CURRICULUM & CREDIT FRAMEWORK FOR 4-YEAR UG PROGRAMME as per NEP, 2020

SYLLABUS

FOR

Bachelor of Science (B. Sc) in CHEMISTRY

(w.e.f. Academic Session: 2023-2024)

Department of Chemistry

(Faculty of Science & Technology)

Aliah University

IIA/27, Newtown, Kolkata 700160, West Bengal, India

1. Structure of the Undergraduate Program

Sl. No.	Broad Category of Course	Minimum Credit Requirement	
		3-Yr UG	4-Yr UG
1	Major (Core)	60	80
2	Minor Stream	24	32
3	Multidisciplinary	09	09
4	Ability Enhancement Courses (AEC)	08	08
5	Skill Enhancement Courses (SEC)	09	09
6	Value Added Courses common for all UG	06-08	06-08
7	Summer Internship	02-04	02-04
8	Research Projects/Dissertation	-	12
TOTAL		120	160
Note:* Honours students not undertaking research will study three courses for 12 credits in lieu of a research project/dissertation.			
A credit is a unit by which the coursework is measured; It determines the no. of hours of instruction required per week over the duration of a semester (minimum 15 weeks).			

2. Curricular components of the UG Program

2.1 Disciplinary/interdisciplinary major: In-depth study of a particular subject or discipline.

2.2 Disciplinary/interdisciplinary minors: Students who take a sufficient number of courses in a discipline or an interdisciplinary area of study other than the chosen major will qualify for a minor in that discipline or in the chosen interdisciplinary area of study.

2.3 Vocational Education and Training: A minimum of 12 credits will be allotted to the 'Minor' stream relating to job-oriented Vocational Education and Training and these can be related to the major or minor discipline or choice of the student.

2.4 Courses from Other Disciplines (Multidisciplinary) (9 credits): All UG students are required to undergo 3 introductory-level courses relating to Natural and Physical Sciences; Mathematics, Statistics, and Computer Applications; Library, Information, and Media Sciences; Commerce and Management; Humanities and Social Sciences:

Students are not allowed to choose or repeat courses already undergone at the higher secondary level (12th class) in the proposed major and minor stream under this category.

2.5 Ability Enhancement Courses (AEC) (08 credits): Modern Indian Language (MIL) & English language focused on language and communication skills.

List of MIL: Assamese, Bangla, Bodo, Dogri, Gujarati, Hindi, Kashmiri, Kannada, Konkani, Maithili, Malayalam, Manipuri, Marathi, Nepali, Oriya, Punjabi, Tamil, Telugu, Santali, Sindhi and Urdu.

2.6 Skills Enhancement Courses (SEC): Objective: imparting practical skills, hands-on training, soft skills, etc., to enhance the employability of students.

• 3 papers of 3 credits each, i.e., total 9 credits

• To be offered in Ist, IInd & IIIrd semesters

2.7 Summer Internship /Apprenticeship (2 – 4 credits): Induction into actual work situations. Students who wish to exit after the first two semesters will undergo a 4-credit work-based learning/internship during the summer term in order to get a UG Certificate.

• Community engagement and service and

• Field-based learning/minor project can be part of summer term activity or part of a major or minor course depending upon the major discipline.

2.8 Research Project / Dissertation: only for 4-Year Bachelor's degree (12 credits)

2.9 Other Activities: National Service Scheme (NCC), National Cadet Corps (NCC), adult education/literacy initiatives, mentoring school students, and other similar activities.

2.10 Value-Added Courses (VAC): Common to All UG Students (6-8 credits)

i. Understanding India: knowledge and understanding of contemporary India with its historical perspective.

ii. Environmental science/education: to take appropriate actions for mitigating the effects of environmental degradation, climate change, and pollution, effective waste management, conservation of biological diversity, management of biological resources, forest and wildlife conservation, and sustainable development and living. The course will also deepen the knowledge and understanding of India's environment in its totality, its interactive processes, and its effects on the future quality of people's lives.

iii. Digital and technological solutions: Courses in Artificial Intelligence (AI), 3-D machining, big data analysis, machine learning, drone technologies, and Deep learning with important applications to health, environment, and sustainable living that will be woven into undergraduate education for enhancing the employability of the youth.

iv. Health & Wellness, Yoga education, sports, and fitness: physical and mental wellbeing.

3. Overview of Curriculum and Credit Framework for 4 year UG Honours offered by Aliah University

3.1

4 YR CURRICULUM & CREDIT FRAMEWORK: UG HONOURS WITH RESEARCH **Annexure -1**

		Major				Minor		Multi-disciplinary		AEC		SEC		VAC		SIP		Dissertation		Total	
Minimum Credit Requirement		80				32		9		8		9		6-8		2-4		12		158-162	
		Core		DSE																	
Year	Semes-ter	No. of Paper	Credit @ 4	No. of Paper	Credit @4	No. of Paper	Credit @4	No. of Paper	Credit @3	No. of Paper	Credit @4	No. of Paper	Credit @ 3	No. of Paper	Credit @ 4	No. of Paper	Credit @ 4	No. of Paper	Credit @ 4+8=12	No. of Paper	Credit
1	I	2	8	0	0	1	4	1	3	1	4	1	3	0	0	0	0	0	0	6	22
	II	2	8	0	0	1	4	1	3	0	0	1	3	1	4	0	0	0	0	6	22
2	III	2	8	0	0	1	4	1	3	1	4	1	3	0	0	0	0	0	0	6	22
	IV	3	12	0	0	1	4	0	0	0	0	0	0	1	4	0	0	0	0	5	20
3	V	3	12	0	0	1	4	0	0	0	0	0	0	0	0	1	4	0	0	5	20
	VI	3	12	1	4	1	4	0	0	0	0	0	0	0	0	0	0	0	0	5	20
4	VII	2	8	2	8	1	4	0	0	0	0	0	0	0	0	0	0	0	4	5	24
	VIII	2	8	1	4	1	4	0	0	0	0	0	0	0	0	0	0	0	8	4	24
	TOTAL	19	76	4	16	8	32	3	9	2	8	3	9	2	8	1	4	0	12	42	174
		23 (Core + DSE) = 92 credits																			

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AEC -	Ability Enhancement Course	SEC -	Skill Enhancement Course	VAC -	Value Added Course

3.2

4 YR CURRICULUM & CREDIT FRAMEWORK: UG HONOURS WITHOUT RESEARCH **Annexure -2**

		Major				Minor		Multi-disciplinary		AEC		SEC		VAC		SIP		Dissertation		Total	
Minimum Credit Requirement		80				32		9		8		9		6-8		2-4		12		158-162	
		Core		DSE																	
Year	Semes-ter	No. of Paper	Credit @ 4	No. of Paper	Credit @4	No. of Paper	Credit @4	No. of Paper	Credit @3	No. of Paper	Credit @4	No. of Paper	Credit @ 3	No. of Paper	Credit @ 4	No. of Paper	Credit @ 4	No. of Paper	Credit @ 4+8=12	No. of Paper	Credit
1	I	2	8	0	0	1	4	1	3	1	4	1	3	0	0	0	0	0	0	6	22
	II	2	8	0	0	1	4	1	3	0	0	1	3	1	4	0	0	0	0	6	22
2	III	2	8	0	0	1	4	1	3	1	4	1	3	0	0	0	0	0	0	6	22
	IV	3	12	0	0	1	4	0	0	0	0	0	0	1	4	0	0	0	0	5	20
3	V	3	12	0	0	1	4	0	0	0	0	0	0	0	0	1	4	0	0	5	20
	VI	3	12	1	4	1	4	0	0	0	0	0	0	0	0	0	0	0	0	5	20
4	VII	2	8	3	12	1	4	0	0	0	0	0	0	0	0	0	0	0	0	6	24
	VIII	2	8	3	12	1	4	0	0	0	0	0	0	0	0	0	0	0	0	6	24
	TOTAL	19	76	7	28	8	32	3	9	2	8	3	9	2	8	1	4	0	0	45	174
		26 (Core + DSE) = 104 credits																			

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AEC -	Ability Enhancement Course	SEC -	Skill Enhancement Course	VAC -	Value Added Course

4. Course Code Configuration

- Programme Code (eg., MBA/ HST/ CHM)
- Degree (UG)
- Paper Type

Major Core	MCC	Major DSE	MDS
Minor	MIN	Multidisciplinary	MDC
Ability Enhancement Courses	AEC	Skill Enhancement Courses	SEC
Value Added Courses	VAC	Summer Internship	SIP
Research Projects/ Dissertation	PRJ		

- Paper No. : 3 digit; Year first; Semester 2nd, 2 digit Course No.
- Example:

C	H	M	U	G	M	C	C	1	1	0	1
PROGRAMME CODE			DEGREE		PAPER TYPE (MAJOR CORE COURSE)			YEAR	SEM	RUNNING NUMBER FOR EACH PAPER TYPE	

5. Assessment scheme including Marks

- For 4 Credit Course: Theory + Practical/Tutorial (3+1)
- No full practical in Major (Core/DSE) and Minor
- Full practical only in SEC
- Teaching hours for 4 credit course (3L+1P/T) * 15 weeks
- Theory = 45 lecture hours
- Practical = 1 practical = 2 hours/week * 15 weeks = 30 practical hours

- Marks:

Credit	Full Marks	Marks Break up	Duration of Examination
3	75	60 + 15 (IA)	2.5 hrs
4	100	80 + 20 (IA)	3 hrs
SIP (4)	100	NIL	NA
Practical/Lab	75		2.5 hrs

IA: Internal Assessment

6. Semester wise Course distribution

6.1 UG Honours with research:

Course Type	Semester-I	Semester-II	Semester-III	Semester-IV	Semester-V	Semester-VI	Semester-VII	Semester-VIII
Major; CC	CHMUGMCC1101 CHMUGMCC1102	CHMUGMCC1203 CHMUGMCC1204	CHMUGMCC2305 CHMUGMCC2306	CHMUGMCC2407 CHMUGMCC2408 CHMUGMCC2409	CHMUGMCC3510 CHMUGMCC3511 CHMUGMCC3512	CHMUGMCC3613 CHMUGMCC3614 CHMUGMCC3615	CHMUGMCC4716 CHMUGMCC4717	CHMUGMCC4818 CHMUGMCC4819
DSE						CHMUGMDS3601	CHMUGMDS4702 CHMUGMDS4703 CHMUGMDS4704 (Any two courses)	CHMUGMDS4805 CHMUGMDS4806 CHMUGMDS4807 (Any one course)
Minor	CHMUGMIN1101	CHMUGMIN1202	CHMUGMIN2303	CHMUGMIN2404	CHMUGMIN3505	CHMUGMIN3606	CHMUGMIN4707	CHMUGMIN4808
Multi-disciplinary	UCCUGMDC1101	CHMUGMDC1201	CHMUGMDC2302					
AEC	UCCUGAEC1101		UCCUGAEC2302					
SEC	CHMUGSEC1101	CHMUGSEC1202	CHMUGSEC2303					
VAC		UCCUGVAC1201		UCCUGVAC2402				
SIP					CHMUGSIP3501			
Dissertation							CHMUGPRJ4701	CHMUGPRJ4802

UCC: University Common Course

6.2 UG Honours without research:

Course Type	Semester-I	Semester-II	Semester-III	Semester-IV	Semester-V	Semester-VI	Semester-VII	Semester-VIII
Major; CC	CHMUGMCC1101 CHMUGMCC1102	CHMUGMCC1203 CHMUGMCC1204	CHMUGMCC2305 CHMUGMCC2306	CHMUGMCC2407 CHMUGMCC2408 CHMUGMCC2409	CHMUGMCC3510 CHMUGMCC3511 CHMUGMCC3512	CHMUGMCC3613 CHMUGMCC3614 CHMUGMCC3615	CHMUGMCC4716 CHMUGMCC4717	CHMUGMCC4818 CHMUGMCC4819
DSE						CHMUGMDS3601	CHMUGMDS4702 CHMUGMDS4703 CHMUGMDS4704	CHMUGMDS4805 CHMUGMDS4806 CHMUGMDS4807
Minor	CHMUGMIN1101	CHMUGMIN1202	CHMUGMIN2303	CHMUGMIN2404	CHMUGMIN3505	CHMUGMIN3606	CHMUGMIN4707	CHMUGMIN4808
Multi-disciplinary	UCCUGMDC1101	CHMUGMDC1201	CHMUGMDC2302					
AEC	UCCUGAEC1101		UCCUGAEC2302					
SEC	CHMUGSEC1101	CHMUGSEC1202	CHMUGSEC2303					
VAC		UCCUGVAC1201		UCCUGVAC2402				
SIP					CHMUGSIP3501			
Dissertation								

6.3 Courses offered by the Department of Chemistry to allied Departments:

Course Type	Semester-I	Semester-II	Semester-III	Semester-IV	Semester-V	Semester-VI	Semester-VII	Semester-VIII
Minor	CHMUGMIN1101	CHMUGMIN1202	CHMUGMIN2303	CHMUGMIN2404	CHMUGMIN3505	CHMUGMIN3606	CHMUGMIN4707	CHMUGMIN4808
Multi-disciplinary		CHMUGMDC1201	CHMUGMDC2302					

7. Semester wise course details (Chemistry)

Semester-I				
Course Type Major/Minor; Core/DSE	**Course Name**	**Topic**	**Course Code**	**Credit**
Major; Core	Physical Chemistry-I	Physical States of Matter	CHMUGMCC1101	4
Major; Core	Inorganic Chemistry-I	Atomic Structure, Radioactivity & Chemical Periodicity-I	CHMUGMCC1102	4
Minor	Physical Chemistry-I	Physical States of Matter	CHMUGMIN1101	4
Multi-disciplinary	Arabic & Islamic Studies		UCCUGMDC1101	3
AEC	Modern Indian Language (Bengali/Urdu/Hindi)		UCCUGAEC1101	4
SEC	Laboratory safety and quality analysis of water		CHMUGSEC1101	3
No of Paper: 6				**Total Credit: 22**
Semester-II				

Course Type Major/Minor; Core/DSE	Course Name	Topic	Course Code	Credit
Major; Core	Organic Chemistry-I	Bonding & Stereochemistry	CHMUGMCC1203	4
Major; Core	Physical Chemistry-II	Chemical Thermodynamics, Chemical Equilibrium and Phase rule	CHMUGMCC1204	4
Minor	Organic Chemistry-I	Bonding & Stereochemistry	CHMUGMIN1202	4
Multi-disciplinary	Chemistry in context: Applying Chemistry to Society		CHMUGMDC1201	3
SEC	Analyses of soil and ores		CHMUGSEC1202	3
VAC	Environmental Science		UCCUGVAC1201	4
No of Paper: 6				**Total Credit: 22**
Semester-III				
Course Type Major/Minor; Core/DSE	**Course Name**	**Topic**	**Course Code**	**Credit**
Major; Core	Inorganic Chemistry-II	Chemical Bonding-I, Chemical Periodicity-II & Acid-Base Concept	CHMUGMCC2305	4
Major; Core	Organic Chemistry-II	Organic Reactions & Mechanisms	CHMUGMCC2306	4
Minor	Inorganic Chemistry-II	Chemical Bonding-I, Chemical Periodicity-II & Acid-Base Concept	CHMUGMIN2303	4
Multi-disciplinary	Molecules of Life		CHMUGMDC2302	3
AEC	English		UCCUGAEC2302	4
SEC	Application of Computer in Chemistry		CHMUGSEC2303	3
No of Paper: 6				**Total Credit: 22**
Semester-IV				

Course Type Major/Minor; Core/DSE	Course Name	Topic	Course Code	Credit
Major; Core	Physical Chemistry-III	Chemical Kinetics, Adsorption and Catalysis	CHMUGMCC2407	4
Major; Core	Inorganic Chemistry-III	Chemical Bonding-II & Redox Reactions	CHMUGMCC2408	4
Major; Core	Organic Chemistry-III	Important Compounds & Rearrangements	CHMUGMCC2409	4
Minor	Physical Chemistry-III	Chemical Thermodynamics, Chemical Equilibrium and Phase rule	CHMUGMIN2404	4
VAC	Understanding India		UCCUGVAC2402	4
No of Paper: 5		**Total Credit: 20**		
Semester-V				
Course Type Major/Minor; Core/DSE	**Course Name**	**Topic**	**Course Code**	**Credit**
Major; Core	Inorganic Chemistry-IV	Coordination Chemistry & Organometallic Compounds	CHMUGMCC3510	4
Major; Core	Organic Chemistry-IV	Synthetic Strategies & Cyclic Stereochemistry	CHMUGMCC3511	4
Major; Core	Physical Chemistry-IV	Colligative Properties, Ionic Equilibrium and Electrochemistry	CHMUGMCC3512	4
Minor	Inorganic Chemistry-IV	Coordination Chemistry & Organometallic Compounds	CHMUGMIN3505	4
SIP	Summer Internship		CHMUGSIP3501	4
No of Paper: 5		**Total Credit: 20**		
Semester-VI				
Course Type Major/Minor; Core/DSE	**Course Name**	**Topic**	**Course Code**	**Credit**

Major; Core	Organic Chemistry-V	Spectroscopy & Biomolecules	CHMUGMCC3613	4
Major; Core	Physical Chemistry-V	Quantum Chemistry and Spectroscopy	CHMUGMCC3614	4
Major; Core	Analytical Chemistry-I	Concept, Analysis of samples; Chromatography	CHMUGMCC3615	4
Major; DSE	Bioinorganic Chemistry		CHMUGMDS3601	4
Minor	Organic Chemistry-V	Spectroscopy & Biomolecules	CHMUGMIN3606	4
No of Paper: 5		**Total Credit: 20**		
Semester-VII				
Course Type Major/Minor; Core/DSE	**Course Name**	**Topic**	**Course Code**	**Credit**
Major; Core	Inorganic Chemistry-V	Chemical Application of Group theory; Cluster compounds & Macrocycles	CHMUGMCC4716	4
Major; Core	Medicinal chemistry-I	Concept of Drugs; Antibiotics & Inorganic pharmaceuticals	CHMUGMCC4717	4
Major; DSE (For UG Honours with research: Any two courses) (For UG Honours without research: All three courses)	Pericyclic reactions & Organic Photochemistry		CHMUGMDS4702	4
	Advanced Physical Chemistry	Quantum Chemistry, Statistical thermodynamics & Polymer Chemistry	CHMUGMDS4703	4
	Research methodology and Data Analysis		CHMUGMDS4704	4
Minor	Inorganic Chemistry-V	Chemical Application of Group theory; Cluster compounds & Macrocycles	CHMUGMIN4707	4
Dissertation-I (For UG Honours with research only)			CHMUGPRJ4701	4

No of Paper: 6			**Total Credit: 24**	
Semester-VIII				
Course Type Major/Minor; Core/DSE	**Course Name**	**Topic**	**Course Code**	**Credit**
Major; Core	Spectroscopy	NMR, Mass, Mössbauer and ESR Spectroscopy	CHMUGMCC4818	4
Major; Core	Analytical chemistry-II	Separation Techniques; Analytical Methods & Instrumental analysis	CHMUGMCC4819	4
Major; DSE (For UG Honours with research: Any one course) (For UG Honours without research: All three courses)	Chemistry of Natural Products	Alkaloids, Terpenoids, Steroids & Flavonoids	CHMUGMDS4805	4
	Biochemistry and Basic Immunology	Organization of life, Metabolism & Immune system	CHMUGMDS4806	4
	Inorganic Materials of Industrial Importance		CHMUGMDS4807	4
Minor	Spectroscopy	NMR, Mass, Mössbauer and ESR Spectroscopy	CHMUGMIN4808	4
Dissertation-II (For UG Honours with research only)	Dissertation-II		CHMUGPRJ4802	8
No of Paper: 6			**Total Credit: 24**	
Overall Credit: 174				

8. Detailed Syllabi (Chemistry)

8.1 Semester-I		
8.1.1 Course Name: Physical Chemistry-I **Topic: Physical States of Matter** **Course Code: CHMUGMCC1101/ CHMUGMIN1202** **Credit: 4**		
Course type: Major/Core Minor-1	**Course Distribution: Theory: 3 Credit Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk) Practical: 30 Class Hours (2h/wk)**

Course Objectives: This course aims to provide understanding of the behavior of matter in different states: gases, liquids, solids, and colloids. Topics include gas laws, kinetic theory, crystal structures, colloidal properties, and their applications. Students will gain insights into fundamental principles and real-world applications of each state of matter.

Theory

Gaseous state (10 Lectures)

Gas laws, Postulates of Kinetic theory of gases, Pressure equation on the basis of the Kinetic theory, gas laws based on kinetic theory, Distribution of velocity of gas molecules-Maxwell's velocity distribution, Values of different types of average velocities of gas, Collision in a gas-mean free path, collision diameter, collision number, mean free path, deviation of gases from ideal behavior, compressibility factor, Andrew's and Amagat's plot Van der Waals equation , existence of critical state, critical constants in terms of Van der Waals constant, reduced equation of state, Principles of corresponding state.

Liquid state (10 Lectures)

Intermolecular forces in liquids, Dipole-dipole attractions, London forces, Hydrogen bonding, Vapour pressure, Effect of temperature on vapour pressure, Effect of vapour on boiling points, Surface tension, Units of surface tension, Spreading of liquid over other surface, Determination of surface tension by capillary rise method, Determination of surface tension by drop formation method, Influence of temperature on surface tension, Parachor and molar refraction of a liquid, Viscosity, Viscosity coefficient, Poiseuille's equation, Measurement of viscosity by Ostwald method, Effect of temperature on viscosity of a liquid, Liquid crystal, Smectic, Nematic and Cholestric Liquid Crystals.

Solid state (15 Lectures)

Classification of solids, Isotropy and anisotropy, crystal habits, Symmetry of crystal, Miller indices, Findings of miller indices, Crystal structures, Parameters of the unit cell, Cubic unit cell, Three types of cubic unit cell, Coordination number of a crystal lattices, X-ray crystallography, Bragg's equation, Measurement of diffraction angles, Ionic crystals, sodium chloride crystal, Cesium chloride crystal, Lattice energy of an ionic crystal, Molecular crystal, Metallic crystals, Hexagonal closed packed structure, Body centered cubic structure, Imperfection in crystal: point defects-Schottky and Frenkel defects, Metal alloys, Semiconductors, Solar cell, Liquid crystal, Application of liquid crystal.

Colloidal State (10 Lectures)

Definition of colloids, classification of colloids, Types of colloidal system, Preparation of sols: by mechanical dispersion method, by Bredig's Arc method, by Peptization, Purification of sols: dialysis, electrodialysis, ultrafiltration. Optical properties of sol: Tyndall effect, Kinetic properties of sol: Brownian motion, Electrical properties of sol, Electrical double layer, Helmholtz Double layer, Electrophoresis of sols, Electro-osmososis, Protective colloids, Hardy- Schulze rule, Gold number, Stability of sols, Associated colloids, Micelles, Cleansing action of soap, Emulsions, Emulsification, De-emulsification, Gels, Preparations of gels, Artificial kidney machine, Macromolecules, Determination of molecular weights of macromolecules, Application of colloidal chemistry.

Reference Books	
I.	Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry Ed., Oxford University Press 13 (2006).
II.	Ball, D. W. Physical Chemistry Thomson Press, India (2007).
III.	Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
IV.	I. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).

Practical	
1.	Determination of viscosity co-efficient of a given solution with Ostwald's viscometer.
2.	To determine the percentage composition of the given mixture consisting of two components by viscosity measurement.
3.	To determine the surface tension of a given liquid at room temperature using Stalagmometer.

4.	To determine the solubility of benzoic acid at room temperature.
5.	Study the effect on Ph of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
6.	pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
Reference Books	
I.	Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson
II.	Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books(2009)
III.	Physical Chemistry Practical: Saroj Kr Maity, Naba Kr Ghosh
IV.	Harris, D. C. Quantitative Chemical Analysis. 9th Ed., Freeman (2016)
V.	An Advanced Course in Practical Chemistry: Ghoshal, Mahapatra, Nad
VI	Palit, S.R., De, S. K. Practical Physical Chemistry Science Book Agency
VII.	Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.

Course Outcome: Through practical experiments, this course enhances students' understanding of the behavior of gases, liquids, solids, and colloids. The hands-on activities develop analytical and experimental skills, bridging theoretical knowledge with real-world applications in physical chemistry.

8.1.2 Course Name: Inorganic Chemistry-I
Topic: Atomic Structure, Radioactivity & Chemical Periodicity-I
Course Code: CHMUGMCC1102
Credit:4

Course type: Major/Core	**Course Distribution:** **Theory: 3 Credit** **Practical: 1Credit**	**Theory: 45 Lectures (3h/wk)** **Practical: 30 Class Hours (2h/wk)**

Course Objectives: This course will enable learners to recall and explain the structure and properties of the atom. Essentially the periodic table is a graphic representation of the patterns in the physical and chemical behavior of the elements. The purpose of the practical experiments is to learn the techniques to separate and identify some common anions.

Theory

Atomic Structure (15 Lectures)

Bohr's theory, spectrum of hydrogen atom, Sommerfeld's model, Quantum numbers, Concept of atomic orbitals; shapes, radial and angular probability diagrams of *s*, *p* and *d* orbitals, Schrödinger's equation, Many electron atoms and ions, Pauli's exclusion principle, Hund's rule, exchange energy, Aufbau principle and its limitation, Term symbols of atoms and ions.

Radioactivity (15 Lectures)

Nuclear stability and binding energy, Nuclear forces, meson theory, Nuclear models, Concept of nuclear quantum number, Magic numbers, Nuclear Reactions: fission, fusion and spallation, Nuclear energy and power generation, Separation and uses of isotopes. Natural radioactivity, Law of radioactive decay, Artificial radioactivity, radio carbon dating, hazards of radiation and safety measures.

Chemical periodicity I (15 Lectures)

Periodic table, group trends and periodic trends, Modern IUPAC Periodic table, General characteristic of s, p, d and f block elements. Position of hydrogen and noble gases, Effective nuclear charges, screening effects, Slater's rules, atomic radii, ionic radii (Pauling's univalent), covalent radii, Ionization potential, electron affinity and electro negativity and factors influencing these properties, Inert pair effect, Group trends and periodic trends in these properties in respect of s-, p- and d-block elements.

Reference

I.	Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
II.	Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970.
III.	Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.

Practicals

I. Systematic qualitative analysis of the following metals and non metal salts

Sulphide, suiphate, sulphite, thiosulphate, nitrite, nitrate, orthoborate, metaborate, fluoride, chloride, bromide, iodide, phosphate, Arsenate, arsenite, silicate, ferocyanide, fericyanide, thiocyanate.

Reference Books

I.	Vogel's Qualitative Inorganic Analysis, A.I. Vogel, Prentice Hall, 7th Edition.
II.	An Advanced Course In Practical Chemistry, Nad, Mahapatra & Ghosal

Course Outcome: At the end of the course, the student will learn about the atomic structure and periodic properties to explain the chemical behavior. The students will be able to describe the periodic table as a list of elements arranged so as to demonstrate trends in their physical and chemical properties. The student will be able to analyze an inorganic compound through systematic qualitative analysis.

8.1.4 Laboratory safety and quality analysis of water
Course Code: CHMUGSEC1101
Credit: 3

Course type: SEC	Course Distribution: Theory: 3 Credit	Theory: 45 Lectures (3h/wk)

Course Objectives: The course is offered to teach students about safety rules for working with chemicals and participating in a safe manner when carrying out lab procedures. Focus will be laid on identifying the safety symbols available on chemical bottles and different instruments that are used in chemistry laboratory along with the concept of MSDS. This module will also focus on prevention of accidents and first aid measures. Furthermore, this course is designed to familiarize students with the methods of water quality analysis and the analytical instruments used to measure the quality of drinking water.

Unit-I: Laboratory safety and handling of Chemicals

General lab safety rules: Common rules that relate to almost every laboratory, Safety policies, First aid measures, Use of fire safety, Use of laboratory hood.

Safe Handling of Hazardous Chemicals: Introduction of hazardous chemicals, Rules for handling chemicals, Essential practices for handling hazardous chemicals, Safety symbols, MSDS, UNGHS,CASRN, Laboratory waste management.

Storing, labeling, handling and personal hygiene: Storage and labeling of chemicals, Storage of Explosive and reactive hazardous chemicals, Transportation of hazardous chemicals.

Unit-II: Water and Its Treatment

Introduction:

Source of water, Characteristics of water, Impurities in water,

Water Quality parameters:

Colour, Taste and Odour, Turbidity, Total Dissolved solid, pH, Hardness, Alkanity, Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD), Fluoride, Arsenic.

Water Treatment:

Trouble caused by impurities in water in industry and domestic use. Softening of water, removal of turbity, disoolve solids and microbes. Waste water treatment system.

Reference

1. https://www.msdsonline.com/
2. http://www.hse.gov.uk/chemical-classification/labelling-packaging/hazard-symbols-hazard-

pictograms.htm
3. https://ehs.princeton.edu/news/know-your-hazard-symbols-pictograms
4. https://www.labmanager.com/lab-health-and-safety/2017/09/science-laboratory-safety-and-hazard-igns-meanings
5. http://www.thermofishersci.in/lit/Laboratory%20first%20aid.pdf
6. http://www.chemistry-assignment.com/laboratory-emergencies-and-first-aid
7. https://www.reagent.co.uk/chemical-first-aid/
8. http://www.kwanga.net/chemnotes/first-aid.pdf
9. Standard methods for the examination of water and wastewater published by APHA 15th ed.
10. Soil and water chemistry by Anu Gopinath
11. Environmental Chemistry by Anil Kumar De

Course Outcome: After studying this course, students will be trained how to ensure safety of all the stakeholders in a chemistry laboratory. They will be able to identify the safety symbols on chemical bottles and different instruments used in chemistry laboratory. Students will be made aware about the possibility of different types of chemical accidents and chemical spills due to negligence and the First Aid Measures in such scenario. Learners will be also able to describe the main sources of water pollution, water quality parameters and how impure water may be treated before discharge to the environment.

8.2 Semester-II

8.2.1 Course Name: Organic Chemistry-I
Topic: Bonding & Stereochemistry
Course Code: CHMUGMCC1203/ CHMUGMIN1202
Credit: 4

Course type: Major/Core Minor-2	**Course Distribution: Theory: 3 Credit Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk) Practical: 30 Class Hours (2h/wk)**

Course Objectives: The course is designed to introduce the students with the concept of chemical bonding which will allow them to understand the structure and properties of organic compounds in molecular level. The pupils will learn about hybridization, conjugation, aromaticity and reactive intermediates. The unit has also been intended to give an insight into basic aspects of stereochemistry of molecules.

Theory

Chemical Bonding (23 Lectures)

Valence bond theory: concept of hybridization, orbital pictures of compounds (sp^3, sp^2, sp: C-C, C-N & C-O system). Inductive effect, bond polarization and bond polarizability, steric effect, resonance, cross conjugation, hyperconjugation, steric inhibition of resonance, acidity-basicity.

Concept of DBE: Prediction of probable structures from chemical formula.

MolecularOrbital Theory: sketch and energy levels of Mos of i) acyclic p orbital system (C=C, conjugated diene and allyl systems) ii) cyclic p orbital system (neutral system: [4], [6] annulenes; charged system: 3,4,5-ring system); Fröst diagram, Hückel's rules for aromaticity & antiaromaticity; homoaromaticity, meso-ionic compounds, ylides.

Physical properties: bond distance, bond angles, mp/bp & dipole moment, intermolecular forces, heat of hydrogenation and heat of combustion.

Transition State Theory: elementary idea, Hammond's postulate.

Bonding weaker than covalent Hydrogen bonding, π-π interactions, addition compounds: electron donor-acceptor complex, crown ether complex, cryptates, inclusion compounds, cyclodextrins, catenanes, rotaxanes.

Application of thermodynamic principles in tautomeric equilibria [keto-enol, amine-enamine, nitro-acinitro, nitroso-oxime, composition of the equilibrium in different systems (simple carbonyl, 1,3 and 1,2- dicarbonyl systems, phenols and related system), substituent and solvent effect].

Stereochemistry (22 Lectures)

Representation of molecules in saw horse, Fischer, flying-wedge and Newman formulae and their inter translations, symmetry elements, molecular chirality.

Optical activity of chiral compounds: specific rotation, optical purity (enantiomeric excess)

Molecular chirality. Configuration: stereogenic units i) stereocentres: systems involving 1, 2, 3 centres, stereogenicity, absolute configuration, CIP rule, chirotopicity. Pseudoasymmetric (D/L and *R*/*S* descriptor, threo/erythro and syn/anti nomenclatures (for aldols) ii) stereoaxis: chiral axis in allenes & biphenyls, *R*/*S* descriptor; *cis*/*trans*, *syn/anti*, *E*/*Z* descriptors (for C=C, C=N), racemization (through cationic and anionic and radical intermediates), resolution of acids, bases and alcohols via diastereomeric salt formation. Topicity of ligands and faces (elementary idea): Pro-*R*, Pro-*S* and *Re*/*Si* descriptors.

Conformation: Conformational nomenclature, eclipsed, staggered, gauche and anti; dihedral angle, torsion angle, energy barrier of rotation, relative stability of conformers on the basis of steric effect, dipole-dipole interaction, H-bonding; conformational analysis of ethane, propane, n-butane, haloethane, 1,2-haloethane, 1,2- glycol, 1,2-halohydrin; invertomerism of trialkylamines.

Reference	
I.	Organic Chemistry – Wade
II.	Organic Chemistry- Paula Y. Bruice
III.	Mechanism & Theory in Organic Chemistry , S.K. Ghosh
IV.	Organic Chemistry, Vol. I – Finar
V.	A guidebook to mechanics in organic chemistry-Sykes
VI.	Organic Chemistry – Solomons
VII.	Advanced Organic Chemistry-Jerry march
VIII.	Basic stereochemistry of organic molecules- Subrata Sen Gupta
IX.	Stereochemistry of organic compounds – Ernest L. Eliel
X.	Stereochemistry of Organic Compounds- Principles and Applications- D. Nasipuri

Practical	
Qualitative analysis of single solid organic compounds	
1.	Physical Characteristics and M. P. detection
2.	Preliminary Tests
3.	Solubility Classification (solvents: H_2O, 5% HCl, 5% $NaHCO_3$, 5% NaOH, c. H_2SO_4)
4.	Detection of special elements (N, S, halogen) by Lassaigne's test
5.	Detection of functional groups (Aromatic $–NH_2$& $-NO_2$, anilido, amido, phenolic –OH, $-CO_2H$, carbonyl, ester/anhydride/lactone).
6.	Preparation, purification and M. P. determination of a crystalline derivative of the given compound.
Reference	
I.	Vogel's Textbook of Practical Organic Chemistry: A. I. Vogel, B. S. Furniss, P. W. Smith
II.	An advanced Course in Practical Chemistry: Ghoshal, Mahapatra, Nad
III.	A Textbook On Chemistry Practical: Bidhan Chandra Ray, Satyanarayan Das

Course Outcome: By the end of the course, students should be able to predict and explain patterns in shape, structure, bonding, hybridization, formal charge, stability, acidity, basicity, solubility, and reactivity for organic compounds. Learners will be able to classify molecules as chiral or achiral, identify chiral carbons as (R) or (S), identify relationships between pairs of molecules as enantiomers, diastereomers, or equivalent, and identify when a solution is racemic versus optically active.

8.2.2 Course Name: Physical Chemistry-II
Topic: Chemical Thermodynamics, Chemical Equilibrium and Phase rule
Course Code: CHMUGMCC1204
Credit: 4

Course type: Major/Core	**Course Distribution:** **Theory: 3 Credit** **Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk)** **Practical: 30 Class Hours (2h/wk)**

Course Objectives: In this course, undergraduates will explore thermodynamics, thermochemistry, and chemical equilibrium, mastering basic concepts like system types, heat, work, and free energy. The practical curriculum includes hands-on experiments covering iodine partitioning, equilibrium constants, and binary systems like Phenol-water with impurities, enhancing real-world application understanding through the integration of theory and practice.

Theory

Thermodynamics-I (10 Lectures)

Importance and scope, thermodynamic terms: system, boundary, surrounding, types of systems: isolated, closed and open, extensive and intensive variables, partial derivatives and cyclic rule, state function and path function, equilibrium and non-equilibrium state, zeroth law of thermodynamics thermodynamic processes, concept of heat and work, work done during expansion and compression of an ideal gas, pressure-volume work, reversible and irreversible processes and work done, comparison of W_{rev} and W_{irrev}, internal energy, calculation of ΔU, ΔH. q and w, enthalpy of a system, heat capacity: heat capacities at constant volume and pressure and their relationship, Joule-Thomson effect, adiabatic expansion of an ideal gas, work done in adiabatic reversible expansion.

Thermochemistry (5 Lectures)

t equations, Methods of writing thermochemical equation, heat of reaction or enthalpy of reaction, laws of thermochemistry, heat of combustion, heat of solution, heat of neutralization, energy changes during transitions, heat of fusion, heat of vaporization, heat of sublimation, heat of transition, Hess's law of constant heat summation, application of Hess's law, bond energy, measurement of the heat of reaction.

Thermodynamics-II (10 Lectures)

Spontaneous process, criteria of spontaneity, second law thermodynamics, different statements of the law. Carnot cycle and its efficiency, Carnot theorem, Maxwell relations, thermodynamic scale of temperature, entropy: unit of entropy, numerical definition of entropy, standard entropy, standard entropy of formation, physical significance of entropy, entropy as a function of V and T, entropy as a function of P and T, entropy change in ideal gases and mixing of gases, entropy change accompanying change of phase, free energy function and work function, variation of free energy with temperature and pressure, Gibb's Helmholtz equations, condition of equilibrium and criteria for a spontaneous process, Clapeyron equation, Clausius-Clapeyron equation. Maxwell relations; thermodynamic equation of state.

Chemical Equilibrium (10 Lectures)

Thermodynamic conditions for equilibrium, degree of advancement; variation of free energy with degree of advancement; equilibrium constant and standard Gibbs free energy change; definitions of K_p, K_c and K_x and relation among them; van't Hoff's reaction isotherm, isobar and isochore from different standard states; shifting of equilibrium due to change in external parameters e.g. temperature and pressure; variation of equilibrium constant with addition to inert gas; Le Chatelier's principle.

Phase Equilibrium (10 Lectures)

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule for nonreactive and reactive systems; Clausius-Clapeyron equation and its applications to solid-liquid, liquid-vapour and solid vapour equilibria, phase diagram for one component systems, with applications.

Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent and incongruent melting points, solid solutions.

Three component systems, water-chloroform-acetic acid system, triangular plots.
Binary solutions: Gibbs-Duhem-Margules equation, its derivation and applications to fractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, lever rule, partial miscibility of liquids, CST, miscible pairs, steam distillation.
Nernst distribution law: its derivation and applications.

References	
I.	Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press (2011).
II.	Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004).
III.	Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012). McQuarrie, D. A. &
IV.	Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.: New Delhi (2004).
V.	Physical Chemistry by P.C. Rakshitvi. Levine, I .N. Physical Chemistry 6th Ed., Tata Mc Graw Hill (2010).
VI.	Metz, C.R. 2000 solved problems in chemistry, Schaum Series (2006).
VII.	Peter, A. & Paula, J. de. Physical Chemistry 9th Ed., Oxford University Press (2011).
VIII.	Castellan, G. W. Physical Chemistry 4th Ed., Narosa (2004). Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
IX.	McQuarrie, D. A. & Simon, J. D. Molecular Thermodynamics Viva Books Pvt. Ltd.:New Delhi (2004).

Practical

1.	Partition coefficient of iodine between CCL_4 and water
2.	Equlibrium constant of $KI+I_2=KI_3$ by partition method
3.	To show that benzene dimerizes in benzene
4.	Study of the adsorption of acetic acid on charcoal-verification of Freunflich's Adsorption Isotherm
5.	To study the phase diagram of a binary system (Phenol + water) and the effect of impurities (e.g. NaCl)

References	
I.	Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson
II.	Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009)
III.	Physical Chemistry Practical: Saroj Kr Maity, Naba Kr Ghosh
IV.	Harris, D. C. Quantitative Chemical Analysis. 9th Ed., Freeman (2016)
V.	An Advanced Course in Practical Chemistry: Ghoshal, Mahapatra, Nad
VI.	Palit, S.R., De, S. K. Practical Physical Chemistry Science Book Agency
VII.	Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.

Course Outcome: Upon completion of this course, undergraduate students will possess a comprehensive understanding of thermodynamics, thermochemistry, and chemical equilibrium, mastering fundamental principles and theoretical concepts. Through hands-on experiments involving iodine partitioning, equilibrium constants, benzene dimerization, and adsorption on charcoal, students will develop practical skills and apply their knowledge to real-world scenarios.

8.2.4 Chemistry in context: Applying Chemistry to Society
Course Code:CHMUGMDC1201
Credit: 3

Course type: Multi-disciplinary	Course Distribution: Theory: 3 Credit	Theory: 45 Lectures

Course Objectives: The goal of 'Chemistry in Context' is to establish a relationship of chemical principles with significance to social, political, economic, and ethical issues. This introductory chemistry course for non-science majors explores the intersection of chemistry with everyday life.

UNIT I: History And Relevance Of Chemistry (20 Lectures)

Life without Chemistry : Chemistry matters

Chemistry of Life: Introduction. Chemical basis of life, Periodic table, Elements in the human body, Essential, Non-essential elements, Criteria of essentiality.

Food preservatives like benzoates, propionates, sorbates, disulphites. Artificial sweeteners: Aspartame, saccharin, dulcin, sucralose and sodium cyclamate. Flavours: Vanillin, alkyl esters (fruit flavours) and monosodium glutamate. Artificial food colorants: Coal tar dyes and non-permitted colours and metallic salts.

UNIT II: Chemistry In Everyday Life (25 Lectures)

(Applications, Uses And Impact Of Chemistry)

Pharmaceuticals: Introduction, Contribution of chemistry to human health and historical developments in medicine, Classification of drugs and some common drugs used in our daily life.

Plastics and Polymers: Introduction to polymers, types of polymers, Plastic in daily use, Environmental Hazards of plastics, Biodegradable plastics.

Cosmetics: Basic concepts-composition and classification of creams-sunscreen and suntan lotions, deodorants, talcum powder, lipsticks, oils, face creams, hair dyes, shaving cream, shampoo.

Soaps and detergents: Soaps - Basic chemical compositions of soaps, Surface active agents, builders, additives, fillers and fragrance, Detergents– Introduction, Detergent action, Significance of acidity and alkalinity. Common detergent chemicals.

References

1. B. K. Sharma: introduction to Industiral Chemistry, Goel Publishing, Meerut (1998)
2. Chemical Analysis of Foods – H.E.Cox and pearson.
3. Foods: Facts and Principles. N. Shakuntala Many and S. Swamy, 4th ed. New Age International (1998)
4. Handbook on Feritilizer Technology by Swaminathan and Goswamy, 6th ed. 2001, FAI.

Course Outcome: This course will enable students of non-science background to develop an appreciation for the importance of the role of chemistry in everyday life. Students would be more aware of the chemicals found in all aspects of daily life. They will become knowledgeable about the connection between chemistry and pollution, health care, energy, nutrition and life. They would learn to apply knowledge of chemistry to improve quality of life.

8.2.5 Analyses of soil and ores
Course Code: CHMUGSEC1202
Credit:3

Course type: SEC	**Course Distribution: Theory: 3 Credit**	**Theory: 45 Lectures (3h/wk)**

Course Objectives: Soil and ores are the important part of planet. These composed of several salts, chemicals and biological matters. This course will teach the students to detect these matters qualitatively and quantitatively.

Unit I: Analysis of soil

Basic concept on soil, Earth crust, Composition of soil, Mositer content in soil and its determination, Particle size distribution, Wilting point, pH of soil, Electrical conductivity.

Determination of following compounds in soil: Calcium and magnesium carbonate, soil organic matter, Total Nitrogen, Phosphorus, Sodium and potassium, soil micronutrient.

Unit II: Analysis of ore

Different types of Ores and Rocks, Formation of ores and rocks, Methods of analysis of ores like colorimetric method, X-ray fluoresecent analyzer, Atomic absorption sepectrosocpy, Inductively coupled plasma (ICP), Determination of following metals in ores: Aluminium in boxite, manganese in pyrulosite, calcium in Gypsum, Iron in hematite.

References

1. Soil Sampling and methods of analysis, carter M.R. and E.G.Gregorich, 2007, 2nd Ed..
2. Methods of soil analysis, Part, American society of Agronomy Inc., Kuete, A. Et.at., 1986.
3. N.H.Furman - Standard Methods of Chemical Analysis.
4. A.I.Vogel - Text Book of Quantitative Inorganic Analysis.

Course Outcome: After completion of this course, students will be able to perform the Chemical analysis of soil and ore samples. They will learn to analyze the samples for precious metals, estimate the errors in results and quantify the results with standards. They will also be exposed towards the use of different equipments for characterization.

8.3 Semester-III

8.3.1 Course Name: Inorganic Chemistry-II
Topic: Chemical Bonding-I, Chemical Periodicity-II & Acid-Base Concept
Course Code: CHMUGMCC2305/ CHMUGMIN2303
Credit: 4

Course type: Major/Core Minor-3	**Course Distribution: Theory: 3 Credit Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk) Practical: 30 Class Hours (2h/wk)**

Course Objectives: This course will describe the relationship between the chemical properties and reactivity of an element and its position in the periodic table. The purpose of the practical experiment is to learn the techniques to separate and identify some common cations.

Theory

Chemical Bonding-I (10 Lectures)

Lewis structures, formal charge. Valence Bond Theory, directional character, hybridizations, equivalent and non-equivalent hybrid orbitals, Bent's rule, VSEPR theory, shapes of molecules and ions, Partial ionic Character, bond moment, dipole moment, Concept of resonance, resonance energy and resonance structures.

Chemical Periodicity II (25 Lectures)

General trends of variation of electronic configuration, elemental forms, metallic nature, magnetic properties (if any), catenation and catalytic properties (if any), oxidation states, inert pair effect (if any), aqueous and redox chemistry in common oxidation states, properties and reactions of important compounds such hydrides, halides, oxides, oxyacids (if any), complex chemistry (if any) in respect of s-block and p-block elements.

Structure, bonding and reactivity of B_2H_6; $(SN)_x$ with x= 2,4; phosphazines; interhalogens. Structure of borates, silicates, polyphosphates, borazole, boron nitride, silicones, thionic acids. Reactivity of polyhalides, pseudo halides, fluorocarbons, freons and NO_x with environmental effects. Chemistry of hydrazine, hydroxylamine, N_3^-, thio- and per-sulphates.

Noble gases from air; oxides, fluorides and oxofluorides of xenon, chemical and photochemical reactions of ozone.

Acid-Base Concept (10 Lectures)

Acid-Base concept: Arrhenius concept, theory of solvent system, Bronsted-Lowry's concept, relative strength of acids, Pauling rules, Amphoterism, Lux-Flood concept, Lewis concept, Superacids, HSAB principle. Acid-base equilibria in aqueous solution and pH scale, Acid-base neutralisation curves, indicator, choice of indicators.

SN	Reference Books
I.	Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
II.	Douglas, B.E. and Mc Daniel, D.H., Concepts & Models of Inorganic Chemistry, Oxford, 1970.
III.	Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K.; Inorganic Chemistry | Fourth Edition.

IV	Sarkar, R.; General and Inorganic Chemistry: Volume I & II.
V	Das, A. K.; Fundamental Concepts of Inorganic Chemistry Vol 1-2, 3rd Edition

Practical	
Systematic qualitative analysis of the following metal salts Hg(I), Hg (II), Pb, Ag, Cu, Bi, Cd, As, Sb, Sn, Al, Fe, Cr, Co, Ni, Zn, Ca, Sr, Ba, Mg, Na, K, NH_4.Semi micro and spot analysis method should be encouraged.	
Reference Books	
I.	G. Svehla, Vogel's Qualitative Inorganic Analysis, 7^{th} Edn.
II.	An Advanced Course In Practical Chemistry, Nad, Mahapatra & Ghosal

Course Outcome: Students should be able to understand the common themes running through ionic, covalent and metallic descriptions of chemical bonding.
At the end of the course, the student will be able to analyze of an inorganic compound through systematic qualitative procedure for functional.

8.3.2 Course Name: Organic Chemistry-II
Topic: Organic Reactions & Mechanisms
Course Code: CHMUGMCC2306
Credit: 4

Course type: Major/Core	**Course Distribution:** **Theory: 3 Credit** **Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk)** **Practical: 30 Class Hours (2h/wk)**

Course Objectives: The course is intended to introduce students with different kinds of organic reactions and their mechanism. The practical experiments will familiarize the attendees with the quantitative estimation of organic compounds.

Theory

General concept of organic reaction (5 Lectures)
Mechanistic classification: ionic, radical and pericyclic; heterolytic bond cleavage and heterogenic bond formation, homolytic bond cleavage and homogenic bond formation; representation of mechanistic steps using arrow formalism.
Reactive intermediates: carbocations (cabenium and carbonium ions), carbanions, carbon radicals, carbenes –Concept of acids and bases: effect of structure, substituent and solvent on acidity and basicity.
Kinetic Isotopic effect: Theory of isotope effects, primary and secondary kinetic isotope effects, heavy atom isotope effects, tunneling effect, solvent effects.
Nucleophilic substitution reactions (10 Lectures)
Substitution at sp^3 centre – Mechanism: S_N1, S_N2, S_N2', S_Ni mechanisms, effect of solvent, substrate structure, leaving group, nucleophiles including ambident nucleophiles (cyanide & nitrite) substitution involving NGP; relative rate & stereochemical features [systems: alkyl halides, allyl halides, alcohols, ethers, epoxides].
Substitution at sp^2 carbon (carbonyl system) – Mechanism: $B_{AC}2$, $A_{AC}2$, $A_{AC}1$, $A_{AL}1$ (in connection to acid and ester). Systems: amides, anhydrides & acyl halides [formation and hydrolysis].
Addition reactions (15 Lectures)
Electrophilic addition to C=C: Mechanism, reactivity, regioselectivity and stereoselectivity. Reactions: halogenations, hydrohalogenation, hydration, hydrogenation, epoxidation, hydroxylation, ozonolysis, electrophiilic addition to diene (conjugated dienes and allenes). Radical addition: HBr addition. Dissolving metal reduction of alkynes and bezenoid aromatics (Birch). Pericyclic addition: Diels-Alder reaction. Addition of singlet and triplet carbenes.

Nucleophilic addition to C=O: Mechanism, reactivity, equilibrium and kinetic control. Reactions with alcohols, amines, thiols, HCN, bisulfite, Wittig reaction.
Carbonyl Reduction: hydride addition, Wolff-Kishner reduction, dissolving metal (Bouveault-Blanc reduction, Clemmensen Reduction); Cannizzaro reaction, Tischenko reaction, aldol condensation, benzoin condensation.
Nucleophilic addition to α,β-unsaturated carbonyl system (general principles).

Elimination and aromatic substitution(15 Lectures)

Elimination – Mechanisms: E1, E2 and E1Cb; reactivity, orientation (Saytzeff/ Hofmann) and stereoselectivity; substitution vs elimination.
Electrophilic aromatic substitution: Mechanisms, orientation and reactivity. Reactions: nitration, nitrosation, sulfonation, halogenation , Friedel-Crafts reactions, one carbon electrophiles (reactions: chloromethylation, Gatterman-Koch, Gatterman, Hoesch, Vilsmeier-Haack reaction, Reimer-Tiemann, Kolbe-Schmidt).
Nucleophilic aromatic substitution: Addition-elimination mechanism, S_N1 mechanism, benzyne intermediate.

Reference books	
I.	Mechanism & Theory in Organic Chemistry-S.K. Ghosh I. Organic Chemistry, Vol. I – Finar
II.	A guidebook to mechanics in organic chemistry- Peter Sykes
III.	Advanced Organic Chemistry-Jerry march
IV.	An advanced Course in Practical Chemistry: Ghoshal, Mahapatra, Nad

Practical	
Quantitative Estimation of organic compounds	
1.	Estimation of glucose solution by Fehling's solution
2.	Estimation of sucrose solution by Fehling's solution
3.	Estimation of phenol/aniline by bromination
4.	Estimation of formaldehyde
5.	Estimation of acetone
6.	Estimation of Vitamin-C
7.	Estimation of amino acids
8.	Estimation of calcium in milk

Reference	
I.	Vogel's Textbook of Practical Organic Chemistry: A. I. Vogel, B. S. Furniss, P. W. Smith
II.	AA Textbook On Chemistry Practical: Bidhan Chandra Ray, Satyanarayan Das

Course Outcome: By the end of the course, students should be able to recognize, classify, explain, and apply fundamental organic reactions. They will be able to apply concepts associated with these general reaction types to product prediction, synthesis design, and reaction mechanism. The students will be able to draw logical and detailed mechanisms for various fundamental reactions.

8.3.4 Molecules of Life
Course Code: CHMUGMDC2302
Credit: 3

Course type: Multi-disciplinary	**Course Distribution: Theory: 3 Credit**	**Theory: 45 Lectures (3h/wk)**

Course Objectives: The module is expected to exposure the students of non-allied disciplines with the nature of various biomolecules present in living cells. The learners will understand the properties of carbohydrates, proteins, lipids, cholesterol, DNA, RNA and their importance in biological systems.

Carbohydrates (Lectures: 15)

Classification of carbohydrates, reducing and non-reducing sugars, biological functions, general properties and reactions of glucose and fructose, their open chain structure, epimers, mutarotation and

anomers, reactions of monosaccharides, cyclic structure of glucose Cyclic structure of fructose. Structure of disaccharides (sucrose, maltose, lactose) and polysaccharides (starch and cellulose) excluding their structure elucidation.

Amino Acids, Peptides and Proteins (Lectures: 10)

Classification of amino acids and biological uses of amino Acids, peptides and proteins. Zwitter ion structure, isoelectric point and correlation to acidity and basicity of amino acids. Overview of primary, secondary, tertiary and quaternary structure of proteins, denaturation of proteins.

Nucleic Acids (Lectures: 10)

Components of Nucleic acids: Adenine, guanine, thymine ,cytosine and uracil (structure only), other components of nucleic acids, nucleosides and nucleotides (nomenclature), structure of polynucleotides; structure of DNA (Watson-Crick model) and RNA(types of RNA),difference between DNA and RNA, genetic code, biological roles of DNA and RNA: replication, transcription and translation.

Lipids (Lectures: 5)

Introduction to lipids, classification. Oils and fats: Common fatty acids present in oils and fats, Omega-3& 6 fatty acids, trans fats, hydrogenation, hydrolysis, acid value, saponification value, iodine number.

Enzymes (Lectures: 5)

Classification of enzymes and their uses. Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance.

References

1. Finar, I. L. Organic Chemistry (Volume 1 & 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Morrison, R. N.; Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Berg, J. M.; Tymoczko, J. L.; Stryer, L. (2002), Biochemistry, W. H. Freeman.

Course Outcome: The learners will understand the properties of carbohydrates, proteins, lipids, cholesterol, enzymes, DNA, RNA etc. and their importance in biological systems.

8.3.5 Application of Computer in Chemistry
Course Code: CHMUGSEC2301
Credit: 3

Course type: SEC	Course Distribution: Theory: 3 Credit	Theory: 45 Lectures (3h/wk)

Course Objectives: This course introduces the application of computer methods in chemistry. The course will be helpful to learn simple programming and use of softwares needed for research purpose. By this course student will learn the use of computer and different software for different types of analyses.

Unit-I: Computer programming

The languages used for scientific programming, FORTRAN language, preparation of flow chart, writing of simple programming.

Unit-II: use of different softwares

Chem draw, excel, mirosoft origin, mercury, Mnova, Gaussian etc.

Unit-II: Statistical analysis

Data collection procedure, analysis of data, determination of different types of statistical parameters, regression analysis, use of software for different statitistical analysis.

References

1. Computers In Chemistry; K.V. Raman; Tata McGraw Hill.
2. Computer Applications In Chemistry; Kishor Arora; Anmol Publications Pvt. Ltd. (2004).

Course Outcome: The course is designed to train chemistry students in computer and several softwares required nowadays to complete the assignments, to design presentations and to make chemical drawings. Students will be trained in the applications of above mentioned software.

8.4 Semester-IV

8.4.1 Course Name: Physical Chemistry-III
Topic: Chemical Kinetics, Adsorption and Catalysis
Course Code: CHMUGMCC2407/ CHMUGMIN2404
Credit: 4

Course type: Major/Core Minor-4	**Course Distribution: Theory: 3 Credit Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk) Practical: 30 Class Hours (2h/wk)**

Course Objectives: In this course, chemistry students will study chemical kinetics and adsorption/catalysis. They'll explore rate laws, reaction orders, and collision theory in chemical kinetics, including concepts like activation energy. The section on adsorption and catalysis will explore practical applications, catalyst traits, and enzyme catalysis, aiming to give students a strong understanding of these important chemical processes and how they apply in real-world situations.

Theory

Chemical kinetics (20 Lectures)

Chemical kinetics and its scope, Rate of a reaction, Average rate of reaction, Instantaneous rate of reaction, Rate laws, Order of a reaction, Zero order reaction, Molecularity, Molecularity of a elementary reaction, Molecularity a complex reaction, Molecularity vs order of a reaction, Pseudo order reactions, Mathematical characteristics of simple chemical reactions – zero order, first order, second order, third order, Rate constant, Half life of a reaction, Determination of order of a reaction by: integrated rate equations, graphical method, half-life method, differential method, Concentration and temperature dependence of rates Collision theory of reaction rates, Arrhenius equation, concept of activation energy. Simultaneous reactions: consecutive reaction, parallel reactions, opposing reactions, Limitation of collision theory, transition state theory, concept of activation energy, Lindeman's theory of unimolecular reactions.

Adsorption and catalysis (25 Lectures)

Adsorption phenomenon, Mechanism of adsorption, Types of adsorptions, Adsorption of gases by solids, Adsorption isotherm: Freundlich adsorption isotherm, Langmuir adsorption isotherm, Derivation of Langmuir Adsorption Isotherm, Adsorption of solutes from solutions, Application of adsorption, Ion exchange adsorption. Catalysts, Classification of catalysis: homogenous and heterogenous, Characetristics of catalytic reaction, Promoters, Catalytic poisoning, Autocatalysis, Negative catalysis, Activation energy and catalysis, Intermediate compound formation theory, The adsorption theory, Hydrogenation of ethyne in presence of nickel, Active centres,

Acid-base catalysis, Enzyne catalysis, Enzyme catalysis, Mechanism of enzyme catalysis, Michaelis-menten equation, Uses of catalysts in industry.

References

I.	Peter Atkins & Julio De Paula, Physical Chemistry 9th Ed., Oxford University Press (2010).
II.	Castellan, G. W. Physical Chemistry, 4th Ed., Narosa (2004).
III.	McQuarrie, D. A. & Simon, J. D., Molecular Thermodynamics, Viva Books Pvt. Ltd.: New Delhi (2004). Engel, T. & Reid, P. Physical Chemistry 3rd Ed., Prentice-Hall (2012).
IV.	Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. Commonly Asked Questions in Thermodynamics. CRC Press: NY (2011).

V.	Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).
Practical	
1.	Study of kinetics of acid hydrolysis of ester
2.	Determination of rate constant of inversion of sucrose by polarimeter
3.	Kinetic study of decomposition of hydrogen peroxide in presence of I-ion
4.	Adsorption of acetic acid on charcoal
5.	Study of reaction between $K_2S_2O_8$ and KI
6.	Studies on kinetics of acid catalyzed hydrolysis of methyl acetate/ ethyl acetate: (i) Determination of rate constants (ii) Determination of catalytic co-efficient
References	
I.	Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson
II.	Viswanathan, B., Raghavan, P.S. *Practical Physical Chemistry* Viva Books (2009)
III.	Physical Chemistry Practical: Saroj Kr Maity, Naba Kr Ghosh
IV.	An Advanced Course in Practical Chemistry: Ghoshal, Mahapatra, Nad
V.	Levine, I. N. Physical Chemistry 6th Ed., Tata McGraw-Hill (2011).
VI.	Palit, S.R., De, S. K. *Practical Physical Chemistry* Science Book Agency
VII.	Levitt, B. P. edited *Findlay's Practical Physical Chemistry* Longman Group Ltd.

Course Outcome:
In this course, students will learn about how reactions happen quickly or slowly and how substances adsorbed onto the surfaces and help reactions in catalyzing chemical reaction. They will understand how to apply these ideas in real situations, making them ready for practical work in chemistry.

8.4.2 Course Name: Inorganic Chemistry-III
Topic: Chemical Bonding-II & Redox Reactions
Course Code: CHMUGMCC2408
Credit: 4

Course type: Major/Core	**Course Distribution: Theory: 3 Credit Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk) Practical: 30 Class Hours (2h/wk)**

Course Objectives: The course is aimed at introducing students with different type of chemical bonding along with their theoretical perspective. This will help to make students understand that Molecular orbital theory and valence bond theory are the foundational theories of quantum chemistry. The lessons will familiarize students with redox reactions and idea of redox potential/formal potential in determining the product of a reaction.

Theory

Chemical Bonding-II (25 Lectures)
Ionic bonding: Size effects, radius ratio rules and their limitations. Packing of ions in crystals, lattice energy, Born-lande equation, Born-Haber cycle and its applications. Salvation energy, polarizing power and polarizibility, ionic potential, Fazan's rules. Defects in solids.
Molecular orbital concept of bonding: sigma and pi-bonds, multiple bonding, MO diagrams of H_2, F_2, O_2, C_2, B_2, CO, NO, CN^-, HF and H_2O; bond orders, bond lengths, Walsh Diagram. Hydrogen bonding and its effects. *Metallic bonding:* qualitative idea of band theory, conducting, semi conducting and insulating properties with examples.
Coordinate bonding: Lewis acid-base adducts, double salts and complex salts, Werner theory of coordination compounds. Ambidentate and polydentate ligands, chelate complexes. IUPAC nomenclature of coordination compounds. Coordination numbers, constitutional isomerism. Stereoisomerism in square planar and octahedral complexes.
Redox Reactions (20 Lectures)

Solubility product principle, common ion effect and their applications to the precipitation and separation of common metallic ions as hydroxides, sulfides, phosphates, carbonates, sulfates and halides. Ion-electron method of balancing equation of redox reaction. Elementary idea on standard redox potentials with sign conventions, Nernst equation (without derivation). Influence of complex formation, precipitation and change of pH on redox potentials; formal potential. Feasibility of a redox titration, redox potential at the equivalence point, redox indicators. Redox potential diagram (Latimer and Frost diagrams) of common elements and their applications. Disproportionation and comproportionation reactions (typical examples).

References

I.	J. D. Lee: A New Concise Inorganic Chemistry, E.L.B.S
II.	F.A. Cotton & G. Wilkinson: *Basic Inorganic Chemistry,* John Wiley
III.	D. F. Shriver and P. W. Atkins: *Inorganic Chemistry,* Oxford University Press.

Practical

Redox titration Estimation

Estimation of Mohr salt solution by permanganometry and dichromometry, Fe^{+2}/ Fe^{3+} by permanganometry and dichromometry, iron-copper mixture, estimation of the strength of hydrogen peroxide, estimation of Cu in brass, estimation of available chorine in bleaching powder.

Reference

I.	Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.
II.	An Advanced Course In Practical Chemistry, Nad, Mahapatra & Ghosal

Course Outcome: Students would be able to understand different types of chemical bonding along with their theoretical perspective. They would acquire knowledge about molecular orbital theory and be able to sketch molecular orbital diagram/picture for different diatomic and triatomic molecules. The learners would be able to predict different redox reactions using redox potential/formal potential.

8.4.3 Course Name: Organic Chemistry-III
Topic: Important Compounds & Rearrangements
Course Code: CHMUGMCC2409
Credit: 4

Course type: Major/Core	**Course Distribution: Theory: 3 Credit Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk) Practical: 30 Class Hours (2h/wk)**

Course Objectives: This course is meant for the students to understand the methods for preparation of nitrogen containing compounds, polynuclear hydrocarbons, heterocyclic compounds and organometallic compounds. This module also includes the reactivity of these types of compounds. The use of different important organic reagents is expected to help the students to carry out different synthetic transformations utilizing these types of compound. Students will learn about different rearrangement reactions in organic chemistry.

Theory

Nitrogen compounds (10 Lectures)

Nitrogen compounds: amines (aliphatic & aromatic) [preparation, separation and identification of primary, secondary and tertiary amines], E. Clarke reaction, enamines, Mannich reaction, diazomethane, diazoacetic ester, nitrile and isonitrile.

Carbocycles and Heterocycles (15 Lectures)

Polynuclear hydrocarbons: syntheses and reactions of naphthalene, anthracene and phenanthrene.

Heterocyclic compounds: reactivity, orientation and important reactions of furan, pyrrole, thiophene,

pyridine, indole, synthesis (including retrosynthetic approach) pyrrole: Knorr pyrrole synthesis and Hantzsch synthesis. Hantzsch pyridine synthesis. Indole: Fischer, Madelung and Reissert synthesis, Skraup quinoline and Bischler-Napieralski Synthesis of isoquinoline.

General Reagents (5 Lectures)

DCC I, 1,3-dithianes, Polyphosphoric acid, diazomethane, ethyldiazoacetate, Boron Trifluoride, Trifluoro acetic acid, cuprous chloride, N-bromosuccinamide, Mont- K-10, and KSF (clays). Phase Transfer catalysts.

Organometallics: Preparation of Grignard reagent and organo lithium. Reactions: addition of Grignard and organo lithium to carbonyl compounds, substitution on –COX, conjugate addition by Gilman cuprates, Reformatsky reaction.

Rearrangements (15 Lectures)

1,2-shift: Rearrangement to electron-deficient carbon (Wagner-Meerwein rearrangement, pinacol rearrangement, dienone-phenol; Wolff rearrangement in Arndt- Eistert synthesis, benzil-benzilic acid rearrangement.

Electron-deficient nitrogen (Beckmann rearrangement, Schmidt rearrangement, Hofmann rearrangement, Lössen rearrangement, Curtius rearrangement).

Electron-deficient oxygen (Baeyer-Villiger oxidation, hydroperoxide rearrangement, cumene hydroperoxide-phenol rearrangement), Dakin reaction.

Aromatic rearrangements [migration from oxygen to ring carbon (Fries rearrangement, Claisen rearrangement), migration from nitrogen to ring carbon (Hofmann-Martius rearrangement**,** Fischer-Hepp rearrangement, *N*-azo to *C*-azo rearrangement, Bamberger rearrangement, Orton rearrangement, benzidine rearrangement.

References	
I.	Organic Chemistry – Marc Loudon
II.	Organic Chemistry – Bruice
III.	Organic Chemistry, Vol. I and II – Finar
IV.	Organic Chemistry – Solomons
V.	Organic Chemistry- Clayden, Greeves, Warren
VI.	Organic Chemistry–Morrison, Boyd & Bhattacharjee
VII.	Heterocyclic Chemistry, T.L. Gilchrist
VIII.	Heterocyclic Chemistry, J.A. Joule, K. Mills and G.F. Smith
IX.	Mechanism & Theory in Organic Chemistry–S.K. Ghosh
X.	Organic Chemistry, Vol. I – Finar
XI.	A guidebook to mechanics in organic chemistry– Peter Sykes
XII.	Advanced Organic Chemistry–Jerry march
Practical	
Qualitative Analysis of liquid compounds	
1.	Qualitative analysis of liquid compounds. Determination of boiling point.
2.	Preparation of derivatives
Quantitative Analysis	
1.	Estimation of acid value (analysis of an oil)
2.	Estimation of methoxy group by Zeisel's method
3.	Estimation of nitrogen by kjeldahl's method

Reference books

1. Textbook of Practical Organic Chemistry, A.I. Vogel, Prentice Hall, 5th edition.
2. An advanced Course in Practical Chemistry: Ghoshal, Mahapatra, Nad

Course Outcome: Students would be able to understand the nomenclature, classification, properties, preparations and applications of various types of organic compounds, included in this course. The students will be able to fully comprehend the mechanism and application of different reagents. They

will be able to grasp the concept of various kinds of rearrangement reactions.

8.5 Semester-V

8.5.1 Course Name: Inorganic Chemistry-IV
Topic: Coordination Chemistry & Organometallic Compounds
Course Code: CHMUGMCC3510/ CHMUGMIN3505
Credit: 4

Course type: Major/Core; Minor-5	**Course Distribution: Theory: 3 Credit Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk) Practical: 30 Class Hours (2h/wk)**

Course Objectives: This subject is planned to introduce students with Coordination Chemistry and its different theoretical aspects such as VBT, CFT etc. The topics are expected to assist students to explore magnetic and spectral properties of compounds of d-block and f-block elements. Students will be given laboratory training for quantitative estimation of Ca^{+2}, Mg^{+2} etc. in mixture as well as in their individual solutions using complexometric titration. The students are expected to gain laboratory training for quantitative estimation using colorimetric method.

Theory

Coordination Chemistry (15 Lectures)
Structure and bonding: VB description and its limitations. Crystal Field Theory: splitting of d^n configurations in octahedral, square planar and tetrahedral fields, crystal field stabilization energy in weak and strong fields; pairing energy. Jahn- Teller distortion. Metal-ligand bonding (MO concept). Magnetism and Colour: Orbital and spin magnetic moments, spin only moments of d^n ions; quenching of magnetic moment: super exchange and antiferromagnetic interactions; d-d transitions; L-S coupling; qualitative Orgel diagrams for $3d^1$-$3d^9$ ions and their spectroscopic ground states; selection rules for electronic spectral transitions; spectrochemical series of ligands; charge transfer spectra. Isomerism, reactivity and stability: *cis*- and *trans*- isomers, Labile and inert complexes, substitution reaction on square planer complexes, trans effect, Stability constants of coordination compounds.

Chemistry of *d*- and *f*- block elements (10 Lectures)
d-block elements: electronic configuration, elemental forms, metallic nature, atomization energy, oxidation states, redox properties, coordination chemistry, spectral and magnetic properties.

f-block elements: electronic configuration, ionization energies, oxidation states, variation in atomic and ionic (3+) radii, magnetic and spectral properties of lanthanides, comparison between lanthanide and actinides, separation of lanthanides (by ion-exchange method).

Organometallic Compounds (15 Lectures)
Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. Acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation and structure, evidences of synergic effect and comparison of synergic effect with that in carbonyls.
Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler – Natta Catalyst). Species present in ether solution of Grignard reagent and their structures, Schlenk equilibrium. Ferrocene: Preparation and reactions (acetylation,

alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

Study of the following industrial processes and their mechanism: (5 Lectures)

1. Alkene hydrogenation (Wilkinsons Catalyst)
2. Hydroformylation (Co salts)
3. Wacker Process
4. Synthetic gasoline (Fischer Tropsch reaction)
5. Synthesis gas by metal carbonyl complexes.

References	
I.	Cotton, F.A. G.; Wilkinson & Gaus, P.L. *Basic Inorganic Chemistry 3rd Ed.;*Wiley India
II.	Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles of Structure and React 4th Ed.*, Harper Collins 1993, Pearson, 2006.
III.	Sharpe, A.G. *Inorganic Chemistry*, 4th Indian Reprint (Pearson Education) 2005
IV.	Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry3rd Ed.*, John Wiley and Sons, NY, 1994. Greenwood, N.N. & Earnshaw Chemistry of the Elements, Elsevier 2nd Ed, 1997 (Ziegler Natta Catalyst and Equilibria in Grig Solution).
V.	Lee, J.D. *Concise Inorganic Chemistry 5th Ed.*, John Wiley and sons 2008.
VI.	Powell, P. *Principles of Organometallic Chemistry*, Chapman and Hall, 1988.
VII.	Shriver, D.D. & P. Atkins, *Inorganic Chemistry 2nd Ed.*, Oxford University Press, 1994.

Practical

Complexometric titration

Determination of Hardness of water, Determination of Calcium and Magnesium in mixture, Ca in chalk, iron calcium mixture, Zinc-Magnesium mixture.

Colorimetric estimation

Colorimetric estimation of Mn in commercial H_3PO_4, colorimetric estimation of Fe in thiocyanate complex.

Reference

I. Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.

Course Outcome: Students would be able to understand the structure and bonding of transition metal complexes. They would be able to predict the magnetic and spectral properties of compounds of d-block and f-block elements. They would acquire knowledge and techniques of quantitative estimation using complexometric and colorimetric method.

8.5.2 Course Name: Organic Chemistry-IV
Topic: Synthetic Strategies & Cyclic Stereochemistry
Course Code: CHMUGMCC3511
Credit: 4

Course type: Major/Core	**Course Distribution: Theory: 3 Credit Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk) Practical: 30 Class Hours (2h/wk)**

Course Objectives: The course is anticipated to introduce students with the concept of carbanion chemistry. Retrosynthetic analysis and synthesis strategies are expected to assist students to design efficient multi-step syntheses of target molecules. Students are expected to gain knowledge about cyclic stereochemistry and asymmetric synthesis. After studying this module, students shall be able to recognize the stereoselective and stereospecific reactions.

Theory

Carbanion chemistry (8 Lectures)

Carbanions: formation of enols and enolates (metal), alkylation of enolates, reactions of enolates with carbonyls (aldehydes, ketones and esters), conjugate addition of enolates.

Synthetic strategies (10 Lectures)

Retrosynthetic analysis: disconnections, synthons, donor and acceptor synthons, functional group interconversion, C-C disconnections and synthesis [one group and two group (1,2 to 1,6-dioxygenated], reconnection (1,6-di carbonyl), natural reactivity and umpolung.

Protecting group chemistry: protection-deprotection strategy [alcohol, amine, carbonyl, acid]

Strategy of ring synthesis (7 Lectures)

Thermodynamic factor, synthesis through enolate anion chemistry and carbonyl condensation reactions (including acetoaceticester & malonic ester synthesis), synthesis through rearrangement (including pinacol, Favorski), synthesis of large rings, high dilution technique and acyloin reaction, Stobbe condensation, Pauson Khand reaction, Bergman cyclization, Nazarov cyclization.

Asymmetric Synthesis (5 Lectures)

Stereoselective and stereospecific reactions: Definition and examples. Diastereoselectivity and enantioselectivity, diastereoselective addition of nucleophiles to C=O, Cram's rule, Felkin-Anh model.

Cyclic stereochemistry (15 Lectures)

Baeyer strain theory. Conformational analysis: small ring, cyclopentane, cyclohexane, mono and disubstituted cyclohexane, symmetry properties and optical activity.

Conformation & reactivity in cyclohexane system: elimination (E2), rearrangement, nucleophilic substitution (S_N1, S_N2, NGP), oxidation of cyclohexanol, esterification, saponification, lactonisation.

References	
I.	Organic Chemistry-Wade
II.	Organic Chemistry- Marc Loudon
III.	Organic Chemistry- Bruice
IV.	Organic Chemistry, Vol. I and II – Finar
V.	Organic Chemistry – Solomons
VI.	Organic Chemistry- Clayden, Greeves, Warren
VII.	Organic Chemistry- Morrison, Boyd & Bhattacharjee
VIII.	Basic stereochemistry of organic molecules- Sengupta
IX.	Stereochemistry of organic compounds – ELIEL
X.	Stereochemistry of Organic Compounds- Principles and Applications- D. Nasipuri
XI.	Organic Synthesis: The Disconnection Approach- Warren
XII.	Modern Methods of Organic Synthesis- W. Carruthers

Practical	
Preparation of organic compounds involving single/two step process (minimum six)	
1.	*p*-Nitroacetanilide from acetanilide
2.	*p*-Bromoaniline from acetanilide
3.	Benzil from benzoin
4.	Benzilic acid from benzil
5.	Iodoform
6	Phthalimide from phthalic anhydride
7	Benzoic acid from benzamide
8	Dibenzylideneacetone
9	Benzanilide from aniline
10	Methyl Orange
11	1,1'-bi-2-naphthol

References	
I.	Vogel's Textbook of Practical Organic Chemistry: A. I. Vogel, B. S. Furniss, P. W. Smith
II.	An advanced Course in Practical Chemistry: Ghoshal, Mahapatra, Nad
III.	A Textbook On Chemistry Practical: Bidhan Chandra Ray, Satyanarayan Das
IV.	B. Sc. Honours Practical Chemistry: Sachin dutta

Course Outcome: Students will be able to critically plan and evaluate all the aspects of successful synthesis of versatile organic compounds. They will be acquainted with the concept and application of stereoselective and stereospecific reactions in asymmetric synthesis.

8.5.3 Course Name: Physical Chemistry-IV
Topic: Colligative Properties, Ionic Equilibrium and Electrochemistry
Course Code: CHMUGMCC3512
Credit: 4

Course type: Major/Core	Course Distribution: Theory: 3 Credit Practical: 1 Credit	Theory: 45 Lectures (3h/wk) Practical: 30 Class Hours (2h/wk)

Course Objectives:
This course helps undergraduate students understand colligative properties, solubility, and electrochemistry. Students will learn about concentration, solubility, and electrolysis. The goal is to apply these concepts to real situations and gain practical skills in analyzing chemical systems.

Theory

Colligative properties (10 Lectures)
Ways of expressing concentration, Solutions of gases in gases, Henry's law, Solutions of liquids in liquids, Solubility of completely miscible liquids, Solubility of partially miscible liquids, Phenol-water system, Trimethylamine-water system, Azeootropes, Theory of fractional distillation, Steam distillation, Solution of solids in liquid, Determination of solubility, Solubility of solids in solids.

Ionic equilibria-solubility product (10 Lectures)
Ostwald's dilution law, Experimetal verification of Ostwald's law, Limitation of Ostwald's law, Theory of strong electrolytes, Ghosh's formula, Debye-Huckel theory, Degree of dissociation, The common ion effect, Factors influencing the degree of dissociation, solubility equilibria and the solubility product, application of solubility product principle in qualitative analysis, selective precipitation, separation of the basic ions into groups.

Electrochemistry (15 Lectures)
Mechanism of electrolysis, Faraday's laws of electrolysis, specific conductance, equivalent conductance, strong electrolytes, weak electrolytes, determination of cell constant, Arhenius theory of ionization, transport number, determination of transport number, Kohlrausch's law, Conductometric titrations, Electrochemical cells, EMF, measurement of EMF, Nerst equation, electrodes, potentiometric titration, acid base titration, redox titration, overvoltage, Arhenius theory of ioniozation, Migration of ions, transport number, determination of transport number, Hittorf's method, Moving boundary method, Kohlrausch's law, application of Kohlrausch's law, conductometric titrations, difference between conductometric and volumetric titration, half reaction.

Electrochemical cells (10 Lectures)
Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell.
Nernst equation and its importance. Types of electrodes. Standard electrode potential.
Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. Ph determination using hydrogen electrode and quinhydrone electrode.

Reference books

I.	Physical Chemistry, G.M. Barrow, Int. Students Edition, McGraw Hill
II.	Physical Chemistry, R.A. Alberty, Wiley Eastern Ltd.
III.	Physical Chemistry, P.W. Atkins, Oxford University Press.
IV.	Principles of Physical Chemistry, B.R. Puri & L.R. Sharma, Shoban Lal Nagin Chand & Co.

Practical	
1.	To determine the equivalent conductance at infinite dilution of a strong electrolyte (KCl)
2.	To determine the equivalent conductance of weak electrolyte at infinite dilution by Kohlrausch's law of independent migration of ions and verification of Ostwald's dilution law.
3.	To determine the ionization constant of a weak electrolyte (say CH_3COOH).
4.	To determine the solubility product of a sparingly soluble salt by conductance measurement.
5.	Conduct metric titration of oxalic acid by a standard NaOH solution.
Reference books	
I.	Vogel's Textbook of Practical Organic Chemistry: A. I. Vogel, B. S. Furniss, P. W. Smith
II.	An advanced Course in Practical Chemistry: Ghoshal, Mahapatra, Nad
III.	A Textbook On Chemistry Practical: Bidhan Chandra Ray, Satyanarayan Das
IV.	B. Sc. Honours Practical Chemistry: Sachin Dutta

Course Outcome: Students will understand colligative properties, ionic equilibria, and electrochemistry. They'll use this knowledge to predict how solutions behave, selectively separate ions, and perform practical analyses like titrations and pH determinations. The course aims to provide a versatile skill and preparing students for advanced studies or careers in chemistry.

8.5.5 Course Name: Summer Internship
Course Code: CHMUGSIP3501
Credit: 4

Course Objectives: Summer internship is an added prospect offered to the students to obtain experience in research or industry. Students may choose to pursue summer internship in one of the research institutes, CSIR laboratories, Universities or manufacturing industries. Students shall submit a work done report endorsed by the mentor/institute or industry authority. The internship program may include community engagement and services.

Course Outcome: Students are expected to get exposure to diversified work culture and domain knowledge by going to other institutes or industry. After successful completion of this course, the student will be able to demonstrate lifelong learning processes through critical reflection of internship experiences.

8.6 Semester-VI

8.6.1 Course Name: Organic Chemistry-V
Topic: Spectroscopy & Biomolecules
Course Code: CHMUGMCC3613/ CHMUGMIN3606
Credit: 4

Course type: Major/Core; Minor-6	**Course Distribution: Theory: 3 Credit Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk) Practical: 30 Class Hours (2h/wk)**

Course Objectives: The course is aimed at:

a) Familiarizing students with the basic concept of different spectroscopic techniques such as UV, IR and ^{1}H-NMR;
b) Enabling students to identify organic compounds from spectral data;
c) Introducing students with the chemistry of different bio-molecules such as carbohydrates, amino acids, peptides, proteins and nucleic acids.

Theory

UV Spectra (5 Lectures)

Electronic excitations, origin of UV band structure, principle of absorption spectroscopy, instrumentation, presentation of spectra, solvent effect, chromophore, steric effect, effect of conjugation, Woodward-Fieser rules, red shift (bathochromic shift), blue shift (hypsochromic shift), hyperchromic effect, hypochromic effect (typical examples).

IR Spectra (5 Lectures)

Infrared absorption process, uses of IR spectrum, modes of stretching and bending, application of Hooke's law, bond properties and absorption trends, characteristic stretching frequencies of O-H, N-H, C-H, C-D, C=C, C=N, C=O functions; factors effecting stretching frequencies (H-bonding, mass effect, electronic factors, bond multiplicity, ring size), Infrared Spectrometer, preparation of samples, analysis of IR spectra.

^{1}HMR Spectra (15 Lectures)

Nuclear spin, nuclear magnetic moments, NMR active nuclei, principle of proton magnetic resonance, equivalent and non-equivalent protons, chemical shift (δ), shielding/deshielding of protons, up-field and down-field shifts. NMR peak area (integration), diamagnetic anisotropy, relative peak positions of different kinds of protons (alkyl halides, olefins, alkynes, aldehyde H), substituted benzenes (toluene, anisole, nitrobenzene, halobenzene, dinitrobenzenes, chloronitrobenzene), first order coupling (splitting of the signals: ordinary ethanol, bromoehane, dibromoehanes), spin-spin splitting, (n+1) rule, Pascal's triangle, coupling constant.

Carbohydrate chemistry (10 Lectures)

Monosaccharides: Aldoses upto 6 carbons, structure of D-glucose & D-fructose (configuration & conformation), anomeric effect, mutarotation. Reactions: osazone formation, oxidation, reduction, reaction with acid and base, stepping–up (Kiliani-Fischer method) and stepping–down (Ruff's & Wohl's method) of aldoses.

Disaccharides: Structure of sucrose, maltose.

Amino acids, peptides, proteins and nucleic acids (10 Lectures)

Amino acids: Synthesis: (Strecker, Gabriel, acetamido malonic ester, azlactone); isoelectric point, ninhydrin reaction.

Peptides: peptide linkage, syntheses of peptides using *N*-protection &*C*-protection, solid phase synthesis; peptide sequence: C–terminal and *N*–terminal unit determination (Edmann, Sanger & dansyl chloride).

Nucleic acids: pyrimidine & purine bases (only structure & nomenclature), nucleosides and nucleotides, DNA: Watson-Crick model, complimentary base –pairing in DNA, Structure of RNA.

References	
I.	Spectrometric identification of organic compounds- Silverstein
II.	Organic spectroscopy-Kemp
III.	Introduction To Spectroscopy- Pavia, lampman, Kriz, Vyvyan
IV.	Organic Chemistry, Vol. I and II - Finar
V.	Organic Chemistry- Marc Loudon
VI.	Organic Chemistry-Morrison, Boyd & Bhattacharjee
Practical	
1.	Assignment of labeled peaks in the IR spectrum of the same compound. (C-H, O-H, NH, C=C, C=O, NO_2 stretching frequencies) At least three compounds from among the list given below are to be chosen: (i) *p*-Bromoacetanilide (ii) *p*-Methyl-*α*-bromoacetophenone (iii) Vanillin (iv) Cinnamic acid (v) *p*-Aminobenzoic acid (vi) *o*-Hydroxybenzaldehyde (vii) *p*-Nitroaniline
2.	Separation techniques by chromatography: (a) Separation of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the R_f values. (b) Separation of mixture of amino acids by paper chromatography and identify them on the basis of their R_f values.
3.	Application of green chemistry in organic synthesis: (a) Acetylation of primary amine (preparation of acetanilide). (b) Preparation of benzilic acid in solid state under solvent-free condition. (c) Green approach for nitration of salicylic acid. (d) Transesterification reaction (synthesis of biodiesel). (e) Three component coupling (synthesis of dihydropyrimidinone). (f) Solvent free, microwave assisted one pot synthesis of phthalocyanine complex of copper (II).
References	
I.	Spectrometric identification of organic compounds- Silverstein
II.	Organic spectroscopy-Kemp
III.	Introduction To Spectroscopy- Pavia, lampman, Kriz, Vyvyan
IV.	Mikes, O. & Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
V.	Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York, 1974
VI.	Lancaster, M. Green Chemistry: An Introductory Text RSC Publishing, 2nd Edition, 2010.
VII.	Pavia, D.L., Lampman, G.M., Kriz, G.S. & Engel, R.G. Introduction to Organic Laboratory Techniques: A Microscale and Macro Scale Approach, W.B.Saunders, 1995.

Course Outcome: Students will be able to predict the spectral behavior of different organic molecules. They would be able to understand the structure, synthesis and properties of important biomolecules such as carbohydrates, amino acids, peptides and nucleic acids. The green chemistry based practical module will help students to perform synthesis of organic compounds using environment friendly methodologies.

8.6.2 Course Name: Physical Chemistry-V
Topic: Quantum Chemistry and Spectroscopy
Course Code: CHMUGMCC3614
Credit: 4

Course type: Major/Core	**Course Distribution:** **Theory: 3 Credit** **Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk)** **Practical: 30 Class Hours (2h/wk)**

Course Objectives: This course teaches undergrads about quantum chemistry, aiming to help them understand quantum theory and its applications. In Quantum Chemistry-I, they'll learn about the basics, including the Schrödinger wave equation. Quantum Chemistry-II focuses on using quantum mechanics for things like simple harmonic oscillators and molecular spectroscopy. The goals include providing students with knowledge in quantum principles, interpreting molecular spectra, and applying theoretical concepts practically in chemistry.

Theory

Quantum Chemistry-I

Origin of quantum theory, Blackbody radiation, Planck's radiation law, photoelectric effect, Compton effect, de Broglie's hypothesis, Heisenberg's uncertainty principle. Postulates of quantum mechanics. Concept of operator, Schrodinger wave equation and its application to a particle in a box, energy levels, wave functions and probability densities.

Quantum Chemistry-II

Simple Harmonic Oscillator: setting up of the Schrodinger stationary equation, energy expression (without derivation), expression of wave function for n = 0 and n = 1 (without derivation) and their characteristic featuresStationary Schrodinger equation for the H-atom in polar coordinates, separation of radial and angular (θ, φ) parts. Solution of φ-part and emergence of quantum number 'm'; energy expression (without derivation), degeneracy. Hydrogenic wave functions up to n = 2 (expression only); real wave function. Concept of orbitals and shapes of s and p orbitals.

Spectroscopy

Introduction: electromagnetic radiation, regions of the spectrum, basic features of different spectrometers, statement of the Born-Oppenheimer approximation, degrees of freedom.

Rotational Spectrum

Diatomic molecules, Energy of a rigid rotor (semi-classical principles), selection rules, spectral intesity, distribution using population distribution (Maxwell-Boltzmann distribution), determination of bond length, qualitative description of non-rigid rotor, isotope effect.

Vibrational Spectrum

Infrared spectrum: Energy levels of simple harmonic oscillator, selection rules, pure vibrational spectrum, intensity, determination of force constant and qualitative relation of force constant and bond energies, effect of anharmonic motion and isotope on the spectrum, idea of vibrational frequencies of different funcitonal groups.

Raman Spectrum

Concept of polarizability, pure rotational and pure vibrational Raman spectra of diatomic molecules, selection rules.

Electronic Spectrum

Concept of potential energy curves for bonding and antibonding molecular orbitals, qualitative description of selection rules and Franck-Condon principle.

Reference books	
I.	Physical Chemistry, G.M. Barrow, Int. Students Edition, McGraw Hill.
II.	Physical Chemistry, R.A. Alberty, Wiley Eastern Ltd.
III.	Physical Chemistry, P.W. Atkins, Oxford University Press.
IV.	Physical Chemistry, Maron & Lando.
V.	Quantum Chemistry, R.K. Prasad, New Age.
VI.	Physical Chemistry, Vol. 04, K.L. Kapoor, Macmillan
VII.	Fundamentals of Molecular Spectroscopy, Colin N Banwell, McGraw Hill.
Practical	
1.	Elements of FORTRAN Language.
2.	FORTRAN Keywords and commands.
3.	Logical and Relational Operators, iteration, Array variables.
4.	Matrix addition and multiplication.

5.	Function and Subroutine.
	OR
1	Determination of rate constant of decomposition of H_2O_2 by acidified KI solution using clock reactions.
2	Determination of strengths of hydrocholoric acid and acetic acid in their mixture pH metrically.
3	Determination of concentration of HCl conductometrically using standard NaOH solution.
4	To study the phase diagram of a binary system (Phenol + water) and the effect of impurities (e.g. NaCl).

Reference

1. A. I. Vogel, B. S. Furniss, P. W. Smith, Vogel's Textbook of Practical Organic Chemistry
2. G. Svehla, Vogel's Qualitative Inorganic Analysis, 7th Edn.
3. A. I. Vogel, J.Mendham, Vogel's Textbook of Quantitative Chemical Analysis, Prentice Hall, 2000.
4. Ghoshal, Mahapatra, Nad, An advanced Course in Practical Chemistry, New Central Book Agency (P) Ltd.

Course Outcome: After completing this course, students will understand quantum principles, including the basics of quantum theory and using Schrödinger's wave equation. They'll gain skills to analyze molecular spectra, interpret data, and apply quantum mechanics to real-world situations, enhancing their problem-solving abilities. This course provides a theoretical foundation in quantum chemistry, preparing students for advanced studies or practical applications in understanding of molecular structures.

8.6.3 Course Name: Analytical Chemistry-I
Topic: Concept, Analysis of samples; Chromatography
Course Code: CHMUGMCC3615
Credit: 4

Course type: Major/Core	**Course Distribution:** **Theory: 3 Credit** **Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk)** **Practical: 30 Class Hours (2h/wk)**

Course Objectives: Current day's analysis and separation of different soil products, natural products and synthetic products are emerging area in research and industrial field. From this course students will learn how to use the chromatographic and other analysis technique for the separation and analysis of soil products, natural products and synthetic products.

Theory

Introduction

Introduction to Analytical Chemistry and its interdisciplinary nature. Concept of sampling. Importance of accuracy, precision and sources of error in analytical measurements. Presentation of experimental data and results, from the point of view of significant figures.

Analysis of soil

Composition of soil, Concept of Ph and Ph measurement, Complexometric titrations, Chelation, Chelating agents, use of indicators

a. Determination of Ph of soil samples.

b. Estimation of Calcium and Magnesium ions as Calcium carbonate by complexometric titration.

Analysis of water

Definition of pure water, sources responsible for contaminating water,water sampling methods, water purification methods.

a. Determination of Ph, acidity and alkalinity of a water sample.

b. Determination of dissolved oxygen (DO) of a water sample.

Analysis of food products

Nutritional value of foods, idea about food processing and food preservations and adulteration.

a. Identification of adulterants in some common food items like coffee powder, asafoetida, chilli powder, turmeric powder, coriander powder and pulses, etc.
b. Analysis of preservatives and colouring matter.

Chromatography

Definition, general introduction on principles of chromatography, paper chromatography, TLC etc.
a. Paper chromatographic separation of mixture of metal ion (Fe^{3+} and $Al3^{+}$).
b. To compare paint samples by TLC method.

Analysis of cosmetics

Determination of constituents of talcum powder: Magnesium oxide, Calcium oxide, Zinc oxide and Calcium carbonate by complexometric titration.

Reference

I. Skoog & Lerry. Instrumental Methods of Analysis, Saunders College Publications, New York.
II. Skoog, D.A.; West, D.M. & Holler, F.J. Fundamentals of Analytical Chemistry 6th Ed., Saunders College Publishing, Fort Worth (1992).
III. Harris, D. C. Quantitative Chemical Analysis, W. H. Freeman.
IV. Dean, J. A. Analytical Chemistry Notebook, McGraw Hill.
V. R.W. Lenz: Organic Chemistry of Synthetic High Polymers.
VI. Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India.
VII. Freifelder, D. Physical Biochemistry 2nd Ed., W.H. Freeman and Co., N.Y. USA (1982).
VIII. Cooper, T.G. The Tools of Biochemistry, John Wiley and Sons, N.Y. USA. 16 (1977).
IX. Vogel, A. I. Vogel's Qualitative Inorganic Analysis 7th Ed., Prentice Hall.
X. Vogel, A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Prentice Hall.
XI. Robinson, J.W. Undergraduate Instrumental Analysis 5th Ed., Marcel Dekker, Inc., New York (1995).

Practical

Instrumental demonstrations

a. Principles involved in chromatographic separations. Paper chromatographic separation of following metal ions:
i. Ni (II) and Co (II)
ii. Fe (III) and Al (III)
b. Spectrophotometric determination of Iron in Vitamin / Dietary Tablets.
c. Spectrophotometric Determination of Caffeine and Benzoic Acid in Soft Drink.

Reference

1. Vogel, A. I. Vogel's Qualitative Inorganic Analysis 7th Ed., Prentice Hall.
2. Vogel, A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Prentice Hall.
3. Robinson, J.W. Undergraduate Instrumental Analysis 5th Ed., Marcel Dekker, Inc., New York (1995).

Course Outcome: Students will learn the separation of several chromatographic technique, which will help to grow their knowledge in separation of several compounds mixture.

8.6.4 Course Name: Bioinorganic Chemistry
Course Code: CHMUGMDS3601
Credit: 4

Course type: Major/DSE	**Course Distribution: Theory: 3 Credit Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk) Practical: 30 Class Hours (2h/wk)**

Course Objectives: The course is meant for introducing students to the role of metals in biological system and natural biological phenomena such as photosynthesis, respiration etc. Students are expected to be familiarized with behavior of metalloproteins in different biological processes. Students will learn about the role of metal ions in medicine and its toxicity. The lessons are further focused on introducing students with inorganic models or mimics that imitates the behaviour of metalloproteins.

Theory

Elements of life (20 Lectures)

Essential major, trace and ultratrace elements. Basic chemical reactions in the biological systems and the role of metal ions (specially Na^+, K^+, Mg^{2+}, Ca^{2+}, $Fe^{3+/2+}$, $Cu^{2+/+}$ and Zn^{2+}). Metal ion transport across biological membrane Na+-ion pump, ionophores. Biological functions of hemoglobin and myoglobin, cytochromes and ferredoxins, carbonate bicarbonate buffering system and carbonicanhydrase. Biological nitrogen fixation, Photosynthesis: Photosystem-I and Photosystem-II.

Toxicity of metal ions (15 Lectures)

Toxic metal ions (Hg, Pb, Cd and As) and their effects, reasons for toxicity, chelation therapy,

Metal ions in medicine (10 Lecture)

Pt and Au complexes as drugs, metal dependent diseases. Use of chelating agents in medicine.

Reference Books	
I.	Lippard, S.J. & Berg, J.M. Principles of Bioinorganic Chemistry Panima Publishing Company 1994.

Practical
a) Gravimetric estimation of Ni^{2+} b) Estimation of Calcium in milk

Reference Book	
I.	Vogel's Quantitative Chemical Analysis, A.I. Vogel, Prentice Hall, 6th Edition.

Course Outcome: Students would be able to understand the role of metals in biological system and natural biological phenomena such as photosynthesis, respiration etc. They would acquire knowledge of metalloproteins involved in different biological processes. Students would acquire knowledge of role of metal ions in medicine and its toxicity. Learners would be able to design inorganic models or mimics that imitate the behaviour of metalloproteins.

8.7 Semester-VII

8.7.1 Course Name: Inorganic Chemistry-V
Topic: Chemical Application of Group theory; Cluster compounds & Macrocycles
Course Code: CHMUGMCC4716/ CHMUGMIN4707
Credit: 4

Course type: Major/Core; Minor-7	**Course Distribution: Theory: 3 Credit Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk) Practical: 30 Class Hours (2h/wk)**

Course Objectives: The course is designed:

1. To introduce students with chemical application of group theory.
2. To familiarize students with symmetry of molecules and symmetry operation.
3. To make students familiar with the concept of Character Table and its applications in spectroscopy.
4. To understand the scientific approach to characterization of products.
5. To refine the scientific reporting skills on data presentation, analysis and discussion.

Theory

Unit-I : Chemical application of group theory

Symmetry, Symmetry elements and symmetry operations, Point groups, Representation of Point group, reducible and irreducible representations, definition of classes and character, statement of Great Orthogonality theorem, Construction of Character table, reduction formula, direct product representation and its uses, symmetry of normal modes, normal mode analysis, selection rules for IR and Raman transition.

Unit-II: Chemistry of cluster compounds and macrocycles

Structure and bonding in polyhedral boranes and carboranes, *styx* notation; Wade's rule; electron count in polyhedral boranes; synthesis and reactions of polyhedral boranes.

Synthesis and structure of crown ethers, cryptands, calixarenes, cyclodextrins, cyclophanes, cryptophanes, catenanes and rotaxanes. Host-Guest interactions, lock and key analogy.

References

1. F. A. Cotton, Chemical Applications of Group Theory, Wiley, 1996.
2. Carter, R. L., Molecular Symmetry and Group Theory, John Wiley and Sons, 3rd Edn.,1998.
3. K. V. Reddy, Symmetry and spectroscopy of molecules, New Age International (P) Ltd. Publishers, 2nd Edition 2009.
4. R. Ameta, Symmetry and Group Theory in Chemistry, New Age International (P) Ltd. Publishers, 1st Edition 2013.
5. N. N. Greenwood and E. A. Earnshaw; Chemistry of elements, Second Edition, Butterworth-Heinemann, 1997.
6. T. P. Fehlner, J. F. Halet and J-Y. Saillard; Molecular Clusters: A Bridge to solid-state Chemistry, Cambridge University press, 2007.
7. J.-M. Lehn; Supramolecular Chemistry-Concepts and Perspectives (Wiley-VCH, 1995).
8. P. D. Beer, P. A. Gale, D. K. Smith; Supramolecular Chemistry (Oxford University Press, 1999)
9. J. W. Steed and J. L. Atwood; Supramolecular Chemistry (Wiley, 2000).
10. A. K. Das; Fundamental Concepts of Inorganic Chemistry, CBS

Practical

Synthesis and characterization of metal complexes

1. Preparation of hexamine nickel (II) chloride and estimation of ammonia and nickel by titrimetric and gravimetric methods.
2. Synthesis, isolation and spectroscopic characterization of the complexes of transition metal acetyl acetonates
3. Preparation of chloropentamine cobalt (III) chloride $[Co(NH_3)_5Cl]Cl_2$ and characterized by FT-IR spectroscopy
4. Preparation of potassium trs(oxalate) iron (III) trihydrate and characterized by FT-IR spectroscopy

References

University laboratory guide book

Course Outcome: Students would be able to:

a) understand symmetry of molecules and symmetry operation,
b) prepare character table of molecules using idea of group theory,
c) predict the spectroscopic properties of different compounds,
d) evaluate structural of inorganic compounds by spectroscopic study.

8.7.2 Course Name: Medicinal chemistry-I
Topic: Concept of Drugs; Antibiotics & Inorganic pharmaceuticals
Course Code: CHMUGMCC4717
Credit: 4

Course type: Major/Core	Course Distribution: Theory: 3 Credit Practical: 1 Credit	Theory: 45 Lectures (3h/wk) Practical: 30 Class Hours (2h/wk)

Course Objectives: In present time, with the increase of pharmaceuticals industries, skilled man power having good knowledge on synthesis and mechanism of pharmaceuticals product is growing. This course will help the students to urge the basic knowledge on drug and pharmaceuticals compounds.

Unit-I

Basic concept of drug, drug receptor interaction, agonist and antagonist, isoster and bioisoster.

Unit-II

Beta lactam antibiotics: Penicillins, Cephalosprins including their semi-synthetic products. Monobactams.

Unit-III

Tetracyclines, Semi-synthetic tetracyclines, Gentamycins, Neomycins, Kanamycins, Fluoroquinoolines type of antibacterials.

Unit-IV

Antiprotozoal such as Antimalarials, Antiamoebics, Antihelminths.

Unit-V

Antifungal drugs includes Amphotericin-B, Nystatin, Natamycin, Griseofulvin, Clotrimazole, Econazole, Butoconazole, Oxiconazole Tioconozole, Miconazole*, Ketoconazole, Terconazole, Itraconazole, Fluconazole.

Unit-VI

Inorganic pharmaceutical products

Major extra and intracellular electrolytes: Functions of major physiological ions, Electrolytes used in the replacement therapy: Sodium chloride*, Potassium chloride, Calcium gluconate* and Oral Rehydration Salt (ORS), Physiological acid base balance.

Gastrointestinal agents

Acidifiers: Ammonium chloride* and Dil. HCl

Antacid: Ideal properties of antacids, combinations of antacids, Sodium Bicarbonate*, Aluminum hydroxide gel, Magnesium hydroxide mixture

Cathartics: Magnesium sulphate, Sodium orthophosphate, Kaolin and
Bentonite

Antimicrobials: Mechanism, classification, Potassium permanganate, Boric
acid, Hydrogen peroxide*, Chlorinated lime*, Iodine and its preparations

Radiopharmaceuticals: Radio activity, Measurement of radioactivity, precautions & pharmaceutical application of radioactive substances.

Reference

1. William O. Foye, Principles of Medicinal Chemistry, 3rd ed., Varghese Publishing House,Mumbai, 1989.
2. Jaime N. Delgado & William A. Remers, Wilson and Gisvold's, Text Book of Organic Medicinal and Pharmaceutical Chemistry, 9th ed. J.B. Lippincott Company, Philadelphia, 1991.
3. Manfred E. Wolff, Burger's Medicinal Chemistry & Drug Discovery, 5th ed., Wiley Interscience, New York, 1995.
4. H. Singh and V.K. Kapoor, Medicinal and Pharmaceutical Chemistry, 1st ed., Vallabh Prakashan, Delhi, 1996.
5. Ashutosh Kar, Medicinal Chemistry, New Age International (P) Limited, New Delhi, 1993.

Practical

Identification and assay of paracetamol, aspirin, metronidazole, ampicillin. Estimation of pracetamol present in tablet, Assay of different antibiotics and determination of MIC value against bacterial strain.

Reference

1. Ashutosh Kar, Medicinal Chemistry, New Age International (P) Limited, New Delhi, 1993.

Course Outcome: The course will help to develop the knowledge of students on pharmaceuticals products, the practical course had been designed to assay several pharmaceuticals and drugs.

8.7.3 Course Name: Pericyclic reactions & Organic Photochemistry
Topic: Pericyclic reactions & Photochemistry of Organic molecules
Course Code: CHMUGMDS4702
Credit: 4

Course type: Major/DSE	**Course Distribution:** **Theory: 3 Credit** **Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk)** **Practical: 30 Class Hours (2h/wk)**

Course Objectives: The purpose of the course is to make students acquainted with the concepts and applications of two important topics in advanced organic chemistry, i.e. concerted pericyclic reactions and organic photochemistry. Pericyclic reactions are concerted organic reactions and are governed by Woodward-Hoffmann rules. Different methods of analysis of pericyclic reactions to arrive at the Woodward-Hoffmann rules will be presented. Synthetic applications and mechanisms of diverse pericyclic reactions will be discussed. Likewise the notions involved in understanding organic photochemical reactions, their mechanisms and applications in organic synthesis will be covered.

Unit-I: ***Pericyclic reactions***

Molecular orbitals: MOs of acyclic and cyclic polyenes and arenes. FMO. Role of FMO in organic reactions.

Pericylic reactions: Classification of pericyclic reactions. Thermal and photochemical reactions. Four approaches: Conservation of orbital symmetry and correlation diagram, Frontier molecular orbital approach [FMO] and Aromatic (Huckel and Mobius) transition state approach, Woodward-Hoffmann rules.

Cycloaddition reactions: 4n and (4n+2) π electron systems. Diels-Alder reactions, Cycloreversion, 1,3-Dipolar cycloadditions and cheletropic reactions.

Electrocyclic reactions: Conrotatory and disrotatory motions, 4n and (4n+2) π electron systems and other systems. Valence tautomerism.

Sigmatropic rearrangements: H-shifts and alkyl-shifts, supra and antarafacial migrations. Cope and Claisen rearrangements. Degenerate Cope rearrangement, Fluxional tautomerism. Wittig rearrangement, 2,3-sigmatropic shifts.

Group Transfer reaction: the ene reactions, reaction of diimide.

Unit-II: ***Photochemistry of Organic molecules***

Photochemical reactions: Interaction of electromagnetic radiation with matter, types of excitations, fate of excited molecule, quantum yield, transfer of excitation energy.

Types of photochemical reactions-photo dissociation, gas-phase photolysis.

Photochemistry of alkenes: Intramolecular reactions of the olefinic bond –cis-trans isomerism, cyclisation reactions, rearrangement of 1,4- and 1,5-dienes.

Photochemistry of carbonyl compounds: Intramolecular reactions of carbonyl compounds-saturated, cyclic and acyclic, β,γ-unsaturated and α, β-unsaturated compounds, cyclohexadienones. Intermolecular cyloaddition reactions-dimerisations and oxetane formation.

Photochemistry of aromatic compounds: Isomerisations, additions and substitutions.

Miscellaneous photochemical reactions: Photo-Fries reaction of anilides, Photo-Fries rearrangement. Barton reaction. Singlet molecular Oxygen reaction. Photochemical formation of smog. Photodegradation of polymers. Photochemistry of vision.

Reference

1. Photochemistry and Pericyclic Reactions- Jagadamba singh
2. Pericyclic Reactions - A Textbook: Reactions, Applications and Theory- S. Sankararaman, Roald Hoffmann

3. Advanced Organic Chemistry-Jerry march
4. Advanced Organic Chemistry- Carey and Sandberg
5. Aspects of Organic Photochemistry-W. M. Horspoot
6. Organic Photochemistry- J. Coxon and B Halton
7. Pericyclic reactions- S.M Mukherji

Practical

1. Qualitative Analysis of binary mixtures: Separation, purification and identification of the mixture of two organic compounds.
2. Diels-Alder reaction between furan and maleic acid.
3. Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

Reference

1. Practical Chemistry: Prof. S. Dutta
2. Monograph on Green Chemistry Laboratory Experiments, Green chemistry Task force Committee, DST

Course Outcome: This course will help the students to understand various theoretical aspects of pericyclic reactions and Organic Photochemistry, along with application towards the generation of simple and complex molecules which will be otherwise difficult to obtain through conventional methods.

8.7.4 Course Name: Advanced Physical Chemistry
Topic: Quantum Chemistry, Statistical thermodynamics & Polymer Chemistry
Course Code: CHMUGMDS4703

Course type: Major/DSE	Course Distribution: Theory: 3 Credit Practical: 1 Credit	Theory: 45 Lectures (3h/wk) Practical: 30 Class Hours (2h/wk)

Course Objectives: In present day, the quantum mechanics is a growing field. Statistical thermodynamics is also a modern are of chemistry, while polymer chemistry has great applications in several industries. This course will helpful to acquire the basic knowledge on quantum mechanics, Statistical thermodynamics and polymer chemistry.

Unit-I: ***Quantum Chemistry***

Simple Harmonic Oscillator: setting up of the Schrodinger stationary equation, energy expression (without derivation), expression of wave function for n = 0 and n = 1 (without derivation) and their characteristic features, Stationary Schrodinger equation for the H-atom in polar coordinates, separation of radial and angular (θ, φ) parts. Solution of φ-part and emergence of quantum number 'm'; energy expression (without derivation), degeneracy. Hydrogenic wave functions up to n = 2 (expression only); real wave function. Concept of orbitals and shapes of s and p orbitals. Approximate methods in quantum mechanics, variational principle, Hückel Theory and its applications, Perturbation theory, first order non-degenerate and degenerate perturbation theory and applications.

Unit II: ***Statistical thermodynamics***

Macrostates and microstates, thermodynamic probability, entropy and probability, Boltzmann distribution formula (with derivation). Applications to barometric distribution. Partition function and Einstein's theory of heat capacity of solids. Limitations of Einstein's theory and Debye's modification (qualitative). Nernst heat theorem. Approach to zero kelvin, adiabatic demagnetisation. Planck's formulation of third law and absolute entropies.

Unit III: ***Polymer Chemistry***

Basic concepts of polymer science, Degree of polymerization, classification of polymers based on source, composition, structure, mode of polymerization, molecular forces, tacticity; types of polymerization: condensation or step polymerization, chain polymerization, coordination polymerization, molecular mass of polymer. plastics, biopolymers, conducting polymers, molecular forces and chemical bonding in polymers, Copolymerization - Kinetics of copolymerization, the copolymer equation, monomer reactivity ratios, instantaneous composition of polymer.

Practical

1. Polymer synthesis: Addition polymer—Polystyrene
2. Condensation Polymer: Synthesis of Glyptal Resin
3. Modification of polymers: Experiment on crosslinking with Glue
4. Polymer fabrication: Polyethylene bottle

Reference

1. Physical Chemistry : A Molecular Approach – D.A. McQuarrie, J.D. Simon
2. Quantum Mechanics-J. L. Powell, B. Crasemann
3. Quantum Chemistry – I. N. Levine

Course Outcome: The course will be helpful to grow the knowledge on modern area of Chemistry. Quantum chemistry will allow students to predict the molecular structure and spectroscopic behavior of atoms. Statistical thermodynamics will provide the students a quantitative link between the properties of the microscopic particles and the behaviour of the bulk material. Pupils will learn about the methods of measuring the molecular weight, polymerization kinetics and copolymerization and polymer processing technologies.

8.7.5 Course Name: Research methodology and Data Analysis
Course Code: CHMUGMDS4704
Credit: 4

Course type: Major/DSE	**Course Distribution:** **Theory: 3 Credit** **Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk)** **Practical: 30 Class Hours (2h/wk)**

Course Objectives:
To provide students a brief idea about the research. Students will know about the literature survey, methods of Scientific research, data analysis and writing scientific papers.

Literature Survey:

Print: Sources of information: Primary, secondary, tertiary sources; Journals: Journal abbreviations, abstracts, current titles, reviews, dictionaries, text-books, current contents, Introduction to Chemical Abstracts and Beilstein, Subject Index, Substance Index, Author Index, Formula Index, and other Indices with examples.

Digital

Web resources, E-journals, Journal access, TOC alerts, Hot articles, Citation index, Impact factor, H-index, E-consortium, UGC infonet, E-books, Internet discussion groups and communities, Blogs, Preprint servers, Search engines, Scirus, Google Scholar, Chem Industry, Wiki- Databases, ChemSpider, Science Direct, SciFinder, Scopus.

Information Technology and Library Resources

The Internet and World Wide Web. Internet resources for chemistry. Finding and citing published information.

Methods of Scientific Research and Writing Scientific Papers: Reporting practical and project work. Writing literature surveys and reviews. Organizing a poster display. Giving an oral presentation. Writing scientific papers – justification for scientific contributions, bibliography, description of methods, conclusions, the need for illustration, style, publications of scientific work. Writing ethics. Avoiding plagiarism.

Data Analysis:

The Investigative Approach: Making and Recording Measurements. SI Units and their use. Scientific method and design of experiments.

Analysis and Presentation of Data: Descriptive statistics. Choosing and using statistical tests. Chemometrics. Analysis of variance (ANOVA), Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, *r* and its abuse. Basic aspects of multiple linear regression analysis.

Benesi–Hildebrand plot and analysis, determination of binding constant.

Reference Books	
I.	Dean, J. R., Jones, A. M., Holmes, D., Reed, R., Weyers, J. & Jones, A. (2011)
II.	*Practical skills in chemistry*. 2nd Ed. Prentice-Hall, Harlow.
III.	Hibbert, D. B. & Gooding, J. J. (2006) *Data analysis for chemistry*. Oxford University Press.
IV.	Topping, J. (1984) *Errors of observation and their treatment.* Fourth Ed., Chapman Hall, London.
V.	Harris, D. C. *Quantitative chemical analysis*. 6th Ed., Freeman (2007) Chapters 3-5.

PPT presentation

Literature and reviews surveys and giving an oral presentation.

Course Outcome:

This course will help the students to understand the writing of manuscript, presentation and publication. It also helps to know the writing ethics and plagiarism during the preparation of manuscript.

6.7.8 Course Name: Dissertation-I
Course Code: CHMUGPRJ4701
Credit: 4

Dissertation-I (For UG Honours with research only)	**Course Distribution: Theory: 4 Credit**	**Project Work**

Course Objectives: This course will offer students to get hands on experience of doing research. Students shall choose or shall be allotted a mentor to undertake the project work. Students shall do supervised mini investigatory project under the mentor. The motto of the dissertation work is as follows:

1. To enable students to develop research problems, identify research gaps and to formulate research objectives.
2. To train students in reviewing literature systematically and to familiarize them to the process of systematic search indexing.
3. To familiarize students with various instruments and equipments used in preparation and characterization and application of compounds.

Course Outcome: The students will be able to

a) formulate research problem and develop a sufficiently coherent research design;
b) use various qualitative and quantitative methods for synthesis and characterization of chemical compounds;
c) have an awareness of data analysis, including descriptive & inferential measures;
d) be able to write & develop independent thinking for critically analyzing research reports;
e) recognize, and take account of the importance of ethical conduct in undertaking research, honesty and integrity in analysis and reporting in the design, implementation and evaluation of a research project.

8.8 Semester-VIII

8.8.1 Course Name: Spectroscopy
Topic: NMR, Mass, Mössbauer and ESR Spectroscopy
Course Code: CHMUGMCC4818/ CHMUGMIN4808
Credit: 4

Course type: Major/Core; Minor-8	**Course Distribution: Theory: 3 Credit Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk) Practical: 30 Class Hours (2h/wk)**

Course Objectives: The course is aimed at introducing students with different spectroscopic techniques such as Mass, NMR, EPR, Mössbauer, PES etc. so that they are capable of analyzing spectroscopic data to identify organic and inorganic compounds.

Theory

Unit-I: Nuclear magnetic resonance spectroscopy (NMR)

a) ^{13}C NMR spectroscopy-principles, instrumentation, principles of decoupling, 13C-chemical shifts and structure of organic molecules. Interpretation of ^{13}C-NMR spectra of organic compounds.

b) Gated decoupling difference spectroscopy; Relaxation process, Population transfer, Selective polarization transfer.

c) INEPT, basic two-dimensional sequence, Homonuclear shift correlation.

d) Application of DEPT, ^{1}H- ^{1}H COSY, HMBC, HOHAHA (TOCSY).

e) NOE in structure elucidation of organic compounds.

Unit-II: Mass spectroscopy

Theory, Instrumentation and Ionization methods (FAB, ESI, MALDI, FD etc.), Application of HRIEMS, MS-MS, GC-MS, LC-MS.

Mass spectrometers (MALDI, TOF, ES) in structure elucidation of small and macromolecules.

Unit-III: Mössbauer spectroscopy

Basic Principles, Instrumentation, spectral parameters and spectral display. Centre shift, Quadrupole and magnetic interactions. Application to the to the elucidation of structure and bonding of Fe(III) and Fe(II) , Sn(IV), and Sn(II) compounds. Detection of oxidation states and in equivalent MB atoms.

PES: Photo excitation and photo ionization (XPS, ESCA) and valence level (UPS) experiments, detection of atoms in molecules, chemical shift, differentiating same element in different environment.

Unit-IV: Electron Spin Resonance (ESR) spectroscopy

Introduction, Principles, Instrumentation and application in detection of free radicals in chemical and biological systems.

Practical

a) Identification of compound using NMR and IR spectroscopy
b) Identification of compound using Mass spectrometry
c) Identification of oxidation state of iron using Mössbauer Spectroscopy
d) Identification of different radical using ESR spectroscopy

Reference

1. Herald Gunther, NMR Spectroscopy: Basic Principles Concepts and Applications in Chemistry, John Wiley 2002.
2. Atta-ur- Rahman, One and Two Dimensional NMR Spectroscopy, Elsevier, 2010.
3. Mossbauer Spectroscopy and Transition Metal Chemistry (Fundamentals and Applications)-Philipp Guetlich, Eckhardt bill, A. X. Trautwein.
4. Electron Paramagnetic Resonance-Elementary Theory and Practical Applications-John A. Weil, James R. Bolton & John E. Wertz.

5. Mössbauer Spectroscopy by N. N. Greenwood and T. C. Gibb.

Course Outcome: Students will be able to predict the structure of different compounds from the spectral data. They will also be able to predict the spectral behaviour of different organic and inorganic molecules.

8.8.2 Course Name: Analytical chemistry-II

Topic: Separation Techniques; Analytical Methods & Instrumental analysis

Course Code: CHMUGMCC4819

Credit: 4

Course type: Major/Core	**Course Distribution:** **Theory: 3 Credit** **Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk)** **Practical: 30 Class Hours (2h/wk)**

Course Objectives: Several industries and research institutes need analytical chemists having deep knowledge in instrument handling and analysis. The following course had been designed to grow the knowledge of students on instrument handling and analysis

Unit-I: ***Separation by solvent extraction and distillation methods***

Extraction methods and theory, distribution law, partition coefficient, the distribution ratio, the percentextraction, types of extraction procedures, simple extraction, exhaustive or continuous extraction, counter current extraction, application of extraction-procedure, inorganic separation. Examples of solvent extraction equilibria, partition of a weak acid, extraction of a metal as chelate compounds,extraction systems involving ion pairs and solvates, problems.Basic principles of distillation, concept of volatility, theory of fractional distillation, idea of theoretical plates and HETP, separation of some species by distillation, problems.

Unit II: ***Chromatographic Separations***

Basic principles, theory, theoretical plates, the Van Deemter equation, diffusion processes, resolution, separation factor, retention factor, distribution coefficient, effect of temperature, column chromatography, paper chromatography, thin layer chromatography, HPLC, affinity chromatography, gas chromatography.

Unit III: ***Principle and application of titrimetric and gravimetric analysis***

Complexometric analysis, effect of pH, indicators' range, gravimetric analysis.

Unit IV: ***Instrumental analysis***

Basic principles and application of the followings:
Thermal method-TGA, DTA, DSC, Polarimetry, Coulometric analysis, voltammetric analysis, flame photometry, atomic absorption spectroscopy, atomic emission spectroscopy.

Reference Books:

1. Analytical Chemistry by Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch.
2. Fundamentals of Analytical Chemistry by Dougias A. Skoog, Donald M. West, F. James Holler and Stanley R. Crouch.
3. Instrumental Analysis by Dougias A. Skoog, F. James Holler and Stanley R. Crouch.
4. Textbook of Practical organic Chemistry by Brain S. Fruniss, Antony J. Hannaford, Peter W. G. Smith and Austin R. Tatchell.

Practical

1. Separation of mixtures by paper chromatography and reporting the R_f values: (i) Co^{2+} and Ni^{2+} . (ii) Amino acids present in the given mixture.
2. Solvent Extractions (i) To separate a mixture of Ni^{2+}& Fe^{2+} by complexation with DMG and

extracting the Ni^{2+} DMG complex in chloroform, and determine its concentration by spectrophotometry.
3. Ion exchange: (i) Determination of exchange capacity of cation exchange resins and anion exchange resins. (ii) Separation of amino acids from organic acids by ion exchange chromatography.

Reference

1. Jeffery, G.H.; Bassett, J.; Mendham, J.; Denney, R.C.(1989),
2. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley and Sons.

Course Outcome: Students will learn the basic functions and uses of several instruments and analyses techniques, which will be beneficial for various industrial jobs and research.

8.8.3 Course Name: Chemistry of Natural Products
Topic: Alkaloids, Terpenoids, Steroids & Flavonoids
Course Code: CHMUGMDS4805
Credit: 4

Course type: Major/DSE	**Course Distribution:** **Theory: 3 Credit** **Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk)** **Practical: 30 Class Hours (2h/wk)**

Course Objectives: The course is designed to introduce students to the chemistry of various kinds of natural products such as Terpenoids and Carotenoids, Alkaloids, Steroids, Flavonoids and Isoflavonoids. The objective of the Practical course is to make the students familiar with basic techniques, equipments and instrumentations for isolation, purification and identification of different types of naturally occurring compounds possessing pharmaceutical and biological activity.

Theory

Unit-I: Terpenoids and Carotenoids
Classification, nomenclature, occurrence, isolation, isoprene rule and special isoprene rule general methods of structure determination. Structure determination, stereochemistry and synthesis of the following representative molecules: Citral, Geraniol, Terpineol, Farnesol and Zingiberene.

Unit-II: Alkaloids
Definition, nomenclature and physiological action, occurrence, classification, isolation, general methods of structure elucidation, degradation. Structure determination, stereochemistry and synthesis of the following: Ephedrine, Nicotine, Atropine, Reserpine and Morphine.

Unit-III: Steroids
Occurrence, nomenclature, basic skeleton, Diel's hydrocarbon and stereochemistry. Isolation, structure determination and synthesis of Cholesterol. Bile acids, Androsterone, Testosterone, Progesterone.

Unit-IV: Flavonoids and Isoflavonoids
Occurrence, nomenclature, Isolation, structure determination and synthesis of Apigenine, Luteoline, Quercetin, Butein.

References

1. Chemistry of Alkloids-S. W. Pelletier
2. The Molecules of Nature-J. B. Hendricsion
3. Biogenesis of Natural Compound – Benfield
4. Natural Product Chemistry and Biological Significance- J. Mann, R. S Devison, J. B. Hobbs, D. V. Banthripde and J. B. Horborne
5. Introduction to Flavonoids-B. A. Bohm, Harwood
6. Organic chemistry, Vol-I&II,- Finar
7. Organic Chemistry- Clayden, J, Greeves, N, Warren, S. and Wothers, P

Practical

Isolation of Organic Compounds from Natural Source

Isolation of:

a) caffeine from tea leaves.
b) casein from milk
c) lactose from milk
d) nicotine dipicrate from tobacco
e) piperine from black pepper
f) eugenol from cloves
g) Citric acid from lemon

Reference

1. Vogel's Textbook of Practical Organic Chemistry: A. I. Vogel, B. S. Furniss, P. W. Smith
2. Natural Products Isolation, 2nd Edition, Authors: Satyajit D. Sarkar, Zahid Latif, Alexander I Gray

Course Outcome: Students are expected to acquire in-depth knowledge about the occurrence, nomenclature, isolation, structure elucidation, physiological action, stereochemistry and synthesis of diverse array of representative compounds belonging to the important class of natural products. They will have first-hand comprehensive theoretical and practical knowledge about how to isolate important compounds from natural source, purify and then identify the desired compound using classical or advanced analytical methods.

8.8.4 Course Name: Biochemistry and Basic Immunology
Topic: Organization of life; Metabolism & Immune system
Course Code: CHMUGMDS4806
Credit: 4

Course type: Major/DSE	**Course Distribution:** **Theory: 3 Credit** **Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk)** **Practical: 30 Class Hours (2h/wk)**

Course Objectives: Students will learn about several chemicals and biochemicals reactions in living organisms, structure and function of different biomolecules, cells, tissues etc.

Unit-I: ***Organization of life***

Importance of water. Cell structure and organelles. Biochemical separation techniques and characterization: ion exchange, size exclusion and affinity chromatography, electrophoresis, UV-visible, fluorescence and Mass spectrometry. Protein structure, folding and function: Myoglobin, Hemoglobin, Lysozyme, Ribonuclease A, Carboxypeptidase and Chymotrypsin. Enzyme kinetics including its regulation and inhibition, Vitamins and Coenzymes.

Unit-II:*Metabolism and bioenergetics*

Generation and utilization of ATP. Metabolic pathways and their regulation: glycolysis, TCA cycle, pentose phosphate pathway, oxidative phosphorylation, gluconeogenesis, glycogen and fatty acid metabolism. Metabolism of Nitrogen containing compounds: nitrogen fixation, amino acids and nucleotides. Photosynthesis: the Calvin cycle.

Biological membranes. Transport across membranes. Signal transduction; hormones and neurotransmitters. DNA replication, transcription and translation; Biochemical regulation of gene expression; Recombinant DNA technology and applications: PCR, site directed mutagenesis and DNA-microarray.

Unit-III:Immune system

Active and passive immunity. Complement system. Antibody structure, function and diversity. Cells of the immune system: T, B and macrophages. T and B cell activation. Major histocompatibilty complex. T cell receptor. Immunological techniques: Immunodiffusion, immunoelectrophoresis, RIA and ELISA.

Reference Books:

1. Robert K. Murray, Daryl K. Granner, Peter A. Mayes, Victor W. Rodwell, Harper's Biochemistry, 25th ed. McGraw Hill health Professions Division, New York, USA, 1998.
2. A.V.S.S. Rama Rao, Text Book of Biochemistry, 6th ed., L. K. & S. Publishers, Visakhapatnam, 1991.
3. Melson David L. Lehninger Principles of Biochemistry, 3rd ed. Macmillan worth Publishers, N. Y. USA, 2001.
4. Stryer Lubert, Berg Jeremy M., Tymoczko Johan L, Biochemistry, 5th ed. W. H. Freeman & Company New York, 2002
5. M. C. Pant, Essentials of Biochemistry, 8th ed., Kedar nath Ram Nath & Co. Publishers, Meerut, 1996.
6. E. David Metzler, Carol M. Metzler, David J. Sauke, Biochemistry the chemical reactions of living cells, 2nd ed., Har court/Academic Press, New York.

Practical

Identification of carbohydrate, amino acids, proteins and fats.

Reference

1. M. C. Pant, Essentials of Biochemistry, 8th ed., Kedar nath Ram Nath & Co. Publishers, Meerut, 1996.
2. E. David Metzler, Carol M. Metzler, David J. Sauke, Biochemistry the chemical reactions of living cells, 2nd ed., Har court/Academic Press, New York.

Course Outcome: From the theoretical part student will learn about structure and functions of several biomolecules in between living organisms. The practical part will be helpful to grow their skill on identification of important biomolecules, which will be helpful to get job in different fields.

8.8.5 Course Name: Inorganic Materials of Industrial Importance

Course Code: CHMUGMDS4807

Credit: 4

Course type: Major/DSE	**Course Distribution:** **Theory: 3 Credit** **Practical: 1 Credit**	**Theory: 45 Lectures (3h/wk)** **Practical: 30 Class Hours (2h/wk)**

Course Objectives: The course introduces learners to the diverse roles of inorganic materials in the industry. It gives an insight into how these raw materials are converted into products used in day to day life. Students learn about silicates, fertilizers, surface coatings, and batteries. The course helps develop the interest of students in the frontier areas of inorganic and material chemistry.

Unit I:

Silicate Industries Glass: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, different types of safety glass, borosilicate glass, fluorosilicate glass, coloured glass, photosensitive glass, photochromic glass, glass wool and optical fibre.

Ceramics: Brief introduction to types of ceramics. glazing of ceramics.

Cement: Manufacture of Portland cement and the setting process, Different types of cements: quick setting cements, eco-friendly cement (slag cement), pozzolana cement.

Unit II

Fertilizers: Different types of fertilizers (N, P and K). Importance of fertilizers, chemistry involved in the manufacture of the following fertilizers: urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates, superphosphate of lime, potassium chloride and potassium nitrate.

Unit III

Surface Coatings: Brief introduction to and classification of surface coatings, paints and pigments: formulation, composition and related properties. Special paints: heat retardant, fire retardant, eco-friendly paints, plastic paints, water and oil paints. Preliminary methods for surface preparation, metallic coatings

Unit IV

Batteries: Primary and secondary batteries, characteristics of an Ideal Battery, principle, working, applications and comparison of the following batteries: Pb- acid battery, Li-metal batteries, Li-ion batteries.

Reference

1. Smart, L. E.; Moore, E. A. (2012), Solid State Chemistry An Introduction, CRC Press Taylor & Francis.
2. Kent, J. A. (ed) (1997), Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
3. Kingery, W. D.; Bowen H. K.; Uhlmann, D. R. (1976), Introduction to Ceramics, Wiley Publishers, New Delhi.

Practical

1. Detection of constituents of Ammonium Sulphate fertilizer (Ammonium and Sulphate ions) by qualitative analysis and determine its free acidity.
2. Detection of constituents of CAN fertilizer (Calcium, Ammonium and Nitrate ions) fertilizer and estimation of Calcium content.
3. Detection of constituents of Dolomite (Calcium, Magnesium and carbonate ions) and determination of composition of Dolomite (Complexometric titration).

Reference

1. Svehla, G.(1996),Vogel's Qualitative Inorganic Analysis, Prentice Hall.
2. Banewicz, J. J.; Kenner, C.T. Determination of Calcium and Magnesium in Limestones and Dolomites, Anal. Chem., 1952, 24 (7), 1186–1187

Course Outcome: By the end of the course, the students will be able to: (a) Learn the composition and applications of the different kinds of glass,
(b) Understand glazing of ceramics and the factors affecting their porosity,
(c) Give the composition of cement and discuss the mechanism of setting of cement,
(d) Explain the suitability of fertilizers for different kinds of crops and soil,
(e) Explain the process of formulation of paints and the basic principle behind the protection offered by the surface coatings,
(f) Explain the principle, working and applications of different batteries.

8.8.8 Course Name: Dissertation-II
Course Code: CHMUGPRJ4802
Credit: 8

Dissertation (For UG Honours with research only)	**Course Distribution: Theory: 8 Credit**	**Project Work**

Course Objectives: Investigations included in final dissertation are anticipated to enable students:
1. To complete the research project undertaken by the students in previous semester.
2. To represent the results of the undertakings with due analysis and interpretations.
3. To orient the learners to pursue higher studies and PhD in current topics of Chemical Science.

Course Outcome: Students will be trained to present their research findings in proper format. They will be taught to deliver lectures on their research endeavors. Furthermore, Students will be encouraged to publish their findings in reputed journals, which in turn, will create opportunity for them to secure jobs in Industry and Research Institutes.