SYLLABUS FOR SCI - J153

CHEMISTRY

GENERAL OBJECTIVES

At the end of the series of courses, candidates should be able to:

1. provide a course of instruction and other facilities for the acquisition of knowledge in the field of chemistry.
2. build on the knowledge and skills acquired in chemistry at the Senior Secondary School level.
3. provide candidates with advanced knowledge in chemical concepts and principles through efficient selection of content.
4. enable candidates improve on and develop new laboratory skills including an awareness of hazards and safety in the laboratory.
5. provide candidates with unique and sufficient academic and technical knowledge relevant for professional careers in industries, governmental agencies, research institutes and the academia.
6. make the study of chemistry enjoyable and satisfying by creating a sustained interest in the subject.
7. deduce the electronic configuration of atoms and ions given the proton number.
8. explain qualitatively the periodic variation in atomic properties.
9. describe chemical bonding (ionic, covalent, coordinate metallic, etc.).
10. predict the shapes and bond angles in molecules using the valence shell electron pair repulsion theory.
11. describe intermolecular forces and relate them to observed properties of compounds.
12. perform stoichiometric calculations.
13. differentiate between reaction types.

FIRST SEMESTER COURSES

CHM 001: GENERAL CHEMISTRY (3 units)

CHM 002: PHYSICAL CHEMISTRY (3 units)

SECOND SEMESTER COURSES

CHM 003: INORGANIC CHEMISTRY (3 units)

CHM 004: ORGANIC CHEMISTRY (3 units)

COURSE DESCRIPTION

CHM 001: GENERAL CHEMISTRY

Specific Objectives

At the end of this course, candidates should be able to:

1. apply scientific quantities and units.

2. perform statistical analysis of data.
3. analyze mass spectra to determine relative abundances and relative atomic mases.
4. determine empirical and molecular formulae.
5. describe the development of the modern atomic structure.

Course content

S/N	Topic	Sub-topic	Details & Notes
1	Measurement	Units of Measurement	Basic S.I. Units, derived units, conversion of units, significant figures.
		Data analysis	Precision and accuracy, errors (systematic and random errors). Error calculations (Standard deviation, relative error, absolute error and percentage relative error).
2	Mole concept	Atomic masses	Isotopy. Use of mass spectrometry in the determination of Relative Atomic Mass. Calculation of relative abundances and isotopic masses.
		The mole	Definitions of the mole based on ^{12}C and Avogadro's constant. Calculation based on Avogadro's constant. Relative Molecular Mass.
		Empirical and molecular formula	Definition and calculations of Empirical and Molecular formulae from percentage composition by mass and combustion data.
		Stoichiometry	Definition and calculations of molarity, molality, mole fraction and mass concentration.
		Standard solutions	Primary and secondary standard. Preparation of standard solutions, serial dilution.
3	Atomic structure	Discovery of sub-atomic particles	Shortcomings of Dalton's atomic theory. Various experiments that led to the discovery of neutrons, protons, electrons and nucleus [Cathode ray, Millikans cathode ray, Rutherford and Chadwick experiment].
		Planck's theory	Black body radiation, photoelectric effect, quantisation of energy.

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		Bohr's theory	Bohr's assumption, atomic spectra of hydrogen and determination of spectra lines, determination of ionisation energy from line spectra (when n=∞).
		Wave theory of atom	Particle wave duality. Atomic orbitals, quantum numbers (n, l, m, and s). Including relation to energy level, degeneracy and orientation of atomic orbitals. Shapes of s, p and d orbitals only.
		Electron configuration	Aufbau principle, Pauli's exclusion principle, Hund's rule.
4	Periodicity	Periodic Table	Development of the modern periodic table, building up periods, identifying blocks and groups of elements, Periodic law.
		Atomic Properties	Trends of atomic size, ionisation potential, electron affinity, electronegativity and ionic radii, isoelectronic species.
5	Types of chemical reactions	Neutralisation	Definition and identification of neutralization reactions.
		Precipitation	Predicting solubility. Identification of precipitation reactions.
		Oxidation and Reduction	Various definitions of oxidation and reduction reaction. Calculation of oxidation numbers, balancing of redox reactions using oxidation state and half-reaction method (both in acidic and basic media). Disproportionation reaction.
		Displacements	Single and double displacement reactions, metathesis.
6	Chemical Bonding	Electrovalent/Ionic Bonding	Describe ionic bonding using some ionic compounds e.g. NaCl, energy considerations of ionic bonding, definition of lattice energy (no derivation), properties of ionic compounds.
		Covalent bonding	Describe covalent bonding using some covalent compounds (e.g., CO_2,) coordinate/dative covalent bonding (e.g. in ammonium ion

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			(NH_4^+), Al_2Cl_6 molecule), bond energy, bond length and bond polarity (Fajan's rule). Properties of covalent compounds, hybridisation concept (sp, sp^2, sp^3, sp^2d, sp^3d, sp^3d^2).
		Molecular geometry	Shapes of simple molecules (e.g. H_2O, NH_3, CH_4, PCl_5, SF_6, CO_2) using the valence shell electron-pair repulsing theory.
		Metallic bonding	Describe metallic bonding in terms of a lattice of positive ions surrounded by delocalised electrons.
		Intermolecular	Van der Waals forces, permanent and induced dipoles, hydrogen bonding. The effect of intermolecular forces on the physical properties of substances (e.g. unusual high boiling, miscibility of water with ethanol, nylon, polyester).

CHM 001 Practical

1. Sensitivity of weighing equipment, Gradation of measuring equipment, and determination of significant figures in readings.
2. Preparation of standard solutions: Serial dilution.
3. Volumetric analysis: Practice in volumetric analysis, acid-base, redox and precipitation titrations. Acid base titrimetry involving NaOH, oxalic acid, HCl and Na_2CO_3. Determination of percentage composition of iron using $KMnO_4$ (redox Titrimetry), Titrimetric analysis of mixtures, NaOH/$NaHCO_3$ and Na_2CO_3/$NaHCO_3$, and gravimetric analysis.
4. Introduction to the statistical analysis of data: Use of supplied data to illustrate elements of simple statistics.

CHM 002: PHYSICAL CHEMISTRY

Specific Objectives

At the end of this course, candidates should be able to:

1. state the assumptions of the kinetic theory for ideal gases.
2. understand the difference between ideal and real gases.
3. apply Hess's Law to construct simple energy cycles and carry out calculations involving such cycles.

4. use redox equation to construct an electrochemical cell using relevant half equations.
5. use experimental data to deduce rate laws and order of reactions.

Course content

S/N	Topic	Sub-Topic	Details & Notes
1	Nature of matter	Phase and phase diagrams	Interconversion between the three states of matter. Interpretation of phase diagram for one component system.
2.	Kinetic Molecular Theory of Gases	Gas Laws	Statement of and calculations involving Boyle's, Charles', Avogadro's law, Dalton's, Graham's laws, and Gay Lussac's law.
		Ideal and Real Gases	Kinetic theory of gases (assumptions only). Calculations involving general and Ideal gas equations. Gas densities and molar mass. Boltzmann's distribution of molecular speed. Real gases deviation from ideal gas behaviour, Van der Waal's equation.
3.	Solutions	Ideal and Non-Ideal Solutions	Definition of ideal solutions, Raoult's Law and its Deviations.
		Colligative Properties	Lowering of vapour pressure, depression of freezing point, elevation of boiling point and osmotic pressure. Determination of molar masses using Colligative properties. (The derivation not required).
4	Thermochemistry	Enthalpy Change	Exothermic and endothermic changes. Definition of enthalpy changes for processes (combustion, neutralization, hydration, formation, solution and atomization) under standard condition.
		Hess's Law	State Hess' law Calculation based on Hess's law and Construction of energy cycles based on Hess' law. Born-Haber cycle for and carry out calculation of lattice energy. s based on Hess' law Use of bond energy to calculate energy changes.
5	Thermodynamics	First law of thermodynamics	Calculations in first law of thermodynamics: Internal energy, heat change and work done (no derivations). Concept of isothermal and adiabatic processes.

S/N	Topic	Sub-Topic	Details & Notes
		Entropy and Gibb's free energy	Definition of entropy changes. Calculations involving entropy change and Gibb's free energy change for reactions using $\Delta G = \Delta H - T\Delta S$. Predicting the spontaneity of reactions
4	Electrochemistry	Electrolysis	Faraday's first and second laws of electrolysis and calculations based on them. Identify the substances liberated during electrolysis based on the state of electrolyte, position in electrochemical series, concentration of electrolyte and nature of electrodes. Industrial uses of electrolysis.
		Electrochemical Cells	Definitions of electrode potential, standard electrode potential, cell potential. Calculations of e.m.f of a cell. Application of Nernst equation. Use of cell potential to predict the feasibility of reactions.
		Fuel Cells and Batteries	H_2/ O_2 fuel cell, rechargeable batteries.
5	Chemical Kinetics	Rate Equations	Define and explain rate of reaction, order, molecularity and rate determining step and reaction mechanism. Factors affecting rate of reaction, rate constants. Determination of orders of reaction (0, 1 and 2), half-life and, rate constants from experimental data. Calculations of order of reaction from experimental data.
		Activation energy	Simple collision theory. Definition of activation energy. Arrhenius equation.
		Catalysis	Homogeneous and Heterogeneous catalysis. Identify homogenous and heterogeneous catalyst from equations.
6	Equilibrium State	Mass Action	Equilibrium changes, reaction quotient (Q), equilibrium expressions (homogenous and heterogeneous equilibria). Calculations of equilibrium constants in terms of concentration (K_c) and partial pressure (K_p). Relationship between K_c and K_p. Predicting spontaneity using equilibrium constant
		Le-Chatelier's Principle	Application of Le-Chatelier's principle to deduce the effects of changes in

S/N	Topic	Sub-Topic	Details & Notes
			temperature, pressure and concentration on a system at equilibrium.
		Acid-Base Equilibria	Arrhenius, Bronsted-Lowry and Lewis concepts of acid and base. Auto-ionisation of water. Acid strengths, pH of acids and bases (strong and weak). Indicator theory. Buffer solution: Definition, types, pH (Henderson equation).
		Ionic Equilibra in Aqueous System	Solubility product, common ion effect. Selective precipitation of ions. Salt hydrolysis.
7	Nuclear Chemistry	Radioactivity	Types of radiations, nuclear stability, types of radioactivity. History of Radioactivity. Types of radiations. Radioactive disintegration. Balancing of nuclear equations, half-life, radioactive carbon dating. Detectors and applications of radioactivity.
		Energy changes in nuclear reaction	Mass defect, energy changes

CHM 002 Practical

1. Experiments to calculate` enthalpy changes.
2. Determination of molecular mass using freezing point depression.

CHM 003: INORGANIC CHEMISTRY

Specific Objectives

At the end of this course, candidates should be able to:

1. describe the trends in physical and chemical properties of elements and their compounds in period 3.
2. discuss gradation in properties across the period from metal through metalloid to non-metals.
3. explain what a transition element is in terms of d – block elements.
4. describe the tendency of transition metals to form variable oxidation states and write their electronic configuration.
5. use valence bond theory to explain properties of coordination compounds.

Course content

S/N	Topic	Sub-Topic	**Details & Notes**
1.	Periodicity	General Trends in Properties	General trends in physical and chemical properties of period III elements and their compounds (chlorides, oxides and hydrides). Solid structure of the elements, e.g. face centered, body centered and hexagonal closed packing. Diagonal relationship. Anomalous behaviour of period II.
2.	Chemistry of Hydrogen	Hydrogen	Occurrence, isotopes, preparation and reactions, hydrides.
3.	s-block elements	Group 1	Physical and chemical properties, extraction of group 1 metals e.g. Sodium. Trends in properties of their compounds (chlorides, oxides, hydrides, carbonates, hydroxides, nitrates and sulphates). Uses of group 1 metals.
		Group 2	Physical and chemical properties, extraction of group 2 metals e.g. Calcium. Trends in properties of their compounds (chlorides, oxides, hydrides, carbonates, hydroxides, nitrates and sulphates). Uses of group 2 metals.
		Group 14	Occurrence, allotropic forms of carbon (diamond, amorphous carbon and fullerene) and tin. Trends in physical and chemical properties of the elements, oxides, hydrides and halides. Uses of group 14 elements.
		Group 15	Occurrence, allotropic forms. Trends in physical and chemical properties of the elements, oxides, hydrides and halides. Uses of group 15 elements.
		Group 16	Occurrence, allotropic forms. Types of oxides. Trends in physical and chemical properties of the elements, oxides, hydrides and halides. Uses of group 16 elements.

		Group 17	Occurrence, physical and chemical properties, hydrogen halides, metal halides and inter-halogen compounds. Uses of group 17 elements.
5	Chemistry of the Environment	Environmental impact	Greenhouse effect. Environmental impacts of greenhouse gases, NOx, SOx. Acid rain, ozone layer depletion, global warming.
6.	d-block elements	First Row Transition Elements	Definition of transition elements, electronic configuration. Periodic trends in atomic radii, ionization potential and variable oxidation states. Properties of transition elements.
		Introduction to Coordination Chemistry	Definition of metal complex and ligands, types of ligands. Bonding in metal complexes (chain theory and its limitations, Werner's theory). Valence bond theory (to explain properties of coordination compounds). Study of structure and magnetic properties of octahedral and tetrahedral complexes. Nomenclature of coordination compounds.
7	Nanochemistry	Introduction to dimensions of nanomaterials	Definition of nanomaterials and nanotechnology. Classification of nanostructures. Sources of nanomaterials and examples.

CHM 003 Practical

Qualitative Inorganic Practical

1. Flame tests and systematic analysis of mixtures containing two salts.
2. Identification of anions: preliminary tests for anions, preparation of Na_2CO_3 extracts and confirmatory tests.
3. Identification of cations group I – VI: Group separation and analysis of ions within a group (group analysis).

CHM 004: ORGANIC CHEMISTRY

Specific Objectives

At the end of this course, candidates should be able to:

1. interpret and use nomenclature and general formulae of alkanes, alkenes, alkynes, aldehydes, ketones, alcohols, alkyl halides and carboxylic acids and their derivatives.
2. describe the synthetic routes to simple organic compounds and the reactions of the above classes of compounds.
3. identify the monomer present in a given section of a polymer molecule**.**
4. relate chemical principles to industrial processes.
5. explain the various types of isomerism exhibited by organic compounds.

Course content

S/N	Topic	Sub-Topic	**Details & Notes**
1.	Separation and Purification techniques	Separation Techniques	Distillation, liquid extraction, sublimation, recrystallization and melting point. Chromatography (TLC and Paper chromatography)
		Determination of Elements	Sodium fusion test. Determination of empirical formula and molecular formula.
2.	Structure and Bonding in Organic Compounds	Hybridization	Tetravalency and hybridization of carbon. Sigma and pi bond formation.
		Classes and Nomenclature of Organic Compounds	Homologous series, Functional groups, Naming of organic compounds (IUPAC): alkanes, alkenes, alkynes, aldehydes, ketones, alcohols, alkyl halides, arenes, carboxylic acids (and derivatives), amines and amides.
3	Organic Reactions	Covalent Bond Cleavage	Homolytic and heterolytic fission, free radicals, Nucleophiles and electrophiles.
		Types of Reactions	Addition, Substitution and Elimination reactions. Differences between S_N1 and S_N2 S_E1 and S_E2.
		Electronic Concepts in Organic Chemistry	Inductive, steric, mesomeric and electrometric effects.
4.	Isomerism in Organic Compounds	Isomerism in Organic Compounds	Constitutional; chain, position, metamerism and functional group isomerism. Tautomerism. Stereoisomerism; geometrical (Cis/ Trans, E/Z) and optical isomerism (chirality and optical activity).

5.	Organic Compounds	Alkanes, Alkenes and Alkynes	Nomenclature, structure, synthesis, properties and reactions (for alkene include Markovnikov and Saytzeff's rules).
		Alcohols	Nomenclature, classes and structure. Synthesis, properties and reactions. Distinguishing tests for alcohols (Lucas and Jones reagents).
		Alkyl halides	Nomenclature, structure, synthesis, properties and reactions.
		Carbonyl Compounds	Nomenclature, structure, synthesis, properties and reactions (including reduction, reaction with HCN, NaCN, reaction with aqueous I_2). Tests for aldehydes and ketones.
		Carboxylic acids and their derivatives (treat each separately).	Nomenclature, properties. Preparation and reactions.
		Amines	Nomenclature and classification of amines. Preparation of primary alkylamines. Basicity of amines in terms of their structure. Reactions of amines (formation of diazonium salt)
		Aromatic compounds	Kekule structures. Aromaticity. Reactions of benzene (Nitration, sulphonation, halogenation, Friedel Craft's). Nomenclature of benzene derivatives (mono and di-substituted). Effects of substituents on reaction of benzene (o, m, p-directors).
6.	Macromolecules	Carbohydrates (Open chain structures only)	Classes of carbohydrates. Simple tests
		Proteins	Amino acids. Reactions of amino acids (formation of peptide bonds, zwitterions). Classification of peptides. Types of proteins.

		Polymers	Types of polymerization reactions and their differences. Simple structures of polymers. Uses of common polymers. Differences between thermosets and thermoplastics.
7.	Petroleum Industry	Petrochemicals	Constituents of crude oil, refining, cracking. Chemicals derived from crude oil.

CHM 004 Practical

1. Reactions of simple functional groups: Simple organic tests, solubility, sodium fusion test, functional group identification (with emphasis on ketones, aldehydes and carboxylic acids).
2. Re-crystallisation and determination of melting point of organic compounds.

RECOMMENDED TEXT

1. Ebbing, D., Ragsdale, R. O., & Gammon, S. D. (2005). Essentials of General Chemistry (2nd Ed). Boston M: Houghton Mifflin College Div.
2. Lee, J. D. (1999). Concise Inorganic Chemistry (5th Ed.). New Jersey: Wiley – Blackwell.
3. Cann, P. & Hughes, P. (2015). Cambridge International As and A level Chemistry. United Kingdom: Cambridge University Press.
4. Madam, R. L. & Tuli, G. D. (2010). Inorganic Chemistry for Universities (Revised Ed.) New Delhi, India: S. Chand.
5. Canhan, G. R. & Overton, T. (2013). Descriptive Inorganic Chemistry. New York: W. H. Freeman and Co.
6. Matthews, P. (1992). Advanced Chemistry (Low Price Ed.). United Kingdom: Cambridge University Press.
7. Ramsden, E.N. (2000). A – Level Chemistry (4th Edition) Stanley Thornes.
8. Osuntogun, O. B., Familoni, O. B. & Alo, B. I. (2012). Basic Organic Chemistry (Third Edition). Lagos: University of Lagos Press.
9. Tan, J. & Chan, K. S. (2009). Understanding Advanced Physical Inorganic Chemistry. World Scientific.
10. Silberberg, M. S. (2010). Principles of General Chemistry (Second Edition), New York: McGraw Hill.
11. Wong, Y. C., Wong, C. T., Onyiruka, S. O. & Akpanisi, L. E. S. (2002). University General Chemistry, Inorganic and Physical. Africana – FEP Publishers Ltd.