

Progressive Education Society's
Modern College of Arts, Science and Commerce (Autonomous),
Shivajinagar, Pune -05

(An Autonomous College Affiliated to Savitribai Phule Pune University)

Framework of Syllabus

For

M.Sc. (Organic Chemistry)

(Based on NEP 2020 framework)

(To be implemented from the Academic Year 2025-26)

P. E. Society's
Modern College of Arts, Science and Commerce (Autonomous), Shivajinagar, Pune-05
M.Sc. I (Analytical Chemistry) Syllabus 2025-26

Semester 1

Course Type	Code	Course	Course / Paper Title	Hours / Week	Credit	CIA	ES E	Total
Major Mandatory (4 + 4+4+2)	23ScCheP111	Major Paper 1 (Theory)	Fundamentals of Physical Chemistry I	4	4	50	50	100
	23ScCheP112	Major Paper 2 (Theory)	Molecular Symmetry and Main group Chemistry	4	4	50	50	100
	23ScCheP113	Major Paper 3 (Practical)	Lab Course on 23ScCheP111 & 23ScCheP112	4	4	50	50	100
	23ScCheP114	Major Paper 4 (Theory)	Basic Organic Chemistry	2	2	25	25	50
Major Electives (4)	23ScCheP121	Major Elective (T+P)	Organic Reactions (T + P)	6	4	50	50	100
Major Electives (4)	23ScChOP122	Major Elective (T+P)	Organic Intermediates and Applications in Organic Synthesis (T + P)	6	4	50	50	100
RM (4)	23ScCheP131	RM Paper 1	RM Core Paper	2	4	50	50	100
	23ScCheP131	RM Paper 2	Department Specific Paper	2				
OJT (4)		–	–	–	–	–	–	–
Total				26	22	275	275	550

Semester 2

Course Type	Code	Course	Course / Paper Title	Hours/ Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4+4+2)	23ScCheP211	Major Paper 1 (Theory)	Molecular Spectroscopy and Nuclear Chemistry	4	4	50	50	100
	23ScCheP212	Major Paper 2 (Theory)	Coordination and Bioinorganic Chemistry	4	4	50	50	100
	23ScCheP213	Major Paper 3 (Practical)	Lab Course on 23ScCheP211 & 23ScCheP212	4	4	50	50	100
	23ScCheP214	Major Paper 4 (Theory)	Organic Spectroscopy	2	2	25	25	50
Major Electives (4)	23ScCheP221	Major Elective (T+P)	Synthetic Organic Chemistry (T + P)	6	4	50	50	100
Major Electives (4)	23ScChOP222	Major Elective (T+P)	Advanced Green Chemistry (T + P)	6	4	50	50	100
RM (4)		–	–	–	–	–	–	–
		–	–	–				
OJT(4)	23ScCheP241	OJT	On Job Training	8	4	50	50	100
Total				30	22	275	275	550

Semester 3

Course Type	Code	Course	Course / Paper Title	Hours/ Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4+4+2)	23ScChOP311	Major Paper 1 (Theory)	Photochemistry, Free radicals and Pericyclic Reactions	4	4	50	50	100
	23ScChOP312	Major Paper 2 (Theory)	Heterocyclic Chemistry	4	4	50	50	100
	23ScChOP313	Major Paper 3 (Practical)	Lab Course on Organic Chemistry I	4	4	50	50	100
	23ScChO314	Major Paper 4 (Theory)	Organic Reaction Mechanism	2	2	25	25	50
Major Electives (4)	23ScChOP321	Major Elective (T+P)	2D Spectroscopy of Organic Compounds (T + P)	6	4	50	50	100
Major Electives (4)	23ScChOP322	Major Elective (T+P)	Protection and Deprotection of Organic Compounds (T + P)	6	4	50	50	100
RP (4)	23ScChOP351	RP	Research Project	8	4	50	50	100
OJT(4)	-	-	-	-	-	-	-	-
Total				30	22	275	275	550

Semester 4

Course Type	Code	Course	Course / Paper Title	Hours/ Week	Credit	CIA	ESE	Total
Major Mandatory (4 + 4+4+2)	23ScChOP411	Major Paper 1 (Theory)	Retrosynthesis and Advanced Synthesis of New Reagents	4	4	50	50	100
	23ScChOP412	Major Paper 2 (Theory)	Natural Products	4	4	50	50	100
	23ScChOP413	Major Paper 3 (Practical)	Lab Course on Organic Chemistry II	4	4	50	50	100
Major Electives (4)	23ScChOP421	Major Elective (T+P)	Chiron approach (T + P)	6	4	50	50	100
Major Electives (4)	23ScChOP422	Major Elective (T+P)	Biogenesis (T + P)	6	4	50	50	100
RP (4)	23ScChOP451	RP	Research Project	12	6	75	75	150
OJT(4)	-	-	-	-	-	-	-	-
Total				30	22	275	275	550

OE : Open Elective

AEC: Ability Enhancement Course

VEC: value Education Courses

CC : Co-Curricular Courses

IKS : Indian Knowledge System

OJT : On Job Training

FP : Field Project

VSC : Vocational Skill Courses

CEP : Community Engagement Project

Semester 1

23ScCheP111: Fundamentals of Physical Chemistry I (4 Credits, 60 L)

Course Outcomes

CO1: Understand the laws of thermodynamics and their applications.

CO2: Know the phase diagram of single component systems and binary mixtures.

CO3: Understand of the quantum chemistry of free electron and H-atom.

CO4: Understand the theories of the determination of the rate of the reactions.

CO5: Understand the kinetics of the explosive photochemical and unimolecular reactions.

CO6: Understand of the applications statistical thermodynamics.

Chapter No.	Section I: Thermodynamics (2 Credits, 30 L)	
1	Recapitulation Basic concepts of Chemical Mathematics, Heat, work & Conservation of energy – The basic concepts, the First law, infinitesimal changes, mechanical work, work of compression & expansion, free expansion, expansion against constant pressure, reversible expansion. Heat: - Heat Capacity, Enthalpy. State functions & differentials – State functions, exact & inexact differential, changes in internal energy, temperature dependence of the internal energy, temperature dependence of the enthalpy. Work of adiabatic expansion – Irreversible adiabatic expansion, reversible adiabatic expansion	3 L
2	The Second law of Thermodynamics The second law of Thermodynamics, definition of entropy, the entropy changes in the system, natural events. Entropy changes in the universe: The enthalpy change when a system is heated. c. The entropy of phase transition. The entropy of irreversible changes. Concentrating on the system: The Helmholtz & Gibbs function, some remarks on the Helmholtz function. Maximum work, some remarks on Gibbs function. Evaluating the entropy & Gibbs function. c, Third law entropies standard molar Gibbs function	6 L

3	Combining First & Second law of Thermodynamics Fundamental equations, The temperature dependence of the Gibbs functions. The chemical potential of a Perfect gas. The open system & changes of composition.	5 L
4	Changes of State Physical Transformation of pure materials. The stabilities of phases, Phase equilibrium & phase diagrams. The solid – liquid boundary. The liquid - vapor boundary. The solid-liquid-vapor boundary.	4 L
5	Quantum Chemistry Historical development of quantum theory, failure of classical mechanics, black body radiation, photo electric effect, specific heats of solids, Atomic spectra, wave particle duality, uncertainty principles, Wave particle and its interpretation, Operators, Eigen value equation, exception, value, degeneracy, Schrödinger equation, free particle, particle in one dimensional box, two dimensional box and three dimensional box, hydrogen like atoms (No derivation), atomic orbitals, Application of quantum theory-Variation and perturbation theory.	12 L
Section II: Chemical Kinetics and Reaction Dynamics (2 Credits, 30 L)		
1	Recapitulation Rate of reaction, rate constants, rate law, Order of reaction, molecularity of reaction, zero order, first order and second order reactions, higher order reactions, half life periods, fractional order reactions and their half life periods, Arrhenius equation, energy of activation, steady state approximations.	3 L
2	The kinetics of complex reactions Kinetics of reversible reactions, parallel reactions, consecutive reactions, chain reaction- explosion, photochemical reactions, quantum efficiency, fast reactions- flash photolysis, flow techniques, relaxation methods.	6 L
3	Molecular reaction dynamics Theories of reaction rates - collision theory, the steric requirements, Diffusion control reactions- classes of reactions, diffusion and reactions, the details of diffusion, Activated complex theory- the reaction coordinate and the transition	7 L

	state, the formation and decay of the activated complex, Eyring equation, thermodynamics aspects, reactions between ions.	
4	Catalysts Definition of catalysis, Types of catalysis, Enzyme catalysis, Michaelis-Menten mechanism, limiting rate, Lineweaver Burk and Eadie plots, Enzyme inhibition: competitive and non-competitive inhibition.	4 L
5	Molecular Thermodynamics Molecular energy levels, Boltzmann distribution law, partition functions and ensembles, translational, rotational and vibrational partition functions of diatomic molecules, Obtaining energy, heat capacity, entropy free energy, equilibrium constants from partition functions, equipartition of energy, Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics	10 L

References:

- 1) Physical Chemistry- P.W. Atkins and De Paule 8th edition (2010)
- 2) Physical Chemistry-T. Engel and P. Reid, Pearson Education (2006)
- 3) Physical Chemistry and molecular approach- D. Mcquarie and J. Simon (University Science) (2000)
- 4) Physical Chemistry for Biological Sciences by Raymond Change (Universal books) (2000)
- 5) Physical Chemistry – Marron and Prouton
- 6) Physical Chemistry- G.M. Barrow, Tata Mc Grow Hill 1988
- 7) Quantum Chemistry- Ira Levine 5th edition, Prentice Hall, 1999.
- 8) Text book of Physical Chemistry by Samuel Glasstone.

23ScCheP112: Molecular Symmetry and Main Group Chemistry (4 Credits, 60 L)

Course Outcomes

CO1: To explain the concepts of geometry of molecules.

CO2: They understand how to determine the point group to the molecule.

CO3: Create an awareness of actual applications of group theory

CO4: To understand the positions of lanthanide and actinide in the periodic table.

CO5: Describe bonding models that can be applied to a consideration of the properties of P-block elements, and; the student's familiar about the inorganic halogen compounds.

CO6: To understand types and structure of halogen compounds.

Chapter No.	Section I: Molecular Symmetry (2 Credits, 30 L)	
1	Molecular Symmetry and Groups theory Introduction, Importance of molecular symmetry, Symmetry operations, Symmetry elements, The inversion centre or center of symmetry(i), Proper rotation axis(C_n)/ Rotational axis of symmetry, Classification of rotational axes: a) Principal axis b) Simple or secondary rotational axes (C_2) Symmetry planes or mirror plane(σ): a)Vertical Plane(σ_v) b)Horizontal Plane(σ_h) c) Dihedral Plane(σ_d), Improper rotation axis(S_n), Identity element (E), Products of symmetry operations, Equivalent symmetry elements and equivalent atoms, General relations between symmetry elements and symmetry operations, Symmetry elements and optical isomerism	8 L
2	Concept of point group Assignment of point groups, C-type point groups, D-type point groups, Higher symmetry point groups: $C_{\infty v}$ point groups, $D_{\infty h}$ point groups, C_{2v} point groups, C_{3v} point groups, C_{2h} point groups, D_{3h} point groups, D_{nd} point groups, S_n point groups, Exercise on point groups (example of each point group)	3 L
3	Group, Subgroups, Classes Group multiplication tables, Group generating elements	3 L
4	Representations of Groups	4 L

	Matrix representation of symmetry elements, Matrix representation of point groups, Transformation matrices, The Great Orthogonality Theorem and its consequences, Character tables (No mathematical part)	
5	Group theory and quantum mechanics Reducible and irreducible representation, Wave function as basis for irreducible representations, Theoretical treatment of rotational, vibrational and electronic spectroscopy of point groups	3 L
6	Symmetry Adapted Linear Combinations Projection operators and their use in construction of Interhalogens SALC (Construction of SALC for sigma bonding for molecules belonging point groups: D _{2h} , D _{3h} , D _{4h} , C _{4v} , T _d , O _h , normalization of SALC.	5 L
7	Molecular Orbital Theory Transformation properties of atomic orbital, MOs for Sigma bonding AB _n molecules, tetrahedral AB ₄ and Oh AB ₆ cases.	4 L
	Section II: Main group chemistry (2 Credits, 30 L)	
1	S-Block elements Types of hydrides: metallic hydrides, Alkali and alkaline earth metals: Solutions in non-aqueous medium, Application of crown ethers in extraction of alkali and alkaline earth metals	4 L
2	Boron group Simple hydrides of boron, Higher boranes and borohydrides, Synthesis and interconversion of lower and higher boranes, Bonding in boranes, Wade's rules and structures of boranes, Characteristic reactions of boranes, Metalloboranes and carboranes, Silicates: Zeolites and their applications	7 L
3	Carbon group Allotropy of carbon, Graphite intercalation compounds, Fullerenes: Structure, properties and application, Carbon nanotubes: Single-Walled & Multi-Walled CNTs, their synthesis, and application (Electronic, thermal, biomedical, catalytic, etc.), Graphene: Synthesis, properties and application and Graphene oxide, Carbon dots	4 L
4	Nitrogen Group	3 L

	Oxidation states of Nitrogen and their interconversion, Oxides of Oxoanions of Nitrogen, Phosphazenes, SN and BN compounds	
5	Oxygen Group Oxyacids and Oxoanions of Sulphur, Metal Sulphides, Selenides and Tellurides	2 L
6	Halogen Group Pseudohalogens, Interhalogens, Chemical properties, Cationic interhalogens, Polyhalides, Oxoacids & oxoanions: Structure & properties, Fluorocarbons	2 L
7	Important compounds of Noble gases Xenon fluoride: Synthesis, structure and reactions, Xenon oxygen compounds	2 L
8	Organometallic chemistry Synthesis, properties, structures and uses of organometallic compounds of following elements: Al & Bi, 18-electron Rule, Ligand substitution in square planar complexes	6 L

References:

- 1) Chemical Applications of Group Theory, 3rd Edn., Author - F. A. Cotton (Wiley, New York)
- 2) Symmetry and spectroscopy of molecules, 2nd Ed. 2009; K. Veera Reddy, (New Age International Publication)
- 3) Group Theory and its Chemical Applications, P.K. Chattarghya
- 4) Inorganic Chemistry: Shriver & Atkins (4th edition 2003, Oxford)
- 5) Concise Inorganic Chemistry, J. D. Lee, Fourth Edn.(Chapman and Hall)
- 6) Inorganic chemistry: principle of structures and reactivity, Huheey, Keiter, Keiter, Medhi, Pearson Education, 4th Edn. (2007).
- 7) Inorganic Chemistry: Catherine Housecroft
- 8) Inorganic Chemistry: Messler & Tarr, Pearson Publishers 3rd Edition
- 9) Organometallic Chemistry-A Unified Approach: R. C. Mehrotra & A. Singh

23ScCheP113: Lab Course on 23ScCheP111 & 23SCheP112 (4 Credits)

Course Outcomes

CO1: Prepare the solution of the desired concentration and the desired volume.

CO2: Know the principle and handling of pH meter, potentiometer, conductivitymeter, colorimeter, viscometers etc.

CO3: Plot accurate graph of the desired scale for the calculations.

CO4: The students will develop skills about dissolution and estimation of elements.

CO5: Develop skill in planning and conducting advanced chemical experiments as well as accurately record and analyze the results of such experiments

CO6: Gather experience on the synthesis of coordination complexes and analyze structure of inorganic complexes from spectral data

Experiment No.	Name of the Experiment
	PHYSICAL CHEMISTRY
1	Colorimetry & spectrophotometry
	Determination of amount of copper present in the given solution by colorimetric titration method using standard EDTA
	To determine the concentration of dichromate and peramagnet ions by simultaneously determination method from their mixture Spectrophotometrically
	Simultaneous determination of Ni and Co by spectrophotometry
2	Chemical kinetics
	Determine the individual orders of iodide and persulphate ions and overall order of oxidation reaction of iodide ion by persulphate ion.
	Investigation of influence of ionic strength on rate constant of rate constant of reaction between potassium persulphate and potassium iodide (Bronsted Primary Salt effect).
	Determine the temperature coefficient and energy of activation of acid catalyzed hydrolysis reaction of ester.
	Study of the kinetic decomposition of diacetone alcohol by dilatometric method.

	Study of the kinetic of oxidation of ethanol by potassium dichromate.
3	Non-instrumental experiments
	Analysis of crystal structure from X-ray diffraction pattern.
	To determine the molecular weight of a given organic liquid by steam distillation method
	Study of three-component system: Water-Acetic acid-Chloroform.
4	Electrical conductance
	Study the Hydrolysis of ammonium chloride or sodium acetate or aniline hydrochloride conductometrically.
	Determination of concentrations of strong acid and weak acid present in the mixture by titration with using strong base.
5	Potentiometry
	Determine the concentrations of strong acid and weak acid present in the mixture by titrating with strong base.
	Determine of stability constant of silver-ammonia complex by potentiometric method.
	Estimation of Fe by ceric sulphate and potassium dichromate titration potentiometrically
	Simultaneous estimation of Cl and I by potentiometric method
6	pH metry
	Determine the acid and base dissociation constant of an amino acid and hence the isoelectric point of the acid.
7	Estimation of vitamin B2 in the medicinal tablets fluorimetrically.
	INORGANIC CHEMISTRY
1	Alloy Analysis
	Determination of tin & lead from solder alloy.
	Determination of iron & chromium from stainless steel alloy.
2	Inorganic synthesis & purity determination
	a) Synthesis of chloropentaamminocobalt (III) chloride. b) To determine the purity of chloropentaamminecobalt (III)chloride.

	a) Synthesis of nitropentaamminocobalt (III) chloride. b) To determine the purity of nitropentaamminocobalt (III) chloride.
3	Spectrophotometry
	Estimation of phosphate from waste water sample by calibration curve method.
	Determination of composition of complex formed between Fe (III) & salicylic acid by Job's continuous variation method & thereafter to find the stability constant of the complex.
	Determination of composition of complex formed between Fe (III) & sulphosalicylic acid by Job's continuous variation method & thereafter to find the stability constant of the complex.
	Determination of Cu (II) by solvent extraction as 8- hydroxyquinoline
4	Gravimetric Analysis
	Determination of H ₂ O of crystallization in hydrated salts.(At least 4 compounds)
5	UV visible spectral studies
	Recording UV visible spectrum of 4 - 5 coordination complexes & interpretation of the spectra.(demonstration only)

References:

- 1) Practical physical chemistry, A. Findlay, T. A. Kitchner (Longmans, Green and Co.)
- 2) Experiments in Physical Chemistry, J. M. Wilson, K. J. Newcombe, A. R. Denko. R. M. W. Richett (Pergamon Press)
- 3) Senior Practical Physical Chemistry, B. D. Khosla and V. S. Garg (R. Chand and Co., Delhi).

23ScCheP114: Basic Organic Chemistry (2 Credits, 30 L)

Course Outcome

CO1: Understand and apply principles of stereochemistry, including isomerism and chirality.

CO2: Understand basic concepts of hyperconjugation, inductive effect, resonance effect etc

CO3: Learn concepts of Aromaticity, antiaromatic and non-aromatic compounds annulenes

CO4: Learn R/S and E/Z for various systems like allene, spirane, biphenyls.

CO5: Understand acid-base concepts and application of electronic effects in systems

CO6: Learn cram's rule and felkin ahn's rule

Chapter No.	Basic Organic Chemistry	
1	Structure and reactivity Chemical bonding and basis of reactivity- Chemical bond, delocalization, conjugation, resonance, hyperconjugation, tautomerism, inductive effects, Acidity and basicity: various structural effects, HSAB concept, Aromaticity: Benzenoid and non-benzenoid compounds, Huckels rule, antiaromaticity, Application to carbocyclic and heterocyclic systems, annulenes, azulenes, current concepts of aromaticity, Structure and stability of reactive intermediates, carbenes, nitrenes, carbocations, carbanions and free radicals	10 L
2	Stereochemistry Stereochemical principles, enantiomeric relationship, distereomeric relationship, R and S, E and Z nomenclature in C, N, S, P containing compounds, Prochiral relationship, stereospecific and stereoselective reactions, optical activity in biphenyls, spiranes, allenes, examples of chiral metal complexes. Conformational analysis of cyclic (4, 5, 6 membered) and acyclic compounds, Structural effect on reactivity of cyclohexane, Cram's rule and Felkinahn Model	20 L

References:

- 1) Organic Chemistry–by J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford)
- 2) Advanced Organic Chemistry –by J. March 6th Edition

- 3) Advanced Organic Chemistry (part A) –by A. Carey and R.J. Sundberg
- 4) Stereochemistry of carbon compound-by E.L. Eliel
- 5) Stereochemistry of organic compound-by Nasipuri
- 6) Guide book to Reaction Mechanism–Peter Sykes

23ScCheP121: Organic Reactions (Theory) (2 Credits, 30 L)

Course Outcomes

CO1: Recognize and classify different types of organic reactions (e.g., substitution, elimination, addition).

CO2: Understand and predict the mechanisms of various organic reactions.

CO3: Understand the role of reaction conditions (e.g., temperature, solvent) and reagents in controlling reaction outcomes.

CO4: Predict and interpret the stereochemical and regiochemical outcomes of organic reactions.

CO5: Apply knowledge of organic reactions to design and propose multi-step syntheses of complex molecules.

CO6: Design and propose syntheses for simple organic compounds and analyze their structures.

	Organic reactions (2 Credits, 30 L)	
1	Substitution reaction of saturated carbon Aliphatic nucleophilic substitution - SN^1 , SN^2 mechanism, NGP by pi and sigma bonds, classical and non-classical carbocations, phenonium ions, norbornyl system, carbocation rearrangement in NGP, SN^i mechanism, nucleophilic substitution in allylic, trigonal and vinylic carbon. Effect of structure, nucleophile, leaving group and solvent on rate of SN^1 and SN^2 reactions, ambident nucleophile and regioselectivity	8 L
2	Aromatic Electrophilic substitution Arenium ion mechanism, orientation and reactivity, energy profile diagram, ortho, para, ipso attack, orientation in other ring systems, six and five membered heterocycles with one hetero atom Important reactions like Friedel crafts alkylation and acylation, Nitration, halogenation, formylation, chloromethylation, sulphonation, diazonium coupling	7 L
3	Aromatic nucleophilic substitution $\text{S}_\text{N}\text{Ar}$, SN^1 , Benzyne and SNR^1 reactions, reactivity: effect of substrate structure, leaving group and attacking nucleophile	3 L

4	Addition reactions Addition to C-C multiple bonds - mechanism and stereochemical aspects of addition reaction involving electrophile, nucleophile and free radicals, Regio and chemo selectivity, orientation and reactivity, conjugate addition	4 L
5	Elimination reactions E ¹ , E ² , E1cB mechanisms, orientation and stereochemistry in elimination reaction, reactivity effect of structure, attacking and leaving group, competition between elimination and substitution, syn eliminations	4 L
6	Heterocyclic Chemistry: Recapitulation of Synthesis and reactivity of Pyrrole, Furan and Thiophene, Synthesis and reactivity of Benzofuran, Benzopyran, Benzothiophene, Quinoline, Isoquinoline, Indole, etc.	4 L

References:

- 1) Organic Chemistry—by J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford)
- 2) Advanced Organic Chemistry –by J. March 6th Edition
- 3) Advanced Organic Chemistry –by A. Carey and R.J. Sundberg

23ScCheP121: Organic Reactions (Practical) (2 Credits)

Course Outcomes

CO1: Demonstrate hands-on skills in recrystallization, including crystallization, filtration, and washing.

CO2: Synthesize simple organic compounds through single-stage reactions.

CO3: Evaluate the yield and purity of products from single-stage reactions.

CO4: Choose suitable reagents, solvents, and conditions for single-stage reactions.

CO5: Perform basic organic reactions, understand reaction mechanisms.

CO6: Analyze reaction products and apply safety protocols in a laboratory.

	ORGANIC CHEMISTRY
1	Techniques of Purification
	Recrystallization 3 samples (Yield, TLC, and M.P.)
	Recrystallization 3 samples (Yield, TLC, and M.P.)
	Distillation (Steam distillation, vertical distillation, Fractional distillation, etc.) (Yield, TLC, and M.P.)
	Column chromatography separations (Yield, TLC, and M.P.)
2	Single Stage Preparations
	Coupling of β -Naphthol
	Diels alder reaction
	Multicomponent synthesis
	Riemann – Tiemann reaction
	Nitration reaction
	Henry reaction
	Reduction using NaBH_4
	Chalcone from acetophenone
	Benzoylation of Glycine
	Oxidation of Cyclohexanone
	Acetylation of Resorcinol (Resaceto Phenol)

References:

1) Textbook of practical organic chemistry – A. I. Vogel

23ScChOP122: Organic Intermediates and its Applications organic synthesis (4 Credit, 60 L)**Course Outcome**

CO1: Learn in depth about intermediate and its application.

CO2: Learn about stability, formation of carbanion and related reactions

CO3: Learn about Carbene, nitrene and nitron intermediates

CO4: Learn about C-C bond forming reactions involving free radicals.

CO5: Learn about Carbocation- its formation, stability and reactions

CO6: Learn about enamine and its application.

Chapter No.	Organic Intermediates and its Application in Organic Synthesis (2Credits, 30 L)	
1	Carbanion- Formation, Stability and Reactions. Ionization of carbon hydrogen bond and prototopy, Base and acid catalyzed halogenation of ketones, keto-enol equilibria, structure and rate in enolisation, concerted and carbanion mechanism for tautomerism, carbanion character in phenoxide and pyrrolyl anions, hydrolysis of haloforms, Aldol, Mannich, Cannizzaro, Umpolung, Darzens, Dieckmann, Claisen Baylis-Hillman reactions, Knoevenagel, benzoin condensation, alkylation of enolates and stereochemistry thereof, Conjugate additions. Enamines and Imines in Organic Synthesis Formation and Stability and its application, stork enamine synthesis. Carbocation and Ester hydrolysis Formation and stability of carbocation, Reactions involving carbocation such as Wagner-Meerwein rearrangement, Dienone phenol rearrangement, Tiffeneau-Dejancov reaction.	20 L
2	Carbene, Nitrene, Nitron Structure and stability of carbene and nitrene, Reactions involving carbene, nitrene, nitron.	05 L

3	Free Radical Generation, stability, Nucleophilic and electrophilic radicals, characteristics reactions, -free radical substitution, addition to multiple bonds, Radicals in synthesis: Inter and intra molecular C-C bond formation via mercuric hydride, tin hydride, thiol donors, cleavage of CX, C-Sn, C-Co, C-S, O-O bonds, Oxidative coupling, C-C bond formation in aromatics.	05 L
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References:

1. Advanced Organic Chemistry by J. March, 8th Ed.
2. Organic chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford Press)
4. Some modern methods of organic synthesis – W. Carruthers (Cambridge)
5. Organic synthesis – Michael B. Smith
7. Advanced organic chemistry, Part B – F. A Carey and R. J. Sundberg, 5th edition (2007)
8. Guidebook to organic synthesis-R K Meckie, D M Smith and R A Atken
9. Organic synthesis- Robert E Ireland
10. Strategic Applications of named reactionsin organic synthesis-Laszlo Kurti and Barba

23ScChOP122: Organic Intermediates and its Application in Organic Synthesis (Practical)
(2 Credits)

Course Outcomes

CO1: Predict and analysis of the major and minor products of a variety of organic reactions

CO2: Learn how to Calculation of yield, percentage yield of the chemical reactions.

CO3: Learn how to monitor reaction through TLC.

CO4: Learn about Purification of the organic compounds by crystallization.

CO5: Know about the predictions of various reactions involved in a particular organic molecule by the changes which are occurred in apparatus

CO6: Product analysis by physical and chemical methods

	ORGANIC CHEMISTRY
1	Synthesis of β -hydroxy naphthaldehyde (Reimer-Tiemann reaction)
2.	Synthesis of p-chlorobenzoic acid and p-chlorobenzyl alcohol from p-chlorobenzaldehyde (Cannizzaro reaction)
3	Synthesis of 2,2'-Dihydroxy-1,1'-binaphthyl (coupling)
4.	Synthesis of Vanillyl alcohol (Reduction)
5	Synthesis of 2,4,6-Tribromoaniline (Bromination)
6	Synthesis of 1-Nitronaphthalene (Nitration)
7.	Synthesis of β -phenyl propionic acid. (Reduction)
8.	Synthesis of anthrone from anthraquinone
9.	Synthesis of 1-formyl-2-methoxy naphthalene (Vilsmeier-Haack)
10.	Synthesis of 3-methyl pyrazol-5-one
11.	Synthesis of phenyl hydrazone.
12.	Synthesis of Acetanilide (Beckmann rearrangement)
13.	Synthesis of cinnamic acid.

References:

1. Ahluwalia, V. K. and Aggarwal, R. (2000). Comprehensive practical organic chemistry: Preparation and Quantitative Analysis, Universities Press
2. Vogel's Textbook of Practical Organic Chemistry" by A.I. Vogel

23ScCheP131: Research Methodology Core Paper (2 Credits, 30 L)

Course outcomes

CO1: To understand of ethical issues related to research, publication, patents and rights.

CO2: To understand publication ethics and related issues.

CO3: Decision making on research topics

CO4: Identifying sources of research problems

CO5: Application of computing skills and computer applications in research.

CO6: Collecting and analyzing data.

Chapter No.	Research Methodology Core Paper (2 Credits, 30 L)	
1	Research Problem and Design Introduction to research: meaning and definition of research, objective of research, importance of research characteristics of good research, purpose and role of research classification of research Research problem: defining of research problem Criteria for selecting the research problem, importance of literature survey in defining research problem. Hypothesis: Defining Hypothesis, types of hypothesis, characteristics of good hypothesis, formulation of hypothesis Research Design: Definition and features of research design, Concept of research design, types of research design, preparation of research design, Sampling techniques, characteristics of good sampling designs	15 L
2	Data analysis, report writing and publication ethics Definition of Data, methods of data collection, analysis of data, types of data analysis, Questionnaire, Design of Questionnaire. Testing hypothesis parametric and non-parametric tests T-test, Z-test, Chi-square test. ANOVA Report writing: Importance of interpretation of results, meaning, definition and significance of report /thesis writing. Principals of research report drafting. Types of reports, layout of research report, important parts of reports, precautions of preparation of report/ thesis	15 L

Publication ethics: Definition, introduction and importance, best practices/standard settings initiative and guidelines COPE, WAME, etc, conflict of interest. Publication misconduct definition, concept problems that lead to unethical behavior violation of publication ethics, predatory publishers and journals, software tools to identify predatory publications developed by SPPU
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References:

- 1) C. R. Kothari (2004) Research Methodology Methods and Techniques 2" Edition New age International (p) Ltd Publications, New Delhi, India
- 2) J W Creswell and J D. Creswell (2017) Research Design Qualitative, Quantitative, and Mixed Methods Approaches, 5th Edition. SAGE Publications, USA
- 3) CG Thomas (2021) Research Methodology and Scientific Writing, 24 Edition, Springer Nature, New York.
- 4) M. Kheider lectures from University of Biskra (2017) <https://univ-biskra.dz/sites/f/images/houadili%20Ahmed%20Chaouki.pdf>

23ScCheP131: Department Specific Paper (2Credit, 30 L)

Course Outcomes

CO1: Students who complete this course will be able to understand and comprehend the basics in research methodology and applying them in research/ project work.

CO2: This course will help them to select an appropriate research design.

CO3: With the help of this course, students will be able to take up and implement a research project/ study.

CO4: The course will also enable them to collect the data, edit it properly and analyse it accordingly.

CO4: The Students will develop skills in qualitative and quantitative data analysis and presentation.

CO4: Students will be able to demonstrate the ability to choose methods appropriate to research objectives.

Chapter No.	Nanomaterials (2 Credits, 30 L)	
1	The Big world of nanomaterials History and scope-Can small things make big difference? – Classification of nanomaterials – Fascinating Nanostructures – Applications of nanomaterials- The nature: The Bets Nanotechnologist – Challenges and future prospects	4 L
2	Unique Properties of Nanomaterials Microstructure and defects in monocrystalline Materials - Effect of Nano dimensions on material behaviour Optical Properties, Electrical Properties, Mechanical Properties, Magnetic Properties	5 L
3	Synthesis Routes Bottom-Up approaches – Top-Down approaches - Consolidation of Nano powders Mechanical Grinding, Wet Chemical Synthesis of Nanomaterials –Sol Gel Process, Gas Phase Synthesis, Flame assisted ultrasonic spray pyrolysis, Gas Condensation Processing, Chemical Vapour Condensation (CVC) etc.	7 L
4	Application of Nanomaterials Nano electronics –Micro and Nano-Electromechanical Systems (MEMS/NEMS) – Nanosensors –Nanocatalysts- Food and Agriculture Industries – Cosmetic and Consumer goods – Structure and Engineering – Automotive Industry-Water treatment and environment –	7 L

	Nanomaterial applications – Nanomedical applications – Textile-Paints –Energy-Defence and space applications – Structural applications , etc.	
5	Tools to Characterize Nanomaterials X-Ray Diffraction (XRD) – Small Angle X Ray Scattering (SAXS)-Scanning Electron microscopy (SEM) – Transmission Electron Microscope (TEM)-Atomic Force Microscope (AFM) –Scanning Tunnelling Microscope (STM) - Field Ion Microscope (FIM) –Three Dimensional Atom Probe (3DAP) –Nano indentation	7 L

References:

- 1) Text Book of Nanoscience and Nanotechnology by B S Murty, P Shankar, Baldev Raj, B B Rath, James Murday – Springer and University Press (2013)
- 2) Chapter - Introduction to Nanomaterial - Alagarasi, A, -2016-Research Gate.

Semester 2

23ScCheP211: Molecular Spectroscopy & Nuclear Chemistry II (4 Credits, 60 L)

Course outcomes

CO1: Understand of the principle of Microwave, IR, Raman, Electronic, NMR, ESR and Mossbauer spectroscopy

CO2: Draw of the schematic Microwave, IR and Raman spectrum of di and triatomic molecules based on the selection rules.

CO3: Understand the interpretation of sample analysis.

CO4: Understand of decay kinetics and measurement of radioactivity.

CO5: get knowledge of types of nuclear reactors.

CO6: study the applications of radioactivity, Understand Radiolysis and radicals.

Chapter No.	Section I: Molecular Spectroscopy (2 Credits, 30 L)	
1	Introduction to spectroscopy Basic Elements of practical spectroscopy Signal to noise: resolving power, Width and intensity of spectral transitions, Fourier Transform Spectroscopy, Enhancement of spectra: computer Averaging.	3 L
2	Microwave Spectroscopy The Rotation of Molecules, Rotational Spectra, Diatomic molecules, Polyatomic molecules, Techniques and Instrumentation, Chemical Analysis by Microwave Spectroscopy, The Microwave Oven, Problems.	5 L
3	Infrared spectroscopy Harmonic and anharmonic oscillator, vibrational spectra of di –and poly- atomic molecules, coarse and fine structure, Nuclear spin effect, application, Problems.	5 L
4	Raman Spectroscopy: Introduction, Rotational Raman- spectra, Vibrational Raman Spectra, polarization of light and Raman effect, structure elucidation from combined Raman and IR spectroscopy, applications in structure elucidation, Problems.	6 L
5	Electronic spectroscopy of molecules:	6 L

	Born – Oppenheimer approximation, electronic spectra of diatomic molecules, vibrational coarse structure, rotational fine structure dissociation energy and dissociation products, electronic structure of diatomic molecules, molecular photoelectron spectroscopy and applications.	
6	ESR and Mossbauer spectroscopy applications. ESR-Introduction, g factor, The Hyperfine Structure of ESR, Double Resonance, Electron-Electron Coupling, Techniques of ESR, Problems. Mossbauer Spectroscopy - Introduction, Principle, Applications of Mossbauer Spectroscopy, Problems.	5 L
	Section II: Nuclear and Radiation Chemistry (2Credits, 30 L)	
1	Radiation Chemistry Recapitulation – Types of radioactive decay, Decay Kinetics, Detection & measurement of radiation (G.M. & Scintillation counter), Radiation chemistry, interaction of radiation with matter, passage of nucleus through matter, Units for measuring radiation absorption, Radiation dosimetry, Radiolysis of water, free radiation in water Radiolysis, Radiolysis of some aqueous solution	9 L
2	Nuclear Reactor The Natural uranium reactor, the four factor formula- The reproduction factor K, the classification of reactor, Reactor power, Critical size of thermal reactor, excess reactivity & control, the Breeder reactor, Reprocessing of spent fuel, Recovery of Uranium & Plutonium, Nuclear waste management, Natural nuclear reactor	7 L
3	Isotopes for nuclear reactors Isotope separation, separation of selected isotopes, Plutonium	4 L
5	Applications of radioactivity Typical reaction involved in preparation of radio isotopes: ^3H , ^{14}C , ^{22}Na , ^{32}P , ^{35}S and ^{127}I , General principles of using radioisotopes. Physical constants – Diffusion coefficients, surface area, solubility. Analytical applications neutron activation analysis, dilution analysis, radiometric titration. Industrial applications– radiation gauging, friction and wear out, gamma radiography	10 L

References:

- 1) Fundamentals of molecular spectroscopy: C.N. Banewell and E.Mc. Cash (Fourth edition)
- 2) Elements of Nuclear chemistry – H. J. Arnikar, fourth edition wiley Estern Ltd.
- 3) Source book of atomic energy – S. Glasstone, D. Van Norton Company
- 4) Chemical applications of radioisotopes – H. J. M. Brown Buffer & Jammer Ltd.

23ScCheP212: Coordination and Bioinorganic Chemistry (4 Credits, 60 L)

Course Outcomes

CO1: To understand the key features of coordination compounds, coordination numbers, ligands, chelates, bonding and stability of complexes.

CO2: To become familiar with some applications of coordination compounds.

CO3: To be able to use Crystal Field Theory to understand the magnetic properties (and in simple terms the colour) of coordination compounds.

CO4: To understand & study about the concepts of bioinorganic chemistry

CO5: They get well exposure about amino acids.

CO6: To understand the key features of Bioinorganic compounds

Chapter No.	Section I: Coordination Chemistry (2 Credits, 30 L)	
1	Concept & Scope of Ligand Fields Free ion configuration, Spin – Spin coupling, Orbital coupling, Spin –Orbital coupling, The Energy terms coupling schemes, Russell- Saunders's coupling scheme, J-J Coupling scheme, Effect of V_{Oh} & V_{Td} on terms	6 L
2	Basic concepts of electron absorption spectroscopy Selection rules - Spin selection rule, Laporte selection rule	2 L
3	Ligand Field Theory of Coordination Complexes Effect of ligand field on energy levels of transition metal ions, Weak cubic ligand field effect on Russell- Saunders terms, Strong field effect on Russell- Saunders terms, Widths of absorption bands, Relative variation of energy levels under the influence of Crystal field, Orgel diagrams, Application of Orgel diagrams, Use of Orgel diagrams, Correlation diagrams, Tanabe-Sugano diagrams, Spin-Pairing energies	7 L
4	Electronic spectra of Transition Metal Complexes Introduction, Band intensities, Band energies, Band width & shapes, Spectra of 1 st , 2 nd & 3 rd row ions and rare earth ion complexes, Spectrochemical & nephelauxetic series, Charge transfer spectra & luminescence, Calculations of Dq , B , β	7 L

	parameters	
5	Magnetic Properties of Coordination Complexes Origin and types of magnetism, Curie and Curie-Weiss Law, Magnetic properties of complexes-Paramagnetism, 1 st & 2 nd ordered Zeeman Effect, Quenching of orbital angular momentum by ligand fields, Magnetic properties of A, E & T ground terms in complexes, Spin free spin paired equilibria	8 L
	Section II: Bioinorganic Chemistry (2 Credits, 30 L)	
1	Overview of bioinorganic chemistry Biological functions of metal ions, Metalloenzyme functions, Recapitulation of thermodynamic and kinetic aspects related to bioinorganic chemistry, Summary of biomolecules, proteins, Nucleic acids, Other metal binding biomolecules	6 L
2	Bioinorganic chemistry of Cu, Zn Biochemistry of copper, Copper centers in enzymes: Type-1, Type-2 and Type - 3, Copper proteins as oxidases/reductases, Cu-Zn Superoxide Dismutase, Hemocyanin, Biochemistry of Zinc, Carbonic Anhydrase (CA) Carboxypeptidase A (CPA), Alcohol Dehydrogenase (ADH), Zinc Finger protein	8 L
3	Bioinorganic chemistry of Iron Porphyrin based systems: Hemoglobin and myoglobin, Ferritin, Transferrin (Receptor mediated endocytosis), Iron-Sulfur clusters, Cytochrome P-450, Alternative Oxygen Transport in Some Lower Animals: Hemerythrin	9 L
4	Bioinorganic chemistry of Ca, Mn Calcium: Calmodulin & Role of Ca in blood coagulation Manganese: Photosynthesis	4 L
5	Electrolyte balance in human body Generation of ionic gradients (Na^+ - K^+ -ATPase), Acetylcholine receptor	3 L

References:

- 1) Ligand field theory & its applications: B. N. Figgis & M. A. Hitchman (2000) Wiley VCH Publication
- 2) Symmetry and spectroscopy of molecules, Second Edn, by K. Veera Reddy, New Age International Publication 2009.
- 3) Elements of magnetochemistry, R. L. Datta and Syamal, Second Edn , Afiliated East West Press Pvt. Ltd. 2007.
- 4) Principle of Bioinorganic Chemistry: S. J. Lippard and J. M. Berg
- 5) Bioinorganic Chemistry: Inorganic Elements in Chemistry of Life: W. Kaim and B. Schwederski.
- 6) Bioinorganic Chemistry: Bertini, Gray, Lippard and Valentine
- 7) Bioinorganic Chemistry: R. J. P. Williams
- 8) Bioinorganic Chemistry: Robert Hay
- 9) Bioinorganic Chemistry: M.N. Hughes

23ScCheP213: Lab Course on 23ScCheP211 & 23ScCheP212 (4 Credits)

Course outcomes

CO1: Prepare the solution of the desired concentration and the desired volume.

CO2: Know the principle and handling of GM counter, potentiometer, conductivity meter, colorimeter, Viscometers etc.

CO3: Plot accurate graph of the desired scale for the calculations.

CO4: To understand alloy and ore composition

CO5: Students develop the skill related to the sample preparation, instrument operation and data analysis.

CO6: The students know the applications of alloy/ore.

Experiment No.	Name of the Experiment
	PHYSICAL CHEMISTRY
1	Colorimetry & spectrophotometry
	Simultaneous determination of Cations from their mixture Spectrometrically
	The reaction between potassium persulphate and potassium iodide by colorimetry
2	Radioactivity
	Determine the half-life of a given radioactive nuclide and counting error Find the percentage error in the given experimental data by the method of least squares
	Determine $E_{\max}$ of β -radiation and absorption coefficient in Aluminium
3	Non-instrumental experiments
	Determine the radius of glycerol molecule from viscosity measurements
	Determine the densities of a series of solutions and calculate the partial molar volume of the components
	Statistical treatment of experimental data (calculation of mean and standard deviation for given data and least square method for calibration curve method)
4	Electrical conductance
	Determine equivalent conductivity at infinite dilution and dissociation constant of acetic acid conductometrically.

	Study the second order velocity constant of the hydrolysis of ethyl acetate by sodium hydroxide using conductivity measurement
	To determine concentration of Boric acid titrating with NaOH by Conductometry
5	Potentiometry
	Determination of Solubility and Solubility product of the given sparingly soluble salts.
	Determine the amount of chloride, bromide and iodide present in their mixture by potentiometric titration.
6	pH metry
	Determine dissociation constants of tribasic acid.
	To determine dissociation constant of carbonic acid
	To determine the ionization constant of methyl red/ bromophenol blue.
7	Interpretation of spectra/data-I
	Interpretation of ESR spectra.
	Interpretation of Mössbauer spectra
	INORGANIC CHEMISTRY
1	Ion exchange chromatography
	Separation & estimation of a mixture of Zn (II) & Mg (II) using ion exchange chromatography
	Separate the binary mixture of Zinc and Cadmium using ion exchange chromatography
2	Ore analysis
	Determination of Silica (SiO ₂) & Manganese (Mn) in pyrolusite
	Determination of silica & iron from haematite
3	Inorganic synthesis & purity determination
	a) Synthesis of tris-ethylene diaminenickel (II) thiosulphate
	b) To determine the purity of tris-ethylene diaminenickel (II)thiosulphate
	a) Synthesis of tris (thiourea) copper (I) chloride.
	b) To determine the purity of tris (thiourea) copper (I) chloride
	a) Synthesis of potassium trioxalatoaluminate (III) trihydrate
	b) To determine the purity of potassium trioxalatoaluminate (III)
	a) Preparation of Copper Tetramine Sulphate
	b) To determine the purity of Copper Tetramine Sulphate

	a) Preparation of hexamine Ni (II) chloride
4	Conductometry
	To verify Debye- Hukel theory of ionic conductance for strong electrolytes using KCl, BaCl ₂ , K ₂ SO ₄ , K ₃ [Fe(CN) ₆]
5	Photochemistry
	Synthesis & photochemistry of potassiumtrioxalatoferrate (III) trihydrate
6	Synthesis of Nano Materials
	Synthesis of nano size ZnO, its characterization by UV- visible spectroscopy and removal of dye by ZnO photocatalysis
7	Interpretation of spectra/data-I
	Interpretation of DTA, TG, and DTG curves.
8	Table work
	Analysis of Electronic Spectra of transition metal complexes at least for one system [dn (Oh) or (Td)] and calculation of Crystal Field parameters, interelectronic repulsion parameter and bonding parameter.

References:

- 1) Practical physical chemistry, A. Findlay, T.A. Kitchner (Longmans, Green and Co.)
- 2) Experiments in Physical Chemistry, J. M. Wilson, K. J. Newcombe, A.R. Denko. R. M. W. Richett (Pergamon Press)
- 3) Senior Practical Physical Chemistry, B.D. Khosla and V.S. Garg (R. Chand and Co., Delhi.).
- 4) Text book of Quantitative Analysis, A. I. Vogel 4th Edn. (1992).
- 5) Experimental Physical Chemistry by D. P. Shoemaker, Mc. Growhill, 7th Edition, 2003. .
- 6) Physical chemistry by Wien (2001)
- 7) Practical physical chemistry, B. Vishwanathan and P.S. Raghavan, 2nd edition, (2012)
- 8) Experimental Physical chemistry, V.D. Athawale, Parul Mathur, New age International publishers.
- 9) Experimental Inorganic Chemistry, Mounir A. Malati, Horwood Series in Chemical Science (Horwood publishing, Chichester) 1999.
- 10) Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House
- 11) General Chemistry Experiments, Anil. J Elias, University press (2002)
- 12) Electronic Spectroscopy by A.B. P. Lever.

23ScCheP214: Organic Spectroscopy (2 Credits, 30 L)

Course Outcomes

CO1: Identify functional groups and molecular structure from infrared (IR) spectroscopy data.

CO2: To assign structures to organic compounds using ^1H and ^{13}C nuclear magnetic resonance (NMR) spectroscopy.

CO3: To determine molecular weight and fragmentation patterns from mass spectrometry (MS) data.

CO4: To combine data from multiple spectroscopic techniques (IR, NMR, MS) to determine the structure of an organic compound.

CO5: To use spectroscopic data to solve structural problems and identify unknown compounds.

CO6: To describe the principles and instrumentation of various spectroscopic techniques, including IR, NMR, and MS.

Chapter No.	Organic Spectroscopy	
1	UV: Factors affecting UV absorption and interpretation of UV spectra	3 L
2	IR: Basic ideas about IR frequencies, interpretation of IR spectra	5 L
3	NMR: Fundamentals of ^1H -NMR, ^{13}C -NMR factors affecting chemical shift, integration coupling (1st order analysis) , 2D- NMR COSY, HOMO, HETCOR, NOE, DEPT	15 L
4	Introduction to Mass spectrometry	3 L
5	Problems on UV, IR, PMR and Mass	4 L

References:

1. Introduction to spectroscopy – D. L. Pavia, G.M. Lampman, G. S. Kriz, 3rd Edition
2. Spectroscopic methods in organic molecules – D.H. William & I Flemming Mc Graw Hill
3. Spectrometric Identification of Organic Compounds Robert M. Silverstein, Francis X. Webster, David Kiemle
4. Organic Chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford)

23ScCheP221: Synthetic Organic Chemistry (Theory) (4Credits, 60 L)

Course Outcomes

CO1: Apply knowledge of organic reactions to design and propose multi-step syntheses of complex molecules.

CO2: Choose and apply suitable synthetic methods, reagents, and conditions to achieve desired transformations.

CO3: Understand chemoselectivity and regioselectivity.

CO4: Understand various reactions like rearrangement, substitution, Elimination, Addition reaction

CO5: Formation of C-C bond forming reactions

CO6: Learn heterocyclic chemistry and ylides.

Chapter No.	Synthetic Organic Chemistry (2 Credits, 30 L)	
1	Oxidizing agents and their reactions CrO ₃ , PDC, PCC, KMnO ₄ , MnO ₂ , Swern, SeO ₂ , Pb(OAc) ₄ , Pd-C, OsO ₄ , m-CPBA, O ₃ , NaIO ₄ , DDQ, HIO ₄ , Woodward and prevost hydroxylation, etc.	6 L
2	Reducing agents and their reactions Boranes and hydroboration reactions, MPV reduction and reduction with H ₂ /Pd-C, Wilkinson's catalyst, DIBAL and Wolff Kishner reduction, Birch reduction, LAH, Catalytic Hydrogenation. Suzuki coupling, etc.	6 L
3	Rearrangements Beckmann, Hofmann, Curtius, Smith, Wolff, Lossen, Bayer-villiger, Sommelet, Favorskii, Pinacol-pinacolone, Benzil-benzilic acid, Fries, Claisen rearrangement, cope rearrangement, Wagner Meervin rearrangement, etc.	8 L
4	Ylides Phosphorus, Nitrogen and Sulphur ylides	3 L
5	C-C bond formation reactions: Grignard, organozinc, organocopper, organolithium, reagents to carbonyl and unsaturated carbonyl compounds, Palladium catalyst, suzuki, Heck reaction	4 L
6	Heterocyclic Chemistry :	3 L

	Synthesis and Reactivity of Pyrazole, Oxazole, Diazole, Triazole, Flavone, Isoflavones, Coumarin, etc.	
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References:

1. Organic Chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford)
2. Modern Synthetic reactions- H.O. House
3. Organic Synthesis – M.B. Smith
4. Advanced Organic Chemistry (part A & B) – A. Carey and R. J. Sundberg
5. Stereochemistry conformations and mechanism by P. S. Kalsi
6. Organic chemistry by Cram, Hammond, Pine and Handrickson
7. Mechanism and Structure in Organic Chemistry - E.S. Gould

23ScCheP221: Synthetic Organic Chemistry (Practical) (2 Credits)

Course Outcomes

CO1: Identify and separate components of ternary mixture.

CO2: Understand reaction mechanisms and execute multistep synthesis.

CO3: Gain knowledge of physical constant and their properties.

CO4: Plan and carry out double-stage preparations of organic compounds.

CO5: To analyze and purify the synthesized products using techniques like crystallization.

CO6: Evaluate and optimize the overall yield and purity of the final product.

	ORGANIC CHEMISTRY
1	Ternary Mixture Separation (Any 8)
	Using ether separation method including TLC, M. P., Yield (5 Ether Soluble & 3 Ether Insoluble one compound)
2	Double stage Preparations
	Nitrobenzene to <i>m</i> - dinitrobenzene to <i>m</i> - nitroaniline
	β- Naphthol to 2- methoxy naphthalene to 1- formyl-2- methoxy naphtahalene
	Benzaldehyde to Benzalacetophenone to Epoxide
	Resorcinol to 4-methyl-7-hydroxy to coumarin 4-Methyl-7-acetoxy coumarin
	Hydroquinone to Hydroquinone diacetate to 1,2,4 – Triacetoxy
	Hippuric acid to Azalactone to 4-Benzylidene 2-phenyloxazol-5-one
	p-Cresol to p-Cresyl benzoate to 2-Hydroxy-5-methyl benzophenone
	Phthalimide to N-Benzylphthalimide to Benzylamine
	Benzyl cyanide to p-Nitrobenzyl cyanide to <i>p</i> -Nitro phenyl acetic acid
	Chlorobenzene to 2, 4 dinitrochlorobenzene to 2, 4 dinitro phenyl Hydrazine

References:

1) Textbook of practical organic chemistry – A. I. Vogel

23ScChOP222: Advanced Green Chemistry (4 Credits, 60 L)

Course Outcome

CO1: Learn green chemistry concepts such as twelve principles of green chemistry, atom economy, E-Factor

CO2: Learn about Value added chemicals and their synthesis.

CO3: Learn about solvents selection and ionic liquids

CO4: Learn about biomass conversion to energy

CO5: Learn to develop environmentally efficient and benign reformations for conventional protocols.

CO6: Learn, to design safer chemical, products and processes, as compared to conventional alternatives to prevent accidents

Chapter No.	Advanced Green Chemistry (2 Credit, 30 L)	
1	Green Chemistry Principle and Atom Economy. 12 Principles of Green Chemistry, Calculations based on atom economy/atom efficiency, Environmental factor, carbon efficiency.	10 L
2	Introduction to Value added chemicals and their synthesis. Value added chemicals, Renewable chemicals, Synthetic Methodologies for value added chemicals (Heterogenous catalysis/ green chemistry approach).	10 L
3	Solvent in green chemistry Solvent selection guide, Ionic Liquids and its types, properties and application in green chemistry.	05 L
4	Biomass to Chemicals Top 10 platform chemicals from carbohydrates,	05 L

References:

1. Anastas, P. T., Warner, J. Green Chemistry: Theory and Practice; Oxford University Press: London, 1998.
2. Mukesh Doble, Anil Kumar Kruthiventi, in Green Chemistry and Engineering, 2007
3. V.K. Ahluwalia & M.R. Kidwai: New Trends in Green Chemistry, Anamalaya Publishers (2005).
4. P.T. Anastas & J.K. Warner: Oxford Green Chemistry- Theory and Practical, University Press (1998).
5. A.S. Matlack: Introduction to Green Chemistry, Marcel Deckkar (2001).
6. M.C. Cann & M.E. Connely: Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).
7. M.A. Ryan & M. Tinnesand, Introduction to Green Chemistry, American Chemical Society, Washington (2002).

23ScChOP222: Advanced Green Chemistry (Practical) (2 Credits)

Course Outcomes

CO1: Apply green chemistry Principle and minimize waste.

CO2: Use of less hazardous reagents, solvents.

CO3: Critically analyse the existing traditional chemical pathways/processes and creatively think about bringing environmentally benign reformations in these protocols

CO4: Describe how injudicious use of chemicals can have an adverse/potentially damaging effect on humans and the environment

1	Pinacol-pinacolone rearrangement (Ref no 8)
2.	Reformatsky reaction(Ref no 9)
3	Pechmann Condensation (Ref no 6)
4.	Diels-Alder reaction (Ref no 4)
5	Beckmann Rearrangement (Ref no 9)
6	Biginelli reaction (Ref no 7)
7.	Aldol Condensation (Ref no 5)
8.	Knoevenagel condensation (Ref no 1)
9.	Nitration (Ref no 3)
10.	Rearrangement of diazoaminobenzene to <i>p</i> -aminoazobenzene (Ref no 2)
11	Ionic liquid synthesis (minimum 4)

References:

1. K. Kantharaju Prashant B Hiremath & S. Y. Khatavi, Indian Journal of Chemistry Vol 58B, June 2019, pp. 706-719

2. K Pitchumani*, C Venkatachalapathy & S Sivasubramanian Indian Journal of Chemistry Vol. 36B, February 1997, pp. 187-189

3. A. K. Bose,* S. N. Ganguly, M. S. Manhas, S. Rao, J. Speck, U. Pekelny and E. Pombo-Villars, *Tetrahedron Lett.* , **2006**, 47,1885..

4. Monograph on Green Chemistry Laboratory Experiments by Green Chemistry Task Force Committee, DST.