

DEPARTMENT OF PURE AND APPLIED CHEMISTRY
FACULTY OF PURE AND APPLIED SCIENCE
COLLEGE OF COMPUTING, ENGINEERING AND SCIENCE
KADUNA STATE UNIVERSITY



POSTGRADUATE STUDENTS' HANDBOOK
2024/2025 ACADEMIC SESSION

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Faculty of Pure and Applied Science
College of Computing, Engineering and Science
Kaduna State University
Kaduna.**

PREFACE

I congratulate the pioneer students for having the opportunity to be admitted into the postgraduate programme of the Department of Pure and Applied Chemistry, Kaduna State University. We hope that you will find this environment useful for your studies.

This handbook has been compiled purposely to provide the students with basic information about their department. The book comprises of the brief history of the department, graduation requirements, courses and their synopsis.

I urge you to interact well with your course mates as well as your lecturers. Take your studies serious to ensure you finish in time. I wish you success in your research.

Dr. A. M. Nuhu
Head, Department of Pure and Applied Chemistry
Kaduna State University

PRINCIPAL OFFICERS OF THE UNIVERSITY

Visitor

His Excellency, Executive Governor of Kaduna State,
Mallam Uba Sani

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Sanusi Lamido Sanusi

Pro- Chancellor and Chairman of Governing Council

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Bursar

Hauwau Dalhat

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Dr. Babangida Dangani

INTRODUCTION

The Department of Chemistry (now known as Department of Pure and Applied Chemistry) is one of the pioneer departments in the Faculty of Science when the university was established in May, 2004. The department runs the B.Sc. (Hons) Chemistry and B.Sc. (Hons) Industrial Chemistry degrees. The first set of students into the two programmes was admitted into the 100 Level of study in 2005. These students graduated with the B.Sc. (Hons) degree in 2009.

The Department commences its Postgraduate Diploma in Industrial Chemistry (PGD Industrial Chemistry) in 2014/2015 session. The Department hopes to commence its M.Sc and PhD Chemistry during 2024/2025 session with the specialization in Analytical Chemistry, Organic Chemistry, Industrial Chemistry, Polymer Science and Technology Chemistry, Colour Chemistry and Inorganic Chemistry.

The Department is run by a team of dedicated academic, technical and administrative staff, with passion for fairness, firmness, thoroughness and hard work.

PHILOSOPHY, VISION, MISSION, AIMS AND OBJECTIVES

Philosophy

Chemistry is a multidisciplinary subject that is central to industrial growth and development of any nation. The Chemistry content in Agriculture, Engineering, Medicine, Food Technology, etc are well known. Every aspect of human life has benefited from this subject.

Vision

To develop a world class environment for the conduct of postgraduate studies and research to meet the needs of contemporary society.

Mission

To provide platform for maximizing creativity and excellence in research to improve humanity and its environment

Objectives

The main objectives of Postgraduate programme in chemistry are to:

- i. To produce high level manpower in the field of Chemistry through the acquisition of requisite skills and knowledge for national development.
- ii. To develop in graduates of Chemistry a sense of inquiry, capacity for independent research and motivation to extent the frontiers of science and technology.
- iii. To produce graduates who will be adequately equipped for relevance in the global knowledge economy.
- iv. To produce graduates who are capable of applying appropriate principles of Chemistry for solving problems for the promotion of human well-being.
- v. To produced manpower with optimal competencies and skills to function effectively in the academia and the private sector as well as relevant public sector of the economy.

GENERAL REQUIREMENTS (M.Sc and PhD)

(a) M.Sc Chemistry Programme (Full-Time)

Duration

This programme is run on full-time basis and shall be for a minimum period of four (4) semester or twenty four (24) calendar months and a maximum of six (6) semesters or thirty six calendar months.

Admission Requirements

- i. A possession of a first degree from Kaduna State University or any other recognized institution with a first class or second class honour.
- ii. A candidate with a third class degree that has obtained a Postgraduate Diploma from Kaduna State University or any other recognized University with a CGPA not less than 3.50 on 5 point scale may be considered for admission into M.Sc programme.
- iii. All candidates must have five credit passes including English Language, Mathematics, Chemistry, Physics and Biology.

GRADUATION REQUIREMENT

M.Sc Chemistry Programme

A candidate must satisfy the following requirements to graduate:

A candidate must pass a minimum of **38 credit** units made up as follows:

38 Credit Units Core Courses

2 Credit Units Elective Courses

6 Credit Units Compulsory Research thesis.

Student shall present a proposal, seminar, submit and defend a thesis.

A student must have presented a proposal, progress report and external defense

PhD Chemistry Programme

Duration

The minimum duration for a full-time programme is six (6) semester or thirty six (36) calendar months and a maximum of eight (8) semester or forty eight (48) calendar months.

Admission Requirements

- i. A possession of M.Sc. degree from Kaduna State University or any other recognized institution with CGPA 4.00 on 5 point scale.
- ii. A possession of MPhil/PhD with CGPA of 4.00 and above.
- iii. All candidates must have five credit passes including English Language, Mathematics, Chemistry, Physics and Biology.

A candidate must satisfy the following requirements to graduate:

A candidate must pass a minimum of **22 credit** units made up as follows:

10 Credit Units Core Courses

12 Credit Units Compulsory Research Thesis

4 Seminars Presentation comprises of (i) Research proposal (ii) Progress Report

(iii) Final seminar Report (iv) External Defense

Scoring and Grading System

The scores for each course shall make up of 30% continuous assessment and 70% examination. To pass a Postgraduate courses, a student must score at least a total of 50% in continuous assessment and examination.

The performance of a student in a semester will be reported by the Grade Point Average (GPA), while the overall performance at the end of a session will be reported by the Cumulative Grade Point Average (CGPA).

The grading of scores shall be as follows:

Percentage Scores	Letter Grade	Grade Point (GP)
70 – 100	A	5
60 – 69	B	4
50 – 59	C	3
0 – 49	F	0

COURSES OUTLINE FOR M.Sc PROGRAMME

FIRST SEMESTER COURSES

This is mandatory for all students admitted for the MSc Programme

Core Courses			
<i>First Semester:</i>			
S/N	Course Code	Course Title	Credit unit
1	SCI 801	Management & Entrepreneurship	3
2	CHM 811	Separation Methods of Analysis	3
3	CHM 813	Advanced Spectroscopic Techniques	3
4	CHM 815	Advanced Physical Chemistry	3
5	CHM 817	Organo-metallic Chemistry	3
6	CHM 891	Seminar	2
			Total: 17

Available options as proposed include;

a) Analytical Chemistry Core/Elective courses

<i>Second Semester:</i>			
S/N	Course Code	Course Title	Credit unit
1	SCI 802	ICT & Research Methodology	3
2	CHM 802	Statistical Method of Analysis	2
3	CHM 810	Classical Methods of Analysis	3
4	CHM 812	Environmental Chemistry and Pollution Control	3
5	CHM 814	Advanced Water Quality and Analysis	2
6	CHM 816	Food, Drugs and Cosmetics Analysis	3
7	CHM 818	Environmental Assessment Techniques	3
			Total: 19
		ELECTIVES	
8	CHM 802	Analysis of Miscellaneous Materials	2

10	CHM 804	Electro Analytical Techniques	2
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b) Organic Chemistry Core/Elective courses

Second Semester:			
S/N	Course code	Course Title	Credit Units
1	SCI 802	ICT & Research Methodology	3
2	CHM 802	Statistical Method of Analysis	2
3	CHM 820	Advanced Organic Chemistry	3
4	CHM 822	Advanced Natural Products Chemistry	3
5	CHM 824	Advanced Organic Reaction Mechanism	2
6	CHM 826	Advanced Structural and Molecular Organic Chemistry	3
7	CHM 828	Organic Synthetic Methods	2
			Total: 18
8	ELECTIVES		
9	CHM 834	Petroleum Geochemistry	3
10	CHM 806	Laboratory Purification Techniques	3

c) Industrial Chemistry Core/Elective courses

Second Semester:			
S/N	Course code	Course Title	Credit Units
1	SCI 802	ICT & Research Methodology	3
2	CHM 802	Statistical Methods of Analysis	2
3	CHM 830	Analytical Chemical Process Technology	3
4	CHM 832	Advanced Chemistry of Selected Industrial Process	3
5	CHM 834	Heterogeneous & Homogeneous Catalysis	3
6	CHM 836	Industrial Pollution & Waste Management	2
7	CHM 838	Petroleum Geochemistry	3
			Total: 19
	ELECTIVES		
8	CHM 808	Coal, its combustion and processing	3
9	CHM 818	Food, Drugs and Cosmetics Analysis	2
10	CHM 862	Industrial Production Management	2

d) Polymer Science and Technology Core/Elective courses

Second Semester:			
S/N	Course code	Course Title	Credit Units
1	SCI 802	ICT & Research Methodology	3

2	CHM 802	Statistical Methods of Analysis	2
3	CHM 840	Polymer Synthesis, Mechanism of Formation and Kinetics	2
4	CHM 842	Polymer Reactions, Degradation and Recycling	2
5	CHM 844	Polymer Testing and Characterization	3
6	CHM 846	Advanced Plastics, Elastomers and Fibre Processing Technology	3
7	CHM 848	Selected Topics in Polymer Science and Technology	3
			Total: 18
	ELECTIVES		
8	CHM 864	Polymer Blends and Composites	3
9	CHM 866	Structure, Properties and Stereochemistry of Polymers	3

e) Colour Chemistry and Technology Core/Elective courses

<i>Second Semester:</i>			
S/N	Course code	Course Title	Credit Units
1	SCI 802	ICT & Research Methodology	3
2	CHM 802	Statistical Methods of Analysis	2
3	CHM 820	Advanced Organic Chemistry	3
4	CHM 850	Colour Chemistry and Technology	3
5	CHM 852	Physical Chemistry of Dye Adsorption	2
6	CHM 854	Pigments, Colour Measurements & Quality Control	3
7	CHM 856	Coloration Technology	3
			Total: 19
	ELECTIVES		
8	CHM 836	Industrial pollution & Waste management	2
9	CHM 868	Synthesis of Dyes, Pigments and Chemical Intermediate	2

f) Inorganic Chemistry Core/Elective courses

<i>Second Semester:</i>			
S/N	Course code	Course Title	Credit Units
1	CHM 800	Solid State Chemistry	2
1	SCI 802	ICT & Research Methodology	3
2	CHM 802	Statistical Methods of Analysis	2

3	CHM 890	Metal Ion in Solution	3
4	CHM 894	Spectroscopic Techniques in Inorganic Chemistry	2
5	CHM 896	Coordination Compounds	3
6	CHM 898	Advanced Inorganic Reaction Mechanism	3
			Total: 18
	ELECTIVES		
7	CHM 812	Environmental Chemistry and Pollution Control	3
8	CHM 834	Heterogeneous and Homogenous Catalysis	3

COURSE SYNOPSIS: M.Sc CHEMISTRY

FIRST SEMESTER

SCI 802: ICT & Research Methodology

Credit Units: 2

- Spreadsheets and Internet technology
- A review of the Fundamentals: Meaning of Research, Definitions of Research, Objectives of Research, Motivation in Research, General Characteristics of Research, Criteria of Good Research, Types of Research.
- The Research Problem: Scientific Thinking, What is a Research Problem, Selecting the Problem, Sources of the Problem, Defining a Problem, Statement of a Problem, Delimiting a Problem, Evaluation of a Problem.
- The Review of Literature: Meaning of Review of Literature, Need of Review of Literature, Objectives of Review of Literature, Sources of Literature, The Functions of Literature, How to Conduct the Review of Literature, Some Hints for the Review of Literature, Precautions in Library Use, Reporting the Review of Literature.
- The Research Hypotheses: Meaning of Hypothesis, Definitions of Hypothesis, Nature of Hypothesis, Functions of Hypothesis, Importance of Hypothesis, Kinds of Hypothesis, Characteristics of a Good Hypothesis, Variables in a Hypothesis, Formulating a Hypothesis, Testing the Hypothesis.
- Sampling: Meaning and Definition of Sampling, Functions of Population and Sampling, Methods of Sampling, Characteristics of a Good Sample, Size of a Sample.

CHM 811: Separation Methods of Analysis

Credit Units: 3

Ultra purity and ultratrace analysis; Gas Chromatography (GC) and Gas Chromatography-Mass spectroscopy (GC-MS); principles, Plate theory, Instrumentation and working of a GC, Detectors, programmed, temperature GC, applications. Solvent extraction, Thin layer

chromatography, Ion-exchange chromatography, Ion chromatography, Molecular exclusion chromatography, Paper chromatography, High performance liquid chromatography. Super critical fluid chromatography. Emphasis will be on NMR, MS and GCMS High resolution.

CHM 813: Advanced Spectroscopic Techniques

Credit Units: 3

Basic instrumentation and techniques, applications of UV-VIS, IR, N.M.R., M.S., in chemical analysis and structural elucidation. Emphasis will be on N.M.R., M.S., G.C - M.S. High resolution N.M.R., ¹³C N.M.R. and other nuclei. Nuclear overhauser effect. Shift reagents and other new experimental methods. Coupling and decoupling, M.S. All positive and negative ions structure fragmentation. Chemical ionization, field desorption and recent application of linked-scan techniques.

CHM 815: Advanced Physical Chemistry

Credit Units: 3

Kinetic methods; Theoretical basis of kinetic methods of analysis, methods of determining amount of the substance, tangent method, fixed time and concentration method. Addition method, oxidation reactions of H₂O₂ with thiosulphate, Iodine and amino, enzyme catalyzed reactions, Inhibitors and activators. Photochemistry: Laws governing absorption of light, processes of photochemical reaction, quantum yield, fluorescence, phosphorescence and their differences, Jablonski diagram. Thermal methods of analysis; effect of heat on materials, chemical decomposition and TG curves, Analysis of TG curve to show nature decomposition reactions, the product and qualities of compounds, expelled, applications, instrumentation, TG in controlled atmospheres DTA, instrumentation and methodology, application, DSC, theory, instrumentation and applications, Thermometric titrations method and applications.

CHM 817: Organometallic Chemistry

Credit Units: 3

Preparation, reaction and structure including abnormal behavior with emphasis on organometallic compounds of groups I, II, III, IV and transition elements. The organic chemistry of ferrocene and related compounds. Biological organometallic compounds systems. Organometallic complexes in some catalytic reactions.

CHM 881: Seminar

Credit Units: 2

Seminar on student work plan and the state of scientific knowledge in the chosen area of research shall be presented. The student is required to make a critical survey of the literature in the area of specialization and to give a seminar on relevant topics using a power point presentation

ANALYTICAL CHEMISTRY OPTION

CHM 802: Statistical Method of Analysis

Credit Units: 2

Introduction to data analysis with a focus on regression. Initial Examination of data. Correlation. Simple and multiple regression models using least squares. Inference for regression parameters, confidence and prediction intervals. Diagnostics and remedial measures. Interactions and dummy variables. Variable selection. Least squares estimation and inference for non-linear regression. Vocabulary of data analysis, Tests of statistical significance, Principles of research design, Introduction to unix, Introduction to SAS, Elementary significance tests, Multiple regression, Factorial ANOVA, Permutation tests, Power and sample size, Random effects models, Multivariate analysis of variance, Analysis of within-cases designs (repeated measures). The use of statistical software in modern data analysis (Minitab, Excel, SPSS, Origin8 etc.) to analyse and interpret data.

CHM 810: Classical Methods of Analysis

Credit Units: 3

Reaction chemistry of selected elements. Aqueous and non-aqueous acid-base titrimetry, redox titrimetry, complexometric titrations, precipitation titrations. Gravimetry: types, process, PFHS and contamination. Seminars on applications of classical techniques.

CHM 812: Environmental Chemistry & Pollution Controls

Credit Units: 3

Introduction and principles of chemical pollution of environmental media (air, soil and water) and associated resources. Water/waste water chemistry, soil chemistry and fate of pollutants, air pollution chemistry, fate, effects and monitoring. Environmental toxicology. Chemistry of Persistent Toxic substances including Persistent organic Pollutants (POPs). Environmental indicators of chemical pollution and marker compounds. Remediation of contaminated environment.

CHM 814: Advanced Water Quality and Analysis

Credit Units: 2

Water quality parameters for various (Industrial, Agricultural and Domestic) uses. Methods of analysis of water and wastewater for various quality parameters. Analysis for trace organics. Water pollution control and treatment.

CHM 816: Food, Drug and Cosmetics Analysis

Credit Units: 3

Food composition. Methods of analysis of food for proximate composition, vitamins, minerals, additives, food contaminants. Pesticides residues in foods. Food quality control. Analysis of major groups of commonly encountered drugs. Foods and Drugs Regular Control. Analysis of cosmetics; composition of creams and lotions. Determination of water, propylene glycol non-volatile matter and ash content. Determination of borates, carbonates, sulphate, phosphate, chloride, titanium and zinc oxide. Analysis of face powder; estimation of boric acid, Mg, Ca, Zn, Fe, Al and Ba; Analysis of ingredients of hair dyes.

CHM 818: Environmental Assessment Techniques**Credit Units: 3**

Introduction and Principles of Environmental Assessment including Environmental Impact Assessment (EIA) and Environmental Auditing. Environmental baseline studies, Environmental modeling, GIS methods. Types of Environmental Impact Identification, Prediction, Evaluation, Impact mitigation, Environmental Monitoring, Environmental policy and regulations on environmental Assessment. Risk Assessment. Sampling in analysis; definition, theory and techniques of sampling, sampling of gas, liquids and solids, criteria of good sampling, minimization of variables, High pressure ashing techniques (HPAT).

CHM 802: Analysis of the Miscellaneous Materials**Credit Units: 3**

Analysis of air, soils, minerals, rocks, sediments, fish, clinical samples for inorganic and organic chemical pollutant other miscellaneous materials. **(Elective)**

CHM 804: Electro Analytical Techniques**Credit Units: 2**

Potentiometry, Voltammetry, Coulometry, Electrogravimetry, Conductometry, Chronopotentiometry **(Elective)**

ORGANIC CHEMISTRY OPTION**CHM 802: Statistical Method of Analysis****Credit Units: 2**

Introduction to data analysis with a focus on regression. Initial Examination of data. Correlation. Simple and multiple regression models using least squares. Inference for regression parameters, confidence and prediction intervals. Diagnostics and remedial measures. Interactions and dummy variables. Variable selection. Least squares estimation and inference for non-linear regression. Vocabulary of data analysis, Tests of statistical significance, Principles of research design, Introduction to unix, Introduction to SAS, Elementary significance tests, Multiple regression, Factorial ANOVA, Permutation tests, Power and sample size, Random effects models, Multivariate analysis of variance, Analysis of within-cases designs (repeated measures). The use of statistical software in modern data analysis (Excel, SPSS, Origin8 etc.) to analyse and interpret data.

CHM 820: Advanced Organic Chemistry**Credit Units: 3**

Reaction mechanism in organic chemistry- nucleophilic substitution reactions, electrophilic substitution reactions, addition reactions, elimination reactions. Linear free energy relationship. Kinetic studies. Factors affecting reactions rates. Hammett, Taft, Swain-Scott equations and Hine equation. Structure- activity relationships. General acid-base catalysis. Solvent effects and solvent interactions. Polar transition states. Radical transition states, isopolar transition state. Non- classical ions: rearrangement and neighboring group effects. Review of reaction

intermediates, and unusual molecules. Principle of least nuclear motion and its use in organic reactions mechanism. Role of model studies in understanding of the mechanistic aspects of enzymatic reactions, mechanism of intramolecular reactions, and concept of effective molarity. Mechanistic details of few well studied organic reactions - hydrolysis and aminolysis of amides. Amides and esters, nitriles, ylides and heterocyclic chemistry.

CHM 822: Advanced Natural Products Chemistry

Credit Units: 3

Mechanistic and biosynthetic approach to plant and marine secondary metabolites listed below in terms of introduction, definition, nomenclature and physiological action, extraction, properties, classification, occurrence, isolation, general methods of structure determination, isoprene rule, stereochemistry, biosynthesis of the following representative molecules and biological significance will also be discussed:

1. Prostaglandins: Occurrence, nomenclature, classification, biogenesis and physiological effects. Synthesis of PGE₂ and PGF₂α.
2. Terpenes and Terpenoids: Citral, Geraniol, α-Terpeneol, Farnesol, Zingiberene,
3. Coumarins: psoralen, xanthotoxin and umbelliferone. Acetate-malonate pathway (Biosynthesis of plant fatty acids, biosynthesis and oxidation of ricinoleic acid).
4. Polyketides (Biosynthesis of 6-methylsalicylic acid, petulin, penicillanic acid, griseofulvin, tetracyclines). Mixed biogenesis of plant products. Acetate-mevalonate pathway (biosynthesis of psoralen, gibberellic acid, cholesterol, conessine). Shikimic acid pathway (Biosynthesis of chlorogenic acid, cichoriin).
5. Steroids: cholesterol (configuration, structure, biosynthesis, intermediate for: vitamin D, bile acids, corticosteroids, sex hormones);
6. Carotenoids and cardiac glycosides: β-Carotene, α-amyrin, Phytol and Abietic acid. Porphyrins: Structure of Haemoglobin and Chlorophyll. Including its occurrence, nomenclature, basic skeleton, Diels-Alder hydrocarbon, stereochemistry and biosynthesis. Isolation, structure determination of cholesterol and bile acids.
7. Pyrethroids and Rotenones: Structure and reactions.

CHM 824: Advanced Organic Reaction Mechanism

Credit Units: 3

Mechanistic details of few well studied organic reactions. Dissociative processes; carbanion, carbenes, and free radical, synchronous reaction S_N2E₂, thermal syn-elimination and elimination, multivalent reaction. Orbital symmetry rules. Electrocyclic reaction mechanism. Cycloaddition and sigmatropic reaction. Associative reactions -/electrophilic addition to unsaturated system and free radical addition to olefins.

CHM 826: Advanced Structural and Molecular Organic Chemistry Credit Units: 3 **Unit**

1: Basic Concepts in Organic Chemistry

Review of basic concepts in organic chemistry: bonding, hybridisation, MO picture,

inductive effect, electromeric effect, resonance effect, hyperconjugation, steric effect. Bonding weaker than covalent bonds.

The formalism of curved arrow mechanisms. Practicing of line diagram drawing.

Concept of aromaticity: delocalization of electrons - Hückel's rule, criteria for aromaticity, examples of neutral and charged aromatic systems - annulenes. NMR as a tool for aromaticity. Anti- and homo-aromatic systems - Fullerenes, Carbon nanotubes and Graphene.

Mechanism of electrophilic and nucleophilic aromatic substitution reactions with examples. Arenium ion intermediates. SN1, SNAr, SRN1 and Benzyne mechanisms.

Unit-II: Stereochemistry of Organic Compounds

Introduction to molecular symmetry and chirality: examples from common objects to molecules. Axis, plane, center, alternating axis of symmetry.

Center of chirality: molecules with C, N, S based chiral centers, absolute configuration, enantiomers, racemic modifications, R and S nomenclature using Cahn-Ingold-Prelog rules, molecules with a chiral center and C_n, molecules with more than one center of chirality, definition of diastereoisomers, constitutionally symmetrical and unsymmetrical chiral molecules, erythro, threo nomenclature.

Axial, planar and helical chirality with examples, stereochemistry and absolute configuration of allenes, biphenyls and binaphthyls, ansa and cyclophanic compounds, spiranes, exo-cyclic alkylidenecycloalkanes.

Topicity and prostereoisomerism, topicity of ligands and faces as well as their nomenclature. NMR distinction of enantiotopic/diastereotopic ligands.

Stereoisomerism: definition based on symmetry and energy criteria, configuration and conformational stereoisomers.

Geometrical isomerism: nomenclature, E-Z notation, methods of determination of geometrical isomers. Interconversion of geometrical isomers.

Unit III: Conformational Analysis

Conformational descriptors - factors affecting conformational stability of molecules.

Conformational analysis of acyclic and cyclic systems: substituted ethanes, cyclohexane and its derivatives, decalins, adamantane, congressane, sucrose and lactose. Fused and bridged bicyclic systems.

Conformation and reactivity of elimination (dehalogenation, dehydrohalogenation, semipinacolic deamination and pyrolytic elimination-Saytzeff and Hofmann eliminations), substitution and oxidation of 2° alcohols.

Chemical consequence of conformational equilibrium - Curtin Hammett principle.

CHM 828: Organic Synthetic Methods

Credit Units: 3

Review of functional groups and skeletal modifications. New synthetic methods and asymmetric synthesis. Retrosynthesis. Selected topic in natural products - bio synthesis and chemistry of heterocyclic compounds. Plants and insects products. The use of organometallic compounds in

organic chemistry. Selected organic reagents - for synthesis - protection groups and other multi-step organic transformations.

CHM 838: Petroleum Geochemistry

Credit Units: 3

Introduction and objectives of geochemistry. Source rocks: depositional environment, Quality assessment of source rocks, Generation, Migration (from kitchen to trap) and expulsion of hydrocarbons. Oil finger printing: Objective of oil analyses, Basic chemistry of hydrocarbons, Analytical techniques in petroleum geochemistry, The basic parameters for oil typing, The gasoline fraction: the "star diagram method". Non-conventional fossil fuels, shales, tar-sands, hydrates. Isotope geochemistry. Exploration applications: Basins and petroleum systems, Biomarkers, Oil family mapping, Gas geochemistry, Biodegradation of oil, Prospect risking using geochemical data. Reservoir compartmentalisation: Reservoir architecture and filling history, High Resolution GC for reservoir geochemistry, Maturity effects and reservoir compartments, Case histories: Monitoring, compartmentalisation, near-field exploration. Wells, pipeline, infrastructure: Water washing, Evaporative fractionation, TSR, BSR, Pay-zone detection and completion intervals, Precipitation of solids during production (Wax, pyro-bitumen, asphaltenes), Application of water geochemistry. Field visitation (if possible).

(Elective)

CHM 806: Laboratory Purification Techniques**Credit Units: 3****1. Techniques: At least Two Practical of Each Technique**

General methods of separation, purification and identification of organic compounds of binary mixture (one liquid and one solid) such as: Solvent extraction, Soxhlet extraction, Crystallization, Sublimation, Distillation, Steam Distillation, Vacuum Distillation, Column Chromatography, Thin Layer Chromatography and Paper Chromatography.

- i. Separation of Organic binary mixtures by chemical/solvent separation methods
- ii. Separation of organic mixtures by TLC
- iii. Separation/ purification of organic mixtures by column chromatography

2. Preparation of Derivatives: (Each Derivative of two Compounds)

Oxime, 2, 4-DNP, Acetyl, Benzoyl, Semicarbazone, Anilide, Amide, Aryloxyacetic acid.

3. Preparations: Single Stage (Any 10)

- i) Cyclohexanone to Adipic acid
- ii) Benzophenone to Benzhydral
- iii) Anthracene to Anthraquinone
- iv) Chlorobenzene to 2,4-Dinitrochlorobenzene
- v) 2,4-Dinitrochlorobenzene to 2,4-Dinitrophenol
- vi) Acetoacetic ester to 1-Phenyl-3-methyl-5 pyrazolone
- vii) Benzaldehyde to Cinnamic acid
- viii) 4-Chlorobenzaldehyde to 4-Chlorobenzoic acid + 4-Chlorobenzyl alcohol
- ix) Benzene to β -Benzoyl propionic acid
- x) Benzaldehyde to Dibenzylidene acetone
- xi) p-Aminobenzoic acid to p-Chlorobenzoic acid
- xii) N,N-Dimethylaniline to 4-Formyl-N, N-dimethyl aniline
- xiii) Benzophenone to Benzpinacol
- xiv) p-Nitrotoluene to p-Nitrobenzoic acid
- xv) Anisole to 2,4-Dinitroanisole
- xvi) Phthalic anhydride to phthalimide
- xvii) Phthalimide to Anthranilic acid
- xviii) Acetanilide to p-Bromoacetanide
- xix) p-Bromoacetanide to p-Bromoaniline
- xx) m-Dinitrobenzene to m-Nitroaniline

4. Use of Computer: Draw the structure of organic molecules and reaction schemes by ChemDraw, Symyx Draw and Chems sketch of simple aliphatic, aromatic, heterocyclic organic compounds with substituents. Get the correct IUPAC name.

Draw the structures and generate the IR and NMR spectra of the substrates and products in the following reactions:

1. Cycloaddition of diene and dienophile (Diels-Alder reaction)
2. Oxidation of primary alcohol to aldehyde and then to acid
3. Benzoin condensation
4. Esterification of simple carboxylic acids
5. Aldol condensation

6. Interpretation of UV, FT-IR, 1- & 13C-NMR spectrum of above synthesized compounds. (Elective)

INDUSTRIAL CHEMISTRY OPTION

SECOND SEMESTER

CHM 802: Statistical Method of Analysis

Credit Units: 2

Introduction to data analysis with a focus on regression. Initial Examination of data. Correlation. Simple and multiple regression models using least squares. Inference for regression parameters, confidence and prediction intervals. Diagnostics and remedial measures. Interactions and dummy variables. Variable selection. Least squares estimation and inference for non-linear regression. Vocabulary of data analysis, Tests of statistical significance, Principles of research design, Introduction to unix, Introduction to SAS, Elementary significance tests, Multiple regression, Factorial ANOVA, Permutation tests, Power and sample size, Random effects models, Multivariate analysis of variance, Analysis of within-cases designs (repeated measures). The use of statistical software in modern data analysis (Excel, SPSS, Origin8 etc.) to analyse and interpret data.

CHM 830: Analytical Chemical Process Technology

Credit Units: 3

Chemical plant design: Chemical plant functions will be compared to laboratory methods. Preparations of flow sheet. Calculation of advanced materials and energy balances. Estimation of equipment sizes, capital cost and operating cost. Evaluation of project. Chemical reactor theory: Basic reactor and applied mathematics and applied reactor design. Mass transfer in distillation process. Drying extraction, filtration and unit operation. Process analysis and simulation. Process control: establishment of the operating objectives of a process. Definition of control system objectives. Determinations of constraints on the process and identification of cause and characteristics of disturbances.

CHM 832: Advanced Chemistry of Selected Industrial Process

Credit Units: 3

- **Chemistry of pulp and paper**
Pulp making from hard and soft woods. Paper making industry. Paper recycling.
- **Chemistry of fertilizers and pesticides**
Fertilizers formulation and manufacturing process biorational design. Pesticides. Manufacturing process formulation. Discovery of new agents. Environmental consideration.
- **Chemistry of Perfumery and cosmetics**
Simple esters. Monoterpenes and sesquiterpenes, shaving lotions, creams, deodorants and air fresheners.
- **Chemistry of soaps and non- soap detergents**

Surface chemistry. Micelle formulation and the detergency process. Soaps and soap products – the manufacturing process. Synthetic surfactants. Anionic, cationic and non-ionic surfactants. Household detergents products and based on synthetic surfactants.

- **Chemical from wastes**

Alcohols from wood and molasses, Biogas from organic refuse including brewery wastes, furfural from corn-cobs.

CHM 834: Heterogenous and Homogenous Catalysis

Credit Units: 3

General principles of heterogeneous catalysis, Activity patterns, Efficiency of catalysts, Effects of temperature, Rates and kinetic models of catalytic reactions, Pulse microreactors, catalytic hydrogenation, olefin oxidation, carbonylation, oligomerisation and dimerisation, General methods of catalyst manufacture and quality evaluation, Trends in heterogeneous catalysis in the 21st century and beyond.

CHM 836: Industrial Pollution and Waste Management

Credit Units: 3

Environmental concern and regulatory systems. Criteria for presumptive limit and stand setting. Modern process technology and environmental protection. Emission and effluent technology. Health and economic aspect of industrial pollution. Modern waste management, including various forms of handling and treatment.

CHM 838: Petroleum Geochemistry

Credit Units: 3

Introduction and objectives of geochemistry. Source rocks: depositional environment, Quality assessment of source rocks, Generation, Migration (from kitchen to trap) and expulsion of hydrocarbons. Oil finger printing: Objective of oil analyses, Basic chemistry of hydrocarbons, Analytical techniques in petroleum geochemistry, The basic parameters for oil typing, The gasoline fraction: the "star diagram method". Non-conventional fossil fuels, shales, tar-sands, hydrates. Isotope geochemistry. Exploration applications: Basins and petroleum systems, Biomarkers, Oil family mapping, Gas geochemistry, Biodegradation of oil, Prospect risking using geochemical data. Reservoir compartmentalisation: Reservoir architecture and filling history, High Resolution GC for reservoir geochemistry, Maturity effects and reservoir compartments, Case histories: Monitoring, compartmentalisation, near-field exploration. Wells, pipeline, infrastructure: Water washing, Evaporative fractionation, TSR, BSR, Pay-zone detection and completion intervals, Precipitation of solids during production (Wax, pyro-bitumen, asphaltenes), Application of water geochemistry. Field visitation (if possible).

CHM 818: Food, Drugs and Cosmetics Analysis

Credit Units: 3

Food composition. Methods of analysis of food for proximate composition, vitamins, mineral additives, Food contaminants. Food quality control. Analysis of major groups of commonly encountered Drugs. Foods and Drugs Regulatory Control. **(Elective)**

CHM 808: Coal, its Combustion & Processing

Credit Units: 2

Origin & development of coal; coal mining technologies, chemical structure and compositions of coal; routes for obtaining chemicals from coal; briquetting of coal, methods of coal studies – reflection and optical constants, pore structure, surface area and density, electrical microscopy, X-ray diffraction, electrical properties, thermal analysis; coal liquids. **(Elective)**

CHM 862: Industrial Production Management

Credit Units: 2

Analytical methods (decision-making) forecasting, linear programming, waiting-line models, simulation models, network planning), production planning (product and process design, plant location and layout), production control (maintenance, inventory control, quality control), selected special topics. **(Elective)**

POLYMER SCIENCE AND TECHNOLOGY

SECOND SEMESTER

CHM 802: Statistical Method of Analysis

Credit Units: 2

Introduction to data analysis with a focus on regression. Initial Examination of data. Correlation. Simple and multiple regression models using least squares. Inference for regression parameters, confidence and prediction intervals. Diagnostics and remedial measures. Interactions and dummy variables. Variable selection. Least squares estimation and inference for non-linear regression. Vocabulary of data analysis, Tests of statistical significance, Principles of research design, Introduction to unix, Introduction to SAS, Elementary significance tests, Multiple regression, Factorial ANOVA, Permutation tests, Power and sample size, Random effects models, Multivariate analysis of variance, Analysis of within-cases designs (repeated measures). The use of statistical software in modern data analysis (Excel, SPSS, Origin8 etc.) to analyse and interpret data.

CHM 840: Polymer Synthesis, Mechanism of Formation and Kinetics Credit Units: 3

Polymerization reactions, condensation and addition reactions leading to polymer formation, their kinetics and mechanisms. Mechanism and kinetics of polymerization processes: Step-reaction; free-radical; ionic; coordination-complex and copolymerization.

Unit-I: Mechanisms of Addition Polymerization

Free radical addition polymerization-mechanism and kinetics of free radical addition polymerization, chain transfer, Mayo equation, thermodynamics of addition polymerization, effect of temperature, pressure, enthalpies, entropies, free energies and activation energies on polymerization, inhibition and retardation.

Ionic polymerization: common features of the two types of ionic polymerization mechanism and kinetics of cationic polymerization, expression for the overall rate of polymerization and the number average degree of polymerization, mechanism and kinetics of anionic polymerization, expression for the overall rate of polymerization and the average degree of polymerization, living polymers.

Ziegler-Natta polymerization: Ziegler-Natta catalysts, mechanism of coordination polymerization-monometallic and bimetallic mechanisms.

Unit-II: Methods of Polymerization

Copolymerization: types of copolymers, the copolymer composition equation, monomer reactivity ratio and copolymer structure, influence of structural effects of monomers on monomer reactivity ratios, the Q-e scheme, synthesis of alternating, block and graft copolymers.

Step reaction(condensation) polymerization-kinetics and mechanism of step reaction polymerization, Carothers equation, number distribution and weight distribution functions, polyfunctional step reaction polymerization, prediction of gel point.

Controlled polymerization methods-nitroxide mediated polymerization, Atom Transfer Radical Polymerization (ATRP), Reversible Addition Fragmentation Termination (RAFT), electrochemical polymerization, metathetical polymerization, group transfer polymerization. Polymerization techniques-bulk polymerization, solution polymerization, emulsion polymerization, suspension polymerization, interfacial polymerization, meltpolycondensation, solution polycondensation, solid and gas phase

CHM 842: Polymer Reactions, Degradation and Recycling

Credit Units: 2

The reactions of functional groups in the polymeric environment treated generally. Polymer degradation processes, radiation effects in polymers. Reprocessing of thermoplastic recyclates, contaminants. Recycling techniques, size reduction, washing, identification and sorting of plastics agglomeration, other methods of recycling and waste disposal options, chemical recycling, thermal conversion technologies.

CHM 844: Polymer Testing and Characterization

Credit Units: 3

1. Thermal analysis such as dilatometry, TMA, DSC, DTA, TGA and DTG, Scanning Electron Microscopy (SEM); Spectroscopic techniques such as FTIR, NMR, EPR, Raman, UV-visible, Fluorescence. X-ray diffraction, environmental stability, chemical resistance, particle size, adhesion, permeability and diffusion.

2. Mechanical properties-stress, strain, elongation, yield point, yield strength, proportional limit, modulus of elasticity, ultimate strength, secant modulus, stress strain behaviour of different types of polymers, tensile strength, stress-strain behaviour in tension compression, flexure, elongation at break, modulus, tear strength, hardness, impact properties, creep, stress-relaxation, abrasion, fatigue resistance.
3. Thermal properties-specific heat, heat deflection temperature, thermal conductivity, thermal expansion, brittleness temperature.
4. Electrical properties: dielectric strength, dielectric constant, dissipation factor, electrical resistance, volume resistivity and surface resistivity, arc resistance.
5. Optical properties: optical clarity, colour assessment, refractive index, luminous transmittance, haze and gloss, total internal reflection, birefringence.

CHM 846: Advanced Plastics, Elastomers and Fibre Processing Technology Credit Units: 3

Discuss various types of polymers in use, the size and impact of the polymer processing as well as the most important processes for thermoplastic materials, namely extrusion and injection moulding. Single and twin screw extruders are used for melting and pumping of polymers and for die extrusion for the production of film, sheet, pipe, tubing, profiles and fibres. Injection moulding is the process used for the production of numerous parts, small and large, by injecting a molten polymer into mould cavities. Other processes described include: calendaring, compression moulding, rotational moulding, powder injection moulding and thixomoulding. Finally to discuss the current trends and future challenges faced by the polymer industry. Additives for compounding plastics, fillers, plasticizers and softeners, lubricants and flow promoters, antiaging additives, flame retarders, colorants, blowing agents, UV stabilizers, requirement and functions of each ingredient.

Compounding ingredients for rubber: fillers-reinforcing, semi reinforcing and non-reinforcing, peptizers, vulcanizing agents, activators, accelerators, anti-oxidants, antiozonants, pigments, tackifiers, blowing agents, bonding agents and processing aids. Vulcanization of rubber, types of vulcanisation, rheograph, cure time, scorch time.

Compound development-formulation of mixes, compounding for specific applications, ozone resistance heat resistance, weather, oil and radiation resistance, impermeability, medical application, low temperature properties, electrical and optical applications.

Processing methods for the manufacture of products with dry rubber-blending and mastication,

Master batching of polymers, mixing and compounding in mills and internal mixers, calendaring, sheeting, fabric coating, extension, moulding, batch curing, cold curing, continuous vulcanization methods-high pressure steam, hot air tunnel, molten salt bath, fluidized bed, continuous drum cure and microwave curing.

Finishing rubber products-flash and spew removal, punching, grinding, shot blasting painting and lacquering and chemical surface treatment.

Processing methods of plastics-methods of mixing-injection, reaction injection, compression and transfer moulding, extrusion, calendaring, thermoforming, blow moulding, rotational moulding and slush moulding.

A study of the design of processing equipment and the processing of plastics and rubbers including mixing, extrusion, injection moulding, thermoforming, calendaring, casting, mastication, compounding, vulcanization etc/degradation and stabilization of elastomers.

CHM 848: Selected Topics in Polymer Science and Technology **Credit Units: 3**

Chemistry of Paints and Adhesives: The manufacturing processes and general formulating of paints. Classification of paints in terms of use and constitution. Latex paints, enamels etc. Industrial maintenance of paints. Testing of paints colour. Thickeners, wetting agents and emulsifiers. Paints and varnish removers. Mechanism of paint removal. Classification of adhesives based on composition. Nature of adhesion and the development of strength. Formulation of adhesives. Mechanism of adhesion, mechanical interlocking, inter-diffusion, adsorption and surface reaction, electrostatic attraction. Surface and interfacial properties, surface topography, surface tension and energy, wetting and setting, thermodynamic work of adhesion. The bonding processes. Applications of adhesives. Preservation and concentration of natural rubber latex, types of dipping processes, Dunlop Process.

Leather Chemistry: Animal skin chemistry – pertaining process. Vegetable tanning processes. Materials, their properties and chemistry synthetic tanning materials; chrome and other tanagers; theory of tanning.Finishing processes.

Textile chemistry and Dyestuffs: Classification of fibre. Natural fibres – Animal and vegetable fibres. Regenerated fibres – Rayon, cellulose and acetate. Synthetic fibres including polyamides polyesters, acrylics and polyolefins. Elastometric fibres. High temperature fibres. Testing and standards. Manufacturing process. Basic of colour in organic chemistry. Azo dyes – preparations, structure, colour and applications. Other types of dyes –Anthraquinone, vat, indigoid and thio indigoid dyes. Triarylmethanes, phthalocyanine and reactive dyes.

CHM 864: Polymer Blends and Composites **Credit Units: 3**

- 1 Polymer blends: definition and importance of blending, blending techniques solution mixing, mechanical mixing, latex blending, mechano chemical blending.
- 2 Compatibility of polymer in solution, determination of mutual solubility of polymers, miscibility through specific interactions, copolymer effect, phase diagrams of polymer-polymer systems. LCST and UCST behaviour, binodal and spinodal curves, critical point, phase separation mechanisms.
- 3 Thermodynamic treatment of phase behaviour of polymer mixtures, Flory-Huggins theory, blend morphology, morphology generation and control, capillary number,

- morphology characterization techniques, commercial blends and their applications.
- 4 Methods for determining polymer-polymer miscibility, criteria for establishing miscibility, dielectric methods, microscopy, cloud point method, rheological methods, dilatometry, viscosity methods, free volume measurement, volume of mixing, mutual solvent method, heat of mixing, melting point depression, inverse gas chromatography, specific advantages of miscible and immiscible polymer blends.
 - 5 Compatibilisation-fundamental concepts, general routes to compatibility, types of compatibilisers-addition of graft of block copolymers, *in situ* formed copolymers, separately added copolymers, reactive compatibilisation by low molecular weight additives, compatibilisation theories-contributions of Noolandi, Hong and Leibler.
 - 6 Polymer composites: definition and classification, role of fibre and matrix in improving composite properties, mechanics of short and long fibre composites, bonding between fibre and matrix-functions of bonding agents, critical fibre length in short fiber composites, failure mechanism in composites.

Significance and Classification of Polymer nanocomposites, Difference between conventional polymer composites and polymer nanocomposites, type of nanofillers, nanoclays, nanometals, carbon nanotubes and safety aspects of nanofillers. Thermodynamics and Nanocomposites formation, Characterisation and Applications. Future Prospects and Challenges.

CHM 866: Structure, Properties and Stereochemistry of Polymers Credit Units: 3

Introduction to chemical structure and morphology of polymer; stereochemistry; the crystalline state; the amorphous state; rheology of polymers; rubber-like state of polymers; mechanical properties – stress/strain behavior; influence of temperature on modulus; time-dependence of mechanical behavior; viscoelasticity-models; stress, relaxation and creep.

Polymer architecture, Orientation, Configuration and conformation, Geometric isomerism and factors influencing stereoregulation. Homogeneous stereospecific cationic and anionic polymerisations. Nature of catalytic and active centres in polymerisations and mechanisms.

COLOUR CHEMISTRY AND TECHNOLOGY OPTION:

CHM 802: Statistical Method of Analysis

Credit Units: 2

Introduction to data analysis with a focus on regression. Initial Examination of data. Correlation. Simple and multiple regression models using least squares. Inference for regression parameters, confidence and prediction intervals. Diagnostics and remedial measures. Interactions and dummy variables. Variable selection. Least squares estimation and inference for non-linear regression. Vocabulary of data analysis, Tests of statistical significance, Principles of research design, Introduction to unix, Introduction to SAS, Elementary significance tests, Multiple regression, Factorial ANOVA, Permutation tests, Power and sample size, Random effects

models, Multivariate analysis of variance, Analysis of within-cases designs (repeated measures). The use of statistical software in modern data analysis (Excel, SPSS, Origin8 etc.) to analyse and interpret data.

CHM 850: Colour Chemistry and Technology

Credit Units: 3

Historical development of colour chemistry since Perkin's synthesis of mauveine. Classification of dyes. Aromatic substitution reactions and their application in the synthesis of dyestuff intermediates. Sulphonation, nitration, halogenation, Friedel-Craft reaction. Hydroxylation, animation etc. Diazo and diazonium compounds. The synthesis and use of important groups of dyes - azo dyes, quinonoid and indigoid dyes, phthalocyanine, triphenylmethane dyes, etc. Colour and chemical constitution; early theories of colour - molecular spectra and electronic transitions, quasi classical theory, valence bond, resonance theory, application of molecular orbital theory, Huckel molecular orbital (HMO) method, perturbation molecular orbital (PMO) method, Free electron molecular orbital (FEMO) method.

CHM 852: Physical Chemistry of Dye Adsorption

Credit Units: 2

The forces responsible for substrate/dye adsorption, the electrical properties of surfaces, adsorption isotherms. Application of classical thermodynamics to dye absorption phenomena, e.g. ion exchange systems, the kinetics of absorption processes, dyeing systems, covalent bonding between dyes and substrates.

CHM 854: Pigments, Colour Measurement and Quality Control

Credit Units: 3

The history of pigments; natural pigments, dyeing and pigmentation, the importance of media, black and white organic pigments, the chemistry of organic pigments, nucleation and the growth of particulate in solution, the physics of pigments, methods of measuring particle size distribution, testing of optical properties.

Colour Measurement: Reflectance and absorption spectroscopy, C.I.E colour measurement system, colour matching, colour tolerance, use of computer application in dyeing and pigment (surface) coloration.

The measurement of colour with instruments, instrumental colour match prediction and correction colour control and formulation using pigments.

Quality Control: Test methods in the assessment and quality control in paints industry, quality control of the chemically processed textile materials. Assessment of the colour fastness. Testing inks and quality control in plastics and allied industries. Health regulations in food and drugs colorants.

CHM 856: Coloration Technology**Credit Units: 3**

Classification of colorants according to methods of application. Fundamental of coloration behavior in relation to practical coloration methods, cellulosic dyes, nylon - acid dyes, acrylic fibres - basic dyes, energy requirements in coloration processes, printing and leather coloration.

Paints: The functions of painted surfaces, paint formulations (solvent and water-base) and stabilization of additives, recent developments in paint technology (e.g. uv curing).

Inks: The more important printing processes, development in technological aspects and also in ink formulations. Ink vehicles, the importance of the nature of the substrate in any printing operation, industrial significance of printing and printed materials (e.g. packaging, newsprint etc.)

Colour and Cosmetics: Coloring matters and coloration processes of importance for cosmetic application, skin coloration, nail, lacquers and varnishes and hair coloration, health factors of each area of colour application.

Food Colours: Natural and synthetic colorants, the colour needs of the food industry. Certified colour additives, current regulation of the F.D.A. regarding colours used in food processing.

CHM 836: Industrial Pollution and Waste Management Credit Units: 3

Environmental concern and regulatory systems. Criteria for presumptive limit and standard setting. Modern process technology and environmental protection. Emission and effluent technology. Health and economic aspect of industrial pollution. Modern waste management, including various forms of handling and treatment. **(Elective)**

CHM 868: Synthesis of Dyes, Pigments and Chemical intermediates Credit Units: 3

Industrial manufacturing process of dyes, pigments and intermediate chemicals, chemical reactions, unit process operations used in dye production, structure and effects of the chemical constituents of synthetic and organic dyes. **(Elective)**

INORGANIC CHEMISTRY OPTION

SECOND SEMESTER

CHM 800: Solid State Chemistry (2 CU)

Structure of solids. Basic crystallography. Characterization of solids: diffraction techniques, electron microscopy, spectroscopy, thermal analysis. Bonding in solids. Real structure of crystals, defects. Electrical, magnetic and optical properties.

SCI 802: ICT & Research Methodology (3 CU)

- . Spreadsheets and Internet technology

- A review of the Fundamentals: Meaning of Research, Definitions of Research, Objectives of Research, Motivation in Research, General Characteristics of Research, Criteria of Good Research, Types of Research.
- The Research Problem: Scientific Thinking, What is a Research Problem, Selecting the Problem, Sources of the Problem, Defining a Problem, Statement of a Problem, Delimiting a Problem, Evaluation of a Problem.
- The Review of Literature: Meaning of Review of Literature, Need of Review of Literature, Objectives of Review of Literature, Sources of Literature, The

Functions of Literature, How to Conduct the Review of Literature, Some Hints for the Review of Literature, Precautions in Library Use, Reporting the Review of Literature.

- The Research Hypotheses: Meaning of Hypothesis, Definitions of Hypothesis, Nature of Hypothesis, Functions of Hypothesis, Importance of Hypothesis, Kinds of Hypothesis, Characteristics of a Good Hypothesis, Variables in a Hypothesis, Formulating a Hypothesis, Testing the Hypothesis.
- Sampling: Meaning and Definition of Sampling, Functions of Population and Sampling, Methods of Sampling, Characteristics of a Good Sample, Size of a Sample.

CHM 802: Statistical Method of Analysis Credit (2 CU)

Introduction to data analysis with a focus on regression. Initial Examination of data. Correlation. Simple and multiple regression models using least squares. Inference for regression parameters, confidence and prediction intervals. Diagnostics and remedial measures. Interactions and dummy variables. Variable selection. Least squares estimation and inference for non-linear regression. Vocabulary of data analysis, Tests of statistical significance, Principles of research design, Introduction to unix, Introduction to SAS, Elementary significance tests, Multiple regression, Factorial ANOVA, Permutation tests, Power and sample size, Random effects models, Multivariate analysis of variance, Analysis of within-cases designs (repeated measures). The use of statistical software in modern data analysis (Minitab, Excel, SPSS, Origin 8 etc.) to analyse and interpret data.

CHM 890: Metal Ion in Solution (3 CU)

Metal ions, solvent, ions in solution, distribution of aquo-cations: The sp-elements, first row transition elements, second row transition elements, lanthanide and actinide elements. Solvating properties of elements. NMR spectroscopy, Ultraviolet-Visible spectroscopy, Infrared and Raman Spectroscopy, Electron Spin Resonance Spectroscopy and Mossbauer Spectroscopy. Non-Spectroscopic methods of investigation: Transport properties, thermo-chemical Approaches. Mixed Solvents and Selective Solvation. Thermochemistry of Metal ion Solvation. Redox Potentials. Hydrolysis: acidity of solvated cations. Polymerization of metal ions in solution.

CHM 894: Spectroscopic Techniques in Inorganic Chemistry (2 CU)

Advanced study of the following topics: Photoelectron Spectroscopy, Electronic Absorption Spectroscopy, Vibrational and Rotational Spectroscopy, Electron Paramagnetic Resonance Spectroscopy, Nuclear Quadruple Resonance Spectroscopy, Mossbauer Spectroscopy, Raman Spectroscopy.

CHM 896: Coordination Compounds (3 CU)

Definition and application of coordination compounds. Nomenclature, coordination number, isomerism and stability of complex compounds. Theories of structures i.e. valence bond theory, crystal field theory and molecular orbital theories. Kinetics and mechanism of complex formation. Electronic spectra of transition metal complexes as well as their magnetic properties. Preparations, reactions and structure of complexes. Applications of infrared and NMR spectroscopy to problems of coordination chemistry. Jahn-Teller distortions.

CHM 898: Advanced Inorganic Reaction Mechanism (3 CU)

Types of inorganic reactions. Rate laws and interpretation of rate laws.

Experimental methods for fast and slow reactions. Substitution reaction in

Octahedral and square planar complexes. Trans effect. Redox reactions.

CHM 812: Environmental Chemistry & Pollution Controls (3 CU)

Introduction and principles of chemical pollution of environmental media (air, soil and water) and associated resources. Water/waste water chemistry, soil chemistry and fate of pollutants, air pollution chemistry, fate, effects and monitoring. Environmental toxicology. Chemistry of Persistent Toxic substances including Persistent organic Pollutants (POPs). Environmental indicators of chemical pollution and marker compounds. Remediation of contaminated environment.

CHM 834: Heterogeneous and Homogeneous Catalysis (3 CU)

General principles of heterogeneous catalysis, Activity patterns, Efficiency of catalysts, Effects of temperature, Rates and kinetic models of catalytic reactions, Pulse microreactors, catalytic hydrogenation, olefin oxidation, carbonylation, oligomerisation and dimerisation, General methods of catalyst manufacture and quality evaluation, Trends in heterogeneous catalysis in the 21st century and beyond.

SECOND YEAR

CHM 892: Research/Thesis

Credit Units: 6

A student for the M.Sc. degree shall be expected to undertake original research project under the guidance of Supervisor(s) on a particular topic from the area of specialization in accordance with the Postgraduate Regulations of the University.

PhD CHEMISTRY COURSES

PhD Analytical Chemistry

FIRST SEMESTER COURSES

S/N	Course Code	Course Title	Credit unit	Status
1	CHM 901	Research Methodology & computer Applications	4	Core
2	CHM 903	Recent Trends in Analytical Chemistry	4	Core
3	CHM 915	Literature Review	2	Core
			Total: 10	

SECOND SEMESTER COURSES

S/N	Course Code	Course Title	Credit unit	Status
1	CHM 920	Thesis	12	Core

PhD Organic Chemistry

FIRST SEMESTER COURSES

S/N	Course Code	Course Title	Credit unit	Status
1	CHM 901	Research Methodology & Computer Applications	3	Core
2	CHM 905	Recent Trends in Organic Chemistry	4	Core
3	CHM 915	Literature Review	2	Core
			Total: 10	

SECOND SEMESTER COURSES

S/N	Course Code	Course Title	Credit unit	Status
1	CHM 920	Thesis	12	Core

PhD Industrial Chemistry**FIRST SEMESTER COURSES**

S/N	Course Code	Course Title	Credit unit	Status
1	CHM 901	Research Methodology & Computer Applications	4	Core
2	CHM 907	Recent Trends in Industrial Chemistry	4	Core
3	CHM 915	Literature Review	2	Core

			Total: 10	
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SECOND SEMESTER COURSES

S/N	Course Code	Course Title	Credit unit	Status
1	CHM 920	Thesis	12	Core

PhD Polymer Science and Technology

FIRST SEMESTER COURSES

S/N	Course Code	Course Title	Credit unit	Status
1	CHM 901	Research Methodology & Computer Applications	4	Core
2	CHM 909	Recent Trends in Polymer Science and Technology	4	Core
3	CHM 915	Literature Review	2	Core
			Total: 10	

SECOND SEMESTER COURSES

S/N	Course Code	Course Title	Credit unit	Status
1	CHM 920	Thesis	12	Core

PhD Colour Chemistry

FIRST SEMESTER COURSES

S/N	Course Code	Course Title	Credit unit	Status
1	CHM 901	Research Methodology & Computer Applications	4	Core
2	CHM 911	Recent Trends in Industrial Chemistry	4	Core
3	CHM 915	Literature Review	2	Core
			Total: 10	

SECOND SEMESTER COURSES

S/N	Course Code	Course Title	Credit unit	Status
1	CHM 920	Thesis	12	Core

PhD Inorganic Chemistry***FIRST SEMESTER COURSES***

S/N	Course Code	Course Title	Credit unit	Status
1	CHM 901	Research Methodology & Computer Applications	4	Core
2	CHM 913	Recent Trends in Inorganic Chemistry	4	Core
3	CHM 915	Literature Review	2	Core

			Total: 10	
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SECOND SEMESTER COURSES

S/N	Course Code	Course Title	Credit unit	Status
1	CHM 920	Thesis	12	Core

PhD COURSE SYNOPSIS

CHM 901: Research Methodology and computer Applications (4 CU)

Part A: Research Methodology

Introduction to Research Methodology: Meaning of Research, Objectives of Research, Motivations in Research, Types of Research, Criteria of good Research, What is Research Problem? Basic and Applied research.

The Research Report: General format of the Research report, style and formatting of writing, typing of the research report.

Testing of Hypotheses and Sampling design: Definition, Concepts Concerning testing of Hypotheses, Formulation of hypotheses and related difficulties; Needs of sampling, Sampling for chemical analysis, Random sampling

Quantification of research output: Impact Factor, h-index, i10-index and i20-index, G-index.

Ethics in Research and Intellectual Property Rights: Environmental Impacts, Ethical Issues, Reproduction of published material, Plagiarism, Citation and Acknowledgement, Reproducibility and accountability. Intellectual Property

Rights, Patents, Copyright, Royalty.

Part B: Computer Applications

Literature survey using web, handling search engines which includes:

- (i) Research papers: Using word processing software – MS Word/Latex/others,
- (ii) Drawing graphs and diagrams – Origin/Excel/others,
- (iii) Seminar presentations – Power point for oral and poster presentations,
- (iv) Data presentation,
- (v) Figure insertions in documents.

CHM 903: Recent Trends in Analytical Chemistry (4 CU)

Lectures, seminars and paper presentation on the topics such as:

- (i) Use of statistical softwares such as SPSS, Excel, ANOVA, (one tailed and two tailed significant test), correction analysis etc.
- (ii) Solid phase extraction (SPE) and super critical fluid extraction (SFE): principles and application.
- (iii) Chromatographic techniques: ion chromatography (IC), ion Exclusion chromatography (IEC), hydrophobic interaction chromatography (HIC) and HPLC

CHM 905: Recent Trends in Organic Chemistry (4 CU)

Lectures, seminars and paper presentation on the topics in organic chemistry, such as:

- (i) Transition metal complexes as catalysts in organic synthesis.
- (ii) Combinatorial chemistry including throughput screening in drug development.
- (iii) Application of biological catalysts and proline in organic transformations
- (iv) Application of microwave and ultrasound in organic transformations.
- (v) Green chemistry (solvent free organic transformations).

CHM 907: Recent Trends in Industrial Chemistry (4 CU)

Lectures, seminars and paper presentations on cutting edge research on topics such as:

- (i) Porous solids (activated carbons, zeolites etc) preparation, characterization and applications.

(ii) Chemical process optimization using response surface methodology such as design of experiments, full factorial, fractional factorial, central composite

design etc.

(iii) Application of organic and inorganic compounds in corrosion inhibition.

(iv) Various techniques in the treatment of industrial wastes.

CHM 909: Recent Trends in Polymer Science and Technology (4 CU)

Lectures, seminars and paper presentations on the topics such as:

(i) Green polymers/applications and strategies for polymer recycling

(ii) Nanofabrication in polymer matrices.

(iii) The concept of bio-refinery and its implications

(iv) Current instrumental methods for polymer characterization.

CHM 913: Recent Trends in Inorganic Chemistry (4 CU)

Lectures, seminars and paper presentations on the topics such as:

(i) Bioinorganic chemistry: Interaction of metals with biological molecules, role of bioinorganic compounds in biological systems.

(ii) Catalysis: Synthesis and characterization of new catalytic materials and their applications in industries.

(iii) Properties of coordination and organometallic compounds with respect to synthesis of new compounds.

CHM 915: Review of Literature (2 CU)

COURSE OUTLINE

This enables the students:

To know the meaning and Purpose of the Literature Review

To learn the review of literature about the developments in the fields of organic chemistry, analytical chemistry, polymer Science and Technology, Industrial Chemistry, Inorganic chemistry and Physical chemistry .

Conduct a thorough literature review and provide a properly referenced written report to acquire thorough knowledge of the literature and a comprehensive understanding of scientific methods and techniques applicable to their own research.

To understand the analysis of research work, compilation and presentation of past work in the respective field and design of new research in the chosen area.

LIST OF EXISTING ACADEMIC STAFF FOR THE PROGRAMME

NAME OF ACADEMIC STAFF	AREA OF SPECIALIZATION	DISCIPLINE	QUALIFICATION	RANK
Dr. Abdullahi M. Nuhu	Organic Chemistry	Chemistry	B.Sc, M.Sc, PhD	Assoc. Professor (HOD)
Prof. S. P. Bako	Organic Chemistry	Chemistry	B.Sc, M.Sc, PhD	Professor
Prof. I.M. Inuwa	Polymer Engineering	Chemistry	B.Sc, M.Sc, PhD	Professor
Prof. Zakari Ladan	Organic Chemistry	Chemistry	B.Sc, M.Sc, PhD	Professor
Prof. A. A. Nuhu	Analytical Chemistry	Chemistry	B.Sc, M.Sc, PhD	Professor
Prof. Gideon Wyasu	Analytical Chemistry	Chemistry	B.Sc, M.Sc, PhD	Professor
Dr. C.O Nwokem	Analytical Chemistry	Chemistry	B.Sc, M.Sc, PhD	Assoc. Professor
Dr. Bako Myek	Inorganic Chemistry	Chemistry	B.Sc, M.Sc, PhD	Senior Lecturer
Dr. Yahaya Yakubu	Organic Chemistry	Chemistry	B.Sc, M.Sc, PhD	Senior Lecturer
Dr. Abdullahi Ibrahim	Organic Chemistry	Chemistry	B.Sc, M.Sc, PhD	Lecturer I
Dr.(Mrs.) Maryam	Pharmaceutical &	Chemistry	B.Sc, M.Sc, PhD	Lecturer I

D. Mahmud	Medicinal Chemistry			
Dr.(Mrs.) Hauwa M. Mustafa	Industrial Science	Chemistry	B.Sc, M.Sc, PhD	Lecturer I
Dr. Mary Gojeh	Inorganic Chemistry	Chemistry	B.Sc, M.Sc, PhD	Lecturer I
Dr. Mustapha Abdullahi	Physical/Theoretical Chemistry	Chemistry	B.Sc, M.Sc, PhD	Assist. Lecturer