematics syllabus at the Senior Secondary School (S.S.S) level.

ii. that candidates have developed competencies and skills as spelt out in the Chemistry teaching syllabus at the Senior Secondary School level.

iii. that each center has a well-equipped laboratory

iv. that candidates are familiar with the use of significance figures, S.I units and the IUPAC system of nomenclature

1.2 Aims and Objectives

a. Aims: The broad aims of the syllabus are to provide knowledge in Chemistry adequate for candidates who:

i. wish to continue the study of Chemistry in tertiary institutions particularly for entry at 200 level in the universities.

ii. require the advanced principle and application of Chemistry in their vocational studies.

57

iii. want broad knowledge of Chemistry to enable them fit into the middle manpower requirements at the Chemical industry and therefore will end their study of Chemistry at this level.

b.   Objectives: The broad objectives of the syllabus are to:
   i.   build on the knowledge and skills acquired in Chemistry at the Senior Secondary School level.
   ii. provide students with advanced knowledge in Chemical concepts and principles through efficient selection of content
   iii. enable students to appreciate experimentation, accurate observation, recording, deduction and interpretation of scientific data.
   iv. enable students improve on and develop new laboratory skills including an awareness of hazards and safety in the laboratory.
   v.   appreciate the inter-relations of Chemistry with Physics, Geology, Biology, etc.
   vi. appreciate the link between Chemistry and the industry, the environment and everyday life in terms of benefits and hazards.

1.3   Syllabus Contents

The syllabus content consists of course topics/contents/duration and performance objectives/activities. The performance objectives are defined in specific, measurable and behavioural terms such as recall, state, identify, deduce, define, differentiate, sketch interpret, analyze, etc.; these performance objectives clearly reflect what the learners are expected to gain after they have been taught the topics.

A time framework has been attached to each main topic to ensure that the syllabus is covered before the IJMB examination. Some of the lecture hours could be used for tutorials on each topic to further enhance the teaching and learning process making for a better understanding of the lecture topics by students.

1.4   The Examination Structure

The examination will consist of three papers, paper 1, paper 2, and paper 3.
a.   Paper 1: The paper is a theory paper divided into section A and section B, which covers all aspects of General, Physical and Inorganic Chemistry.

58

The paper shall be for duration of 3 hours and carries a total score of 150 marks.

   i.   Section A: shall consist of ten (10) structured questions. Students are required to attempt all questions within I hour. (Total marks = 50)

   ii. Section B: shall consist of six (6) essay questions. Students are required to attempt any for (4) questions within 2 hours. Each carries 25 marks. (Total marks = 100).

b.   Paper 2: The paper is a theory paper divided into section A and section B, which covers all aspects of Organic Chemistry. The paper shall be for duration of 2 hours and carries a total score of 100 marks.

   i.   Section A: shall consist of ten (10) structured questions each carrying five (5) marks. Students are required to attempt all questions within I hour (Total marks = 50).

   ii. Section B: shall consist of four (4) essay questions. Students are required to attempt any two (2) questions, within 1 hour. Each carries 25 marks. (Total marks = 50.

c.   Paper 3: the paper is a three (3) hour practical paper comprising of two questions and shall carry a total of 80 marks. Candidates will be required to answer all the two questions. One question is on quantitative analyses (50 marks) and one question on qualitative analyses (30 marks). The questions may also contain some aspects of theory of practicals.

1.5   Results

1.   The final IJMB examinations account for 80 percent (i.e. 330 marks scaled down to 80 by multiplying score obtained with 0.2424) of the final score while the continuous assessment accounts for the remaining 20 percent.

2.   The 20 percent continuous assessment score is made up of 10 percent from end of semester/mock examinations, 5 percent from practical exercises, 3 percent from class tests/assignments and 2 percent from regular class attendance. All written assessments should be conducted under examination condition. Record of continuous assessment should be kept up-to-date so that the examiner can periodically check question papers, scripts and marks obtained by students.

59

3. It is a condition that a candidate must have a score in each of the three examination papers and the continuous assessment to qualify for a final grade.

4. At the end of the marking exercise each year, the subject panel will recommend to the IJMB board for approval a final grade scheme for the examination. The final grade recommended shall be in order of merit from A to F, with A, B, C, D, E, as pass grades and F as failure. The letter grade shall conform to the score range structure for the IJMB examination.

60

DETAILED SYLLABUS

FIRST SEMESTER SYLLABUS 132 Hours Lectures + 24 Hours Tutorials=156 Hours

S/No	TOPICS AND CONTENTS	ACTIVITIES / PRACTICAL GUIDE	INSTRUCTIONAL MATERIALS	DURATION
GENERAL CHEMISTRY				
1.	ATOMS, MOLECULES, ELEMENTS AND COMPOUNDS (a) Definition of atoms, molecules, elements and compounds and interrelation with one another	Define and Differentiate between atoms, molecules, elements and compounds.	Recommended texts	8 hours
	(b) The law of conservation of matter, law of constant proportion, the combining volumes, Avogadro's hypothesis: definitions and experimental verifications and calculations. Limitations of the laws	Recall the laws of chemical combination, definite proportion, etc. and calculations based on the laws given appropriate data	Periodic table of elements Four figure table Simple electronic calculator	
	(c) Atomic mass scale: ^{12}C as the standard, determination of the relative atomic and molecular masses by mass spectrometry (Details of mass spectrometry not required).	a. Recall the ^{12}C atomic scale for relative atomic and molecular masses b. Define isotopes and give some examples c. Calculate the relative atomic mass of an element from the percentage abundances of the isotopes		
	(d) Relative vapour densities and relationship with relative molecular mass (RMM). Determination of molecular mass by Victor Meyer's method. Use of the simple gas law, $PV = nRT$ to determine relative molecular masses of gases	a. Define relative vapour density and state its relationship with RMM of a compound b. Describe Victor Meyer's experiment for RMM determination and the calculations involved c. Recall that the molar volume of a gas at S.T.P. is $22.4dm^3$		
	(e) Avogadro's number, the			

61

	mole as a fundamental unit in Chemistry, mass and mole ratios in reactions, mole concept and its applications in volumetric analysis should be treated in details.	a. Define the mole and Explain the relationship with Avogadro's number b. Recall that Avogadro's number is 6.023×10^{23} mole^{-1}. c. Define molarity and molality d. Convert from one concentration unit to another e. Calculations involving solutions i.e. mode of expressing concentration: moldm^{-3} molkg^{-1} solvent, w/w percent w/v percent, mole ratio. f. Steps involved in solution preparation and calculations involving standard solutions of simple salts acids/bases g. Explain and use the dilution principle $m_c v_c = m_d v_d$ (c = concentrated d = dilute)		
2.	GROSS FEATURES OF ATOMIC STRUCTURE (a) Electrical nature of atoms: electrons, protons and neutrons from the works of Faraday, Goldstein, Thompson, Millikan, Becquerel (natural radioactivity) Moseley and Rutherford. Mathematical aspect not required. Qualitative treatment only.	a. Describe Dalton's atomic theory and test it in the light of the contribution of each listed scientists to the elucidation of atomic structure b. List and give relative charges and masses of the 3 fundamental particles in an atom	Periodic table of elements Models of atomic structure Recommended texts	12 hours
	(b) Atomic number, mass number isotopes – detection and uses	a. Recall the definition of isotopes, atomic number and mass number b. Recall some methods of detection of isotopes		
	(c) Models of the atom, qualitative descriptions of (i) Rutherford's atomic models,	a. State the contributions of – Rutherford, Thompson and Bohr to	Models chart of s, p and d orbitals	

62

electronic energy levels' (evidence from emission spectra). (ii) Bohr's atomic theory: the basic postulates arrangement of the electrons in the energy levels. Main levels, sublevels orbitals, electron spin, quantum numbers: principal, subsidiary, magnetic and spin. Shapes and symmetries of s, p and d orbitals. Energy level diagrams Aufbau principle, Pauli's exclusion principle, Hund's rule, Heisenberg uncertainty principle and electron configuration. Degeneration of atomic orbitals and filling of electrons

the theories of the atom
b. Give the limitations of Rutherford and Bohr's analyses of the atom
c. Explain the origin of lines in the spectrum of hydrogen using Bohr's theory
d. Recall the use of K, L, M, N, etc to identify electron shells
e. Define an orbital
f. List and explain the significance of the 4 quantum numbers.
g. Recall simple charge cloud representations of the s, p and d orbitals and the rules for assigning electrons into orbitals
h. Sketch the shapes of the s, p and d orbitals
i. Write electron configuration of atoms
j. Recall the advantages of quantum model of the atom over other atomic models

(d) The periodic law and periodic table: The periodicity of electronic configuration leading to periodicity of properties such as atomic radius, ionization energy, electronegativity and electron affinities. Classification into s, p, d and f block elements. Horizontal, vertical and diagonal relationships to be mentioned. Note: Periodic table giving symbol, atomic number and mass shall be provided to students at the time of examination

a. State the periodic law and Explain the terms period and group as they relate to the periodic table.
b. Define the terms: electron affinity, electronegativity, ionization potential, etc. and Account for the variation of these properties in the periodic table
c. Account for horizontal relationships between elements in the periodic table
d. Identify s, p, d and f block elements from their electronic configuration and their block chemical

63

		and physical properties. e. Periodic bond types between elements by virtue of their ionization energy, electron affinities or electronegativities		
3.	CHEMICAL BONDING Use of Lewis structure (electron dot/cross formular) to discuss;			
	(a) Electrovalent (ionic bond) Importance of octet rule to explain valences, importance of ionization potential, electron affinity and electronegativity in predicting bond types.	a. Write Lewis structures for ionic compounds. b. List factors that will determine whether a bond is ionic or otherwise. c. Recall that octet of electrons confer stability. d. Explain physical and chemical properties of ionic solids in relation to bond type	Periodic table of elements Chart / model showing nature of bonding in molecules	12 hours
	(b) Covalent Bonds, comparison of electron dot structures for ionic, partially ionic and covalent bonds. Valence bond description, electron sharing, concept of hybridization, single, double and triple bonds. Polar covalent bonds e.g. H_2S, H_2O, BCl_3 etc. Prediction of bond types using Fajan's rules and properties associated with bond types. The concepts of resonance to rationalize the possible existence of multiple structures	a. Write Lewis structures for covalent compounds. b. Explain unequal sharing of electron pair by bonded atoms. c. List some properties of covalent compounds. d. Explain sp, sp^2 and sp^3 hybridization in carbons. e. Explain the arrangement of carbon atoms and differences in the physical properties in diamond and graphite. f. State Fajan's rule and use it to predict bond type. g. Explain the concept of resonance h. List common compounds that have multiple bonds	Model of diamond and graphite structures Models of CO, H_2O, CO_2, CH_4, etc. molecules	
	(c) Co-ordinate covalent bonds – examples with Cu salts, ammonium chloride, hydroxonium ion and	a. Differentiate a covalent bond from a co-ordinate covalent bond.		

64

ammonia/borontrifluoride complex	b. Explain the formation of co-ordinate bonding in transition metal complexes and hydrated ions, e.g. Cu with NH_3 and H_2O. c. Identify some common ligands, e.g. NH_3, H_2O. d. Relate ligands to Lewis bases		
(d) Metallic bonding – General properties of metals and explanation for them in terms of electron cloud structure e.g. metallic lustre, ductility, malleability, conductivity and cation formation. Brief comparison of electrons in atoms, molecules and metals in terms of energy levels	a. Explain metallic bonding and Account for metallic properties based on nature of bonding. b. Differentiate between metallic and electrolytic conduction	Chart showing metallic bonding	
(e) Intermolecular bonding: i. Hydrogen Bonding especially using hydrides of Group V to VII. Explanation of molecular association for H_2O and HF compare the dipole-dipole effect that exists in acetone but not in butane.	a. Explain why H-bonding and van der Waals forces are called intermolecular forces. b. Use H-bonding to explain why H_2O is a liquid but H_2S and HCl are gases; and why HF is a weaker acid than HCl c. Explain why dipole-dipole effect is absent in butane	Chart showing hydrogen bonding	
ii. van der Waals forces. Explanation of existence in non-polar molecules, e.g. Helium. Relationship between the strength of van der Waals forces and phase change temperature e.g. bpt of inert gases and hydrogen halides: iodine(s) and chlorine (g)	a. Recall that in non-polar molecules electron arrangement occurs. b. Recall that van der Waals forces increase with increasing dipole and size of the electron cloud. c. Explain why Cl_2 is a gas but I_2 is a solid. d. Use van der Waals forces to explain the low melting points of molecular solids such as candle wax, iodine etc.		

(f) Molecular orbital theory: Qualitative Description. Comparison with valence bond theory, combination of atomic orbitals for hydrogen and helium to give bonding and anti-bonding orbitals, non-existence of Be_2. Existence of H_2, O_2, and F_2. Introduction of p-orbital overlap and rules for electron distribution applied to second period molecules. Bond order calculations and application to simple molecules

a. Differentiate between the valence bond theory and the molecular orbital theory.
b. Write electron configurations for simple diatomic molecules using the molecular orbital theory.
c. Calculate bond orders
d. Predict existence or non-existence of simple molecules from bond order calculations.
e. Differentiate between σ_s and σ_p orbitals.

(g) Dipole moment: Qualitative description and comparison for some molecules. Bond dipoles and molecular dipoles. No numerical problems to be given

a. Define (qualitatively) dipole moment.
b. Differentiate between bond dipoles and molecular dipoles.
c. Use molecular dipoles to predict shapes of simple molecules e.g. CO_2 and SO_2

(h) Shapes of molecules. Use molecular dipole moment in predicting and/or rationalizing molecular shape e.g. CO_2 (linear) SO_2 (non-linear). The concepts of bond angles and bond lengths (effect of atomic number, bond type and nature of group). Electron pair repulsion theory, basic assumptions e.g. octet molecules/ions: CH_4, NH_4^+, H_2O, NH_3. Non-octet molecules: BF_3, $SnCl_2$, $HgCl_2$. Reasons for deviation in bond angles from expected values

a. Explain shapes of simple molecules.
b. Explain the concepts of bond angles and bond lengths.
c. State the effects of factors such as atomic number, bond type and nature of group on bond angle and length.
d. Sketch shapes of some simple molecules.
e. State the electron pair repulsion theory and use it to explain deviations in bond angles from expected values for some molecules.
g. Use the concept of hybridization to explain bond angles in some octet molecules such as CH_4,

66

		NH$_3$, H$_2$O, etc.		
4.	STOICHIOMETRY, OXIDATION- REDUCTION REACTIONS Electronic concepts, half reactions and oxidation number. Candidates will be expected to use the concept of oxidation numbers and half reaction equations to balance oxidation reduction (Redox) reactions	a. Define oxidation reduction (Redox) reactions b. Recall the rules for assigning oxidation numbers to elements in compounds and reactions. c. List some common oxidizing and reducing agents and their reactions. d. Use half reaction and oxidation number methods to balance Redox reaction equations. e. State and apply the rules for balancing Redox equations in aqueous acid/alkaline medium. f. Do volumetric analysis with some Redox systems in aqueous medium	Voltmeter	4 hours

PHYSICAL CHEMISTRY

5.	STATES OF MATTER (a) Gases – Ideal. Boyle's Law, Charles Law and the absolute temperature scales, Dalton's Law of partial pressures, Graham's Law of diffusion, General gas equation, Gay Lussac's Law of combining volumes, Avogadro's Law, the concepts of molar volume and the value of the gas constant R= 8.314 Jk^{-1}mol^{-1}	a. State all ideal gas laws and do calculations b. Illustrate Boyle's and Charles' laws graphically. c. Explain the concept of absolute zero temperature. d. Evaluate volumes of ideal gases (from moles at S.T.P.) given suitable data. e. Recall 22.4 dm^3 as molar volume of an ideal gas at S.T.P.	Simple charts showing graphical representation of the gas laws	12 hours
	(b) Kinetic molecular theory. Derivation of the equation PV = 1/3 nmc^2 from the postulate of the theory and its application to the gas law	a. State the postulate of the kinetic molecular theory for an ideal gas and the derivation of the expression PV=1/3nmc^2. b. Deduce the ideal gas		

	laws from the kinetic molecular theory equation and State the causes of deviation of real gases from ideal behaviour	
(c) Real gases Qualitative account of deviations from ideal behaviour. Introduction of van der Waals' equation (qualitative account)	a. Differentiate between ideal and real gases. b. Identify the kinetic molecular theory postulate that may not hold for real gases at certain temperatures and pressures. c. State the van der Waals equation and account for the constants 'a' and 'b' in the equation and relate the values for H_2 & CO_2	
(d) Liquids: Liquids as intermediates between gases and solids. Changes of state, phase diagrams of one component system, cooling and heating curves, super cooling, vapour pressure and boiling point. Effect of bond type on the boiling point.	a. Define phase and phase diagram b. Sketch and label simple phase diagrams e.g. of water and carbon dioxide. c. Use the kinetic molecular theory to explain phase change. d. Sketch cooling and heating curves and explain the various segments of the curves. e. Account for liquid vapour pressure. f. Define normal boiling point. g. State the effect of bond type on b.pt of liquids. h. Arrange liquids in order of increasing/ decreasing b.pt when the saturated vapour pressures are given at a particular temperature	A chart showing phase changes Distillation set up Charts of liquid mixtures
(e) Solutions: solution terminology, solubility of	a. List different types of solution. b. Express solution concentration in different units. c. Predict temperature	

68

solutions, Raoults Law, separation of liquid mixtures by distillation or by cooling. Colligative properties, effect of non-volatile solutes on the phase diagram of pure solvents e.g. b.pt elevation and freezing point depression, boiling point elevation and related calculations. Osmotic pressure. Deviation from Raoults law. Brief mention of separation of non-ideal liquid mixture and formation of azeotropes.	substances. d. State Raoults law and Calculate the vapour pressure of an ideal solution. e. Explain separation by fractional distillation using an appropriate vapour pressure/ composition diagrams e.g. in crude oil and liquid air. f. Explain deviations from Raoult's law and formation of azeotropic mixtures. g. Define colligative properties and list examples. j. Calculate b.pt elevation or freezing pt depression using the equation $\Delta T = km$. k. Calculate osmotic pressure using the equation $PV = nRT$.		
(f) Solids. Structure of ionic solids – isomorphism, unit cell, lattice structure and lattice defects. Types of crystal systems and classification of solids by units that occupy the lattice points e.g. molecular ionic, covalent and metallic solids. (Students will not be required to do calculation geometry)	a. Define unit cell, lattice, lattice energy and lattice defects. b. List the types of crystal systems. c. Explain solid physical properties based on units that occupy the lattice points e.g. why b.pt of ionic solids are so much higher than for molecular solids. Why metallic solids conduct electricity but ionic solids do not.	Models of crystal lattice	
6. THERMOCHEMISTRY

(a) Relationship between chemical energy and thermal energy. Exothermic & endothermic reactions, | a. Define exothermic and endothermic reactions b. Write thermochemical equations for reactions | Electronic calculator / four figure table | 8 hours |

thermochemical equations, effect of physical state on the heat of reaction and the use of energy level diagrams. (b) Heat (or enthalpy) of formation, combustion, neutralization, solution (effect of lattice energy on the heat of solution, difference between integral heat of solution & at infinite dilution) dilution, reaction and change of state.	c. Draw energy level diagrams for exothermic and endothermic reactions a. Define the different heats of reaction. b. Differentiate between the integral heat of solution and heat of solution at infinite dilution. c. Relate latent heat to heat of change of state. d. Explain the effect of dilution on heats of solution and hydration.
(c) Hess's Law and its application	State Hess's law and apply to problems, e.g. in calculation of heat of reaction and heat of formation for reactants and products.
(d) Energy factor in the formation of ionic compounds, the Born Haber cycle, lattice energy and calculations	Calculate lattice energy using Born Haber cycle given relevant data.
(e) Bond dissociation energy and calculation of enthalpy with particular reference to certain bonds e.g. $C-C$, $C=C$, $C\equiv C$, $C-H$, $C=O$, $C\equiv N$	a. Differentiate between bond energy and mean bond energy. b. Write thermochemical equations to depict bond dissociation. c. Calculate heat of a reaction from mean bond energies and Explain why the heat of reaction by means of bond energy method may differ markedly from experimental values. d. Calculate bond energies for specified bonds in a compound from suitable data.
(f) Spontaneity of a reaction. Entropy as a driving force in	a. Explain the concepts of spontaneity of reactions and entropy.

thermochemical equations, effect of physical state on the heat of reaction and the use of energy level diagrams. (b) Heat (or enthalpy) of formation, combustion, neutralization, solution (effect of lattice energy on the heat of solution, difference between integral heat of solution & at infinite dilution) dilution, reaction and change of state.	c. Draw energy level diagrams for exothermic and endothermic reactions a. Define the different heats of reaction. b. Differentiate between the integral heat of solution and heat of solution at infinite dilution. c. Relate latent heat to heat of change of state. d. Explain the effect of dilution on heats of solution and hydration.
(c) Hess's Law and its application	State Hess's law and apply to problems, e.g. in calculation of heat of reaction and heat of formation for reactants and products.
(d) Energy factor in the formation of ionic compounds, the Born Haber cycle, lattice energy and calculations	Calculate lattice energy using Born Haber cycle given relevant data.
(e) Bond dissociation energy and calculation of enthalpy with particular reference to certain bonds e.g. $C-C$, $C=C$, $C\equiv C$, $C-H$, $C=O$, $C\equiv N$	a. Differentiate between bond energy and mean bond energy. b. Write thermochemical equations to depict bond dissociation. c. Calculate heat of a reaction from mean bond energies and Explain why the heat of reaction by means of bond energy method may differ markedly from experimental values. d. Calculate bond energies for specified bonds in a compound from suitable data.
(f) Spontaneity of a reaction. Entropy as a driving force in	a. Explain the concepts of spontaneity of reactions and entropy.

70

chemical reactions. Introduction of the idea of structural stability and thermal stability of products. The concept of free energy as a predictor of spontaneity. $\Delta G^o = \Delta H^o - T\Delta S^o$	b. Relate structural stability to entropy and thermal stability of product to enthalpy. c. Recall the equation $\Delta G = \Delta H - T\Delta S$. d. Recall that ΔG must be negative for a spontaneous reaction. e. Use the free energy concept to explain why some exothermic reactions are non spontaneous while some endothermic processes are.		

ORGANIC CHEMISTRY

Mechanisms should be discussed whenever applicable and IUPAC system of nomenclature used 7. INTRODUCTION TO ORGANIC CHEMISTRY Brief review of the development of organic chemistry (a) Molecular compounds (aliphatic, aromatic, cyclic, unsaturated and saturated). (b) Purification of organic compounds i. Purity and physical characteristics ii. Determination of melting and boiling points iii. Crystallization and recrystallization iv. Simple distillation v. Fractional distillation (e.g. benzene and toluene) vi. Steam and vacuum distillation vii. Liquid extraction viii. Sublimation ix. Chromatographic separation (c) Detection and determination of elements (C, H, N, S and	Candidates should recall the contribution of Wohler who transformed ammonium cyanate into urea, the first synthetic organic compound. Candidate should: Classify organic compounds as aliphatic, aromatic and cyclic; and as either saturated and unsaturated a. Recall the methods used to purify organic compounds b. Identify the best method of choice for purifying different types of impure organic compounds. c. Relate the concept of melting and boiling points to purify of organic compounds.	Melting and boiling point apparatus Simple distillation kit, extractors, chromatographic paper, TLC plates, columns	8 hours

71

		halogens - sodium fusion test) Determination of empirical and molecular formular	Candidates should: i. Describe the Lassigne test (sodium fusion test) in the detection of the elements nitrogen, sulphur and halogen in organic compounds. ii. Calculate empirical and molecular formula from experimental data.		
8.		ELECTRONIC CONCEPTS IN ORGANIC COMPOUNDS (a) Hybridization (sp, sp^2, sp^3)	Candidates should: i. Define hybridization ii. Sketch the shapes of sp, sp^2, sp^3 hybridization. iii. Describe the bond angles of organic compounds that are sp, sp^2, sp^3 hybridized.	Periodic table Charts on bonding Recommended text Chart showing s, p and hybrid orbitals	6 hours
		(b) Characterization of bond types into $H_3C–CH_3$, $H_2C=CH_2$ and $HC\equiv CH$	Candidates should: a. Recall the term orbitals and explain their involvement in bond types. b. Characterize bond types of single, double and triple bond in organic compounds. c. Describe covalent bonding and explain σ and π bonds formation, then apply it to characterize bond types		
		(c) Effect of structure on reactivity: i. Polarity and dipole moments ii. Molecular association, hydrogen bonding. iii. Inductive effect iv. Electrometric effect v. Steric effect	Candidates should be able to: i. Define each of the concepts with suitable examples ii. Relate polarity of bonds and dipole moments iii. Relate molecular association and hydrogen bonding. iv. Describe inductive		

72

		effect particularly groups or atoms that exhibit positive and negative inductive effect. v. Explain the influence of electrometric effect in compounds that have πbonded groups such as carbonyl, alkenes, alkynes, and benzene ring during chemical reactions. vi. Describe the effect of bulky groups on the reaction centre of an organic compound during chemical reaction.		

PHYSICAL CHEMISTRY

9.	CHEMICAL KINETICS (a) Overall reaction and elementary process	a. Define overall reaction and Differentiate from elementary process. b. Write overall reaction from a number of reactions elementary processes and identify intermediates of the reaction. c. Differentiate between a reaction intermediate and an activated complex.	Graph board Calculators / four figure table	14 hours
	(b) Order and molecularity concept	a. Differentiate between order and molecularity. b. Differentiate between overall order and order with respect to a reactant of the reaction. c. Deduce order from a given rate law. d. Predict the change on reaction rate with a change in a reactant concentration given data.		
	(c) First order rate law. Analysis of experimental results for first order reactions.	a. Represent graphically the change in rate with reactant concentration for a 1st order reactant.		

73

i. For gaseous reactions when pressure measurements are observed. ii. For homogenous liquid reactions e.g. acid hydrolysis of an ester. iii. For reactions in solution when a physical property is used, e.g. application of a polarimeter to measure angle of rotation.	b. Recall that for a first order reaction 'ln (a/a-x) = kt' and perform calculations using the equation. c. Suggest suitable experimental methods to monitor the rate of known reactions. d. Recall that the rate law is an experimental law. e. Relate measured reactant or product concentration to a practically measurable quantity like pressure or angle of rotation. f. Analyze experimental results for first order reactions by making graphs or calculation. g. Differentiate between the differential and integral method of analysis. h. Interpret first order reaction in terms of half-life.	
(d) Second order rate law. Analysis of experimental results for second order reactions. i. For gaseous reactions and ii. For reactions in solution	a. Recall that for a 2nd order reaction $$\frac{1}{a-x} = \frac{1}{a} + kt$$ and perform calculations using the equation. b. Analyze experimental results for second order reactions by making appropriate graphs or calculation.	
(e) Reaction of any order. Analysis of experimental results. The differential method of analysis log Rate = log k + nlogC as used in various physical systems.	a. List the advantages and disadvantages of the differential method of kinetic data analysis when compared to the integral method. b. Calculation of rate constant and order from suitable kinetic data for	

74

		reaction of any order.		
	(f) Factors influencing the rate of reactions i. Concentration – Determination of rate law by observing the effect of concentration on rate and related calculation ii. Temperature – Using simple collision theory to explain the effect of concentration and temperature. iii. Catalysis – Qualitative treatment of types of catalysts and their modes of action.	a. List factors that will affect the rate of reactions. b. Sketch the distribution of molecular energies at given temperature. c. Explain the effect of increased temperature on the energy distribution in 'b' above. d. Explain the effect of concentration and temp. on reaction rate using the collision theory. e. Relate activation energy to effective collisions. f. Explain catalyst effect on the activation energy of a reaction. g. Recall the two types of catalysts with examples. h. Explain the modes of action of heterogeneous & homogeneous catalyst. i. Define and explain the action of a catalyst poison.		
	(g) Activation energy. Introduction of Arrhenius equation and the plotting of log k versus T^{-1} values from experiment.	a. Recall that rate usually increases with temperature. b. Use the Arrhenius plot to explain the effect of temperature on the reaction rate. c. Deduce the activation energy from calculation and graphically given suitable kinetic data. d. Explain the significance of the activation energy and the pre-exponential factor in the Arrhenius equation.		

ORGANIC CHEMISTRY

10.	ALIPHATIC HYDROCARBONS			

			12 hours
(a) Aliphatic Hydrocarbon i. Alkane - Homologous series – general formula - Nomenclature - Alkyl groups (up to decyl and phenyl).	Candidates should: (i) Recall the general molecular formula (ii) List the characteristics of a homologous series. (iii) List and give IUPAC nomenclatures of the members of the homologous series up to carbon atom 20. (iv) Recall how alkyl groups are derived from their corresponding alkanes and phenyl from benzene. (v) List the alkyl groups (up to decyl)	Models and chart showing nature of bonding in organic molecules	
- Structural isomerism (up to decane)	(i) Describe structural isomerism in alkanes with up to five carbon atoms (pentane) (ii) Draw the structural isomers of butane and pentane. (iii) Predict and draw structural isomers in cyclic compounds up to five carbon atom.		
- Physical properties (gradation)	Candidates should explain the gradation of physical properties from simpler to higher alkanes.	Chart showing variables of physical properties of homologous series	
- Preparation of alkanes from: (i) Carbon(II) oxide, carbon(IV) oxide, and hydrogen. (ii) Alkenes and alkynes– reduction. (iii) Alkyl halides (Wurtz synthesis) and Grignard reagents. (iv) Other methods	Candidates should recall the methods used to prepare alkanes stating starting materials and reaction conditions. Candidates should explain the relative inertness of alkanes to react.		
- Chemical properties (i) Reactivity – (explanation for inertness)	Candidates should be able to recall the following: (i) halogenation of alkanes and show		

(ii) Reactions of alkanes 1. Combustion 2. Substitution - Halogenations	mechanism of chlorination of methane. (ii) nitration of alkanes stating reaction condition(s) and product. (iii) combustion of alkanes and relate this to the use of alkanes as fuels for energy production. (iv) the pyrolysis of alkanes as an important industrial process e.g. cracking of petroleum.
- Petroleum	Candidates should recall that crude oil is made up of mainly hydrocarbons (To be treated in details later)
- Simple cycloalkanes: a. Nomenclature b. General properties of cyclopropane to cyclohexane. - Shape and stereochemistry of molecules.	Candidates should recall the name and general properties of cyclopropane to cyclohexane. Candidates should: (i) Recall the differences between straight chain and ring compounds – ring strain (ii) Draw the shape of the first four members of the cycloalkane. (iii) Define conformation isomers in cyclic systems.
ii. Alkenes - Nomenclature (dienes and trienes)	Candidates should be able to: (i) Recall the general molecular formula (ii) Name members of the alkene homologous series using the IUPAC nomenclature. (iii) Describe the alkenes as unsaturated due to the possession of double bonds.

	- Physical properties	Candidates should recall and account for the gradation in properties from simple to higher members.		
	- Positional and geometric isomerism (cis-trans influence on the properties)	Candidates should: i. Recall positional isomerism in alkenes due to the relative position of the double bond e.g. but-1-ene and but-2-ene. ii. Recall that geometric isomerism is due to the nature of arrangement of groups around the double bond.	Models showing shapes & stereo-chemistry of organic molecules- cis & trans isomerism	
	- Preparation of alkenes from: a. Alkanols b. Haloalkanes c. Dihalides d. Petroleum	Candidates should: a. Recall the methods of preparation of alkenes. In each case the starting materials and reaction conditions must be stated. b. Define the terms, dehydration, dehalogenation, dehydrohalogenation. c. Recall the process of cracking of petroleum.		
	- Chemical properties	**Note:** (a) Differences in reactions involving alkanes and alkenes relates to the nature of single and double bonds. (b) Starting materials and reaction conditions must be mentioned.		
	(a) Addition reaction	(i) Recall addition reactions with halogens e.g. bromination, with bromine water, with hydrogen (hydrogenation) and alkyl halide. (ii) State Markovnikoff's rule and apply the rule to predict the product		

78

		obtained from an unsymmetrical alkene compound. (iii) Describe the relevance of hydrogenation in the hardening of fats in the margarine industry.		
	(b) Oxidation reaction with O_2, H_2O_2, RCO_3H, H_2SO_4, MnO_4^-	Recall the oxidation reactions of alkenes with O_2, H_2O_2, RCO_3H, H_2SO_4, MnO_4^- in each case stating the starting materials and reaction conditions.		
	(c) Ozonolysis	Explain ozonolysis and the decomposition products obtainable from ozonide.		
	(d) Polymerization	(i) Define polymerization (ii) Describe briefly addition polymerization and List some addition polymers and their monomers. (iii) State the uses of polymerization, e.g. in the manufacture of PE, PVC, etc	Samples of polymeric materials made from alkenes	
	- Test for alkenes	Recall the use of addition reaction with bromine water or bromine to test for alkenes and distinguish between alkenes & alkanes		
	iii. Alkynes - IUPAC nomenclature	Candidates should: i. Recall the general molecular formula and name the members of the homologous series up to ten carbon atoms. ii. Recall alkynes as another example of unsaturated hydrocarbon with similar characteristic		

79

		as alkenes.		
		- explain all the gradation in physical properties.		
	- Physical properties	Candidates should: i. Recall the terms dehydrogenation and dehydrohalogenation. ii. Describe the preparation of ethyne and other alkynes		
	- Preparation methods of alkynes: ethyne from calcium carbide alkynes from dihalides and tetrahalides.			
	- Chemical properties a) Acetylide formation (Cu, Ag and Na acetylides)	Candidates should: i. Recall the formation of metallic derivatives of alkynes by Cu, Ag and Na using terminal alkynes. ii. Recall the exothermic nature of reactions of carbides obtained in (i) and their use in welding.		
	b) Addition reactions with 1. Water 2. Hydrogen 3. Hydrogen halides	Candidates should be able to: Show the mechanism of addition of water (hydration); hydrogen halides (hydrohalo-genation) and hydrogen (reduction) to alkynes.		
	- Conversion of ethyne to benzene	Candidates should recall the polymerization of ethyne to benzene stating the reaction conditions.		
	- Test for alkynes	Candidates should: i. Recall the use of bromination with bromine or bromine water to distinguish between alkynes and alkanes. ii. Recall the formation of metallic derivatives to distinguish between terminal alkynes and alkenes.		
11.	AROMATIC HYDROCARBONS			

(a) Structure and names of simple aromatic compound
  i) Benzenes and alkyl benzene
  ii) Isomerism of benzene derivatives.
  iii) Naphthalene and anthracene
	Candidates should:
	i. Draw the structure of benzene and its functional derivatives.
	ii. Name the functional derivatives of benzene using IUPAC nomenclature.
	iii. Recall the existence of 1:2, 1:3, 1:4 isomers of disubstituted benzene.
	iv. Draw the structures of naphthalene and anthracene.
		Orbital models of benzene	8 hours

(b) Benzene i. Physical properties	Candidates should list the physical properties of benzene.		
ii. Aromaticity	Candidates should describe the aromaticity of benzene.		
iii. Chemical properties 1) Electrophilic substitution reaction	Candidates should: i. List electrophiles and the reagents they are derived from. ii. Recall in terms of reagents, reaction conditions and products, the electrophilic substitution reaction of: Benzene with		
- Nitration - Sulphonation - Halogenation - Alkylation and Acylation	- mixture of concentrated tetraoxosulphate(VI) acid and trioxonitrate(V) acid. - conc. Tetraoxosulphate (VI) acid. - chlorine and bromine. - haloalkanes and alkanoyl halides in the presence of Lewis acids – Friedel Crafts reaction.		
2) Addition reactions i. Hydrogenation ii. Halogenation	Benzene with - hydrogen in the presence of transition metal catalyst. - chlorine in the presence		

81

		of light.	
	3) Effect of substituents on the reactivity of benzene ring.	Candidates should: i. Explain the directing influence of functional groups (-R, -X, -OH, NH$_2$, NO$_2$, -CHO, -CN, -COOH, -SO$_3$H) on the benzene ring towards electrophilic substitution (X = halogen, R = alkyl) ii. Recall activating and deactivating, and directing (ortho/para or meta) effects of the substituents. iii. Relate the directing influence to inductive and mesomeric effects of substituents. iv. Show canonical structures for ortho, para, and meta attack.	
	iv. Contrast benzene with aliphatic unsaturated compounds.	Candidates should use the following to contrast benzene with aliphatic unsaturated compound. i. Concept of resonance stabilization. ii. The electrophilic substitution reactions. iii. Aromaticity	
	(c) Resonance i. Orbital model of benzene	Candidates should - describe and draw the orbital model of benzene.	
	ii. Comparison with hypothetical cyclohexatriene	- explain why benzene is more stable than cyclohexatriene.	
	iii. Resonance energy	- define resonance energy and explain and draw resonating structures of benzene.	
	iv. Rules for resonance v. Resonating structures of	- describe and apply the rules for resonance.	

82

	benzene and directing influence of functional groups.	- relate the concept of resonance to the mechanism of substitution reactions of benzene and its derivatives.		

12.	TYPES OF ORGANIC REACTIONS
	
	(a) Substitution reactions
	  i. Mechanism of S_N1
	  ii. Mechanism of S_N2
		Candidates should
		- describe the mechanism of S_N1 reactions and of S_N2 reactions
			Chart showing nature of S_N1, S_N2, E1 and E2 reactions	6 hours

	iii. Factors that influences substitution reaction a. Alkyl substituents b. Leaving groups c. Nucleophiles d. Solvents effect	Candidates should: i. Relate the structural effects of alkyl substituents, leaving group on the halo-alkanes and the influence of nucleophilic reagents on S_N1 and S_N2 reactions. ii. Recognize and list nucleophilic reagent and the nucleophiles derived from them. iii. Recall the effects of specific solvents in S_N1 and S_N2 reactions.		

	(b) Elimination reaction
	  i. Mechanism of E1
	  ii. Mechanism of E2
		Candidates should:
		i. Recall the mechanism of E1 and E2 processes using haloalkanes and alcoholic potassium/sodium hydroxide to produce alkenes.
		ii. Recall the effects of the nature of alkyl group, nucleophilic reagents and solvents on the E1 and E2 mechanism.		

	iii. Elimination versus substitution	- predict reaction path (elimination or substitution) of substrates under the influence of nucleophilic reagents, solvents and the nature of alkyl group.		

83

	(c) Addition reactions:	Candidates should recall: i. That only unsaturated compounds can undergo addition reactions. ii. Nucleophilic and electrophilic reagents.		
	i. Nucleophilic addition to polar double bonds.	Candidates should describe i. Addition of a nucleophile to a compound with a polar double bond e.g. alkanals and alkanones. ii. The addition of an electrophile to an organic compound with a non-polar multiple bonds e.g. alkenes and alkynes.		
	(d) Rearrangement reactions Brief mention only	Candidates should briefly describe the rearrangement reactions of carbonium ion.		

INORGANIC CHEMISTRY

13.	HYDROGEN (a) Variable position of hydrogen in the periodic table. (b) Occurrence and preparation from acid and water using active metal in the laboratory. Large-scale preparation of hydrogen from water gas (only the outline). (c) Isotopes of hydrogen.	Candidate should be able to : - give reasons why hydrogen is placed in either group I (as group 1) or VII (as group 17). i. recall that hydrogen occurs as a molecule. ii. recall the methods of preparing hydrogen from active metals e.g. Na, K, Ca, etc from water. i. recall the three isotopes of hydrogen and what makes an isotope different from the other. ii. recall the differences in the physical properties of H_2O and D_2O.	Periodic table	4 hours
14.	ALKALI AND ALKALINE			

84

	EARTH METALS			
	Position in the periodic table and electronic configuration.	Candidates should: i. Write the electron configurations of the metals. ii. Recall that, because the valence electron is in the s-orbital they are also called s-block elements.	Periodic table	6 hours
	Occurrence	Candidates should: i. Recall that the elements are very reactive and as a result are always found in combined state. ii. Give few examples of the important mineral ores.		
	General properties with emphasis on comparison with the group (i.e. trends) in the light of physical and chemical properties.	Candidates should recall: i. Characteristic physical properties of the elements and how these properties vary down a group and between the alkali and alkali earth metals. ii. The characteristic flame colours shown by the compounds of the elements and application of this to qualitative analysis.		
	Nature of their compounds: oxides, hydrides, halides, trioxocarbonates(IV) and hydrogen trioxocarbonates(IV)	i. The reactions of the elements with oxygen, chlorine and water. ii. That the oxides are normally basic and react with water to give alkaline solutions. iii. That the oxidation states of the alkali and alkaline earth metals are +1 and +2 respectively. iv. That sodium and potassium form peroxides while potassium alone forms superoxide, which is paramagnetic. v. That the hydrides of		

		these elements are ionic and react with water to give alkaline solutions. vi. That the trioxocarbonates(IV) of the alkaline earth metals are not soluble in water. vii. The uses of some of the salts e.g. $NaCl$, $CaCO_3$, Na_2CO_3, $MgCO_3$ etc for industrial, domestic and pharmaceutical purposes.		
15.	BORON AND ALUMINIUM GROUP			6 hours
	Electron configuration	Candidates should: i. Write the electron configuration of the elements. ii. Recall that the elements belong to the p-block elements.		
	Occurrence	Candidates should recall the important ores of aluminium, e.g. Bauxite and cryolite.		
	General properties Physical properties (trends only)	Candidates should recall the variation in the physical properties of the group (i.e. ionization potential, atomic/ionic size, electronegativity, etc).		
	Chemical properties Brief treatment of their oxides, hydrides (only borane and diborane) and halides.	Candidates should: i. Give reasons why B^{3+} is not normally formed but Al^{3+} exist is a simple ion. ii. Recall that alumina (Al_2O_3) is used in chromatographic separations. iii. Recall the chemical reactions that lead to the formation of boranes and diboranes. iv. Recall that boranes are		

		electron deficient and could form dative bonds with an electron donor such as ammonia (NH_3). v. Describe the bonding in diboranes.	
16.	CARBON GROUP		
	Electronic configuration	Candidates should write the group electron configuration	
			6 hours
	Physical and chemical properties. The unique properties of carbon should be discussed.	Candidates should: i. Explain trends in physical properties within the group. ii. Recall that metallic character increases down the group. iii. Recall that the +2 oxidation state becomes more stable than the +4 oxidation state as the atomic number increases. iv. Recall that Sn(II) is reducing and Pb(IV) is oxidizing. v. Recall the concept of catenation and how it can be explained using ionization potential and inert-pair effect.	
	Brief treatment of Oxides, Hydrides, Halides and Sulphides	Candidates should: i. List few examples of the oxides formed. ii. Describe the bond in CO_2 and CO. iii. Recall the poisonous nature of CO. iv. Explain the differences in the structure and properties of CO_2 and SO_2. v. Recall that CO_2 is an acidic gas while CO is neutral. vi. Write simple chemical equations for the	

87

		formations of hydrides (i.e. silanes), chlorides and sulphides. vii. List few uses of the sulphides such as PbS.		
PRACTICAL CHEMISTRY = 60 Hours Practical Chemistry is to run concurrently with Theory for at least 60 hours per semester
A	WEIGHING PRACTICE	Candidates should be able to: i. Recall the principle of weighing using the analytical and top loading balances. ii. Recall the precision of the two balances iii. Use the analytical balance to weigh accurately	Weighing balances – top loading and analytical; - - weighing practice	6 hours
B	INTRODUCTION TO COMMON LABORATORY APPARATUS, GLASSWARE, AND SAFETY PRECAUTIONS Identification and uses of common laboratory apparatus and glasswares.	Candidates should be able to: i. Identify and recall the names of common laboratory apparatus. ii. Recall the use of each laboratory apparatus or glassware. iii. Select the appropriate apparatus for quantitative measurements based on the level of accuracy required in the experiment. iv. Take quantitative measurement of volume using burette, pipette, beaker, measuring cylinder, etc. (Activity).	Burettes, pipettes beaker, conical flask, cylinder, etc.	6 hours
	Safety precautions	i. Recall the safety precautions to be observed in the laboratory. ii. Demonstrate the use of some common laboratory safety e.g. fire extinguisher, first aid box, etc (Activity).	Fire extinguishers, sand buckets, fire blankets & first aid box	
			Apparatus for	

| | | formations of hydrides (i.e. silanes), chlorides and sulphides. vii. List few uses of the sulphides such as PbS. | | |

PRACTICAL CHEMISTRY = 60 Hours

Practical Chemistry is to run concurrently with Theory for at least 60 hours per semester

A	WEIGHING PRACTICE	Candidates should be able to: i. Recall the principle of weighing using the analytical and top loading balances. ii. Recall the precision of the two balances iii. Use the analytical balance to weigh accurately	Weighing balances – top loading and analytical; -- weighing practice	6 hours
B	INTRODUCTION TO COMMON LABORATORY APPARATUS, GLASSWARE, AND SAFETY PRECAUTIONS	Candidates should be able to: i. Identify and recall the names of common laboratory apparatus. ii. Recall the use of each laboratory apparatus or glassware.	Burettes, pipettes beaker, conical flask, cylinder, etc.	6 hours
	Identification and uses of common laboratory apparatus and glasswares.	iii. Select the appropriate apparatus for quantitative measurements based on the level of accuracy required in the experiment. iv. Take quantitative measurement of volume using burette, pipette, beaker, measuring cylinder, etc. (Activity).		
	Safety precautions	i. Recall the safety precautions to be observed in the laboratory. ii. Demonstrate the use of some common laboratory safety e.g. fire extinguisher, first aid box, etc (Activity).	Fire extinguishers, sand buckets, fire blankets & first aid box	
			Apparatus for	

| C | TITRIMETRIC ANALYSIS
(a) Acid-Base Titration
- Acid-base titration (neutralization)

- Theory of acid base titrations | Candidates should be able to:
i. Define neutralization.
ii. Recall common acids and bases and write balanced reaction equations for their reactions.
iii. Explain the terms weak acid and weak base or strong acid and strong base, hydroxonium ion, concentration and pH.
iv. Differentiate between end point and equivalence point.
v. Explain why indicators are used in neutralization reaction
vi. Explain the working of some common acid-base indicator.
vii. Explain the choice of indicators for neutralization reactions.
viii. Sketch and explain the change of pH of a titration mixture with volume of acid or alkali added. | titration- burettes, pipettes, etc

pH meters

Apparatus for titration | 6 hours

9 hours

6 hours |
| | - Preparation and standardization of solutions | Candidates should be able to:
i. Explain the terms primary and secondary standard substances and solutions.
ii. List some common primary standard substances and their properties
iii. Prepare a standard solution of NaOH.
iv. Standardize a solution of dilute H_2SO_4 acid using standard NaOH solution.
v. Standardize a solution of ethane-1,2-dioic acid | | 6 hours

9 hours |

89

		using standard NaOH solution		
	- Titration using double indicator	Candidate should be able to: i. Explain why Na_2CO_3 is used in acid-base titrations ii. Obtain suitable titration data to calculate the concentration of NaOH and Na_2CO_3 present in a mixture using double indicator methods.		
	(b) Redox Titrations - Introduction to redox reaction titration	Candidates should be able to: i. Define oxidation and reduction reactions. ii. Balance redox reactions in aqueous acids solutions using common oxidizing and reducing agent. iii. give names and formula of some common oxidizing and reducing agents in the laboratory. iv. List some primary standard substances used in redox titrations.	6 hours	
	- Redox properties of potassium tetraoxomanganate(VII), potassium heptaoxodichromate(VI) and tetraoxodicarbonate(III) ion (oxalate).	Candidates should be able to: i. Explain why titrations with $KMnO_4$ do not require an external indicator. ii. Explain the effect of pH on the reaction of $KMnO_4$ with a reducing agent. iii. List advantages of $KMnO_4$ or $K_2Cr_2O_7$ as aoxidizing agent in volumetric analysis. iv. Standardize a given $KMnO_4$ solution using a standard ethane-1,2-dioic acid solution (Activity)	6 hours	

		v. Recall that the titration of aqueous tetraoxodicarbonate(III) ion with common oxidizing agent is always at elevated temperature. vi. Standardize a solution of iron(II) using a standard solution of $KMnO_4$ (Activity) vii. Recall that ethane-1, 2-dioic acid can react as an acid and as a reducing agent. viii. Analyse quantitatively an ethane-1,2-dioic acid and $Na_2C_2O_4$ mixture by the double titration method (acid-base and redox)	
	- Redox reactions involving iodine (iodometric titrations)	Candidates should be able to: i. Explain the term iodometry ii. Write balanced chemical reaction equation for the reaction of iodine with $Na_2S_2O_3$. iii. Explain why the starch indicator is added only very close to the equivalence point of the titration and not at the beginning. iv. Explain the role of the iodate and tetraoxomanganate (VII) ion in iodometry. v. Standardize aqueous $Na_2S_2O_3$ solution using standard potassium iodate solution and hence determine the number of molecules of water of hydration in the hydrated $Na_2S_2O_3$ (Activity). Candidates should be able to:	

91

Iodometry applied to the determination of percentage purity of an impure sample of copper(II) tetraoxosulphate(VI) pentahydrate solution.	i. Write balanced chemical reaction equation for the reaction of copper(II) ions with the iodate ion. ii. Titrate the liberated iodine from the reaction in (i) above with $Na_2S_2O_3$ solution using starch indicator. iii. Calculate the percentage purity of the copper (II) tetraoxosulphate(VI) pentahydrate using the titre data in (ii) above. iv. List the precautions that are taken. v. Explain the functions of potassium thiocyanate in the reaction.	

SECOND SEMESTER SYLLABUS 108 Hours Lectures + 24 Hours Tutorials = 132 Hours

S/NO:	TOPICS AND CONTENTS	ACTIVITIES / PRACTICAL GUIDE	INSTRUCTIONAL MATERIALS	DURATION
		PHYSICAL CHEMISTRY		
17.	CHEMICAL EQUILIBRIUM (a) Equilibrium Laws and Equilibrium Constants - Properties of a system in equilibrium, the general equilibrium expression as an experimental result, (No derivation based on rates of opposing reactions). The dynamic nature of equilibrium should be appreciated especially when $\Delta G = 0$. K should be expressed both in terms of pressure Kp, and in terms of concentration Kc.	a. Recall various equilibrium expressions in various terms up to e.g. $K_p = K_c (RT)^{\Delta n}$ b. Recall that at equilibrium $\Delta G = 0$ c. Write expressions for some equilibrium reactions e.g. dissociation of H_2O_2, contact process etc. d. Recall that equilibrium are dynamic and that the principles of equilibrium depends on the equilibrium amount of reactants and products, which is dependent on temperature. e. State the factors that affect the equilibrium values and position. f. State Le Chartelier's principle g. Explain why catalyst has no effect on position of equilibrium but affect the rate at which equilibrium is attained.	pH meter Universal indicator paper, litmus paper acid/base indicators Standard buffer solutions	14 hours
	(b) Relationship between Kp and Kc - examples i. Dissociation of H_2O_2 ii. Esterification reaction iii. HI equilibrium iv. Contact process in the manufacture of H_2SO_4 v. Synthesis of NH_3 and PCl_5	a. Deduce the effect of change in concentration, pressure and temperature on the position of equilibrium using the Le-Chartelier's principle, given suitable data b. Compare and contrast values of Kp and Kc for a given reaction, and distinguish between the		

		Kp and Kc.		
	(c) Ionic Equilibrium Ionic Product of Water, pH, pH scale : Dissociation of water, water acting as a base as well as an acid. Definition of pH as a measure of hydrogen ions concentration in solution. pH scale, common ion effect definition. Mixtures of weak acids and its highly ionizable salts – buffer solution, definition and composition. Buffer actions of NH_4Cl / NH_4OH; CH_3COONa / CH_3COOH, calculation of pH values of buffer mixtures from Hasselbach Henderson equation.	a. Define pH in terms of hydrogen ion concentration. b. Write $pH = -\log_{10}[H^+]$ c. Write expression for the dissociation of water as $Kw = [H^+][OH^-]$. d. State why water is acting both as acid and base. e. Calculate pH of a solution given the concentration of hydrogen ion present in $moldm^{-3}$ for strong acid/base and for weak acid/base when K_a or K_b is given. f. Define the term common ion effect and state the effect of common ion in solutions such as $CH_3COONa/CH_3COOH_{(aq)}$, $CH_3COONH_4/CH_3COOH_{(aq)}$, etc g. State the importance of pH in various disciplines e.g. Agriculture h. Write Hasselbach Henderson's equation for buffer solution i.e. $pH = pKa + \log\frac{[salt]}{[Acid]}$ i. Calculate the pH of a buffer solution using the expression above. j. State the importance of selecting an acid whose pKa is very close to the pH desired.	Samples of hydrolysable salts such as CH_3COONa, $FeCl_3$, NH_4Cl	
	(d) Acid/Base Equilibrium Definitions of acids, bases and salts in terms of Arrehnius concept, Proton transfer concept (Bronsted	a. Recall various definitions of Acids and Bases in terms of Arrhenius, Bronsted-Lowry and Lewis concepts. b. Define conjugate		

94

Lowry), conjugate acid/base pair and Lewis concept. Relative strengths of acids and bases. Dissociation of weak acids and bases in water. (Do not treat dissociation of polybasic acids and bases).	base/acid and be able to write the conjugate base of an acid e.g. the conjugate base of CH_3COOH (acid) is CH_3COO^- based on the fact that the difference between an acid and its conjugate base is a proton (H^+). c. The calculation of pH of a solution when the H ion conc. is given. d. Write equilibrium expression for dissociation of weak acids and bases in water. e. Recognize the fact that H^+ ion cannot exist and so easily combine with H_2O to give H_3O^+ ion, which is a measure of acidity of a solution.		
(e) Hydrolysis of salts Definition and types e.g. hydrolysis of salts formed from strong acid/weak base, weak acid/ strong base, weak acid/weak base.	a. Define hydrolysis and b. Distinguish hydrolysis from hydration. c. Write expression for hydrolysis of various salts in solution e.g. CH_3COONa, NH_4Cl, and CH_3COONH_4. d. Explain why salts such as NaCl, KCl, Na_2SO_4 do not undergo hydrolysis. e. Write expression for hydrolysis and get the hydrolysis constant K_h given suitable data. f. Calculate the extent of hydrolysis. g. Calculate the pH of hydrolysed solution.		
(f) Hydrogen ion Indicators or acid-base Indicators Theory of acid-base	a. Categorise indicators into weak acids or weak base. b. Categorize from their dissociation constants e.g.		

indicator, selection of suitable indicator for a titration.	phenolphthalein has $K_{In} = 2.0 \times 10^{-10}$ is a weak acid while methyl orange $= 3.1 \times 10^{-5}$ a weak base. a. Select suitable indicators for a titration. b. Explain the difference between end point and equivalence point. c. Explain when and why end point can have the same value with equivalence point. d. Select suitable indicator using suitable pH colour charge data for titration such as HCl versus NaOH, HCl versus NH_4OH (use weak base indicator), CH_3COOH versus NaOH (use weak acid indicator) e. Sketch the curves of pH versus concentration of base or acid (titration curve) f. Use of pH meters in volumetric analysis.		
Hydrogen ion indicator			
(g) Solubility Products Limit to slightly soluble salts (and no hydrolysis).	a. Distinguish solubility product expression from general equilibrium expression e.g. $AB(s) \rightleftharpoons A^+ + B^-$; $K_{sp} = [A^+][B^-]$ b. State the meaning of solubility products in terms of products of concentration of ions in solution. c. Determine the solubility of sparingly soluble salt in water when the solubility product constant is given and vice versa. d. State the effect of common ion on solubility of compounds such as $BaSO_4$ e.g. solubility of $BaSO_4$ in 100 dm^3 of 0.100 mole dm^{-3} Na_2SO_4	Chart showing solubility curves	

	solution [$K_{sp} = 1.5 \times 10^{-9}$]. e. State various applications of solubility product - Determination of sparingly soluble salts - Precipitation (prediction) - Precipitation of insoluble salts - Inorganic analysis – precipitation of sulphides		

	ORGANIC CHEMISTRY		
18.	**HALOALKANES** (a) Nomenclature (b) Preparation from i. Alkenes and hydrogen halides	 Candidates should name any haloalkanes using IUPAC nomenclature Candidates should recall all the preparative method stating starting materials		 8 hours

ii. Alkanols and PX_3 or PX_5 (X=Cl, Br) iii. Alkanols and hydrogen halides	and reaction condition Candidates should recall and apply Markovnikoff's rule to predict the products.		
(c) Chemical properties i. Nucleophilic substitution reaction with Grignard reagents, Ag_2O/H_2O, aqueous alkanol, potassium cyanide, KSH and NH_3	Candidates should recall stating starting materials and reaction conditions of the following reactions of haloalkanes with: i. Grignard reagent for alkanol formation after hydrolysis. ii. Ag_2O/H_2O for alkanol formation iii. Wurtz coupling for alkanes synthesis. iv. Potassium cyanide for nitrile formation. v. Ammonia for alkanamine formation. vi. KSH for thiol and sulphide formation.		
ii. Elimination reaction with alcoholic potassium/sodium hydroxide	Candidates should recall the formation of alkenes by the elimination reaction of haloalkanes with alcoholic potassium/sodium hydroxide		
(d) Name, structure and uses of trihalomethanes	Candidates should: i. Name, draw structure and mention the uses of $CHCl_3$, CHI_3 and $CHBr_3$ ii. Mention the use of fluorochloromethanes as refrigerants and its effects on ozone layer.		
(e) Halogen derivatives of aromatic compounds (only chlorobenzene)	Candidates should describe the chemistry of only chlorobenzene as representative of halobenzenes.		
i. Physical properties	Candidates should list the physical properties of		

98

		chlorobenzene		
	ii. Methods of preparation	Candidates should: i. Recall the Friedel Crafts chlorination of benzene ii. Describe the Sandmeyer's reaction (i.e. benzenediazonium ion and Cu_2Cl_2 / HCl reaction		
	iii. Chemical properties i. Grignard ii. Wurtz - Fitting iii. Aryl Lithium iv. Reactions with amines	Candidates should recall the reactions of haloalkanes stating the starting materials, reaction conditions and products.		
19.	HYDROXYL COMPOUNDS (a) Alkanols i. Introduction – primary, secondary and tertiary alkanols.	Candidates should recall the classification of alkanol as primary, secondary and tertiary with examples.		8 hours
	ii. Nomenclature	Candidates should: i. Name alkanols using IUPAC nomenclature. ii. List the uses of important alkanols e.g. ethanol		
	iii. Preparation	Candidates should be able to describe the methods of preparation of alkanols stating reaction conditions, starting materials and class of alkanol product.		
	- From alkenes - From alkanals and alkanones - From alkanoic acids - By hydrolysis of	i. Recall the hydration and hydrolysis of alkenes and haloalkanes respectively ii. Recall the importance of reduction process and Grignard reagents in alkanol synthesis.		

99

haloalkanes - Industrial method of preparation of ethanol by fermentation	iii. Describe in detail the industrial preparation of ethanol by fermentation and the economic of importance fermentation industry.		
iv. Physical properties of hydroxyl groups	Candidates should describe the effect of –OH group on physical properties – hydrogen bonding.		
v. Chemical properties - Williamson synthesis -. Esterification -. Dehydration - Alcoholysis - Oxidation - Acidic and basic properties	Candidates should: i. Recall all the reactions of alkanols listed stating starting materials, reaction conditions and product formed. ii.. Explain acidity of ROH, metal alkoxides and salt formation with Bronsted acids.		
vi. Polyhydroxyalkanes: diols and triols	Candidates should: i. Draw the structure and names of simple polyhydroxylalkanes e.g. ethane-1,2-diol and propane–1,2,3-triol ii. Recall the oxidation of alkenes to diols. iii. Mention the source of propane-1,2,3-triol from hydrolysis of triglycerides in soap manufacture.		
(b) Phenols: comparison of the properties of alkanols with those of phenol.	Candidates should: a. Explain the acidic nature of phenol. b. Recall the directing ability of –OH in electrophilic substitution reaction on the benzene ring of phenol: i. Bromination, ii. Nitration iii. Sulphonation c. Relate the reactions of		

100

		the -OH group on alkanols to the -OH group on phenol in · i. Ether formation ii. Esterification iii. Alcoholysis in reaction with haloalkanes d. Recall the test for phenol using iron(III) chloride Candidates should compare the properties of alkanols with those of phenols.		
20.	CARBONYL COMPOUNDS (a) Polarization of carbonyl compounds	Candidates should: i. Recognize the carbonyl functional group ii. Describe the polarization of the carbonyl group in alkanal and alkanone. iii. Recall the differences in their structures.		8 hours
	(b) Structure and nomenclature	Candidates should draw the structure and give IUPAC names of some alkanals and alkanones.		
	(c) Alkanals – preparation from: i. Oxidation of primary alkanols ii. Ozonolysis of alkenes iii. Reduction of alkanoic acids iv. Addition of water to alkynes	Candidates should recall the preparation of alkanals stating starting materials, reaction conditions and products.		
	(d) Alkanones – preparation from: i. Oxidation of secondary alkanols ii. Alkanoic acids iii. Alkanols iv. Ozonolysis of alkenes v. Decarboxylation of	Candidates should recall the preparation of alkanones stating starting material, reaction condition and products.		

101

calcium salt			
(e) Physical properties	Candidates should recall the effect of alkanals and alkanone structures on physical properties.		
(f) Chemical properties i. Addition reactions with - Grignard reagents - Hydrogen cyanide - Sodium hydrogen tetraoxosulphate (IV) - Ammonia - Alkanols	Candidates should: i. Recall the nucleophilic addition with all the reagents stating starting material, reaction conditions and products. ii. Use illustrations of these reactions to understand the basic principles of organic reaction mechanisms.		
ii. Condensation reactions with - Methylamine, - Hydrazine - Hydroxylamine - Phenylhydrazine	Candidates should recall the condensation reactions and apply this to explain the reactions, stating starting materials, reaction conditions and products.		
iii. Aldol condensation	Candidates should recall the steps or mechanism of aldol condensation and understand the structural requirement for aldol condensation		
iv. Oxidation of carbonyl compounds	Candidates should recall oxidation of alkanals and alkanones using $KMnO_4$ stating reaction conditions and products.		
v. Reduction of carbonyl compounds - Hydride reduction - Catalytic reduction	Candidates should: i. Recall the reduction of alkanals and alkanones to alkanols using sodium borohydride, lithium aluminum hydride and other hydrides ii. Recall reduction of hydrocarbon by hydrogen and Clemmenson		

102

	vi. Cannizzaro reaction	reduction. Candidates should describe Cannizzaro's reaction showing its mechanisms	
	vii. Tautomerism	Candidates should recognize and recall keto-enol tautomerism in certain carbonyl compounds.	
	(g) Distinguishing test for alkanols and alkanones.	Candidates should recall and explain the silver mirror test (Tollen's reagent), Fehling's test and the Iodoform test - distinguishes between alkanals and alkanones.	
	(h) Aromatic carbonyl compounds (benzaldehyde and benzophenone only)	Candidates should: i. Name and draw the structure of simple aromatic alkanals and alkanones. ii. Recall the influence of the aryl ring on the reactivity of the carbonyl group.	
21.	ALKANOIC ACIDS		
	(a) Structure and nomenclature	Candidates should: i. Recall the alkanoic acid functionality ii. Draw the structure and name of simple alkanoic acid.	10 hours
	(b) Physical properties (Hydrogen bonding)	Candidates should: a. Explain the existence of hydrogen bonding in alkanoic acid and its effect on physical properties b. Explain the difference of hydrogen bond in alkanol and alkanoic acid with emphasis on their relative strength.	

103

	(c) Resonance effects acidity. Comparison with alkanols.	Candidates should recall: i. The acidic behaviour of alkanoic acid when compared to alkanols. ii. The effect of resonance stabilization of the carbonyl group on acidity.	
	(d) Preparation from i. Oxidation of alkanols and alkanals. ii. Hydrolysis of nitriles iii. Grignard and carbon(IV) oxide	Candidates should be able to recall: i. The methods to prepare alkanoic acid, stating starting materials and reaction conditions. ii. The mechanism for the Grignard addition to carbon(IV) oxide as a further illustration of the basic principle of reaction mechanism.	
	(e) Chemical properties i. Esterification ii. Reduction iii. Decarboxylation electrolysis	Candidates should: i. Recall the esterification with alkanol, the reduction with lithium aluminum hydride, decarboxylation of acids and Kolbe electrolysis. Stating starting materials, reaction conditions, and products. ii. Recall the reactions as attack of nucleophiles at the carbonyl groups of the acid.	
	(f) Alkanoic acid derivatives i. Alkanoyl (acyl) halides - Structure and name - Preparation	Candidates should: i. Draw structure and name some aliphatic acyl halides ii. Describe the preparation from the reaction of alkanoic acid with phosphorus(V) chloride, phosphorus(III) chloride and thionyl chloride.	
	ii. Alkanoic anhydrides	Candidates should: i. Draw the structure and	

104

	- Structure and name - Preparation	name of alkanoic anhydride (both aliphatic and simple aromatic) ii. Describe the preparation of ethanoic anhydride.	
	iii. Alkanamides (Amides) - Structure and name - Preparation	Candidates should: i. Draw and name some alkanamides ii. Describe the preparation of amides using - Ammonium trioxocarbonate(IV) and heat - Alkanoic acid and ammonia or alkanamines	
	iv. Nitriles - Structure and name - Preparation	Candidates should: i. Describe nitrile as organic compounds with the cyano group and being unsaturated. ii. Draw structure and name some nitriles iii. Describe the preparation by the following methods: - Dehydration of amides with phosphorus(V) oxide. - Heating haloalkanes with alcoholic potassium cyanide. Candidates should describe the method of preparation and chemical reaction in detail.	
	v. Alkanoates (esters) - Method of preparation	Candidates should recall the preparation of alkanoates stating starting material and reaction conditions: i. Reaction of alkanols with alkanoic acid ii. Reaction of alkanols with acyl chloride or acid	

105

	- Chemical reactions	anhydride.		
		Candidates should recall the following reactions stating starting materials, reaction condition and products:		
	Hydrolysis	(i) Alkali and acid hydrolysis - The industrial importance of alkali hydrolysis which is known as saponification reaction, which results in soap formation must be mentioned.		
	Reduction	(ii) Reduction with lithium aluminum hydride, sodium in ethanol and Reduction with ammonia/Na		
	(g) Dialkanoic acid (Dicarboxylic acid)	Candidates should draw the structure and name oxalic and malonic acid using IUPAC nomenclature.		
	(h) Aromatic acids	Candidates should: i. Mention benzoic, salicylic and phthalic acids as examples of aromatic acids. ii. Draw the structure of the acids.		
	(i) Fatty acids	Candidates should: i. Mention fatty acid as long chain alkanoates. ii. List some members of the fatty acid group. iii. Recall the process involved in the saponification and hardening of oil and its relevance to the chemical industry.		

INORGANIC CHEMISTRY

22.	NITROGEN AND OXYGEN GROUPS			

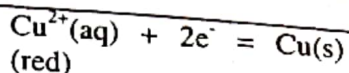|			
	(a) Electron configuration and occurrence	The candidates should recall the percentages of nitrogen and oxygen in air.	
	(b) Physical and chemical properties - Formation of simple oxides and nitrides	The candidates should: i. Explain the differences between nitrogen and oxygen in their respective groups. ii. Recall that oxygen and sulphur combine with many other elements directly, forming compounds that are abundant in nature. iii. Recall the formation and properties of NO, N_2O and NO_2. iv. Describe the industrial preparation of sulphur (IV) oxide, sulphur(VI) oxide and ammonia. v. Give the stoichometry of the principal oxo-anions of nitrogen and sulphur i.e. NO_2^-, SO_3^{2-}, NO_3^-, SO_3^{2-}, SO_4^{2-}. vi. List the allotropes of sulphur and recall how they are formed. vii. Give the importance of inorganic nitrogen and phosphorus compounds in agriculture. viii. Give the importance of tetraoxosulphate(VI) acid in the manufacture of detergents. ix. List some environmental impact of some compounds of nitrogen and sulphur. x. Relate the formation of nitrides to the diagonal relationship that exist between Li and Mg.	8 hours
23.	HALOGEN GROUP		

	(a) Occurrence and electron configuration	Candidates should: i. List some compounds from which the elements are obtained. ii. Write electron configuration of the elements		6 hours
	(b) Physical properties (fluorine, chlorine, bromine and iodine).	Candidates should recall and explain the trend in physical properties within the group.		
	(c) Chemical properties i. Formation of HX compounds. ii. Formation of metal halides including AgCl. iii. Simple reaction of halide salts. iv. Formation of oxo compounds. v. Formation of inter-halogen compounds.	Candidates should be able to recall i. that all HX compounds are water-soluble and are acidic in nature. ii. the reactions of halide salts with concentrated tetraoxosulphate(VI) acid. iii. the analytical importance of the reactions between Ag^+ and X^- iv. the existence of the various oxidation states of chlorine as exhibited in the oxo-anions. v. the uses of chlorine gas as a poisonous gas and as a disinfectant. vi. the uses in the manufacture of pesticides, polymers and refrigerants. vii. few examples of inter-halogen compounds		

PHYSICAL CHEMISTRY

24.	ELECTROCHEMISTRY Explanation of oxidation-reduction reactions in terms of oxidation number and electron transfer. REDOX Reactions (a) Metallic conduction,	a. Explain oxidation and reduction in terms of oxidation number and electron transfer. b. Identify oxidation-reduction from equations e.g. in $Zn(s) + Cu^{2+}(aq) = Zn^{2+}(aq) + Cu(s)$ as $Zn(s) = Zn^{2+} + 2e^-$ (oxid) and	Simple galvanic cells, Batteries	12 hours

	electrolytic conduction, electrolysis of molten NaCl, aqueous NaCl, Na_2SO_4, molten cryolite, aqueous $CuSO_4$ using inert electrodes, aqueous $CuSO_4$ using copper anode.	$Cu^{2+}(aq) + 2e^- = Cu(s)$ (red) c. Deduce/write equations of redox reaction. a Define the terms, conductor, electrolytes electrodes cathode anode ions etc. b. Predict the direction of spontaneous change for redox reaction. c. Analyse the electrolysis of certain electrolytes e.g. dil.HCl, NaCl (molten), NaCl(aq), $CuSO_4(aq)$. d. State the effect of concentration, position of ions in electrochemical series and nature of electrodes. e. Write half equation i.e. what happens at the anode and cathode respectively. The nature of resultant electrolyte.	
	(b) Electrochemical cells and Faraday's laws. Standard Electrode potential (IUPAC). Drawing / writing of cell diagrams e.g. $Li^+ + e^- = Li$ $(E^o = 3.06 \text{ V})$.		
	Laws of Electrolysis Application to simple system. Solutions to problems relating mass and current.	Importance of Electrolysis in industry: a. Recall definition of standard electrode potential and standard redox potential and the convention for presentation of all. b. Recall the bases for defining a standard electrode potential	
	(c) Chemical Changes result in generation of Electric Energy, Galvanic cells, study of some cells – Daniel cell, Dry cell, storage cell, Fuel cell, etc.	c. State the use of the standard hydrogen electrode. d. Interpret ionic half equation in terms of electron transfer. e. State laws of electrolysis. f. Calculate the masses and volumes of substances deposited or liberated given suitable data.	

		g. State the significance of the Faraday. h. State the applications of electrolysis in connection with corrosion.	
	(d) Electrode – Potential and Electrochemical series. Variation of change in free energy (ΔG) with concentration. Graphical explanation of the relationship $\Delta G = \Delta G^* - RT$. Derivations of Nernst equation $E = E^* - \dfrac{0.059}{n} \log_{10} K$ Variation of cell potential with concentration. Solution to problems relating E and K. i.e. Determination of e.m.f. of a cell when concentration are not unity. Spontaneity of reaction. $\Delta G = -nFE$ Calculation of standard free energy change ($<G^*$) and equilibrium constant of a cell reaction.	a. Distinguish between electrochemical and electrolytic cell. i.e. the electrochemical cell is used to generate energy while electrolytic use energy to decompose compounds. b. Recall that Galvanic cell is an example of electrochemical cells and give examples. c. State the importance of storage cells. a. Use the standard electrode potential of each ion or element to determine the species that will be oxidized and reduced in each case. i.e. predict the direction of spontaneous change. b. Interpret the electrochemical series in terms of electrode potentials. c. State the application of electrode potentials in connection with corrosion problem. d. Relate ΔG to the electrode potential, E of the cell. e. Recall that there is a relationship between E and the equilibrium constant (Nernst equation).	
	(e) Corrosion of Metals	a. State causes of corrosion of metals. b. Explain various methods of prevention of	

	From the standpoint of electron transfer. Prevention of corrosion.	corrosion. c. Explain why particular metal is used in coating Fe rather than other metals e.g. Fe coated with Zinc and not Fe coated with Tin (Sn).		
25.	NUCLEAR CHEMISTRY			
	(a) Type and nature of Radiations, charges, relative mass of particles and penetrating power of radiations. Simple nuclear equations.	a. Distinguish between ordinary and nuclear reactions. b. Balance simple nuclear reaction equations. c. State type of changes and particles and their relative masses.	Chart showing penetrating power of α, β, γ radiation	6 hours
	(b) Half-life as a measure of stability of the nucleus, stability belts. Types of radioactivity – natural and artificial. Alpha and beta particles, gamma rays. Geiger Muller's detectors, Radioactive carbon dating.	a. Define half-life and explain its significance. b. Distinguish between natural and artificial radioactivity i.e. one is due to excess mass while the other is caused by (energizing) bombardment with particles such as neutrons. c. Give uses of nuclear fission and fusion. d. Name common detector used.		
	Nuclear Energy Nuclear fusion and fission; nuclear reactors as means of thermal power generation (General discussions in details) Uses of radioactivity in agriculture, medicine and industry.	e. Evaluate quantitatively energy, using Einstein equation $E = mc^2$. f. Recall the various units of energy e.g. MeV and Joules. g. Recall uses as atomic bomb (Give examples of Hiroshima, Japan event) - Carbon dating etc. h. Define Isotopes, Isobars and Isotones. i. Recall the specific uses of radioactivity in specific fields e.g. in Analytical Chemistry as a tracer (reaction mechanism).		

111

26.	AMINOALKANES (Amines)			
	(a) Structure and nomenclature	Candidates should: a. Classify aminoalkanes as primary, secondary and tertiary b. Draw the structure of amines mentioned in (a) above. For aromatic that of amino benzene (aniline) only. c. Name the amines using IUPAC nomenclature.		6 hours
	(b) Physical properties	Candidates should describe the physical properties showing that $-NH_2$ group exhibit hydrogen bonding and their relative strength when compared with $-OH$ group.		
	(c) Basicity of aminoalkanes	Candidates should describe the basicity of aminoalkanes and compare basicity of aromatic and aliphatic aminoalkanes		
	(d) Method of preparation from: i. Haloalkanes ii. Alkanols iii. Hoffmann degradation iv. Beckmann rearrangement v. Reduction of nitro and cyano compounds.	Candidates should be able to: i. Recall the methods of preparation stating starting material, reaction conditions and products. ii. The mechanism of reaction for Hoffmann degradation and Beckmann rearrangement must be shown.		
	(e) Chemical properties - Diazotization - Acylation	Candidates should: i. Recall the reactions listed stating starting materials, reaction conditions and products. ii. Describe in detail the diazotization reaction of		

112

		aminoalkanes with nitrous acid and its industrial importance in the dye industry.	
	(f) Methods to distinguish the classes of aminoalkanes.	Candidates should recall: a. The test used to distinguish primary, secondary and tertiary aminoalkanes [p-toluene sulphonyl chloride test]. b. The test used to distinguish between aliphatic and aromatic aminoalkane, which is diazotization.	

27.	CHEMISTRY, NATURE, INDUSTRY AND ENVIRONMENT
	
	(a) Chemistry in Nature
	  i. Carbohydrates
	  - Structure and nomenclature
		Candidates should:
		i. List simple carbohydrates
		ii. Draw the straight chain structure of carbohydrates and name them.
			14 hours

	- Classes of carbohydrates	i. Classify carbohydrates as monosaccharides, disaccharides and polysaccharides. ii. Recall glucose and fructose as monosaccharide, sucrose as disaccharide, starch and cellulose as polysaccharides.	Samples of carbohydrates, sugars, starch, iodine solution

	- Simple reactions
	  Reducing action
	  Osazone formation
	  Hydrolysis
		i. Recall the reducing reactions of glucose with Fehling's reagent, and Tollen's reagent.
		ii. Recall the formation of an osazone by monosaccharides.
		iii. Recall the hydrolysis of sucrose, starch and cellulose to glucose. Stating reaction	

113

- Importance of carbohydrates	conditions. Candidates should explain the role and relevance of carbohydrate in the sustenance of life.	
ii. Amino Acids and Proteins - Introduction to amino acids and proteins.	Candidates should: i. Describe the functional groups in an amino acid – bifunctional nature. ii. List and draw the structure of the 20 naturally occurring amino acids. iii. Use IUPAC nomenclature to name amino acids.	
- Behaviour of amino acids and proteins in an electric field. - Peptide, dipeptide and polypeptide	Candidates should: i. Describe the acidic and basic nature of amino acids. ii. Describe the dipolar nature of amino acids or zwitterions. iii. Describe the joining of amino acids to form peptide, dipeptide and polypeptide bond. iv. Draw the structure to illustrate peptide bonds	
- Importance of amino acids and proteins.	Candidates should describe the role and relevance of amino acids and proteins in the sustenance of life.	
(b) Chemistry in Industry i. Petroleum industry ii. Polymer Industry	Candidates should: i. List the products obtained by fractional distillation of crude oil and their utility in our day-to-day life. ii. Discuss the uses of petroleum products as the starting material for most organic chemical	Sample of crude petroleum and pure petroleum products

- Nature of polymer	industries petrochemicals. — Candidates should: i. Define monomers ii. Describe polymers as aggregates of monomers iii. List some natural and synthetic polymers and their precursor monomers - cellulose, rubber, nylon, polythene, etc.		
- Types of polymers			
- Synthetic polymers Nylon Polythene Polychloroethene (Polyvinylchloride) Resins Teflon Rubber Terylene	Candidates should: i. Define addition and condensation polymers ii. Classify polymers into addition and condensation polymers iii. Distinguish between thermosetting and thermoplastic polymer.	Samples of thermoplastic and thermosetting plastics	
- Uses of polymers	Candidates should: i. Briefly describe the industrial process leading to the manufacture of the polymers, stating reagents, reaction condition and nature of products. Detailed industrial process not required. ii. Write simple mechanism for the polymerization process — free radical and ionic polymerization. iii. Distinguish between low density and high-density polymers. iv. Recall the importance of catalysis in polymerization.	Samples of polymeric materials, natural and synthetic	
	Candidates should list common polymers and their typical uses.		
	Candidates should: i. Explain the principle		

iii. Biotechnology - Introduction	involved in biotechnology ii. List the advantages in the use of biotechnology	Schematic sketch of the fermentation process	
- Food processing	Candidates should describe the process of fermentation as it relate to production of garri, bread and alcoholic beverages (e.g. ogogoro)		
- Uses	Candidates should list and recall applications of biotechnology in our day-to-day life.		
(c) Environmental Chemistry i. Environmental impact of the Chemical Industry ii. Pollution	Candidates should i. Describe the positive and negative impact of the chemical industry on the environment. ii. Recall the sources, effects and control of pollution iii. List air, water and soil pollutions iv. Recall the green house effect and depletion of the ozone layer v. Classify pollutants as biodegradable and non-biodegradable vi. Identify local chemical industries and the pollutants they release into the environment.		

INORGANIC CHEMISTRY

28.	TRANSITION METALS (OR 3d-BLOCK METALS (a) Electron configuration	Candidates should recall: i. That the elements Sc to Cu (inclusive) are transition elements. ii. That transition elements have characteristic electron configurations.		8 hours
	(b) Variable oxidation states	i. Give reasons for the multiplicity of oxidation states.		

116

		ii. Recall the oxidizing ability of the permanganates, chromates and dichromates in acid medium.		
	(c) General properties	i. Explain the origin of colour and paramagnetism in transition metal complexes. ii. Explain the contraction in atomic radii of the metals as atomic number increases. iii. Relate the contraction in atomic radii to ionization potential. iv. Recall that they are all metals as a result, have high melting points and densities.		
	(d) Introduction to coordination chemistry.	i. Distinguish between a double salt and a complex salt. ii. Define and give examples of ligands. iii. To name simple metal complexes using IUPAC system. iv. Recall the concept of isomerism and apply this concept to transition metal complexes.		

PRACTICAL CHEMISTRY = 60 Hours
Practical Chemistry to run concurrently with Theory for at least 60 hours per semester

D	QUALITATIVE INORGANIC ANALYSIS Analysis of anions CO_3^{2-}, HCO_3^-, S^{2-}, NO_2^-, Cl^-, Br^-, I^-, NO_3^-, SO_4^{2-}, SO_3^{2-}	Candidates should be able to: i. Recall some reactions that will indicate the presence of the anions ii. Confirm the reactions in (i) above by test with known anions. iii. Recall confirmatory test for common anions. iv. Carry out tests to confirm the presence of	Common reagents and apparatus for qualitative inorganic analysis	15 hours

		the unknown anions in solution.		
	Analysis of cations Na^+, Ca^{2+}, K^+, Pb^{2+}, Cu^{2+}, NH_4^+, Zn^{2+}, Fe^{2+}, Fe^{3+}, Ba^{2+}, Sn^{2+}, Sn^{4+}, Al^{3+}	Candidates should be able to: i. Recall characteristics reactions of the listed cation (flame test) ii. Confirm these reactions with known cations. iii. Recall the confirmatory test for the listed cations. iv. Carry out test to isolate and confirm the presence of the unknown cations in solution. v. Group the cations according to their characteristics reactions with some reagents. vi. Recall the importance of precipitation in isolating and confirming the presence of cations.		18 hours
E	QUALITATIVE ORGANIC ANALYSIS Solubility and Litmus Test	i. Test solubility hot water and ethanol ii. State the effect of red and blue litmus paper	Reagents and apparatus for qualitative organic analysis	3 hours
	Organic functional groups analysis: unsaturation, alkanols, alkanals, alkanones, alkanoic acid, amines, phenols.	Candidates should be able to: i. Recall the reactions of the listed functional groups ii. Perform test with known substances to confirm the presence of the functional groups. iii. Perform test to differentiate one functional group from another e.g. alkanals/alkanones, alkanols/phenols,		18 hours

	saturated/unsaturated, phenols/alkanoic acid etc. iv. Recall the use of common reagents in qualitative organic analysis e.g. Tollen's, Fehlings', iodoform, ferric chloride, saturated aqueous sodium hydrogen trioxocarbonate(IV). v. Perform test to differentiate primary, secondary and tertiary amines.		
Tests for starch, proteins, fats and oils.	Candidates should be able to: i. Recall the use of these reagents in qualitative organic analysis: iodine solution, Biuret test, Sudan III solution. ii. Recall some common tests for the compounds iii. Confirm known substances using suitable test. iv. Perform test to confirm the presence of one or more substances in a given sample.		6 hours

Basic Recommended Textbooks

1. Philips Mattews: "Advanced Level Chemistry" (1996). Cambridge University Press, ISBN 0521 566983. Low price paperback.

2. Graham Hill and John Holman: "Chemistry in Context", 4th Edition (1995). Publishers – Thomas Nelson and Sons Ltd. ISBN 0-17-448191-8.

3. Lee, J.D.: "A New Concise Inorganic Chemistry", 4th Edition (2007). ISBN: 0 442 30179 0. Van Nostrand Reinhold Company Ltd, England.

4. Morrison Boyd: "Organic Chemistry", Sixth Edition (2008), ISBN: 0-13-630179-7. Prentice-Hall International Inc.

5. Addae-Mensah, I., Asomaning, W.A., Bempah, O.A. and Yeboah, S.K.: "Intermediate Chemistry" Fifth Edition (2002). ISBN: 978 153 079-0

6. Sharma, K.K. & Sharma, L.K.: A Textbook of Physical Chemistry", Fourth Revised Edition (2006). ISBN 0-7069-9571-6.Vikas Publishing House.

7. Mukherjee, K.S.: "Textbook on Practical Chemistry", (2008). ISBN: 81-7381-583-6. New Central Book Agency, India. www.newcentralgroup.net

Recommended Further Readings

8. Bahl, A. & Bahl, S.K.: "Advanced Organic Chemistry", (2007). ISBN: 81 219 0061-1

9. E.N. Ramsden: "A-Level Chemistry", 4th Edition(2000). Stanley Thornes (Publishers) Ltd.ISBN 0 7487 5299 4.

10. Chadwick: "Chemistry I and II and III".

11. Kneen, W.R., Rogers, M.J. & Cimpson. P: "Chemistry: Facts, Patterns & Principles".

12. Plane, R.A. and Sienko, M.J.: "Chemistry: Principles and Properties". McGraw Hill.

13. Prakash, S., Tull, G.D., Basu, S.K. and Madan, R.D.: "Advanced Inorganic Chemistry" (2007). ISBN 81 219 0263-0.

14. Clugston M. & Flemming R: "Advanced Chemistry" (2000) ISBN: 978 0 19914633-8