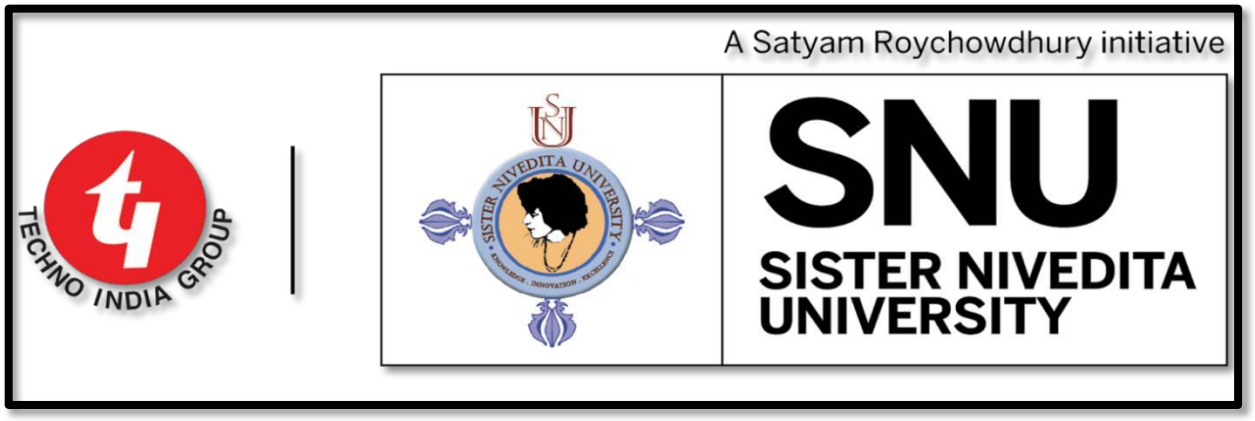


Four-Year B.Sc
(Honours and Honours with Research)
Couses of Studies
(Under Curriculum & Credit framework, 2022)

SYLLABUS
of
CHEMISTRY

Vice-Chancellor,
Sister Nivedita University

Subject Expert

Raj K Datta
Chief General Manager - Product Development, Technical Support & QA
Haldia Petrochemicals Limited

Industry Expert

Head of the Department,
Chemistry, SNU

Draft Syllabus Structure for B.Sc. Chemistry (Four Years)

[Colour Coding: Green (Core Course), Blue (Minor offered by another department), Red (Offered centrally by the University)]

Major – Core Courses (CC);
Minor – Subject Minor
NM – Non-Major
NV – Non-Major Vocational
MDC – Multidisciplinary courses;
AEC – Ability Enhancement Courses;
SEC – Skill Enhancement Courses;
VAC – Value Added Courses;
INT – Internship;
Project – Project.

Semester 1:

Category	Course Name	Teaching Scheme			Credit
		L	T	P	
Semester-I					
CC 1	Fundamentals of Chemistry	2			4
	Fundamentals of Chemistry LAB			4	
CC 2	Inorganic Chemistry-I: Chemical Bonding- I, Acids and Bases, and Daily Life Chemistry	2			4
	Inorganic Chemistry-I LAB			4	
NM1 (NOT Part of MINOR)	Set by the Department	3			4
				2	
NV 1	Vocational - EAA I (Yoga/ Sports/ NCC/ NSS)			2	1
NV 2	Vocational – Soft Skill Development I	1			1
AEC 1	Communicative English I	2			2
VAC 1	Environmental Science I	2			2
SEC 1	Computer Application	2		2	3
Total		**Teaching Hour = 28**			**Credit = 21**

Semester 2:

Category	Course Name	Teaching Scheme			Credit
		L	T	P	
Semester-II					
CC 3	Physical Chemistry-I	2			4
	Physical Chemistry-I LAB			4	
CC 4	Organic Chemistry-I: Stereochemistry and Aliphatic Hydrocarbons	2			4
	Organic Chemistry-I LAB			4	
NV 3	Vocational - EAA II (Yoga/ Sports/ NCC/ NSS)			2	1
NV 4	Vocational – Soft Skill Development II	1			1
MDC 1	Selected by the candidate (Elective)	3			3
AEC 2	Communicative English II	2			2
VAC 2	Environmental Science II	2			2
SEC 2	Selected by the candidate (Elective)	3			3
Total		**Teaching Hour = 25**			**Credit = 20**

Semester 3:

Category	Course Name	Teaching Scheme			Credit
		L	T	P	
Semester-III					
CC 5	Inorganic Chemistry-II: *s*- & *p*- Block Elements	3			5
	Inorganic Chemistry-II LAB			4	
CC 6	Organic Chemistry-II: Chemistry of Aromatic and Halogenated Hydrocarbons	3			5
	Organic Chemistry-II LAB			4	
NM 2	MINOR- I-Selected by the Candidate	4			4
NV 5	Vocational - Mentored Seminar I	1			1
NV 6	Vocational – Soft Skill Development III	1			1
MDC 2	Selected by the candidate (Elective)	3			3
AEC 3	Logical Ability I / Foreign Language I	2			2
Total		**Teaching Hour = 25**			**Credit = 21**

Semester 4:

Category	Course Name	Teaching Scheme			Credit
		L	T	P	
Semester-IV					
CC 7	Physical Chemistry-II	3			5
	Physical Chemistry-II LAB			4	
CC 8	Organic Chemistry-III: Alcohols, Phenols, Carbonyl Compounds and Carboxylic Acids	3			5
	Organic Chemistry-III LAB			4	
NM 3	MINOR- II-Selected by the Candidate	4			4
NV 7	Vocational - Mentored Seminar II	1			1
NV 8	Vocational – Soft Skill Development IV	1			1
MDC 3	Selected by the candidate (Elective)	3			3
AEC 4	Logical Ability II / Foreign Language II	2			2
Total		**Teaching Hour = 25**			**Credit = 21**

Semester 5:

Category	Course Name	Teaching Scheme			Credit
		L	T	P	
Semester-V					
CC 9	Inorganic Chemistry-III: *d*, *f*-Block Elements, Chemical Bonding-II and Supramolecular Chemistry	3			5
	Inorganic Chemistry-III LAB			4	
CC 10	Physical Chemistry-III	3			5
	Physical Chemistry-III LAB			4	
CC 11	Organic Chemistry-IV: Heteroatom Chemistry, Rearrangement and Pericyclic Reactions	4			4
NV 9	Vocational - Mentored Seminar III	1			1
NV 10	Vocational – Soft Skill Development V	1			1
SEC 3	Selected by the candidate (Elective)				3
VAC 3	Ethics Study and IPR / Elective	2			2
Total		**Teaching Hour = 22**			**Credit = 21**

Semester 6:

Category	Course Name	Teaching Scheme			Credit
		L	T	P	
Semester-VI					
CC 12	Inorganic Chemistry-IV: Coordination Chemistry, Redox and Radioactivity	2			4
	Inorganic Chemistry-IV LAB			4	
CC 13	Physical Chemistry-IV	2			4
	Physical Chemistry-IV LAB			4	
CC 14	Organic Chemistry-V: Cycloalkane Conformations and Carbohydrates	2			4
	Organic Chemistry-V LAB			4	
NM 4	MINOR- III-Selected by the Candidate	4			4
NV 11	Vocational-Mentored Seminar IV	1			1
NV 12	Vocational – Soft Skill Development VI	1			1
INT 1	Internship / In-house Mini Project			6	3
Total		**Teaching Hour = 30**			**Credit = 21**

Semester 7:

Category	Course Name	Teaching Scheme			Credit
		L	T	P	
Semester-VII					
CC 15	Physical Chemistry-V	4			4
CC 16	Organic Chemistry-VI: Organic Spectroscopy and Biomolecules	4			4
CC 17	Inorganic Chemistry-V: Organometallic Compounds-I & II, Metal Carbonyls, Bioinorganic Chemistry and Reaction Kinetics and Mechanism	4			4
CC 18	Industrial Chemistry	2			4
	Industrial Chemistry LAB			4	
NM 5	MINOR- IV-Selected by the Candidate	4			4
Total		**Teaching Hour = 22**			**Credit = 20**

Semester 8:

Category	Course Name	Teaching Scheme			Credit
		L	T	P	
Semester-VIII					
CC 19	Physical Chemistry-VI	4			4
CC 20	Inorganic Chemistry-VI	4			4
Project/ Courses	Project/ (Organic Synthesis and Medicinal Chemistry + Special Course-2 + Special Course-3)	0/ (4+ 4+ 4)		24/0	12/ (4+ 4+ 4)
Total		**Teaching Hour = 32/20**			**Credit = 20**

Program Outcomes (PO)

PO-1: Disciplinary knowledge and skill: A graduate student will acquire considerable knowledge in all disciplines of chemistry and expected to develop skills in all aspects of theoretical and practical chemistry.

PO-2: Skilled communicator: The course curriculum incorporates basics and advanced training in order to make a graduate student capable of expressing the subject through technical writing as well as through oral presentation.

PO-3: Critical thinker and problem solver: The course curriculum also includes components that can be helpful to graduate students to develop critical thinking and to design, carry out, record and analyse the results of chemical reactions. Students will develop inquisitive characteristics and sense of inquiry and be able to think and apply evidence based comparative chemistry approach to explain chemical synthesis and analysis.

PO-4: Skilled project manager with Digital proficiency: The course curriculum has been designed in such a manner as to enabling a graduate student to become a skilled project manager by acquiring knowledge about chemistry project management, writing, planning, study of ethical standards and rules and regulations pertaining to scientific project operation. They will also acquire working knowledge in understanding and carrying out data analysis, use of library search tools, use of chemical simulation software and related computational work.

PO-5: Ethical awareness: A graduate student requires understanding and develop ethical awareness or reasoning which is adequately provided through the course curriculum. Students can also create an awareness of the impact of chemistry on the environment, society, and also make development outside the scientific community.

PO-6: Environmental awareness: As an inhabitant of this green planet a Chemistry graduate student should have many social responsibilities. The course curriculum isdesigned to teach a Chemistry graduate student to follow the green routes for the synthesis of chemical compounds and also find out new greener routes for sustainable development. The course also helps them to understand the causes of environmental pollution and thereby applying environmental friendly policies instead of environmentally hazard ones in every aspect.

PO-7: Lifelong learner: The course curriculum is designed to inculcate a habit of learning continuously through use of advanced ICT technique and other available e- techniques, e-books and e-journals for personal academic growth.

PO-8: Analytical skill development and job opportunity: The course curriculum is designed in such a way that Chemistry graduate students can handle many Chemistry based software, decent instruments and advanced technologies to synthesize, characterize and analyse the chemical compounds very skilfully. They can also act as a team player by contributing in laboratory, field

based situation and industry. Such a wonderful practice in the graduate level will bring a good opportunity to the students for getting job in industries besides academic and administrative works. Moreover, in-depth understanding of chemistry together with societal needs for chemical solutions will encourage them to build start-ups and become job creators themselves.

Detailed Syllabus

First Semester

CC-1: Fundamentals of Chemistry

(Credits: 4; Lecture – 02, Tutorial – 00, Practical - 02)

Component: Theory Fundamentals of Chemistry Credits: 2

(30 Lectures)

Unit 1: Inorganic Chemistry **10 L**

Atomic Structure:

Wave-Particle duality; de Broglie hypothesis. Heisenberg's uncertainty principle. Introducing Schrödinger equation. Hydrogen and hydrogen like systems (detailed solution not required). Concept of Atomic Orbital; shapes of s, p and d orbitals. Radial and angular distribution curves. Extension to multielectronic systems. Aufbau principle and its limitations; Pauli's exclusion principle; Hund's rules and multiplicity. Effective nuclear charge. Shielding and penetration; Slater's rule.

Concept of Periodic Table:

The general idea about modern periodic table, atomic and ionic radii, ionization energy, electron affinity and electronegativity –definition, trends of variation in periodic table and their application in explaining and predicting the chemical behavior of elements and compounds. Electronegativity scales (Pauling's, Mulliken's and Allred-Rochow's scales). Inert pair effect.

Unit 2: Organic Chemistry **10 L**

Organic Compounds: Structure and Bonding:

Classification and Nomenclature. Hybridization of orbitals and types of hybridization; Influence of hybridization on bond properties; Shapes of molecules: methane, ethane, ethylene, acetylene, water and carbon dioxide; Important bond parameters: Bond Length, Bond Angles, Bond Energy.

Electronic Displacements and Polarity of bonds:

Inductive, resonance, electromeric, mesomeric, hyperconjugation effects, H-bond and their applications; Dipole moment, Homolytic and heterolytic bond breaking, concepts of organic acids and bases, effect of structure, substituents and solvents on acidity & basicity (comparison between nucleophilicity & basicity).

Reaction intermediates and types of organic reactions:

Types of organic reactions: substitution, addition, elimination, rearrangement, radical, redox, Types of reagents: electrophiles and nucleophiles, comparison between acidity and basicity.

Reaction intermediates and their relative stability: Carbocations, Carbanions, Free radicals, Carbenes and Benzynes.

Unit 3: Physical Chemistry **10 L**

Thermodynamics-I

System and Surrounding; Different types of system, boundary; Thermodynamic functions – path function, state fuction; Euler's theorem and its applications - Exact and inexact differentials. Types of processes; Concept of; Zeroth law of Thermodynamics, 1^{st} law of thermodynamics, Concept of Heat capacities (C_p and C_v)

Chemical Kinetics-I

Introduction to Rate law; Concept of order and molecularity; advancement of a reaction; differential and integrated form of rate expressions up to second order reactions; Determination of order of a reaction by different methods

Electrochemistry-I

Conductance and measurement of conductance; cell constant, specific and equivalent conductance, molar conductance. Oxidation/reduction of ions based on half-cell potentials; Chemical cells, reversible and irreversible cells; Electromotive force of a cell and its measurement, Nernst equation.

Reference books:

1. Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London.
2. Concepts & Models of Inorganic Chemistry, Douglas, B.E. and McDaniel, D.H. Oxford, 1970.
3. Inorganic Chemistry: Principles of Structure and Reactivity by James E. Huheey, Keiter, E.A., Keiter, R.L. and Medhi, O.K; Publisher: Pearson Education India
4. Theoretical Inorganic Chemistry, Day, M.C. and Selbin, J. ACS Publications, 1962.
5. Inorganic and Solid State Chemistry, Rodger, G.E. Cengage Learning India Edition, 2002.
6. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995), John Wiley & Sons, New York.

7. Advanced Inorganic Chemistry (Vol-I, Vol-II); Satya Prakash G. D Tuli S. K Basu R. D Madan; Publisher : S Chand And Company Ltd

8. General and Inorganic Chemistry (Volume-I, Volume-II) by by Ramaprasad Sarkar Publisher: New Central Book Agency

9. A History of Hindu Chemistry: From the Earliest Times to the Middle of the Sixteenth Century A. D with Sanskrit Texts, Variants, Translation and Illustrations by Praphulla Chandra Ray

Component: Lab **Fundamentals of Chemistry** **Credits: 2**

(*Experiments will be conducted based on availability of apparatus and reagents*)

(60 Lectures)

1. pH measurements, buffer preparation and Molarity Concept: pH Range: 9-10: ammonium chloride/ammonium hydroxide buffer.
2. General acid base titration with suitable indicator.
3. Conductometric titration of weak acid *Vs* weak base.
4. Strength comparison of different stomach antacids (active ingredients).
5. General acid base titration with suitable indicator.
6. Preparation of Phenol-formaldehyde resin.

Reference Books

1. Subhash C Das, *Advanced Practical Chemistry*, (2012)
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.*, Pearson (2012).
4. Nad, A. K., Mahapatra, B., Ghoshal, A; An Advanced Course in Practical Chemistry, New Central Book Agency Pvt. Ltd.

Course Outcomes:

After completion of the course, the students will:

CO1: Understand the development of periodic table, properties of s-, p-, d- and f-block elements, periodic properties, assignment of electronic configuration and various models of atomic structures.
CO2: Understand the hybridisation of orbitals, shape of certain molecules based on hybridisation, influence of hybridisation on different types of bond properties.
CO3: Build knowledge on Inductive effect, resonance, mesomeric effect, hyperconjugation and dipole moment. Also learn about different types of organic reactions and the types of intermediates they involve as well as different types of attacking reagents.
CO4: Understand the basics of Thermodynamics like path function, state function as well as gain preliminary of Zeroth and First law of Thermodynamics.

CO5: Understand the rate law, order and molecularity of a reaction. They will also learn about specific and equivalent conductance, different types of electrochemical cells and Nernst equation as well.

CO6: Estimate pH of unknown solutions and conduct different types of acid-base titrations to estimate strength of unknown acidic/ basic solution.

Organic Chemistry Syllabus

Second Semester

CC-4: Organic Chemistry I

Stereochemistry and Aliphatic Hydrocarbons

(Credits: 4; Lecture – 02, Tutorial – 00, Practical – 02)

Component: Theory **Organic Chemistry I** **Credits: 2**

(30 Lectures)

Unit 1 - Stereochemistry **16 L**

Introduction, Chirality, Concepts of Isomerism, Types of Isomerism: Structural and Stereoisomerism, tautomerism.

(R) and (S), (D), (L) (particularly with respect to carbohydrates and amino acids), Nomenclature of asymmetric carbon atoms.

Optical Isomerism or Enantiomerism, Optical Activity

Biological discrimination of enantiomers.

Racemic mixtures, Enantiomeric excess, Racemization, Resolution, Optical purity.

Fischer Projections and their use.

Diastereomers, stereochemistry of molecules with two or more asymmetric carbons.

Topicity of molecules.

Geometrical isomerism: cis–trans and, syn-anti isomerism and E/Z notations,

Conformational analysis of ethane and n-butane,

Conformation analysis of alkanes: Relative stability,

Unit 2: Chemistry of Aliphatic Hydrocarbons: **14 L**

Carbon-Carbon sigma bonds: Reaction Mechanism and Importance

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

Carbon-Carbon pi bonds: Reaction Mechanism and Importance

Reactions of alkenes: Electrophilic additions their mechanisms (Markovnikov/ Anti Markovnikov addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition

reactions in conjugated dienes; Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

Reference Books:

1. Organic Chemistry, 8th Edition by Leroy G. Wade, Junior, Pearson.
2. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press.
4. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
7. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
8. R. L. Madan, Organic Chemistry (For B.Sc. I, II, III Year), S. Chand.

Component: Lab **Organic Chemistry I** **Credits: 2**

(60 Lectures)

(*Experiments will be conducted based on availability of apparatus and reagents*)

1. Determination the melting points of the unknown organic compounds (electrically heated melting point apparatus)
2. Effect of impurities on the melting point – mixed melting point of two unknown organic compounds.
3. Identification of organic compounds by performing different tests:
   a) Benzoic acid
   b) Oxalic acid
   c) Acetic acid
   d) Salicylic acid
   e) Tartaric Acid
   f) Phenol
   g) Chloroform
   h) Ethanol
   i) Methanol
   j) Urea
   k) Aniline
4. Determination of boiling point of liquid compounds. (boiling point lower than 100° C by distillation and capillary method)

Reference Books

1. Furniss, B. S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R., Vogel's Textbook Of Practical Organic Chemistry, *5th Ed.*, Pearson (2016).
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
3. Subhash C Das, *Advanced Practical Chemistry*, (2012).
4. Nad, A. K., Mahapatra, B., Ghoshal, A; An Advanced Course in Practical Chemistry, New Central Book Agency Pvt. Ltd., (2022).

Course Outcomes:

After completion of the course, the students will:

CO1: Understand optical isomerism, optical activity, biological and chemical discrimination of enantiomers, racemic mixtures, enantiomeric excess, racemization, resolution, optical purity, and diastereomerism. Further they will learn about topicity of molecules and geometrical isomerism.
CO2: Interpret chirality, types of Isomerism: Structural and Stereoisomerism, tautomerism. Also, (R) and (S), (D), (L) (particularly with respect to carbohydrates and amino acids) nomenclature of asymmetric carbon atoms.
CO3: Determine different types of Carbon-Carbon sigma bonds and Carbon-Carbon pi bonds forming reactions and acquire knowledge to explain the reaction mechanisms.
CO4: Analyze electrophilic additions to alkenes/ alkynes and their mechanisms including Markovnikov/ Anti Markovnikov addition.
CO5: Understand the mechanism of oxymercuration-demercuration, hydroboration oxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes; and different reactions of alkynes.
CO6: Analyze different common organic compounds by a variety of physical and chemical methods.

CO-PO Mapping (Highly Correlated: **3,** Moderately Correlated**: 2,** Slightly Correlated: **1)**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	-	2	-	-	-	2	2
CO2	2	-	2	-	-	-	2	1
CO3	2	-	2	-	-	-	2	1
CO4	3	1	1	-	-	-	2	-
CO5	3	2	3	2	-	-	3	2
CO6	2	-	2	2	2	1	2	2
Avg	2.50	0.50	2.00	0.67	0.33	0.17	2.17	1.33

Third Semester

CC-6: Organic Chemistry II

Chemistry of Aromatic and Halogenated Hydrocarbons

(Credits: 4; Lecture – 02, Tutorial – 00, Practical – 02)

Component: Theory **Organic Chemistry II** **Credits: 2**

(30 Lectures)

Unit 1: Chemistry of Halogenated Hydrocarbons: Substitution and Elimination Reaction mechanisms **20 L**

Alkyl halides:

Methods of preparation, nucleophilic substitution reactions – S_N1, S_N2, S_Ni mechanisms with stereo chemical aspects and Neighbouring group participation, anchimeric assistance;

Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

Nucleophilic substitution vs. elimination.

Organometallic compounds:

Mg and Li – Use in synthesis of organic compounds.

Unit 2 – Chemistry of Aromatic Hydrocarbons **10 L**

Aromaticity:

Hückel's rule, aromatic character of arenes, aromaticity of 5 and 6 membered rings containing one hetero atom, antiaromaticity, nonaromaticity, homoaromaticity, annulenes, cyclic carbocations/carbanions, polycyclic aromatic hydrocarbons and heterocyclic compounds with suitable examples.

Electrophilic aromatic substitution:

Halogenation, Nitration, Sulphonation and Friedel-Craft's alkylation/acylation with their mechanism.

Addition-Elimination reactions & Elimination-Addition reactions (Cine substitution reaction):

Nucleophilic aromatic substitution; S_NAr, Benzyne mechanism.

Reference Books:

1. Wade, L. G. (Junior) Organic Chemistry, 8th Edition, Pearson.
2. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press.
3. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
5. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

Component: Lab **Organic Chemistry II** **Credits: 2**

(60 Lectures)

(*Experiments will be conducted based on availability of apparatus and reagents*)

1. Lassaigne's tests of special elements (N, S, X) for different organic compounds.
2. Functional group tests for:
   a) Alcohols (aliphatic -OH): Esterification test
   b) Phenols (aromatic -OH): $FeCl_3$ test, Back dye test
   c) Carbonyl groups (aldehydes and ketones): 2,4-DNP test, Tollens's test, Fehling's test
   d) Carboxylic acid groups: Sodium bi-carbonate test, Esterification test, $FeCl_3$ test
   e) Ester group: Hydrolysis test, Hydroxamic acid test
   f) Aromatic Primary amine: Dye test
   g) Secondary Amine: Liebermann's Test
   h) Tertiary Amine: Potassium Ferrocyanide Test
   i) Anilido groups: Dye test (after hydrolysis), Tafel's test ($KMnO_4$ test)
3. Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds)

Reference Books:

1. Furniss, B. S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R., Vogel's Textbook Of Practical Organic Chemistry, *5th Ed.*, Pearson (2016).
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009).
3. Subhash C Das, *Advanced Practical Chemistry*, (2012).
4. Nad, A. K., Mahapatra, B., Ghoshal, A; An Advanced Course in Practical Chemistry, New Central Book Agency Pvt. Ltd., (2022).

Course Outcomes:

After completion of the course, the students will:

CO1: Understand different types of nucleophilic substitution reactions with mechanisms and stereo chemical aspects and effect of solvents.
CO2: Evaluate mechanism of E1, E2, E1cb reactions; Saytzeff and Hofmann eliminations.
CO3: Understand the concept of aromaticity, antiaromaticity, nonaromaticity, homoaromaticity in the context of monocyclic and polycyclic aromatic hydrocarbons, annulenes and heterocyclic compounds.
CO4: Explain different electrophilic aromatic substitution reactions with their mechanisms, namely: Halogenation, Nitration, Sulphonation and Friedel-Craft's alkylation/acylation. Also learn nucleophilic aromatic substitution and Benzyne mechanism.
CO5: Identify special elements (N, S, X) for different organic compounds by Lassaigne's tests.
CO6: Examine the laboratory methods of qualitative analysis of known and unknown organic compounds containing simple functional groups namely alcohols, carboxylic acids, phenols and carbonyl compounds**.**

CO-PO Mapping (Highly Correlated: **3,** Moderately Correlated**: 2,** Slightly Correlated: **1)**

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**
CO1	3	-	2	2	-	-	2	1
CO2	3	-	-	3	-	-	3	1
CO3	3	-	2	2	-	-	2	1
CO4	2	-	-	2	-	-	2	2
CO5	2	-	-	2	2	-	2	2
CO6	2	2	1	2	2	2	2	2
Avg	2.50	0.33	0.83	2.17	0.67	0.33	2.17	1.50

Fourth Semester

CC-8: Organic Chemistry III

Alcohols, Phenols, Carbonyl Compounds and Carboxylic Acids

(Credits: 4; Lecture – 02, Tutorial – 00, Practical – 02)

Component: Theory **Organic Chemistry III** **Credits: 2**

(30 Lectures)

Unit 1: Alcohols, Ethers, Epoxides, and Phenols: **12 L**

Alcohols:

preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Preparation and properties of glycols: Pinacol-Pinacolone rearrangement.

Ethers and Epoxides: Methods of Preparation and Reaction Mechanism

Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$

Phenols:

Preparation and properties; Cumene process, Dakin reaction, Reimer-Tiemann reaction, Ring substitution reactions, Kolbe's–Schmidt Reactions, Fries Rearrangement.

Unit 2: Carbonyl Compounds: **12 L**

Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, noevenagel condensation, Claisan-Schmidt, Perkin, Cannizzaro and Wittig reaction, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV; Addition reactions of unsaturated carbonyl compounds: Michael addition.

Unit 3 : Carboxylic Acids and their Derivatives: **6 L**

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Claisen condensation.

Reference Books:

1. Wade, L. G. (Junior) Organic Chemistry, 8th Edition, Pearson.
2. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry,* Oxford University Press.
4. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
5. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

Component: Lab **Organic Chemistry III** **Credits: 2**

(60 Lectures)

(*Experiments will be conducted based on availability of apparatus and reagents*)

1. Hydrolysis of amides (Benzamide).
2. Hydrolysis of esters (methyl/ propyl benzoate).
3. Semicarbazone of the following compounds:
    a) acetone,
    b) ethyl methyl ketone,
    c) cyclohexanone,
    d) benzaldehyde.
4. Iodoform reaction of Alcohols, aldehydes and ketones.
5. Reduction of nitro group and dye test.
6. Preparation of *meta*-dinitrobenzene from nitrobenzene.
7. Preparation of *para*-bromoacetanilide from acetanilide.

Reference Books:

1. Furniss, B. S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R., Vogel's Textbook Of Practical Organic Chemistry, *5th Ed.*, Pearson (2016).
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)
3. Subhash C Das, *Advanced Practical Chemistry*, (2012)
4. Nad, A. K., Mahapatra, B., Ghoshal, A; An Advanced Course in Practical Chemistry, New Central Book Agency Pvt. Ltd., (2022).

Course Outcomes:

After completion of the course, the students will:

CO1: Illustrate different preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Phenols, Ethers and Epoxides.

CO2: Understand nucleophilic addition-elimination reactions of carbonyl compounds, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions.

CO3: Interpret oxidation and reduction reactions of carbonyl compounds (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PCC and PDC); and addition reactions of unsaturated carbonyl compounds.

CO4: Understand typical reactions of monocarboxylic and dicarboxylic acids, hydroxy acids and unsaturated acids namely succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids;

CO5: Evaluate preparation and reactions of acid chlorides, anhydrides, esters and amides; Claisen condensation, Reduction with DIBAL-H.

CO6: Demonstrate one-step synthesis and reactions of common organic molecules using traditional methods.

Fifth Semester

CC-10: Organic Chemistry IV

Heteroatom Chemistry, Rearrangement and Pericyclic Reactions

(Credits: 04; Lecture – 04, Tutorial – 00, Practical-00)

Component: Theory **Organic Chemistry IV** **Credits: 4**

(60 Lectures)

Unit 1: Nitrogen Containing Functional Groups: **16 L**

Preparation and important reactions of nitro and compounds, nitriles and isonitriles Amines: Effect of substituent and solvent on basicity; Preparation, reaction mechanism and properties: Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hofmann-elimination reaction (Hoffmann's exhaustive methylation), Diazonium Salts: Preparation and their synthetic applications, Group Migration from N to Phenyl ring. Enamine reactions.

Unit 2: Rearrangement Reactions: Reaction Mechanism and Importance **14 L**

Hofmann Rearrangement, Curtius and Lossen-Schmidt rearrangement, Beckmann, Benzilic acid rearrangement, Dienone-Phenol rearrangement, Wagner-Meerwin rearrangement, Wolff rearrangement in Arndt-Eistert reaction, Favorskii rearrangement, Demjanov rearrangement, Tiffneau-Demjanov rearrangement, benzidine-semidine rearrangement, Bamberger rearrangement. Orton rearrangement.

Unit 3: Heterocyclic Compounds: **18 L**

Classification and nomenclature, Structure, Synthesis, reactions and mechanism of substitution reactions of: Furan, Pyrrole, Thiophene, Pyridine, indole, quinoline, isoquinoline.

Unit 4: Pericyclic Reactions **12 L**

Diels Alder cycloaddition reaction: Dienophile, Diene, Regiochemistry, Stereochemistry, Intramolecular DA reactions, Retro DA reaction, Asymmetric DA reactions.

[2+2] cycloaddition reaction

[3,3] sigmatropic rearrangement: Cope rearrangement, Claisen rearrangement,

[1,3] and [1,5] proton shift.

Electrocyclic reactions

Reference Books:

1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry,* Oxford University Press.
3. Wade, L. G. (Junior) Organic Chemistry, 8th Edition, Pearson.
4. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
6. Finar, I. L. *Organic Chemistry (Volume 1),* Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.

Course Outcomes:

After completion of the course, the students will:

CO1: Understand about the synthesis and reactions of nitro, nitriles and isonitriles,

CO2: Illustrate synthesis and different reactions of amino compounds including Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hofmann-elimination reaction and diazo coupling.

CO3: Demonstrate classification and nomenclature of heterocycles. Also learn about the synthesis, reactions and mechanism of substitution reactions of Furan, Pyrrole, Thiophen, Pyridine, Pyrimidine, indole, quinoline and isoquinoline.

CO4: Evaluate different types of rearrangement reactions involving amines like Hofmann Rearrangement, Curtius, Lossen and Schmidt rearrangement.

CO5: Interpret several miscellaneous rearrangement reactions including Beckmann, Benzilic acid rearrangement, Dienone-Phenol rearrangement, Wagner-Meerwin rearrangement, Wolff rearrangement in Arndt-Eistert reaction, Favorskii rearrangement, Demjanov rearrangement and Tiffneau-Demjanov rearrangement.

CO6: Evaluate different aspects of pericyclic reactions including electrocyclic, cycloaddition and sigmatropic reactions.

Sixth Semester

CC-14: Organic Chemistry V

Cycloalkane Conformations and Carbohydrates

(Credits: 4; Lecture – 02, Tutorial – 00, Practical – 02)

Component: Theory **Organic Chemistry V** **Credits: 2**

(30 Lectures)

Unit 1 - Conformational Isomerism of cycloalkanes **12 L**

Axial and Equatorial bonds.

Atropisomerism and axial chirality with respect to Biphenyl, Allene and spiro compounds.

Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

Unit 2: Carbohydrates: **14 L**

Occurrence, classification and their biological importance.

Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimers and anomers, mutarotation, determination of ring size of glucose and fructose, Haworth projections and conformational structures; Reactions of Monosaccharides: side reactions in Base, Reduction of Monosaccharides, Chain shortening: The Ruff degradation, Chain lengthening: The Kiliani-Fischer Synthesis

Disaccharides: Structure elucidation of maltose, lactose and sucrose.

Polysaccharides: Elementary treatment of starch, cellulose and glycogen.

Unit 3: Polynuclear Hydrocarbons: **4 L**

Reactions and mechanism of preparations of naphthalene phenanthrene and anthracene Structure, Preparation and structure elucidation and important derivatives of naphthalene and anthracene.

Reference Books:

1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).
2. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press.
3. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
4. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
5. Carruthers. W; Modern methods of Organic Synthesis. Cambridge University Press.
6. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
8. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.

Component: Lab Organic Chemistry V Credits: 2

(60 Lectures)

(*Experiments will be conducted based on availability of apparatus and reagents*)

1. Qualitative tests for identification of Carbohydrates –Molisch's test
2. Identification of monosaccharaides and reducing disaccharides- Barfoed's test
3. Detection of reducing sugar-Benedict's test
4. Separation of amino acids by thin layer chromatography.
5. Quantitative analysis of Phenol by bromination method.
6. Quantitative analysis of Aniline by bromination method.
7. Preparation of Benzopinacol from benzophenone.
8. Preparation of Benzyl alcohol from Benzaldehyde using Cannizaro reaction.
9. Preparation of *para*-nitrophenol from *para*-nitroaniline.

Reference Books:

1. Furniss, B. S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R., Vogel's Textbook Of Practical Organic Chemistry, *5th Ed.*, Pearson (2016).
2. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009).
3. Subhash C Das, *Advanced Practical Chemistry*, (2012)
4. Nad, A. K., Mahapatra, B., Ghoshal, A; An Advanced Course in Practical Chemistry, New Central Book Agency Pvt. Ltd., (2022).

Course Outcomes:

After completion of the course, the students will:

CO1: Understand the axial chirality and assignment of configuration of Biphenyls, Allenes and spiro compounds.

CO2: Interpret energy diagrams of cyclohexanes and relative stability of Chair, Boat and Twist boat forms.

CO3: Explain occurrence, classification and biological importance of carbohydrates. Also learn about the wide variety of reactions associated with them.

CO4: Analyze amino acid and carbohydrates through different qualitative methods.

CO5: Estimate amount of Phenol and Aniline by bromination method.

CO6: Demonstrate the preparation of chalcones and nitrophenol.

Seventh Semester

CC-17: Organic Chemistry VI

Organic Spectroscopy and Biomolecules

(Credits: 4; Lecture – 04, Tutorial – 00, Practical – 00)

Component: Theory **Organic Chemistry VI** **Credits: 4**

(60 Lectures)

Unit 1: Organic Spectroscopy I **24 L**

UV-Visible Spectroscopy and its Application in Producing Colour:

Types of electronic transitions, λ_{max}, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward Rules for calculation of λmax for the following systems: α,β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

Colour and Chemistry of Dyes: Methyl Orange, Congo Red, Malachite Green Crystal Violet, Phenolpthalein.

IR Spectroscopy:

Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.

Unit 2: Organic Spectroscopy II **16 L**

NMR Spectroscopy:

Basic principles of Proton Magnetic Resonance, chemical shift and factors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simple compounds.

Introduction to ^{13}C-NMR spectroscopy, Chemical shifts and spin-spin decoupling.

Applications of IR, UV and NMR for identification of simple organic molecules.

Unit 3: Biomolecules **20 L**

Nucleic acids:

Pyrimidine and purine bases (only structure and nomenclature), nucleosides, nucleotides corresponding to DNA and RNA; Basic idea about Watson-Crick model: double helical structure of DNA; base–pairing in DNA.

Amino acids, Peptides and Proteins:

Amino acids: classification, structure and properties; Zwitterions; Isoelectric point (pI); pKa values; α-Amino Acids: synthesis and reactions with detailed mechanism-synthesis:

Peptide synthesis: synthesis strategies using N-protection & C-protection, Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis.

Structure of Proteins: Primary, secondary, tertiary, quaternary structures of proteins, classification of proteins, denaturation of proteins.

Lipids:

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils.

Reference Books:

1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry (Volume 1),* Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press.
5. Banwell, C.N.; McCash, E.M. Fundamentals of Molecular Spectroscopy, 4th Edition, India Edition, Tata McGraw-Hill, India.
6. Berg, J.M., Tymoczko, J.L. & Stryer, L. (2006) *Biochemistr*y. 6th Ed. W.H. Freeman and Co.
7. Nelson, D.L., Cox, M.M. & Lehninger, A.L. (2009) *Principles of Biochemistry. IV Edition.* W.H. Freeman and Co.
8. Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2009) *Harper's Illustrated Biochemistry.* XXVIII edition. Lange Medical Books/ McGraw-Hill.

9. Kalsi, P.S. *Spectroscopy of Organic Compounds*, Seventh Edition, New Age Publications, India.

Course Outcomes:

After completion of the course, the students will:

CO1: Understand concept of interaction of electromagnetic radiation with molecules that give rise to the spectroscopy so important for identification/ structural analysis of organic molecules.

CO2: Develop theoretical knowledge and acquire knowledge on applications of important spectroscopic techniques namely UV-visible and Infrared spectroscopy.

CO3: Evaluate Colour and Chemistry of Dyes including Methyl Orange, Congo Red, Malachite Green Crystal Violet, Phenolpthalein.

CO4: Demonstrate the concept of Nuclear Magnetic Resonance spectroscopy and its importance to determine the structure of complex organic molecules.

CO5: Understand the classification, structure and properties of amino acids, peptides and proteins.

CO6: Illustrate the chemistry of nucleic acids.

Eighth Semester

Special Courses

Organic Synthesis and Medicinal Chemistry

(Credits: 4; Lecture – 04, Tutorial – 00, Practical – 00)

Component: Theory **Special Course-I** **Credits: 4**

(60 Lectures)

Unit 1: Disconnection Approach for Synthesis of Complex Organic Molecules **12 L**

Basic principles, guidelines for disconnection with special emphasis on chemo-selective, regioselective, stereoselective and stereospecific reactions, Umpolung reactivity, functional group inter conversion, designing total synthesis of some target molecules with proper retrosynthetic analysis: Menthol, Penicillin V etc.

Unit 2: Olefin Metathesis **6 L**

Grubbs Reaction, Schrock Carbene, Fischer Carbene.

Unit 3: Natural Products **20 L**

Terpenoids, Alkaloids, Natural Pigments, Steroids, Hormones, Structure elucidation methods associated with Natural Products (Chemical & Spectroscopic method): Citral, Morphine, Estrone, Biosynthesis of some Natural Products.

Unit 4: Medicinal Chemistry & therapeutic drugs **22 L**

Definition, classification and mechanism of action of different dru; Pro-drug, agonist, antagonist.

Synthesis of analgesic, antipyretic and anti-inflammatory drugs: paracetamol, aspirin, etc.

Introduction and Classification of antibiotics (Penicillins, tetracyclines), newer generation of antibiotics (chloramphenicol, norfloxacilin)

Drugs in the treatment of angina, hypertension, and drugs acting on central nervous systems: amlodipine, diazepam, phenobarbital, phenytoin, valproic acid and L-dopa.

Reference Books:

1. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry (Volume 1),* Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
3. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, Oxford University Press.
4. Carruthers. W; Modern methods of Organic Synthesis. Cambridge University Press.
5. Chatwal, G. R.; Organic Chemistry of Natural Products, Himalaya Publishing House.

Course Outcomes:

After completion of the course, the students will:

CO1: Understand retrosynthesis of organic molecules. Also gain knowledge of total synthesis of important complex organic molecules.

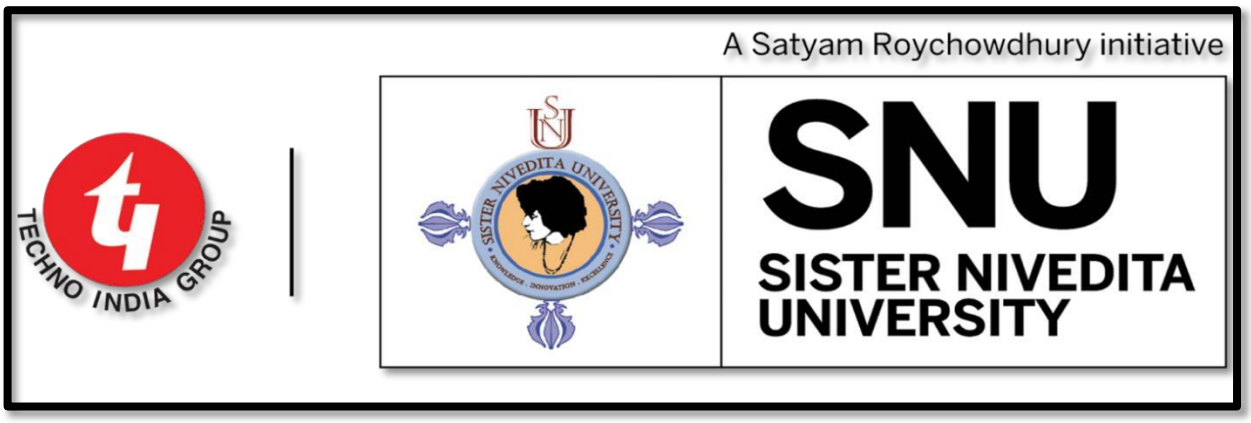
CO2: Illustrate Olefin Metathesis in the light of Grubbs Reaction, Schrock Carbene and Fischer Carbene.

CO3: Develop knowledge about the structure elucidation, properties and reactions of Terpenoids, Alkaloids, Natural Pigments, Steroids, Hormones.

CO4: Demonstrate the Biosynthesis of some important natural products.

CO5: Evaluate classification and mechanism of action of different drugs, Pro-drugs, agonists and antagonists.

CO6: Illustrate the synthesis of analgesic, antipyretic, anti-inflammatory drugs and antibiotics.



Four-Year B.Sc

(Honours and Honours with Research)
Course of Studies

(Under Curriculum & Credit framework, 2022)

SYLLABUS

for

CHEMISTRY

Vice-Chancellor,
Sister Nivedita
University

Subject Expert

Raj K Datta

Chief General Manager - Product Development, Technical Support & QA

Haldia Petrochemicals Limited

Industry Expert

Head of the Department,
Chemistry, SNU

Inorganic Chemistry Syllabus

First Semester

CC-2: Inorganic Chemistry I

Chemical Bonding- I, Acids and Bases, and Daily life Chemistry

(Credits: 4; Lecture – 02, Tutorial – 00, Practical - 02)

Component: Theory **Inorganic Chemistry I** **Credits: 2**

(30 Lectures)

Unit 1: Chemical Bonding-I **12 L**

(i) **Ionic bond:** General characteristics, types of ions, size effects, radius ratio rule and its application and limitations. Packing of ions in crystals. Born-Landé equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy.

(ii) **Covalent bond:** Polarizing power and polarizability, ionic potential, Fazan's rules. Lewis structures, formal charge. Valence Bond Theory. Hybridization. Dipole moments, VSEPR theory, shapes of molecules and ions containing lone pairs and bond pairs and multiple bonding

(iii) **Metallic Bond:** Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids

(iv) **Weak Chemical Forces:** Hydrogen bonding, receptor-guest interactions, Halogen bonds, Effects of chemical force, melting and boiling points.

Unit 2: Acids and Bases: **6 L**

Concept of Acids and Bases, Arrhenius theory, Theory of solvent system, Bronsted-Lowry's concept; relative strength of acids; Relative strength of acids; Pauling's rules; Lewis acid-base concept, Super acid; Characteristics of Lewis acids; Concept of pH, pK_a, pK_b. pK_w, Buffer-strength, buffer capacity; Acid-base neutralisation curves; Indicators, choice of indicators.

Unit 3: Daily life Chemistry **12 L**

Oils and fats:

Composition of edible oils, detection of purity, rancidity of fats and oil. Tests for adulterants like

argemone oil and mineral oils. Halphen test.

Soaps & Detergents:

Definition, classification, manufacturing of soaps and detergents, composition and uses

Artificial food colorants:

Coal tar dyes and non-permitted colors and metallic salts. Analysis of pesticide residues in food

Chemical and Renewable Energy Sources:

Principles and applications of primary & secondary batteries and fuel cells. Basics of solar energy, future energy storer.

Polymers:

Basic concept of polymers, classification and characteristics of polymers. Applications of polymers as plastics in electronics, automobile components, medical fields and aerospace materials. Problems of plastic waste management. Strategies for the development of environment-friendly polymers

TEXT BOOKS:

1. Concise Inorganic Chemistry, J. D. Lee, 5th Edition (1996), Chapman & Hall, London.
2. Concepts & Models of Inorganic Chemistry, Douglas, B.E. and McDaniel, D.H. Oxford, 1970.
3. Theoretical Inorganic Chemistry, Day, M.C. and Selbin, J. ACS Publications, 1962.
4. Inorganic and Solid State Chemistry, Rodger, G.E. Cengage Learning India Edition, 2002.

REFERENCE BOOKS:

1. Basic Inorganic Chemistry, F. A Cotton, G. Wilkinson, and Paul L. Gaus, 3rd Edition (1995), John Wiley & Sons, New York.
2. Inorganic chemistry: principles of structure and reactivity. Huheey, J.E., Keiter, E.A., Keiter, R.L. and Medhi, O.K., 2006. Pearson Education India.
3. A History of Hindu Chemistry: From the Earliest Times to the Middle of the Sixteenth Century A. D with Sanskrit Texts, Variants, Translation and Illustrations by Praphulla Chandra Ray
4. Advanced Inorganic Chemistry (Vol-I, Vol-II); Satya Prakash G. D Tuli S. K Basu R. D Madan; Publisher : S Chand And Company Ltd
5. General and Inorganic Chemistry (Volume-I, Volume-II) by by Ramaprasad Sarkar Publisher: New Central Book Agency

Component: Lab Inorganic Chemistry I Credits: 2

(*Experiments will be conducted based on availability of apparatus and reagents*)

1. Qualitative semi micro analysis of mixtures containing 2 anions and 2 cations. The students should understand the underlying chemical reactions.

Cation radicals:

Na^{+}, K^{+}, NH_4^{+}, Mg^{2+}, $Ca^{2+,}$ Sr^{2+}, Ba^{2+}, $Al^{3+,}$ $Pb^{2+,}$ $Bi^{3+,}$ $Cr^{3+,}$ $Mn^{3+,}$ $Fe^{2+/3+,}$ $Co^{2+/3+,}$ Ni^{2+}, $Cu^{2+,}$ $Zn^{2+,}$ Cd^{2+} , $Sn^{2+/}Sn^{4+}$, As^{3+}/As^{5+}

Anion radicals:

F^{-}, CI^{-}, Br^{-}, I^{-}, NO_3^{-}, NO_2^{-}, SCN^{-}, S^{2-}, $SO_4^{2-,}$ $S_2O_3^{2-}$, PO_4^{3-}, BO_3^{3-}, CrO_4^{2-}, BrO^{3-}, IO^{3-}, $[Fe(CN)_6]^{4-,}$ $[Fe(CN)_6]^{3-}$

Insoluble Materials:

Al_2O_3(ig), Fe_2O_3(ig), Cr_2O_3(ig), SnO_2, $SrSO_4$, $BaSO_4$, CaF_2, $PbSO_4$.

TEXT BOOKS:

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS. 1978
2. Marr, G. and Rockett, R.W. Practical Inorganic Chemistry, Van Nostrand Reinhold. 1972.
3. An Advanced Course In Practical Chemistry by A K Nad, B Mahapatra, A Ghoshal; Publisher: New Central Book Agency Pvt. Ltd.
4. Practical Inorganic Chemistry by Shikha Gulati, JL Sharma and Shagun Manocha Publisher: CBS Publisher & Distributors Pvt. Ltd.

Course outcome:

CO1: State and **explain** students about the fundamental concepts of bonding in various molecules and metals and **Compare** among the different types intra and inter molecular bonds.

CO2: Illustrate about various concepts of acids and bases.

CO3: Understand and **compare** the concept of pH, pK_a, pK_b. pK_w, Buffer-strength, buffer capacity.

CO4: To **develop** an **understanding** among students for chemicals used in daily life and the chemistry involved

CO5: Illustrate different source of alternative energy and inorganic polymers and their uses.

CO6: Illustrate students about the qualitative analysis and **interpret** the **identification of** cations and anions in a given inorganic mixture through quantitative chemical **analysis.**

Third Semester

CC-5: Inorganic Chemistry II

s & p Block Elements

(Credits: 5; Lecture – 03, Tutorial – 00, Practical – 02)

Component: Theory **Inorganic Chemistry II** **Credits: 3**

(45 Lectures)

Unit 1: *s*- Block Elements 6L

Hydrogen : Isotopes, Ortho and para-hydrogen, Hydrides and their classification. Diagonal relationship, solvation and complexation tendencies, Compounds of *s*-block metals (K, Na, Rb, Mg, Ca): oxides, hydroxides, peroxides, superoxides-preparation and properties, anomalous behavior of Li, Be.

Unit 2: *p*-Block elements:

Boron family (Group 13) **12 L**

Comparative study of physical and chemical properties of these elements with their oxides, hydrides, halides and nitirides. inert pair effect, Preparation and properties of boric acids (ortho & meta boric acids) and borax, hydrides of boron (diborane, tetraborane, pentaborane) structure and bonding in diboranes, an idea of three center-two electron bon in the light of molecular orbital theory, Classifications of boranes (*Closo*, *nido*, *Arachno*), borazine, borohydrides.

Unit 3: Carbon and Nitrogen family (Group 14, 15) 10L

Comparative study of physical and chemicals properties of these elements with special references to catenation, fullerenes and its applications their oxides, hydrides, nitrides, sulphides and carbides, study of silicates (structural aspects only), silicones. Allotropy, oxoacids of nitrogen and phosphorus.

Unit 4: Oxygen and Halogens family (Group 16, 17) **10 L**

Comparative study of physical and chemical properties of these elements with special reference to their hydrides, oxides, halides and oxyhalides. Study of oxyacids, peroxyacids and thio-oxyacids of sulphur .

Comparative study of physical and chemical properties of these elements, oxidizing power, reactivity of the elements, hydrides, oxides and oxyacids.

Detailed study of oxyacids, hypohalous acid HOX, halous acid HXO_2, halic oxide HXO_3, perhalic acid HXO_4, strength of oxoacids. Interhalogens, polyhalides ions: ClF, ICl; ClF_3, BrF_3, IF_3; ClF_5, IF_5.

Unit 5: Noble Gases 7 L

Rationalization of inertness of noble gases, Clathrates; preparation and properties of XeF2, XeF4 and XeF6; Nature of bonding in noble gas compounds (Valence bond treatment and MO treatment for XeF2). Molecular shapes of noble gas compounds (VSEPR theory).

Reference Books:

1. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
2. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
3. Inorganic Chemistry: Principles of Structure and Reactivity by James E. Huheey, Keiter, E.A., Keiter, R.L. and Medhi, O.K; Publisher: Pearson Education India
4. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
5. Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.
6. Chemistry of the p-block elements by Anil J Elias; University Press (India) Pvt. Ltd.
7. Advanced Inorganic Chemistry (Vol-I, Vol-II); Satya Prakash G. D Tuli S. K Basu R. D Madan; Publisher : S Chand And Company Ltd
8. General and Inorganic Chemistry (Volume-I, Volume-II) by by Ramaprasad Sarkar Publisher: New Central Book Agency
9. Textbook of Inorganic Chemistry by R. Gopalan; University Press (India) Pvt. Ltd.

Component: Lab **Inorganic Chemistry II** **Credits: 2**

(*Experiments will be conducted based on availability of apparatus and reagents*)

1. Determination of concentration of Ca^{2+} or Mg^{+2} ions by EDTA using Eriochrome black T as indicator.
2. To determine the saponification value of a given fat/oil.
3. Determination of alkali content in an antacid tablet using HCl.
4. Estimation of carbonate and bicarbonate present together in a mixture.
5. Estimation of available chlorine in bleaching powder.

Reference Books:

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS. 1978

2. Marr, G. and Rockett, R.W. Practical Inorganic Chemistry, Van Nostrand Reinhold. 1972.

3. An Advanced Course In Practical Chemistry by A K Nad, B Mahapatra, A Ghoshal; Publisher: New Central Book Agency Pvt. Ltd.

4. Practical Inorganic Chemistry by Shikha Gulati, JL Sharma and Shagun Manocha Publisher: CBS Publisher & Distributors Pvt. Ltd.

Course Outcomes:

CO 1: To discuss the molecular orbital theory, draw the MO diagram of homo diatomic and tri atomic molecules

CO 2: To **describe** the existence of Ortho and Para hydrogen, Hydrides and their utility, how to isolate the s-block elements. Explain chemical properties of the metals and the anomalous behaviour of Li, Be.

CO 3: To **describe** the physical and chemical properties of boron family. To **discuss** three-centred-two electron bond and the chemical properties of oxides and hydrides.

CO4: To **discuss** the physical and chemical properties of carbon and nitrogen family, allotropy and inert pair effect. To demonstrate chemical properties of nitrous acid, nitric acid, hypo nitrous acid, hydrazoic acid.

CO5: To **discuss** the properties of oxygen and halogen family, their oxides, halides and oxy halides and oxidizing power of the halogens. To describe oxy acids, hypohalous and halous acid.

CO6: Students will discuss the sequential discovery of noble gases, and decide isolation of gases and study of xenon compounds.

Fifth Semester

CC-9: Inorganic Chemistry III

d, f- Block Elements, Chemical Bonding-II and Supramolecular chemistry

(Credits: 5; Lecture – 03, Tutorial – 00, Practical – 02)

Component: Theory **Inorganic Chemistry III** **Credits: 3**

(45 Lectures)

Unit 1: d block elements 8 L

General comparison of 3d, 4d and 5d elements in term of electronic configuration, oxidation states, redox properties, coordination chemistry, ionization potential.

Unit 2: f-block elements 7 L

Lanthanoids and Actinoids: general comparison on electronic configuration, oxidation states, color, spectral and magnetic properties; lanthanide contraction; Extraction, purification scheme and technical uses of the following metals: Ti, V, Cr, Mn, Co, Ni, Pt, Ag, Au, Cd, Hg and U; separation of lanthanides-ion-exchange method.

Unit 3: Chemical Bonding-II 8 L

Molecular orbital concept: Linear combination of atomic orbitals (LCAO)): sigma and pibonds and delta interaction, multiple bonding, gerade, ungerade, HOMO, LUMO. Orbital mixing,

MO diagrams of H_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, and their ions. Heteronuclear systems: CO, NO, NO^+, CN^- , HF, BeH_2, CO_2 and H_2O and interpretation of their properties from MO diagram

Metallic Bond: Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids

Unit 4: Supramolecular chemistry 8 L

Hydrogen bonding. Non-covalent interactions – examples of Ion-Dipole Interactions, Dipole-

Dipole interactions, Dipole-Induced Dipole and Ion-Induced Dipole interactions, van der Waals or Dispersion Interactions, Halogen bonding, Cation- interactions, Anion-pi interactions, pi - pi interactions, Aromatic-Aromatic Interactions: Edge-toface *vs* pi-pi Stacking Interactions, N-H- pi interactions, Sulfur-aromatic interactions.

Unit 5: Radioactivity 7 L

Nuclear stability and nuclear binding energy. Nuclear Reactions: Artificial radioactivity, transmutation of elements, fission, fusion and spallation. Nuclear energy and power generation. Radio chemical methods: principles of determination of age of rocks and minerals, hazards of radiation and safety measures.

Unit 6: Redox- I 7 L

Ion-electron method of balancing equation of redox reaction; Basic Concept of Oxidation and reduction; oxidation numbers; Redox potential-sign conventions; Nernst equation; Influence of complex formation, precipitation and change of pH on redox potentials; formal potential; Solubility, solubility product – common ion effect.

Reference Books:

1. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
2. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
3. Inorganic Chemistry: Principles of Structure and Reactivity by James E. Huheey, Keiter, E.A., Keiter, R.L. and Medhi, O.K; Publisher: Pearson Education India
4. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
5. Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.
6. Inorganic Chemistry by Shriver And Atkins; Publisher: Oxford University Press
7. Advanced Inorganic Chemistry (Vol-I, Vol-II); Satya Prakash G. D Tuli S. K Basu R. D Madan; Publisher : S Chand And Company Ltd
8. General and Inorganic Chemistry (Volume-I, Volume-II) by by Ramaprasad Sarkar

Publisher: New Central Book Agency

9. Textbook of Inorganic Chemistry by R. Gopalan; University Press (India) Pvt. Ltd.

Component: Lab **Inorganic Chemistry III** **Credits: 2**

(*Experiments will be conducted based on availability of apparatus and reagents*)

1. Estimation of nickel (II) using Dimethylglyoxime (DMG) gravimetrically.
2. Determination of the amount of citric acid in fruit juices.
3. Synthesis of a polymer/drug.
4. Estimation of free alkali present in different soaps/detergents.
5. Preparation and crystallization of inorganic compounds (*e.g.,* $[Ni(NH_3)_6]Cl_2$)

Reference Books:

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS. 1978

2. Marr, G. and Rockett, R.W. Practical Inorganic Chemistry, Van Nostrand Reinhold. 1972.

3. An Advanced Course In Practical Chemistry by A K Nad, B Mahapatra, A Ghoshal; Publisher: New Central Book Agency Pvt. Ltd.

4. Practical Inorganic Chemistry by Shikha Gulati, JL Sharma and Shagun Manocha Publisher: CBS Publisher & Distributors Pvt. Ltd.

Course Outcomes:

CO1: To discuss of chemistry of d-block elements.

CO2: Students will be able to e**xplain** general characteristics and the separation of Lanthanoids and Actinoids, its color, spectra and magnetic behavior and **discuss** the **importance** of lanthanides and actinides complexes.

CO3: The students will be able to **predict** the bond length and stability of molecules on the basis of Molecular orbital theory.

CO4: The students will be able to **compare** the inter and intra molecular interactions.

CO5: Illustrate students about the qualitative analysis and **interpret** the **identification of** cations and anions in a given inorganic mixture through quantitative chemical **analysis.**

CO6: Illustrate students about the synthesis of various inorganic compounds.

Sixth Semester

CC-12: Inorganic Chemistry IV Coordination Chemistry, Redox and Radioactivity

(Credits: 4; Lecture – 02, Tutorial – 00, Practical - 02)

Component: Theory **Inorganic Chemistry IV** **Credits: 2**

(30 Lectures)

Unit 1: Coordination Chemistry-I 10 L

Bonding in coordination complexes: EAN rule, electro-neutrality principle, valence bond theory, its limitations. Crystal field theory and ligand field theory: splitting of d^n configurations in octahedral, square planar and tetrahedral fields; crystal field stabilization energy (CFSE) in weak and strong fields; pairing energy; calculation of CFSE and pairing energy.

Unit 2: Coordination Chemistry-II 8 L

Magnetic behavior and nature of spectra including charge transfer spectra of transition metal complexes; Orgel diagram for d^n systems, Jahn-Teller distortion; spectrochemical series; elementary idea of charge transfer spectra

Unit 3: Redox -II 5 L

Applications of common ion effect to the precipitation and separation of metallic ions. Disproportionation and comproportionation reactions (typical examples), Chemistry of nonaquous solvents.

Unit 4: Introduction to Group Theory 7L

Definition of group, point groups, Symmetry operations and symmetry elements,

representation of group, Group multiplication table, Schoenflies symbols. Great Orthogonality Theorem, irreducible representation, character table, Selection Rules, Application of group theory towards Optical activity, dipole moment, vibrational spectroscopy and bonding.

Reference Books:

1. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
2. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
3. Inorganic Chemistry: Principles of Structure and Reactivity by James E. Huheey, Keiter, E.A., Keiter, R.L. and Medhi, O.K; Publisher: Pearson Education India
4. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
5. Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.
6. Inorganic Chemistry by Shriver and Atkins; Publisher: Oxford University Press
7. Advanced Inorganic Chemistry (Vol-I, Vol-II); Satya Prakash G. D Tuli S. K Basu R. D Madan; Publisher : S Chand And Company Ltd
8. General and Inorganic Chemistry (Volume-I, Volume-II) by by Ramaprasad Sarkar Publisher: New Central Book Agency
9. Textbook of Inorganic Chemistry by R. Gopalan; University Press (India) Pvt. Ltd.

Component: Lab **Inorganic Chemistry IV** **Credits: 2**

(*Experiments will be conducted based on availability of apparatus and reagents*)

1. Inorganic preparations (*Any One*)

   Cuprous Chloride, Cu_2Cl_2

   Manganese(III) phosphate, $MnPO_4.H_2O$

   Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum.

2. Determination of chloride ion content of water
3. Estimation of free alkali present in different soaps/detergents.
4. Estimation of permanent and temporary hardness of water.
5. Determination of the amount of acetic acid in vinegar

Reference Books:

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS. 1978

2. Marr, G. and Rockett, R.W. Practical Inorganic Chemistry, Van Nostrand Reinhold. 1972.

3. An Advanced Course In Practical Chemistry by A K Nad, B Mahapatra, A Ghoshal; Publisher: New Central Book Agency Pvt. Ltd.

4. Practical Inorganic Chemistry by Shikha Gulati, JL Sharma and Shagun Manocha Publisher: CBS Publisher & Distributors Pvt. Ltd.

Course Outcomes:

CO1: Students will explain the Salient features and characteristic properties of 3d-elements and be able to **c**ategorize the coordination compounds.

CO2: Students will discuss the magnetic behavior and nature of spectra including charge transfer spectra of transition metal complexes.

CO3: State and **explain** students about the balancing equation of redox reaction and Nernst equation; Influence of complex formation, precipitation and change of pH on redox potentials.

CO4: Student can **illustrate** fundamental processes/theories involved in atomic & nuclear Chemistry and to apply these phenomena to explain different observations of daily life.

CO5: Illustrate students about the synthesis and characterisations of various inorganic compounds.

CO6: Illustrate students about the estimation of various inorganic compounds.

Seventh Semester

CC-17: Inorganic Chemistry V

Organometallic Compounds-I & II, Metal Carbonyls, Bioinorganic Chemistry and Reaction Kinetics and Mechanism

(Credits: 4; Lecture – 02, Tutorial – 00, Practical - 02)

Component: Theory **Inorganic Chemistry V** **Credits: 2**

(30 Lectures)

Unit 1- Organometallic Compounds-I 8 L

Introduction – Definition, classification based on metal carbon bond, naming of organometallic compounds. Application of 18e- rule to predict M-M bond. Preparation, properties, bonding and applications of alkyl and aryls of Li, Al, Hg, Sn, Ti.

Unit 2 - Organometallic Compounds-II and Metal Carbonyls 7 L

Metal-alkene complexes, metal-alkyne complexes, Preparation, properties, structure and bonding in ferrocene, Synthesis and properties of metal carbonyls, Nature and bonding in metal carbonyls Application of metal carbonyls. Carbine and carbyne complexes.

Unit 3: Bioinorganic Chemistry 7L

Essential and Trace Elements in Biological Processes, Metalloporphyrins with special reference to Hemoglobin and Myoglobin, oxygen transport with reference to hemoglobin Biological role of alkali and alkaline earth metal ions with special reference to Na^+ and Ca^{2+}.

Unit 4: Reaction Kinetics and Mechanism 8 L

Introduction to inorganic reaction mechanisms. Substitution reactions in square planar complexes, Trans- effect and its application in complex synthesis, theories of trans effect, Mechanism of nucleophilic substitution in square planar complexes.

Reference Books:

1. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
2. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
3. Inorganic Chemistry: Principles of Structure and Reactivity by James E. Huheey, Keiter, E.A., Keiter, R.L. and Medhi, O.K; Publisher: Pearson Education India
4. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
5. Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.
6. Inorganic Chemistry by Shriver And Atkins; Publisher: Oxford University Press
7. Advanced Inorganic Chemistry (Vol-I, Vol-II); Satya Prakash G. D Tuli S. K Basu R. D Madan; Publisher : S Chand And Company Ltd
8. General and Inorganic Chemistry (Volume-I, Volume-II) by Ramaprasad Sarkar Publisher: New Central Book Agency
9. Textbook of Inorganic Chemistry by R. Gopalan; University Press (India) Pvt. Ltd.

Component: Lab **Inorganic Chemistry V** **Credits: 2**

(*Experiments will be conducted based on availability of apparatus and reagents*)

1. Determination of the strength of given $CuSO_4$ solution using thaiosulphate as intermediate and starch as internal indicator.
2. To determine the strength in gm/lit. of given $K_2Cr_2O_7$ solution being provided with approx N/30 hypo solution.
3. Determination of the alkalinity in the given water sample.
4. Determination of the strength of Ferrous ammonium sulphate (Mohr's salt) Solution using $K_2Cr_2O_7$ as intermediate and N-phenyl anthranilic acid as internal indicator.
5. Semi-micro qualitative analysis of inorganic mixture (1) containing not more than 4 radicals.

Reference Books:

1. Vogel, A.I. A Textbook of Quantitative Inorganic Analysis, ELBS. 1978

2. Marr, G. and Rockett, R.W. Practical Inorganic Chemistry, Van Nostrand Reinhold. 1972.

3. An Advanced Course In Practical Chemistry by A K Nad, B Mahapatra, A Ghoshal; Publisher: New Central Book Agency Pvt. Ltd.

4. Practical Inorganic Chemistry by Shikha Gulati, JL Sharma and Shagun Manocha Publisher: CBS Publisher & Distributors Pvt. Ltd.

Course Outcomes:

CO1: Student can **illustrate** the application of 18e- rule to predict M-M bond and naming of organometallic compounds.

CO2: Illustrate students about the metal-alkene complexes, metal-alkyne complexes, Preparation, properties, structure and bonding in ferrocene.

CO3: Students can Understand and explain the chemistry of haemoglobin, myoglobin and importance of alkali and alkaline earth metal ions in living organism.

CO4: Student will explain the mechanisms of important inorganic reactions and can predict which molecule will follow type of mechanism under given set of conditions.

CO5: Analyse students about the strength of given solution.

CO6: Illustrate students about the qualitative analysis and **interpret** the **identification of** cations and anions in a given inorganic mixture through quantitative chemical **analysis.**

Seventh Semester

CC-18: Industrial Chemistry

(Credits: 4; Lecture – 02, Tutorial – 00, Practical - 02)

Component: Theory **Credits: 2**

(30 Lectures)

Unit 1: Chemical Technology 7 L

Basic principles of distillation, solvent extraction, solid-liquid leaching and liquid-liquid extraction, separation by absorption and adsorption. An introduction into thescope of different types of equipment needed in chemical technology, includingreactors, distillation columns, extruders, pumps, mills, emulgators. Scaling upoperations in chemical industry. Introduction to clean technology.

Unit 2: Industrial Gases and Inorganic Chemicals 7L

(a) Industrial Gases: Large scale production, uses, storage and hazards inhandling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen,acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

(b) Inorganic Chemicals: Manufacture, application, analysis and hazards inhandling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid,caustic soda, common salt, borax, bleaching powder, sodium thiosulphate,hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

(C) Industrial Metallurgy

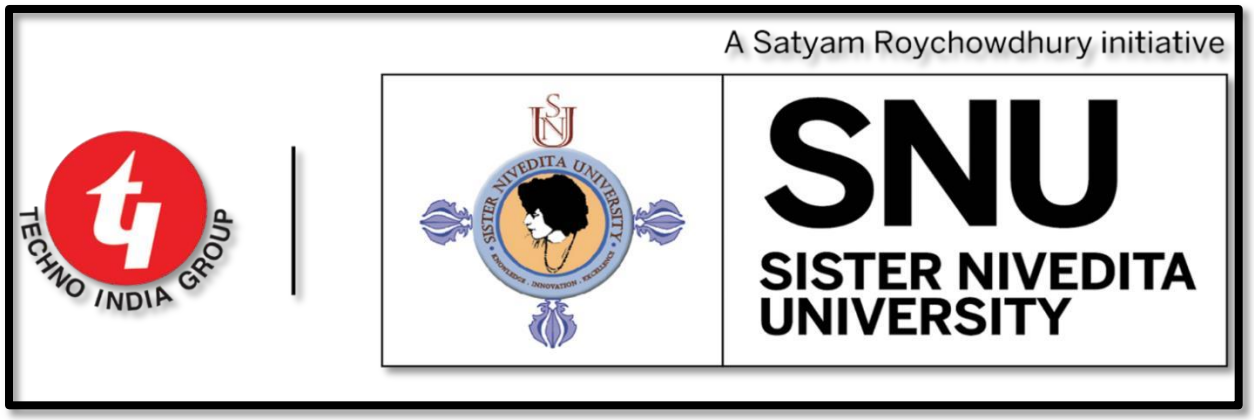
Preparation of metals (ferrous and nonferrous) and ultra pure metals for semiconductor technology.

Unit 3: Chemistry of Cement: 8 L

Indian Cement Industry, Cement Manufacturing Process, Cement Raw Materials, Corrective Materials/ Additives. Raw Mix Proportioning, Raw Mix Design, 89 Modulii Values and their effects. Burnability, Absorption and effect of Coal Ash. Chemical and Phase Composition of Clinker, Bogue Calculation, Clinker Reaction during Clinkerization, Fuels, Mineralisers and Fluxes. Hydration of Cement, Setting, Hardening and Strength gain, Role of various Clinker Phases. Use of Waste Materials – Fly ash and Slag etc., Pozzolanic Reaction, Hydration of Slag. Types of Cement, BIS specifications of various types of Cement

Unit 4: Chemistry of Ceramics 8L

Ceramics: Historical development, Raw materials-their composition, occurrence, properties and classification. Ceramic industries in India. Manufacture of white ware, drying and firing of ceramic products. Ceramic products whiteware porcelain, sanitaryware, glazes; advanced polymer based ceramic products, ceramic coating. Conventional Process – Dry and semi-dry pressing, Slip casting, Extrusion. Advanced Process – Cold Isostatic pressing & Hot Isostatic pressing, Injection moulding, Hot-pressing. Sintering: Solid-state sintering, Liquid Phase sintering and verification, Driving force Of Sintering, controlling factors for sintering of ceramic system.



Four-Year B.Sc
(Honours and Honours with Research)
Couses of Studies
(Under Curriculum & Credit framework, 2022)

SYLLABUS
of
CHEMISTRY

Vice-Chancellor,
Sister Nivedita University

Subject Expert

Raj K Datta
Chief General Manager - Product Development, Technical Support & QA
Haldia Petrochemicals Limited

Industry Expert

Head of the Department,
Chemistry, SNU

Physical Chemistry Syllabus

Second Semester

CC-3: Physical Chemistry-I

(Credits: 4; Lecture – 02, Tutorial – 00, Practical - 02)

Component: Theory **Physical Chemistry-I** **Credits: 02**

(30 Lectures)

Unit 1: Thermodynamics for chemists **15L**

Spontaneous Processes; Calculation of work done for various types of thermodynamic and practical processes; Kirchhoff's equations at constant pressure; Refrigeration; Entropy and the Second Law of Thermodynamics**;** The Physical and Molecular Interpretation of Entropy**;** Entropy Changes in Chemical Reactions**;** Gibbs Free Energy**;** Gibbs-Helmholtz equations; Concept of Fugacity; Maxwell's equations and how they are applied in chemical reactions; Phase change and Clausius equation; Trouton's Rule and its applications; Joule-Thompson effect and liquefaction of gas; The Relationship between ΔG and Work; Free Energy and Temperature**;** Free Energy and the Equilibrium Constant. Application of chemical thermodynamics to address natural observations and problems related to chemical processes. Chemical Thermodynamics (Exercises). Thermochemistry: Bond enthalpies; Hess's law.

Unit 2: Electrochemistry

10L

Kohlrausch's law of independent migration of ions; Variation of specific and equivalent conductance with dilution for strong and weak electrolytes; Estimation of activity coefficient for electrolytes using Debye-Hückel limiting law; Ionic mobility; Transport Number and principles of Hittorf's and Moving-boundary method; Ostwald's dilution law; Ionic mobility; Applications of conductance measurement: hydrolysis constants of salts, degree of dissociation of weak electrolytes; conductometric titrations etc.

EMF: Standard electrode (reduction) potential and its application to different kinds of half-cells; Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone and glass electrodes; Concentration cells with and without transference, liquid junction potential; Potentiometric titrations (acid-base, redox, precipitation)

Unit 3: Ionic Equlibria **5L**

Solubility and solubility product of sparingly soluble salts – applications of solubility product principle; Strong, moderate and weak electrolytes; their degree of ionization; factors affecting degree of ionization; ionization constant and ionic product of water. Ionization of weak acids and bases; Concept of pH, pK_a, pK_b; common ion effect; Salt hydrolysis-calculation of hydrolysis constant; degree of hydrolysis and pH for different salts; Buffer solutions

References:

1. Atkins, P.W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.

2. Castellan, G. W. (1983). Physical chemistry. Wesley Publishing Company.

3. Rakshit, P. C. (1984). Elementary physical chemistry.

4. Kapoor, K. L. (2001). A textbook of physical chemistry (Vol. 3). Macmillan.

Component: Lab Physical Chemistry-I Lab Credits: 2

(60 lectures)

1. Study of kinetics of acid-catalyzed hydrolysis of methyl acetate
2. Determination of solubility of sparingly soluble salt in water, in electrolyte with common ions and in neutral electrolyte (using common indicator)
3. Study of kinetics of decomposition of H_2O_2
4. Determination of partition coefficient for the distribution of I_2 between water and CCl_4/ Distribution of acetic/ benzoic acid between water and cyclohexane
5. Determination of pH of unknown solution (buffer), by colour matching method
6. Determination of adsorption isotherm of acetic acid by activated charcoal

References :

1. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).
2. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
4. International Methods of Chemical Analysis, Himalaya Publishing House, G. R. Chatwal, S. K. Anand

Course Outcomes:

CO1: Students will learn the thermodynamics of more practical system: open system. Concept of equilibrium and factors affecting equilibrium will be discussed. La Chatelier principle and its application will be discussed.

CO2: Students will become skilled at constructing redox reactions, construct electrochemical cells. They will get vast knowledge of electrochemistry. They will acquire knowledge of conductance, conductometric titrations, nature of electrolytes, ion transport.

CO3:. Learn about the different types of electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. They will also learn about Ionization of weak acids and bases, common ion effect, degree of hydrolysis and pH for different salts, Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

CO4:.Students will be alble to prepare buffers of different pH, monitor kinetics of different reactions.

CO5: Students will learn adsorption process (hands on) quantitatively by titrimetric method. Students will also learn how to monitor kinetics of chemical reactions.

CO6:. Students will gain knowledge to analyze solubility and solubility product of sparingly soluble salts and also the partition function.

Fourth Semester

CC-7: Physical Chemistry-II

(Credits: 4; Lecture – 02, Tutorial – 00, Practical - 02)

Component: Theory Physical Chemistry-II Credits: 02

(30 Lectures)

Unit 1: Gaseous State

15L

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure.

Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities.

Behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, *Z*, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

Unit 2: Liquid state **5L**

Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of structure of water.

Unit 3: Solid state

10L

Nature of the solid state, law of constancy of interfacial angles, law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, qualitative idea of point and space groups, seven crystal systems and fourteen Bravais

lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals.

References :

1. Atkins, P.W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.
2. Castellan, G. W. (1983). Physical chemistry. Wesley Publishing Company.
3. Laidler, K. J., & Keith, J. (1965). Chemical kinetics (Vol. 2). New York: McGraw-Hill.
4. Rakshit, P. C. (1984). Elementary physical chemistry.
5. Kapoor, K. L. (2001). A textbook of physical chemistry (Vol. 2). Macmillan.

Component: Lab **Physical Chemistry-II Lab** **Credits: 2**

(60 lectures)

(Experiments will be conducted based on availability of apparatus and reagents)

1. Study of viscosity of unknown liquid (glycerol, sugar) with respect to water/Determination of molecular weight of a high polymer (e.g. PEG) by viscosity measurement
2. Study of the variation of viscosity with the concentration of the solution
3. Determination of surface tension of a liquid using Stalagmometer
4. Verification of Ostwald's dilution law and determination of K_a of weak acid
5. Determination of CMC of a micelle from Surface Tension/conductance Measurement
6. Conductometric titration of an i. Strong acid vs. strong base ii. Weak acid vs. strong base iii. Mixture of strong acid and weak acid vs. strong base iv. Strong acid vs. weak base
7. (a) pH-metric titration of acid (mono- and di-basic) against strong base (b) pH-metric titration of a tribasic acid against strong base.

References :

1. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).
2. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R Chand & Co.: New Delhi (2011).
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry, 8th Ed.; McGraw-Hill: New York (2003).

Course Outcomes:

After completion of the course, the students will:

CO1: Able to explain phase, component and degrees of freedom in the light of phase rule and phase diagram.

CO2: Explain Concept of Phase separation and its classifications and underlying principles will be studied.

CO3: Understand Phase diagram and heat of neutralization will also be learnt experimentally.

CO4: Able to correlate various natural processes with thermodynamical laws.

CO5: Able to understand various natural processes.

CO6: Learn more about nature.

Fifth Semester

CC-10: Physical Chemistry-III

(Credits: 4; Lecture – 02, Tutorial – 00, Lab - 02)

Component: Theory Physical Chemistry-III Credits: 02

(30 Lectures)

Unit 1: Reaction Kinetics and Electrode kinetics 18L

Temperature dependence of reaction rates; Arrhenius equation; activation energy; Collision theory; Lindemann theory of unimolecular reaction; outline of Transition State theory (classical treatment); kinetics of complex reactions (1) Opposing reactions (2) parallel reactions and (3) consecutive reactions and their differential rate equations (steady-state approximation) (iv) chain reactions. Chain reactions; Fast reactions: flow method, relaxation method, flash photolysis; Oscillatory reactions; Autocatalysis

Types of catalyst, specificity and selectivity, mechanisms of catalyzed reactions at solid surfaces; Homogeneous catalysis with reference to acid-base catalysis; Enzyme catalysis; Michaelis-Menten equation, Lineweaver-Burk plot, turn-over number. Physical adsorption, chemisorption, adsorption isotherms. nature of adsorbed state.

Electrode kinetics: Nernst, Butler-Volmer and Tafel equations.

Unit 2: Chemical Equilibrium 12L

Criteria of thermodynamic equilibrium; Concept of fugacity; Gibbs free energy of reaction and reaction quotient; Equilibrium constants and their quantitative dependence on temperature, pressure and concentration; Free energy of mixing and spontaneity; thermodynamic derivation of relations between the various equilibrium constants K_p, K_c and K_x. Le Chatelier principle (quantitative treatment); equilibrium between ideal gases and a pure condensed phase.

References :

1. Atkins, P.W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014.
2. Castellan, G. W. (1983). Physical chemistry. Wesley Publishing Company.
3. Laidler, K. J., & Keith, J. (1965). Chemical kinetics (Vol. 2). New York: McGraw-Hill.
4. Rakshit, P. C. (1984). Elementary physical chemistry.
5. Kapoor, K. L. (2001). A textbook of physical chemistry (Vol. 1). Macmillan.

Component: Lab **Physical Chemistry-III Lab** **Credits: 2**

(60 lectures)

(Experiments will be conducted based on availability of apparatus and reagents)

1. Study of saponification reaction conductometrically
2. Potentiometric titration of Mohr's salt solution against standard $K_2Cr_2O_7$ and $KMnO_4$ solution
3. Determination of K_{sp} for AgCl by potentiometric titration of $AgNO_3$ solution against standard KCl solution
4. Determination of pH of unknown buffer, spectrophotometrically
5. Study of Phase diagram of Phenol-Water system.
6. Computer programs(Using FORTRAN or C or C ++) based on numerical methods/ Software based experiments such as energy minimization of a small molecule

References :

1. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).
2. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R Chand & Co.: New Delhi (2011).
3. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry, 8th Ed.; McGraw-Hill: New York (2003).

Course Outcomes:

After completion of the course, the students will:

CO1: Learn the thermodynamics of more practical system: open system. Concept of equilibrium and factors affecting equilibrium will be discussed. La Chatelier principle and its application will be discussed.

CO2: Discuss properties of ideal systems, vapour pressure, colligative properties, real solutions; deviating from ideality will be discussed.

CO3: Learn temperature dependence of chemical reactions. Deviations of different complex reactions will be discussed. Students will study homogeneous and heterogeneous catalysis and their applications.

CO4: Get the idea of electrokinetic phenomenon, colloids, micelle formation.

CO5: Learn how to control various parameters to make a particular chemical reaction efficient.

CO6: Able to understand basic chemical principles.

Sixth Semester

CC-13: Physical Chemistry-IV

(Credits: 4; Lecture – 02, Tutorial – 00, Practical - 02)

Component: Theory Physical Chemistry-IV Credits: 02

(30 Lectures)

Unit 1: Colligative properties 10L

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Excess thermodynamic functions. Colligative properties: (i) relative lowering of vapour pressure, (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure. Applications in calculating molar masses of normal, dissociated and associated solutes in solution.

Unit 2: Phase diagram 12L

Concept of phase, component and degrees of freedom; Phase rule and its derivations for both for nonreactive and reactive systems; phase diagram for one-component system: water and carbon dioxide; First order phase transition; Clapeyron equation; Clausius-Clapeyron equation - derivation and applications in its applications to solid-liquid, liquid-vapour and solid-vapour equilibria; Phase diagrams for solid-liquid equilibrium systems-eutectic, congruent and incongruent melting points, solid solutions. Principle of fractional distillation; Three component systems, water-chloroform-acetic acid system, triangular plots.

Unit 3: Surface Chemistry 8L

Adsorption; Gibb's adsorption equation and its applications; Different models for adsorption; Adsorption isotherms; Various different types of isotherms and their practical applications; BET; Langmuir film; Electrical double layer concept and its applications; zeta potential; Colloids; Emulsions; Catalysis; Surface effect in catalysis; Basics of nano-colloids

References :

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 10th Ed., Oxford University
2. Castellan, G. W. Physical Chemistry 4 th Ed. Narosa (2004).
3. Engel, T. & Reid, P. Physical Chemistry 3 rd Ed. Pearson (2013)
4. Kapoor, K. L. (2001). A textbook of physical chemistry (Vol. 5). Macmillan.

Component: Lab **Physical Chemistry-IV Lab** **Credits: 2**

(60 lectures)

(Experiments will be conducted based on availability of apparatus and reagents)

1. Determination of the indicator constant of an acid base indicator spectrophotometrically
2. Verification of Beer and Lambert's Law for $KMnO_4$ and $K_2Cr_2O_7$ solution
3. Study of kinetics of $K_2S_2O_8$ + KI reaction, spectrophotometrically
4. Kinetic study of inversion of cane sugar using a Polarimeter
5. Determination of composition of complexes (Ferric-salicylate complex/Ferrous-orthophenanthroline complex) by Job's method
6. Spectrophotometric experiments on enzyme kinetics

References :

1. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012).
2. Subhash C Das, *Advanced Practical Chemistry*, (2012)
3. Nad, A.K.; Mahapatra B.; Ghosal A. *Advanced Course In Practical Chemistry*, New Central Book Agency Ltd.
4. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education (2009)

Course Outcomes:

After completion of the course, the students will:

CO1: Understand properties of different states of matter. They will study details of 14 Bravias lattices, properties of liquid and gaseous state.

CO2: Able to reason the various natural processes that happen around them and will be able to innovate.

CO3: Understand the role of any surface in a chemical reaction.

CO4: Understand how a catalyst works.

CO5: Student will understand how suspensions and emulsions work.

CO6: They can relate various observables with understanding of surface attachments.

Seventh Semester

CC-15: Physical Chemistry-V

(Credits: 4; Lecture – 04, Tutorial – 00, Practical - 00)

Component: Theory **Physical Chemistry-IV** **Credits: 04**

(60 Lectures)

Unit 1: Quantum Mechanics and Quantum Chemistry **30L**

Black body radiation, Planck's radiation law, photoelectric effect, harmonic oscillator; de Broglie hypothesis; Wave-particle duality, light as particles; Postulates of quantum mechanics; Uncertainty principle.

Quantum mechanical operators and its properties: Eigen functions and Eigen values, commutation of operators, Expectation value (x, x2 , p_x and p_x2), Hermitian operator, Commutators, Orthogonality of operators, Linear Operators. Differential equations, partial differential equations.

Schrödinger's time independent equation, acceptability of wave function; acceptability conditions for the wave functions and probability interpretations of wave function, Orthonormality and probability distribution of wave function; degeneracy of energy levels; Particle in a 1-d box: Schrodinger equation for one-dimensional box and its solutions and applications, Properties of Particle in a 1-d box and ring; wave functions its energy levels, Particle in a box problem to two and three dimensions and the concept of degenerate energy levels and Jahn-Teller distortion.

Problem of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, separation of radial and angular parts, solution of Φ part and emergence of magnetic quantum number, quantization of energy

Unit 2: Photochemistry **15L**

Electromagnetic radiation: definition and properties; Lambert-Beer's law, its limitations; molar extinction coefficient; Laws of photochemistry, Stark-Einstein law of photochemical equivalence, quantum yield: definition, calculation and examples of low and high quantum yield values; photochemical equilibrium and the differential rate of photochemical reactions; Photosensitised reactions, HI decomposition, H_2-Br_2 reaction, dimerisation of anthracene; Photostationary state; Chemiluminescence; Role of photochemical reactions in biochemical processes.

Unit 3: Fundamentals of Polymer Chemistry **15L**

Definition of monomer, polymer and polymerization – Classification of polymers - natural, semisynthetic and synthetic - condensation & addition polymers - Linear, branched and crosslinked polymers - Homo polymers and copolymers – Graft and block copolymers, composites, blends, elastomers, fibres, plastics, thermoplastic and thermosetting polymers. Tacticity in polymers-Isotactic, syndiotactic and atactic polymers. Molecular weight determination of polymers by different methods, such as: viscometry, osmometry, light scattering, chromatography and ultracentrifugation methods;; step-growth vs. chain-growth polymerizations

References :

1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 10th Ed., Oxford University
2. Castellan, G. W. Physical Chemistry 4 th Ed. Narosa (2004).
3. Engel, T. & Reid, P. Physical Chemistry 3 rd Ed. Pearson (2013)
4. Andrew Cooksy, Quantum Chemistry and Molecular Interactions, Pearson (2014)
5. Basic Concepts of Polymer Chemistry, Kalyan Kumar Mandal, Kaushik Basu, Priyotosh Dutta, Techno World Publication, ISBN: 9789392145384 (2022)

Course Outcomes:

After completion of the course, the students will:

CO1: Understand the transition from classical mechanics to Quantum mechanics and the basic features of Quantum Mechanics in turn.

CO2: Learn about the need for operators and also about different operators and wave functions. Different features of wave functions and different degree of confinement will also be learnt in due course.

CO3: Learn interaction of light with matter and its laws will be learned. Light assisted reactions and their properties will also be learned.

CO4: Explain common photochemical and photophysical processes.

CO5: Develop general idea about polymers.

CO6: Understand how to use polymers.

Eighth Semester

CC-19: Physical Chemistry-VI

(Credits: 4; Lecture – 04, Tutorial – 00, Practical - 00)

Component: Theory Physical Chemistry-IV Credits: 04

(60 Lectures)

Unit 1: Statistical Thermodynamics 15L

Macrostates & microstates. Probabilty & Thermodynamic Probabilty; Confuguratin; Occupation Number; Boltzmann distribution: Entropy and probability, Boltzmann distribution formula (with derivation); Applications to barometric distribution; Partition function, concept of ensemble - canonical ensemble, micro cannonical and grand canonical ensembles

Partition function: molecular partition function and thermodynamic properties; their relations; 3rd law: Absolute entropy, Plank's law, Calculation of entropy, Nernst heat theorem. Approach to zero Kelvin, adiabatic cooling; Specific heat of solids

Unit 2: Molecular Spectroscopy

30L

Interactions of electromagnetic radiation with matter: origin of spectroscopy, types and energy domain of various spectroscopies; Born Oppenheimer approximation;

Rotational spectroscopy: Principles and origin of rotational spectroscopy, selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

Vibrational spectroscopy: Classical approach and equation to vibrational spectroscopy of linear diatomic molecules, its limitations; force constant- Simple Harmonic Oscillator (SHO) model; emergence of anharmonicity; Morse potential, dissociation energies, zero point energy, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, Rotational-vibrational spectroscopy: diatomic vibrating rotator, P, Q, R branches.

Electronic Spectroscopy: Franck-Condon principle and vibrational structure of electronic spectra; electronic transitions, singlet and triplet states; bond dissociation; decay of excited state by radiative and non-radiative processes; Pre-dissociation; fluorescence and phosphorescence, Jablonsky diagram

Raman spectroscopy: Classical approach; Qualitative treatment of Rotational Raman effect;

Effect of nuclear spin; Vibrational Raman spectra; Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

Unit 3: Basics of Group Theory **15L**

Definition of group, symmetry, point groups, representation of group, Abelian group, Group multiplication table, Groups, sub-groups and classes, Symmetry operations and symmetry elements, Point group, classification and symmetry number, Selection Rules, Schoenflies symbols. Great Orthogonality Theorem, irreducible representation, character table, Point group symmetry.

References :

1. F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley & Sons, Inc, New York, 1999.
2. Molecular Spectroscopy by C.N. Banwell – 3rd Edition, Fundamentals of Molecular Spectroscopy by C.N. Banwell, Authors: C.N. Banwell
3. Modern Techniques of Spectroscopy. Basics, Instrumentation, and Applications. (2021) Dheeraj Kumar Singh, Manik Pradhan, Arnulf Materny (Eds.), Springer, ISBN: 978-981-33-6083-9
4. Physical Chemistry, P. Atkins and J. De Paul, 8th Edition (2006), International Student Edition, Oxford University Press.
5. Group theory in Chemistry Bonding and Molecular Spectroscopy, Universities Press, Asok K Mukherjee, bankim Chandra Ghosh

Course Outcomes:

After completion of the course, the students will:

CO1: Understand to calculate macroscopic (bulk) properties of pure substances and mixtures from the microscopic properties of the molecules and their interactions.

CO2: Calculate the melting and boiling points using fundamental principles of classical and statistical thermodynamics, and the enthalpies and entropies of fusion and vaporization of pure water, and the freezing point depression and boiling point elevation of ideal and nonideal aqueous solutions.

CO3: Learn basic principles of interaction between light and molecules, and the formation of excited states and the time of evolution of excited states in intra- and intermolecular energy and electron transitions and their role in photochemical reactions. All the four different spectroscopy will teach students to understand fundamental properties of matter through analysis of molecular spectroscopy and to determine structure and property relationships in molecules.

CO4: Understand how to relate spectrum with molecular structure.

CO5: Understand the fundamentals of light matter interaction.

CO6: Understand how important is the structural parameters of a molecule in excited state.