M.C.E. Society's

Abeda Inamdar Senior College of Arts, Science and Commerce, Pune 411 001 (Autonomous)

New Syllabus as per NEP-2020
for

M. Sc. Part-I
(M.Sc. Analytical Chemistry and M.Sc. Organic Chemistry)

From Academic Year 2023-24

Board of Studies (Chemistry)
Post Graduate Department of Chemistry and Research Center
Abeda Inamdar Senior College of Arts, Science and Commerce, Pune-411001

New Syllabus as per NEP- 2020 [w.e.f. 2023-24]

Structure of M. Sc. Chemistry

Structure of the Course:

Basic structure (Framework) of the proposed postgraduate syllabus for the two-year M.Sc. (Analytical and Organic Chemistry) in the Abeda Inamdar Senior College, Pune (Autonomous) affiliated to Savitribai Phule Pune University, Pune as per NEP-2020 pattern.

Semester wise credit distribution for two-year PG programe after three year BSc

Sem	Mandatory	Elective	RM	FP/OJT	RP	Total
I	08 (T) + 06 (P)	04 (T)	04	--	--	22
II	08 (T) + 06 (P)	04 (T)	--	04	--	22
III	10 (T) + 04 (P)	04 (T)	--	--	04	22
IV	10 (T) + 02 (P)	04 (T)	--	--	06	22
Total	36 (T) + 18 (P)	16 (T)	04	04	10	**88**

T = Theory P = Practical RM= Research Methodology, FP = Field Project,
OJT = On Job Training RP= Research Project

Semester wise credit distribution for one year PG programe after four-year B.Sc.

Sem	Mandatory	Elective	RM	FP/OJT	RP	Total
III	10 (T) + 04 (P)	04 (T)	--	--	04	22
IV	10 (T) + 02 (P)	04 (T)	--	--	06	22
Total	20 (T) + 06 (P)	08 (T)	--	--	10	**44**

Programme structure for first year M.Sc. I Chemistry

Sr. No.	Paper No.	Subject	Credit
		SEM-I	
1	23SMCH11MM	Chemical Kinetics and reaction dynamics	02
2	23SMCH12MM	Molecular Symmetry and applications	02
3	23SMCH13MM	Stereochemistry, Reagents and Rearrangements in Organic Chemistry	02
4	23SMCH14MM	Chromatography and Spectroscopy	02
5	23SMCH15MM	Physical Chemistry Practical – I	02
6	23SMCH16MM	Inorganic Chemistry Practical – I	02
7	23SMCH17MM	Organic Chemistry Practical – I	02
		(Elective: Anyone from following 23SMCH11ME)	
8	23SMCH11MEA	Chemical thermodynamics	02
8	23SMCH11MEB	Nanomaterials and applications	02
		(Elective: Anyone from following 23SMCH12ME)	
9	23SMCH12MEA	Chemistry of Main Group Elements	02
9	23SMCH12MEB	Clinical Biochemistry	02
10	23SMCH11RM	Research methodology in Chemistry	04
			=22
		SEM-II	
11	23SMCH21MM	Molecular Spectroscopy	02
12	23SMCH22MM	Co-ordination Chemistry	02
13	23SMCH23MM	Organic Spectroscopy	02
14	23SMCH24MM	Instrumental Methods of Analysis	02
15	23SMCH25MM	Physical Chemistry Practical – II	02
16	23SMCH26MM	Inorganic Chemistry Practical – II	02
17	23SMCH27MM	Organic Chemistry Practical – II	02
		(Elective: Anyone from following 23SMCH21ME)	
18	23SMCH21MEA	Organic Reaction Mechanism – I	02
18	23SMCH21MEB	Quantum Chemistry	02
		(Elective: Anyone from following 23SMCH22ME)	
19	23SMCH22MEA	Bio-inorganic Chemistry	02
19	23SMCH22MEB	Molecular and cell biology	02
20	23SMCH21FP	Field Project /On Job Training (OJT)	04
			=22

***N.B.:**

1 credit theory papers = 15 Hours lectures per semester
1 credit practical paper = 30 hours practical per semester

M. Sc. Programme Objectives and Outcomes

M. Sc. Programme Objectives and Outcomes:

Programme Objectives:

1. To develop conscience towards social responsibility, human values and sustainable development through curriculum delivery and extra-curricular activities
2. To develop scientific temperament with strong fundamental knowledge of the subject
3. To develop analytical thinking and problem-solving skills needed for various entrance and competitive examinations and Post Graduate Studies
4. To train students in laboratory skills and handling equipment along with soft skills needed for placement
5. To mold a generation of youth which can apply the chemistry in their life and careers?
6. To inculcate scientific attitude enriched with a multidisciplinary perspective in the students.
7. To update the students with the needs of the industry and society with respect to chemistry.

Programme Outcomes: After completing the M. Sc. Programme, the students shall:

1. Know the basics and applied aspects of the chemistry.
2. Be in a position to apply their knowledge in their professional, social and personal life.
3. Be competent to pursue research or a career in the chemistry.
4. Have the knowledge and confidence to pursue higher studies in Chemistry
5. Have skills in laboratory techniques and experience in instrument handling
6. Develop sensitivity towards social issues and become productive citizens of the nation

Programme Specific Outcome:

A) M.Sc. Analytical Chemistry:

1. The student should know fundamental aspects and the potential uses of Analytical Chemistry from industrial point of view.
2. Apply appropriate analytical techniques for the qualitative and quantitative analysis of chemicals in laboratories and industries as well.
3. Ability to handle/use appropriate tools/techniques/equipment with an understanding of the standard operating procedures, safety aspects and limitations.
4. The student should be able operate advanced analytical technique such as HPLC, Column Chromatography, GC, Coulometry, CV, Solvent Extraction.
5. To interpret the data obtained from techniques like TGA/DTA, XRD, SEM, TEM and the Spectroscopic techniques.

6. Should be able to synthesize and characterize nano particles and nano materials.
7. Should learn about the uses of analytical instruments in industrial chemistry, medicinal chemistry, and green chemistry.
8. Should develop accuracy and precision in performing experiments. Should understand the different types of errors and methods for minimizing errors.

B) M.Sc. Organic Chemistry:

1. Should gain knowledge in basic organic chemistry, re-arrangements, modern synthetic reagents, coupling reaction, multicomponent synthesis and click chemistry reactions
2. Students should be able to gain knowledge in classical organic laboratory techniques and the uses of modern instrumentation to perform new experiments.
3. Should be able to understand Advanced Spectroscopic Techniques, Stereochemistry, Organic Synthesis and basics of Computer Aided Drug Designing as well.
4. Should acquire the ability to synthesize, separate and characterize compounds using laboratory and instrumentation techniques.
5. Should be able to integrate the knowledge learned in Organic Chemistry to various industrial and pharmaceutical needs.
6. Learn about the potential uses of retro-synthetic analysis, medicinal chemistry, natural products chemistry and green chemistry.
7. Should be able to shoulder responsibilities in R & D labs.
8. To interpret the data obtained from various spectral techniques, through theoretical principles.
9. Able to apply knowledge of organic chemistry in research problems
10. Should know about global level research opportunities to pursue Ph.D. programmes, targeted approach of CSIR – NET and other competitive examinations.
11. Should know enormous job opportunities at all levels of chemical, pharmaceutical, food products, life-oriented material industries.

- **Evaluation Pattern:**

For each Theory and Practical Course, 50-50 pattern will be followed. Internal assessment will be of 50 marks for a 4-credit paper of 100 Marks. Internal assessment will be of 25 marks for a 2-credit paper of 50 Marks.

For Continuous Internal Evaluation (CIE), evaluation of theory courses will be done continuously. The 25 marks of Internal Evaluation shall be divided into the following:

a) One Mid Semester Exams of 20 Marks each converted to 10 marks.

b) one or wo Class Tests of 15 marks each converted to 5 Marks.

c) Class Assignments of 5 Marks.

d) One Presentation/Seminar/MCQ Test of 5 Marks. or

e) One Group Discussion/Open Book Test of 5 or 10 Marks.

f) A compulsory Mock Practical Examination and Viva Voce of practical subjects.

g) Internal marks for Journal / project report/ dissertation report completion and certification.

The student has to obtain 40% marks in the combined examination of In-semester assessment and Semester-End assessment with a minimum passing of 40% in both these separately.

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Course/ Paper Title	**Chemical Kinetics and reaction dynamics**
Course Code	**23SMCH11MM**
Semester	**I**
No. of Credits	**2 (30 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
	Students should;
1.	Understand and interpret the principles of physical and chemical observations.
2.	Be able to explain the proposed hypotheses in terms of fundamental concepts.
3.	Solve numerical problems through application of formulae.
4.	Apply logic and reasoning to theoretical and conceptual arguments in Physical Chemistry.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
	Student should be able to;
1.	Determine order and rate law of a chemical change based on experimental data.
2.	Calculate the rate constants of parallel and opposing reactions and derive the rate expressions of chain reactions for the formation of hydrogen halides by applying steady-state approximation.
3.	Explain the kinetics of fast reactions using various instrumentation techniques.
4.	Use the Arrhenius equation to calculate a rate constant, activation energy, and frequency factor.
5.	Collision Theory at the molecular level, activation energy and relationship of reaction rate with temperature.
6.	Explain role of enzymes as biological catalysts and their specificity and rate of reactions.

Syllabus

23SMCH11MM: Chemical Kinetics and Reaction Dynamics

Unit No.	Title with Contents	No. of Lectures
I	**Rate Laws and Complex reactions:** Recapitulations of basic concept, the temperature dependent reaction rates, Kinetics of fractional order reaction, Kinetics of nth order reaction, Reaction moving towards equilibrium, consecutive reaction, parallel reactions, the steady state approximation, pre-equilibria, unimolecular reactions, Problems.	**10**
II	**Kinetics of Fast reactions:** Introduction of Fast reactions, flash photolysis, flow technique, stopped flow technique, relaxation method, chain reactions, free radical polymerization reaction between H_2 and Br_2, explosive reaction, Problems.	**06**
III	**Molecular Reaction Dynamics:** Collision theory of bimolecular gas phase reactions, diffusion controlled and activation-controlled reaction solution, activated complex theory of reaction rate, Eyring's equation, reaction between ions, Primary salt effect, Problems.	**07**
IV	**Kinetics of Enzyme Catalyzed reactions:** Michaelis mechanism, effect of pH and temperature on enzyme catalyzed reactions. Limiting rate. Line weaver Burk and Eadie equation and plots, inhibition of enzyme action competitive inhibition and non-competitive inhibition, Problems.	**07**

Reference Books:

1. Physical Chemistry by P. W. Atkin and De Paul.
2. Physical Chemistry by T. Engel and P. Reid.
3. Principles of chemical Kinetics by James E. House.
4. Chemical Kinetics and reaction dynamics by Santosh K. Upadhyay.
5. Physical Chemistry for biological sciences by Raymond Chang (Universal books, 2000).

Course/ Paper Title	**Molecular Symmetry and Applications**
Course Code	**23SMCH12MM**
Semester	**I**
No. of Credits	**2 (30 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
Student should understand and learn;	
1.	The concept of symmetry elements and symmetry operations, representations of symmetry groups with examples.
2.	Basic concepts of symmetry and point groups of molecules.
3.	The group multiplication tables and character tables.
4.	To apply the projection operator for constructing SALCs.
5	To correlate application of symmetry to spectroscopy and find IR active modes of vibrations.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Students should be able to;	
1.	Understand concept of symmetry element, symmetry operation and point groups.
2.	Classify molecules into point group.
3.	Classify & recognize the symmetry elements and their operations as required to specify molecular symmetry & possible point gr oups from symmetry elements & be able to find point group of molecules by systemic procedure.
4.	Solve problems projection operator for constructing SALCs .

Syllabus : 23SMCH12MM: Molecular Symmetry and Applications

Unit No.	Title with Contents	No. of Lectures
I	**Molecular Symmetry and Symmetry Groups:** Symmetry elements and operations, Symmetry planes and reflections, the inversion centre, proper axis and proper rotations, improper axes and improper rotation, products of symmetry operations, equivalent symmetry elements and equivalent atoms, general relations among symmetry elements and symmetry operations, classes of symmetry operations, symmetry elements and optical isomerism, symmetry point groups, classification of molecular point groups. Defining properties of a group, group multiplication table, some examples of group, subgroups, and classes.	**10**
II	**Representations of Groups**: Matrix representation and matrix notation for geometric transformation, The Great Orthogonality Theorem and its consequence, character tables (No mathematical part), wave functions as basis for irreducible representations.	**06**
III	**Symmetry Adapted Linear Combinations:** Projection operators and their use of construct SALC (Construction of SALC for sigma bonding for molecules belonging point groups: D_2h, D_3h D_4h, C_4v, Td., Oh., normalization of SALC, transformation properties of atomic orbital, MO's for sigma bonding, ABn molecules, tetrahedral AB_4 and Oh AB_6 cases.	**08**
IV	**Application of Group theory to Infrared Spectroscopy:** Introduction, selection rules, polyatomic molecules, possible vibrations in a linear molecule, bending modes, symmetry of vibrations and their IR activity, Group vibration concept and its limitations, IR spectra related to symmetry of some compounds, IR spectra of complex compounds.	**06**

Reference Books:

1. Chemical Applications of Group Theory by F. A. Cotton
2. Symmetry and spectroscopy of molecules by K. Veera Reddy
3. Group Theory and its Chemical Application, P. K. Bhattarchrya
4. Inorganic Chemistry by Shriver and Atkins
5. Concise Inorganic Chemistry by J. D. Lee
6. Inorganic chemistry: principle of structures and reactivity by Huheey, Keiter, Medhi

Course/ Paper Title	**Stereochemistry, Reagents and Rearrangements in Organic Chemistry**
Course Code	**23SMCH13MM**
Semester	**I**
No. of Credits	**2 (30 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
	Student should understand and learn
1.	Concepts of stereochemistry and stereochemical aspects in organic chemistry
2.	The role of oxidizing and reducing agent, write reaction mechanism and stereochemistry of rearrangements reaction and make products as per migratory aptitude of different groups.
3.	The solve problems of rearrangement reactions, mechanism, and the stereo chemical outcomes.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
1.	The students should; Know and apply the fundamental principles of organic rearrangement reactions and mechanism
2.	Understand the role of various reaction intermediates like carbocation, carbanion, carbenes, radicals, and nitrenes in organic reactions
3.	Be able to do interconversion of Fischer to Newmann, Newmann to Sawhorse and vice versa, Able to assign R and S to given molecules; understand stereoselective and stereospecific reactions; acquire knowledge on topicity.
4.	Be able to describe step-wise mechanism of different rearrangement reactions and predict the major product.

Syllabus

23SMCH113MM: Stereochemistry, Reagents and Rearrangements in Organic Chemistry

Unit No.	Title with Contents	No. of Lectures
I	**Stereochemistry:** Recapitulation isomerism, Representation of prospective formulae and interconversion, configurational isomerism and R/S nomenclature in N, S, P containing compounds, Optical activity. **Stereochemical Relationship**- enantiomeric relationship, diastereomeric relationship. Prochirality, Prochiral relationship – Prochiral center, ligands, prochiral faces and their nomenclature. (Pro R/S, Re/Si faces). **Topicity-** Homotopic, enantiotropic and diastereotopic ligand and faces with examples, Diastereoisomerism in Acyclic and Cyclic systems. **Optical activity in the absence of chiral carbon** and their nomenclature: Biphenyls (atropisomerism), allenes, Exocyclic alkylidenes, spiranes, ANSA compounds, paracyclophanes, trans cyclooctenes, helical compounds (P & M nomenclature). Stereospecific and stereoselective reactions with examples, **Stereochemistry and Conformational analysis** of di, tri, tetra-substituted cyclohexane 6- membered rings, R/S nomenclature in chair cyclohexane compounds.	**12**
II	**Oxidation and Reduction Reagents:** Oxidizing agents: CrO_3, PDC, PCC, KMnO4, MnO_2, Swern, SeO_2, $Pb(OAc)_4$, Pd-C, RuO_4, OsO_4, m-CPBA, O_3, $NaIO_4$, HIO_4, TEMPO, IBX, CAN, Dess-Martin, DDQ, Ag_2O. Reducing agents: Boranes and hydroboration reactions, MPV reduction and reduction with H_2/Pd-C, Raney-Ni, $NaBH_3CN$, Willkinsons catalyst, DIBAL and Wolff-Kishner reduction, Birch, Clemenson, Dissolving metal reduction.	**08**
III	**Rearrangements** General mechanistic considerations- nature of migration, migratory aptitude, memory effects. A detailed study of the following rearrangements: - Beckmann, Hofmann, Curtius, Schmidt, Wolf, Lossen, Baeyer Villiger, Sommelet, Favorskii, Pinacole-Pinacolone, Benzil-Benzillic acid, Claisen rearrangements, Cope Rearrangements, and Fries Migration.	**10**

Reference Books:

1. Stereochemistry of carbon compounds - E. L. Eliel
2. Stereochemistry of carbon compounds - E. L. Eliel and S. H. Wilen
3. Stereochemistry of organic compounds - Nasipuri
4. Stereochemistry of organic compounds – Kalsi
5. Organic Chemistry–by J. Clayden, N. Greeves, S. Warren and P. Wothers (Oxford)
6. Mechanism and structure in Organic Chemistry E.S. Gould
7. Advanced Organic Chemistry –by J. March 6th Edition
8. Advanced Organic Chemistry (Part A) –by A. Carey and R.J. Sundberg
9. A guidebook to mechanism in Organic Chemistry – Peter Sykes 6th Ed.
10. Modern methods of organic synthesis, W. Carrathers, Cambridege Univ. P

Course/ Paper Title	**Chromatography and Spectroscopy**
Course Code	**23SMCH14MM**
Semester	**I**
No. of Credits	**2 (30 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
1.	Student should understand the theoretical principles and practical applications of different chromatographic and spectroscopic techniques.
2.	Student should understand and learn concepts in spectroscopy and Chromatography.
3.	Student should learn more about the qualitative/quantitative characterization and separation techniques.
4.	Students are expected to get familiarized with the techniques involving chromatography and spectroscopy.
5.	The students should learn the basics of different chromatographic and spectroscopic techniques.
6.	Student should understand and learn principle and working of analytical Instruments.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
1.	Students will be able to learn various terminologies and concepts relevant to qualitative and quantitative aspects of analyses.
2.	Students should be in a position to understand principle behind different analytical techniques.
3.	Students should be in a position to select the separation techniques for purification of analytes.
4.	Student should be able to evaluate the utility of UV/Vis spectroscopy as a qualitative and quantitative method.
5.	With the knowledge basic techniques used for qualitative and quantitative estimation students should be in a position to choose for appropriate technique.

Syllabus

23SMCH14MM: Chromatography and Spectroscopy

Unit No.	Title with Contents	No. of Lectures
I	**Chromatography:** Principles of Chromatographic Separations, Classification of Chromatographic Techniques, Principle, instrumentation and applications of: Paper chromatography, Thin layer chromatography (TLC), Gel permeation (size exclusion) chromatography, Ion exchange chromatography, Affinity chromatography, Gas chromatography, HPLC and HPTLC. **(Ref. 1, 2)**	**08**
II	**Fundamentals of Chromatographic Methods of Analysis:** Fundamentals of Chromatographic Separation (overview, the development of chromatogram), Characteristics value in chromatogram, Chromatographic theories (plate theory, kinetic theory), High Equivalent Theoretical Plate (HETP), Van Demeter equation, resolution, choice of column, length, and flow velocity, R_s as measure of peak separation, qualitative and quantitative analysis. Numerical problems based on these methods. **(Ref. 1, 2, 3)**	**08**
III	**Spectroscopy:** Principle, instrumentation and applications of Colorimetry, UV-Visible Spectroscopy and choice of source, monochromator and detector for single and double beam instrument, X-Ray Crystallography, Mass Spectrometry. Atomic Absorption Spectrometry and choice of source, monochromator, detector, choice of flame and Burner types and designs. Atomization and sample introduction, sources of chemical interferences and their method of removal. Numerical problem based on these techniques. **(Ref. 1, 2)**	**08**
IV	**Quantitative Calculations:** The Lambert-Beer's Law, Mixtures of absorbing species - laws of additivity of absorbance, calibration curve for calculation of unknown, Spectrometric errors in measurement, Deviation from Lambert-Beer's law: chemical deviation, instrumental deviation, molar extinction coefficient, choice of solvent, Sandell sensitivity, Ringbom's plot, Single beam and double beam UV-Vis spectrophotometer. Numerical problems based on quantitative analysis using UV- Visible spectroscopy. **(Ref. 1, 2)**	**06**

Reference Books:

1. Christian, G. D., Analytical Chemistry, 7th Ed., Wiley India, New Delhi, 2003.
2. Harvey David, Modern analytical chemistry, The McGraw-Hill Companies, Inc., 2000

3. Analytical Chemistry, Ed. by Kellner, Mermet, Otto, Valcarcel, Widmer, 2nd Ed., Wiley – VCH.
4. Skoog, D. A.; Holler F. J.; Crouch, S. R., Principles of Instrumental Analysis, 6th Ed., Cengage Learning India, New Delhi, 2014.
5. Introduction to Instrumental Analysis by R. D. Broun, Mc-Graw Hill, 1987.
6. Chatwal G. R., Anand Sham K., Instrumental Methods of Chemical Analysis, 5th Edition, Himalaya Publishing House, 2005.
7. Instrumental Methods of Chemical Analysis, Dr. B. K. Sharma, Krishna Prakashan Media, 1981.

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Course/ Paper Title	**Physical Chemistry Practical-I**
Course Code	**21SMCH15MM**
Semester	**I**
No. of Credits	**2 (60 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
	Students should understand and learn;
1.	The application of theoretical principles and experimental designs in chemical kinetics.
2.	The principle, working, calibration and handling of spectrophotometer and pH meter.
3.	The application of spectrophotometry and pH-metry calculation and determination of statistical parameters.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
	Students should be able;
1.	To calculate and prepare solution of various molar and normal concentrations.
2.	To find out the acidity, Basicity and pKa Value on pH Meter.
3.	To determination of ionic product of water and titration of a mixture by conductometry.
4.	To use instruments like pH Meter, Colorimeter, Conductometer, Potentiometer and Polarograph with details of operating procedures.
5.	To carry out experiment based on non-instrumental methods like chemical kinetics, viscosity, partial molar volume and calculate statistical parameters related to errors and deviations.

Syllabus for 21SMCH15MM: Physical Chemistry Practical-I

Total 12 practical sessions to be conducted from following

Unit No.	Title with Contents	Practical Sessions
I	**Chemical Kinetics (Any three experiments)** 1. Kinetic decomposition of diacetone alcohol by dilatometry. 2. Determination of an order of a reaction. 3. Brönsted primary salt effect. 4. Kinetics of oxidation of ethanol by $K_2Cr_2O_7$.	**03**
II	**Colorimetry and Spectrophotometry (Any four experiments)** 1. Simultaneous determination of Ni and Co by spectrophotometry. 2. Simulations determination of Mn and Cr by spectrophotometry. 3. To study the adsorption of certain dyes such as methyl violet, picric acid or methylene blue on charcoal. 4. To determine the indicator constant of bromocresolpurple by half height method. 5. Estimation of Cu(II) by titration with Na_2 EDTA by colorimetry. 6. a) Determination of energy of n to π^* transition in acetone and study of effect of solvent on energy of this transition by recording absorbance spectra in n-hexane and water. b) To study the effect of the extended conjugation on the λ_{max} of p-nitro phenol by recording spectrum in acidic and alkaline medium.	**04**
III	**pH Metry (Any two experiments)** 1. Determination of the acid and base dissociation constant of an amino acid and hence the isoelectric point of the acid. 2. Determination of dissociation constants of tribasic acid (phosphoric acid).	**02**

	3. Construct pH curve for titration of strong base – strong acid, strong base - weak acid and predict the best indicator in these titrations (methyl orange, bromo cresol green, phenolphthalein,etc.)	
IV	**Non-Instrumental (Any Two experiments)** 1. Determination of degree of dissociation of calcium nitrate and find its Van't Hoff factor. 2. Determination of molecular weight by steam distillation. 3. Glycerol radius by viscosity. 4. Partial Molar Volume (Polynometry) Determination of the densities of a series of solutions and to calculate the molar volumes of the components.	**02**
V	**Statistical treatment of experimental data (Compulsory)** Statistical treatment of experimental data (calculation of mean and standard deviation for given data and least square method for calibration curve method).	**01**

Reference Books:

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. Experimental Physical Chemistry, R. C. Das and B Behera, Tata McGraw Hill, 1983.
5. Advanced Experimental Chemistry, Vol. I -Physical by Gurtu& R. Kapoor, S Chand & Co.
6. Systematic Experimental Physical Chemistry by S. W. Rajbhoj and T. K. Chondhekar, Anjali Publication.

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Course/ Paper Title	**Inorganic Chemistry Practical –I**
Course Code	**23SMCH16MM**
Semester	**I**
No. of Credits	**2 (60 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
Student should understand and learn;	
1.	Students should understand and learn the pre-requisite concepts in the Ore and Alloy analysis.
2.	Student should understand the experimental aspects of synthesis of coordination compounds.
3.	Students should understand and learn the characterization of compound based through various techniques.
4.	Students should understand and learn basic principle of nanoparticles.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Students should be able to;	
1.	At the end of course student will be able to; carry out Ore and Alloy analysis, run assays and synthesize coordination compounds.
2.	characterize nanoparticles through spectroscopic methods.
3.	Run ion-exchange experiments.

Syllabus

23SMCH116MM: Inorganic Chemistry Practical –I

Unit No.	Title with Contents	Practical sessions
I	**1.** Data analysis, errors, error analysis, least square method. **2.** Determination of Silica and Manganese from pyrolusite ore. **3.** Determination of silica and iron from hematite ore. **4**. Synthesis of ZnO from zinc oxalate - precursor method and determine band gap by absorption spectroscopy. **5**. Synthesis of Colloidal silver nanoparticles and determine band gap by absorption spectroscopy. **6**. Synthesis of Fe_2O_3 nanoparticles sol-gel / coprecipitation / hydrothermal (any one method). **7.** Study of adsorption of phosphate ion on alfa-Fe_2O_3 **8.** Removal and kinetics of photo catalytic dyes, degradation (methylene blue) by ZnO or TiO_2 photo catalysis. **9**. Synthesis and photochemistry of $K_3[Fe(C_2O_4)_3].3H_2O$. **10**. Synthesis and Purity of Chloropenta-ammine cobalt (III) chloride. **11**. Synthesis and Purity of Nitro penta-amminecobalt (III) chloride. **12**. Synthesis and Purity of Bis [Tris Cu(I)thiourea]. **13.** Separation of mixture of Zn (II) and Mg (II) using Amber lite IRA 400 anion exchanger and quantitative estimation of separated ions Zn (II) and Mg (II). **14.** Separation of mixture of Zn (II) and Cd (II) using Amber lite IRA 400 anion exchanger and quantitative estimation of separated ions Zn (II) and Cd (II).	**12**

Reference Books:

1. Vogel's Textbook of Inorganic Quantitative Analysis.

2. Experimental Inorganic Chemistry, Mounir A. Malati, Horwood Series in Chemical Science (Horwood publishing, Chichester) 1999.

3. Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House.

4. General Chemistry Experiments, Anil. J Elias, University Press (2002).

5. Practical physical Chemistry, B. Vishwanathan and P. S. Raghwan, Viva Books.

Course/ Paper Title	**Organic Chemistry Practical – I**
Course Code	**23SMCH17MM**
Semester	**I**
No. of Credits	**2 (60 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
Student should understand and learn;	
1.	Students should understand and learn solvent drying and purification techniques.
2.	The difference between traditional synthesis and green synthesis.
3.	Student should understand and learn concept of green synthesis and its principle.
4.	The selection and differences of procedures used for synthesis.
5.	The practical skill and hands skill during practical.
6.	Students should understand and learn drawing of molecules on chemistry drawing applications.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Student should be able to;	
1.	Student will be able to synthesize organic compounds and derivatives, their purifications and run TLC.
2.	Students will be able to realize the importance of recording observations in laboratory notebook, which includes clear descriptions of original data, observations and experimental procedures and workup protocols.
3.	Students will be able to adapt to the requirement of green chemistry approaches.
4.	Student will be able to draw the structure by using software and predict NMR and CMR.

Syllabus for 23SMCH17MM: Organic Chemistry Practical – I

Total 12 practical sessions to be conducted from following

Unit No.	Title with Contents	Practical Sessions
I	**Purification Techniques:** 1.Thin Layer Chromatography technique of two and three components mixtures. 2. Column Chromatography technique.	**02**
II	**Organic Preparations (Any 05 Experiments):** 1. Benzilic acid from Benzil (Benzilic acid rearrangement) 2. Benzanilide from Benzophenone by Beckmann rearrangement 3. Anthranilic acid from Phthalimide (Hoffmann rearrangement) 4. p-Nitrobenzyl cyanide from Benzyl cyanide (Nitration) 5. Hydantoin from Benzil 6. Coumarin synthesis 7. p-chloro benzyl alcohol from p-chloro benzaldehyde ($NaBH_4$ reduction)	**05**
III	**Green Chemistry Experiments (Any 04 Experiments):** 1. Preparation of acetanilide from aniline and acetic acid using Zn dust. 2. Base catalyzed aldol condensation using $LiOH.H_2O$ as a Catalyst. 3. Bromination of trans-stilbene using sodium bromide and sodium bromate. 4. Benzil-Benzilic acid rearrangement under solvent free condition 5. Solid state synthesis of 7-hydroxy-4-methylcoumarin. 6. Bromination of acetanilide using ceric ammonium nitrate in aqueous medium. 7. Green approach for preparation of benzopinacolone from bezopinacol. 8. Ecofriendly nitration of phenols and its derivatives using Calcium nitrate.	**04**

IV	**Use of ChemDraw, ISIS, Marvin Sketch:** Draw the structure of organic compounds, 3D structures of compounds, reaction sequence. Get the correct IUPAC name. Prediction of NMR, CMR for organic compounds	**01**

Reference Books:

1. Practical Organic Chemistry A. I. Vogel (Longmans).

2. Text Book of practical organic Chemistry F. G. Mann & B.C. Sanders.

3. Comprehensive Practical Organic Chemistry by V.K. Ahluwalia and Renu Agarwal.

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

Course/ Paper Title	**Chemical Thermodynamics**
Course Code	**23SMCH11MEA**
Semester	**I**
No. of Credits	**2 (30 Hours)**

Aims & Objectives of the Course

Sr. No.	**Objectives**
	Students should;
1.	Understand and interpret the principles of physical and chemical observations.
2.	Be able to explain the proposed hypotheses in terms of fundamental concepts.
3.	Solve numerical problems through application of formulae.
4.	Apply logic and reasoning to theoretical and conceptual arguments in Physical Chemistry.

Expected Course Specific Learning Outcomes

Sr. No.	**Learning Outcome**
	Student should be able to;
1.	Understand the thermodynamic properties of ideal and real gases and absolute entropy of a system.
2.	Derive expressions of colligative properties of solution based on chemical potential and its applications to real systems.
3.	Analyze the probability distributions of a system among the energy levels using principles of statistical thermodynamics.
4.	Derive expressions for probability distribution of particles among the various energy levels according to Boltzmann, Bose-Einstein and Fermi-Dirac statistics.

Syllabus

23SMCH11MEA: Chemical Thermodynamics

Unit No.	Title with Contents	No. of Lectures
I	**Thermodynamics:** State function, path function, exact differential and inexact differential, internal energy and enthalpy, temperature dependent internal energy, enthalpy, reversible and irreversible adiabatic expansion. Entropy of irreversible changes, Helmholtz and Gibbs function, Entropy and Entropy change in an ideal gas with temperature and pressure, Clausius inequality, chemical potential, chemical potential of a substance in a mixture, Problems.	**10**
II	**Change of State:** Partial molar quantities, methods for determination of molar quantities, ideal solutions, Raoult's and Henry's law, Thermodynamics of mixing, colligative properties: Derivations of colligative properties based on chemical potential, Elevation in boiling point, depression in freezing point and osmosis, problems.	**12**
III	**Molecular Thermodynamics:** Molecular energy levels, Boltzmann distribution law, partition functions and ensembles, translational, rotational and vibrational partition function of diatomic molecule, obtaining energy, heat capacity, entropy and equilibrium constants from partition functions, Maxwell-Boltzmann, Fermi-Dirac and Bose-Einstein statistics, problems.	**08**

Reference Books:

1. Physical Chemistry by P. W. Atkin and De Paul
2. Physical Chemistry by T. Engel and P. Reid
3. Physical Chemistry for Biological Sciences by Raymond Chang (Universal books, 2000).
4. Physical Chemistry by Merron and C.F. Prouton
5. Physical Chemistry by G.M. Barrow.

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Course/ Paper Title	**Nanomaterials and Applications**
Course Code	**23SMCH11MEB**
Semester	**I**
No. of Credits	**2 (30 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
1.	To learn the top-down and bottom-up approach of preparing nanomaterials.
2.	To understand the physical, chemical and biological approaches of nanomaterials synthesis.
3.	To tune the morphology and functional properties by tuning the preparation parameters.
4.	To apply basic knowledge of synthesis to prepare functional and smart materials
5.	To understand the lithographic process for the fabrication of nanodevices.
6.	To learn nanotechnology applications.
7.	Encourage the Students to carryout research in nanotechnology

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
1.	Synthesize nanomaterials using physical, chemical and biological approaches **(Remember & Understand)**
2.	Tune the size and shape of the nanomaterials for diverse applications **(Analyze)**
3.	Understand the functionalization of nanoparticles for specific applications **(Evaluate)**
4.	Form the nanocomposites for tuning their functional properties. **(Evaluate)**
6.	Understand the applications of nanomaterials in different fields **(Remember)**
7.	Apply the natural dye materials for DSSCs **(Apply)**
8.	Understand the different types of energy devices **(Understand)**
9.	Fabricate nanomaterials for wastewater purification **(Analyze)**
10.	Design a Nanodevice for Biological Applications **(Evaluate)**

Syllabus

23SMCH11MEB: Nanomaterials and Applications

Unit No.	Title with Contents	No. of Lectures
I	Introduction:- Historical development of nanomaterials, Classification of nanomaterials Fundamentals of Nanometerials- Size & Scale Units Scaling Atoms, Molecules, Clusters and Supramolecules, Structure and Bonding in Nanomaterials Chemical Bonds (types and strength) Intermolecular Forces Molecular and Crystalline Structures Hierarchical Structures Bulk to Surface transition, surface reconstruction. Properties and Size dependence of properties Chemical Optical, vibrational, thermal Electrical Magnetic Mechanical Theoretical Aspects-e.g. density functional theory	8
II	**Nanomaterial Synthesis:** Chemical routes Electrochemical methods Vapor growth Thin films methods: chemical vapor deposition, physical vapor deposition (sputtering, laser ablation), Langmuir-Blodgett growth Mechanical methods: ball milling, mechanical attrition Sol-gel methods Special nanomaterials: carbon nanotubes, fullerenes, nanowires, porous silicon Bio-inspired synthesis Nanocomposite fabrication Nanolithography	8
III	**Nanomaterial characterization techniques:** Scanning and Transmission Electron Microscopy Scanning Probe Microscopies: Atomic Force, scanning tunneling microscopy Diffraction and scattering techniques Vibrational spectroscopy Surface techniques	8
IV	**Applications:** Nano-electronics Nano optics Nanoscale chemical- and bio-sensing Biological/bio-medical applications Photovoltaic, fuel cells, batteries and energy-related applications High strength nanocomposites Nanoenergetic materials,	6

Reference Books

1. Nanomaterials- Synthesis, Properties and Applications, Edited by A.S. Edelstein and R.C. Cammarata, Institute of Physics Publishing, London, 1998 (paper back edition)
2. Nanochemistry: A Chemical Approach to Nanomaterials, by G. Ozin and A. Arsenault,

RSC Publishing, 2005

3. Nanophysics and Nanotechnology: An Introduction to Modern Concepts in Nanoscience, Edward L. Wolf, Wiley-VCH, 2nd Reprint (2005)
4. Nanostructures & Nanomaterials: Synthesis, Properties & Applications, Guozhong Gao, Imperial College Press, (2004).
5. Encyclopedia of Materials Characterization, C. Richard Brundle, Charles A. Evans Jr., Shaun Wilson, Butterworth - Heinemann Publishers, (1992).
6. Hand book of Microscopy for Nanotechnology, Ed. By Nan Yao and Zhong Lin Wang, Kluwer Academic Press, (2005).

Course/ Paper Title	**Chemistry of Main Group Elements**
Course Code	**23SMCH12MEA**
Semester	**I**
No. of Credits	**2 (30 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
Student should understand and learn;	
1.	The detailed chemistry of 's' and 'p' block elements with respect to their compounds, reactions and applications.
2.	Advanced chemistry of Boranes, Fullerenes, Zeolites, Carbon Nanotubes and Polymers.
3.	Advanced chemistry of PN and SN Compounds, Cage and Cluster compounds.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Students should be able to;	
1.	Understand the chemistry of main group.
2.	Understand the compounds of main group elements.
3.	Understand the structures, bonding and reactions in main group elements.

Syllabus

23SMCH12MEA: Chemistry of Main Group Elements

Unit No.	Title with Contents	No. of Lectures
I	**Hydrogen and its compounds:** Classification of Hydrides, electron deficient, electron precise and electron rich hydrides; PH3, SbH3, AsH3 Selenides, Tellurides.	03
II	**Alkali and Alkaline Earth Metals:** Solutions in non - aqueous media, application of crown ether in extraction of alkali and alkaline earth metal.	03
III	**Boron Group:** Boron Hydrides, preparation, structure and Bonding with reference to LUMO, HOMO, interconversion of lower and higher boranes, metalloboranes, carboranes, reactions of organoboranes, STYX rules and structure of higher boranes.	05
IV	**Carbon Group:** Allotropes of carbon, Diamond, Graphite, Graphene, fullerenes, carbon nanotube with synthesis, properties, Structure- single walled and multi walled and its application, Intercalation compounds of graphite, Silicates, including zeolites.	05
V	**Nitrogen Group:** Nitrogen activation, Boron nitride, Oxidation states of nitrogen and their interconversion, PN and SN Compounds, Applications of PN and SN compounds.	04
VI	**Oxygen Group:** Metal Selenides and Tellurides, Oxyacids and Oxoanions of Sulphur and Nitrogen. Ring, Cage and Cluster compounds of p-block elements.	03
VII	**Halogen Group:** Interhalogens, Pseudohalagen- Synthesis, Properties and Applications; Structure, Oxyacids and Oxyanions of Halogens	03
VIII	**Noble gases:** Occurrence, Compounds of Xenon-with fluorine and Oxygen and its uses.	04

Reference Books:

1. Inorganic Chemistry by Shriver and Atkins.

2. Concise Inorganic Chemistry by J. D. Lee.

3. Principle of Structures and Reactivity by Huheey, Keiter, Medhi.

4. Inorganic Chemistry by Catherine Housecraft.

5. Inorganic Chemistry by Meisslerand Tarr.

6. Organometallics by Christoph Elschenbroich.

10. 7. “Organometallics: A Concise Introduction” by Christoph Elschenbroich and Albrecht Salzer

11. 8. Basic Organometallic Chemistry by B. D. Gupta and A. J. Elias.

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Course/ Paper Title	**Clinical Chemistry**
Course Code	**21SMCH12MEB**
Semester	**I**
No. of Credits	**2 (30 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
1.	To provide a comprehensive understanding of the principles and techniques of clinical biochemistry.
2.	To familiarize students with the applications of clinical biochemistry in disease diagnosis, monitoring, and treatment.
3.	To develop critical thinking skills for interpreting and analyzing clinical biochemistry data.
4.	To enhance students' knowledge of the biochemical processes underlying human physiology and disease.
5.	To introduce students to emerging trends and advancements in clinical biochemistry research.
6.	To cultivate practical laboratory skills relevant to clinical biochemistry techniques.
7.	To promote ethical and responsible conduct in the practice of clinical biochemistry.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
1.	Demonstrate a deep understanding of the fundamental concepts and principles of clinical biochemistry.
2.	Apply knowledge of biochemical processes to analyze and interpret clinical data.
3.	Evaluate the clinical significance of biochemical tests and their applications in disease diagnosis and management.
4.	Critically analyze scientific literature related to clinical biochemistry research.
5.	Perform basic clinical biochemistry techniques and experiments accurately and safely.

6.	Communicate effectively about clinical biochemistry concepts, research findings, and ethical considerations.

Syllabus

21SMCH12MEB: Clinical Biochemistry

Unit No.	Title with Contents	No. of Lectures
I	**Introduction to Clinical Biochemistry** Definition and scope of clinical biochemistry, Importance of clinical biochemistry in healthcare; Disease diagnosis and monitoring, Predictive and preventive medicine, Therapeutic drug monitoring. Overview of biochemical tests and their clinical applications; Blood tests: Complete blood count (CBC), Liver function tests (LFTs), Kidney function tests (KFTs), Lipid profile, Urine tests: Urinalysis, Measurement of specific metabolites and biomarkers, Endocrine function tests: Hormone level assessment (e.g., thyroid hormones, insulin, cortisol), Glucose tolerance test, Genetic testing: Prenatal genetic testing	**6**
II	**Analytical Techniques in Clinical Biochemistry** Immunoassays and immunochemistry; Principles of immunoassays(e.g., enzyme-linked immunosorbent assay, radioimmunoassay), Types of immunoassays and their applications Electrophoresis techniques in clinical analysis; Principles of gel electrophoresis (e.g., SDS-PAGE, agarose gel electrophoresis), Applications of electrophoresis in clinical biochemistry (e.g., protein separation), Interpretation and analysis of electrophoretic patterns. Point-of-care testing (POCT) devices and methodologies; Overview of POCT devices and their advantages, Common POCT methods in clinical biochemistry (e.g., glucose monitoring, pregnancy tests) Microarray technology in clinical diagnostics; Introduction and Applications of microarrays in clinical biochemistry (e.g., gene expression profiling, mutation detection)	**8**

III	**Microbial Identification and Antimicrobial Susceptibility Testing** Overview of infectious diseases: Introduction to infectious agents (bacteria, viruses, fungi, parasites), Transmission routes and epidemiology of infectious diseases, Host-pathogen interactions and immune responses. Microbial identification techniques: MALDI-TOF mass spectrometry for rapid and accurate identification of microorganisms, Fluorescence in situ hybridization (FISH) for specific detection and identification of pathogens, Shotgun metagenomics for comprehensive analysis of microbial communities Principles of antimicrobial agents and resistance mechanisms: Classes of antimicrobial agents (antibiotics, antifungals, antivirals), Mechanisms of action of antimicrobial agents, Development and spread of antimicrobial resistance Antimicrobial susceptibility testing (AST) methods: Disc diffusion method (Kirby-Bauer) for testing antibiotic susceptibility, Broth microdilution method for determining minimum inhibitory concentration (MIC), Automated systems for AST (e.g., VITEK, Phoenix) and their applications	**8**
IV	**Special Topics in Clinical Biochemistry** Clinical toxicology and drug monitoring: Principles of drug metabolism and elimination, Methods for drug monitoring and interpretation of results Tumor markers and cancer diagnostics: Laboratory techniques for measuring tumor markers, Application of tumor markers in cancer diagnosis and treatment Therapeutic drug monitoring: Pharmacokinetic principles and drug concentration monitoring, Clinical applications of therapeutic drug monitoring Neurotransmitter analysis in clinical biochemistry: Methods for analyzing neurotransmitter levels, Clinical applications in neurological and psychiatric disorders	**8**

	Trace elements and heavy metals in clinical analysis: Analytical techniques for measuring trace elements and heavy metals, Clinical significance of trace element deficiencies and toxic metal exposure	

Reference Books:

1. "Clinical Chemistry: Principles, Techniques, Correlations" by Michael L. Bishop, Edward P. Fody, and Larry E. Schoeff.
2. "Tietz Fundamentals of Clinical Chemistry and Molecular Diagnostics" by Nader Rifai, Andrea Rita Horvath, and Carl T. Wittwer.
3. "Clinical Biochemistry: Metabolic and Clinical Aspects" by William J. Marshall, Márta Lapsley, and Andrew Day.
4. "Koneman's Color Atlas and Textbook of Diagnostic Microbiology" by Gary W. Procop, Elmer W. Koneman, and Paul C. Schreckenberger.
5. "Manual of Clinical Microbiology" by James H. Jorgensen, Michael A. Pfaller, and Karen C. Carroll.
6. "Textbook of Biochemistry with Clinical Correlations" by Thomas M. Devlin.
7. "Lecture Notes: Clinical Biochemistry" by Simon W. Walker, Geoffrey J. Beckett, Peter Rae, and Peter Ashby.

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Course/ Paper Title	**Research Methodology in Chemistry**
Course Code	**21SMCH11RM**
Semester	**I**
No. of Credits	**4 (60 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
At the end of this course, the students should be able to:	
1.	understand some basic concepts of research and its methodologies
2.	identify appropriate research topics
3.	select and define appropriate research problem and parameters
4.	prepare a project proposal (to undertake a project)
5.	organize and conduct research (advanced project) in a more appropriate manner
6.	write a research report and thesis.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
1.	Demonstrate the ability to choose methods appropriate to research aims and objectives
2.	Understand the limitations of particular research methods
3.	Develop skills in qualitative and quantitative data analysis and presentation
4.	Develop advanced critical thinking skills
5.	Demonstrate enhanced writing skills

Syllabus

21SMCH11RM: Research methodology in Chemistry

Unit No.	Title with Contents	No. of Lectures
I	**Introduction to Research methodology:** Objective of research, motivation in research, types of research, Fundamental research, applied research, experimental research, interdisciplinary research, scientific methods of research, criteria of good research, and characteristics of a good research.	04
II	**Scope of Research and Ethics:** Steps in scientific research: Introduction and Scope, Research problem: Identification, Selection, developing research title, Criteria for prioritizing topics for research, Prioritizing Topics for Research, Formulation of research objectives Research design: Components, Types and importance Research ethics, Institutional ethics committee, Plagiarism, Patenting and intellectual property rights.	05
III	**Processes in research proposal development:** Components of research proposal- Components of research proposal: 1. Title page 2. Summary/Abstract 3. Introduction/background 4. Statement of the problem 5. Literature review 6. Hypotheses/questions 7. Conceptual framework 8. Objective/aim of the study 9. Research methods, material, and procedure 10. Work plan 11. Budget 12. References 13. Appendices/annexes.	08
IV	**Literature search technique:** using SCOPUS, Google Scholar, PUBMED, Web of Science, science direct, Indian Citation Index, Research Gate, and scifinder. **Overview of the journal article:** Selection of journals, Data bases and research metrics Databases: 1. Indexing databases 2. Citation databases: Web of Science, Scopus, UGC-Care List etc. Research Metrics: 1. Impact Factor of journal as per Journal Citation Report, SNIP, SJR, IPP, Cite Score 2. Metrics: h-index, g index, i10 index etc	06
V	**Presentation of Scientific findings, Scientific Report Writing:** Publication Process: Types of technical documents- Full length research paper, Short/Brief communications, Letters to editor, Book chapter, Review, Conference report, Patents, dissertation. Components of a research publication: Title/Topic statement, Abstract/key words, Aims and objectives, Hypothesis building, Rationale of the paper, Work plan, Materials and methodology, Results and discussion, Key issues	08

	and arguments, Acknowledgement, Conflict of interest statement, bibliography, Technical Resumes & Cover Letters. Softwares in Chemistry Data plotting Structure Drawing, Grammar Checkers and Sentence Correction Tools.	
VI	**Scientometrics:** How to cite and how to do referencing Styles of referencing: APA, MLA, Oxford, Harvard, Chicago Annotated bibliography; Tools for citing and referencing: Grammarly, Endnote etc., Reference Management Software like Zotero, Mendeley, reference manager and others; Software for paper formatting like LaTeX/MSOffice, software for detection of Plagiarism	**05**
VII	**Data Analysis and interpretation:** Chemometrics. Analysis of variance (ANOVA), Measures of central tendency and dispersion - mean, median, mode, range, standard deviation, variance. Correlation and regression, Curve fitting, fitting of linear equations, simple linear cases, weighted linear case, analysis of residuals, General polynomial fitting, linearizing transformations, exponential function fit, r and its abuse. Basic aspects of multiple linear regression analysis. Types of errors and level of significance. Tests of significance – F & t tests, chi-square tests,	**06**
VIII	**Publications Ethics:** definition, nature of moral judgements and reactions, Ethics with respect to science and research. Intellectual honesty and research integrity. Scientific misconducts: Falsification, Fabrication, and Plagiarism (FFP). Redundant publications: duplicate and overlapping publications. Selective reporting and misrepresentation of data. Publication ethics: definition, introduction, and importance. Conflicts of interest Publication misconduct: definition, concept, problems that lead to unethical behavior and vice versa Violation of publication ethics, authorship and contributorship Identification of publication misconduct, complaints and appeals Predatory publishers and journals.	**04**
IX	**Presentation and Communication skills:** Tables, Figures and Pictures using Excel, PowerPoint slide preparation, Preparation of Posters, Electronic submission of manuscripts, oral and poster, Communication skills.	**04**
X	**Chemistry Laboratory Practices:** **Safety practices in Chemical research:** Safety aspects in Chemistry Good laboratory practices. Handling of various chemicals, solvents & glassware. Fires and fighting with fires. Hazardous substances, classification, and handling Safety Data Sheet. Chemical entries, MSDS, CAS numbers, dead stocks maintenance.	**10**

	Working conditions and equipment: cleaning and washing of required glassware, calibration of equipment, set up chemical reactions, condition, optimization of conditions- temperature, solvent, catalysis; equipment SOP, maintenance and repairing, waste managements. **Maintaining data and observations-** importance of recording observations in research laboratory notebook, which includes clear descriptions of original data, observations and experimental procedures and workup protocols, group discussion, discussion with guides, weekly/monthly/six monthly presentation of research progress.	

Reference book:

1. Best and Kahn, Research Methodology, PHI Limited.

2) Kothari, C. K., Research Methodology-Methods and Techniques, 2nd Ed., New Age International, New Delhi.

3) Kumar, R., Research Methodology - A Step-By-Step Guide for Beginners, Pearson Education, Delhi (2006).

4) Fundamentals of modern statistical methods by Rand R.wilcox.

5) Power Analysis for Experimental research A Practical Guide for the Biological, Medical and social Sciences by R. Barker Bausell, Yi-Fang Li Cambridge University Press.

6) Design of Experience: Statistical Principles of Research Design and Analysis, by Robert O. Kuehl Brooks/cole.

7) Panneerselvam R., Research Methodology, Prentice Hall of India, New Delhi,2004

8) Montgomery, D. C., Design & Analysis of Experiments, 5th Ed., Wiley India (2007).

Semester II

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Course/ Paper Title	**Molecular Spectroscopy**
Course Code	**23SMCH21MM**
Semester	**II**
No. of Credits	**2 (30 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
	Students should;
1.	Student should understand fundamentals of molecular spectroscopy.
2.	To correlate classical and quantum approach in spectroscopic methods.
3.	Learn about rotational spectroscopy and the rigid rotator model to describe a rotating diatomic molecule.
4.	Student should able to solve numerical problems based on various spectroscopic methods.
5.	Student should understand the application of spectroscopic methods and their relevance.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
	Student should be able to;
1.	Recognize spectroscopy in microwave, Rotational spectra of rigid diatomic molecules, selection rules, interaction of spectral lines.
2.	understand nature of vibrating diatomic molecule, energy levels of a diatomic molecule, simple harmonic and anharmonic oscillator, Scattering of light and Raman Spectrum, rotational and vibrational Raman Spectra.
3.	Explain fine structure of ESR absorption, Hyperfine structure, Double resonance in ESR, Techniques of ESR spectroscopy.
4.	Understand what properties of molecule the spectra are based on.

Syllabus

23SMCH21MM: Chemical Kinetics and reaction dynamics

Unit No.	Title with Contents	No. of Lectures
I	**Introduction to molecular spectroscopy:** Characteristics and regions of electromagnetic radiation, quantization of energy, Width and intensity of spectral transition, problems.	03
II	**Microwave Spectroscopy:** Principle of microwave spectroscopy, Types of molecules on the basis of moment of inertia and rotational spectra of di- and polyatomic molecules, problems.	06
III	**Infra-red Spectroscopy:** Principle of Infra-red Spectroscopy, the vibrating diatomic molecule, harmonic and anharmonic oscillator, the diatomic vibrating rotator, breakdown of the Born-Oppenheimer approximation, the vibrations of polyatomic molecule, Fourier transform spectroscopy and its advantages, The carbon dioxide laser, Applications, problems.	08
IV	**Raman Spectroscopy:** Quantum and classical theory of Raman effect, pure rotational Raman spectra, vibrational Raman spectra, polarization of light and Raman effect, structure determination from Raman and Infra-red spectroscopy, applications, problems.	07
V	**Electronic Spectroscopy of molecules:** Electronic spectra of diatomic molecules - The Born- Oppenheimer approximation, Vibrational coarse structure, Frank- Condon principle, dissociation energy and dissociation product, Rotational fine structure of electronic-vibration transition, The fortrat diagram, Pre-dissociation, molecular photoelectron spectroscopy, problems.	06

Reference Books:

1. Fundamentals of molecular spectroscopy by C. N. Banwell and E. M. McCash.
2. Inorganic spectroscopy by R. S. Draggo.
3. Quantum Mechanical Foundations of Molecular Spectroscopy, By Max Diem, Wiley Publisher.
4. Fundamentals of Quantum Chemistry Molecular Spectroscopy and Modern Electronic Structure Computations by Michael Mueller · 2007, Springer.
5. Basic Atomic and Molecular Spectroscopy, By John Michael Hollas, 2002.

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Course/ Paper Title	**Co-ordination Chemistry**
Course Code	**23SMCH22MM**
Semester	**II**
No. of Credits	**2 (30 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
Student should understand and learn;	
1.	The concepts of metal ligand bonding in transition metal complexes.
2.	The ligand field effect, R-S terms in coordination complex.
3.	The concepts of microstate tables and Orgel diagrams.
4.	Analysis of electronic spectra and magnetic properties of transition metal complexes.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Students should be able to;	
1.	Students will be able to understand the concept of ligand field.
2.	Students will be able to explain d-orbital splitting pattern in different geometries like octahedral, tetrahedral.
3.	Students will be able to calculate magnetic moment & crystal field stabilization energy of metal complexes.
4	Students will be able to explain high spin and low spin complexes & formation of metal complexes in solution.

Syllabus

23SMCH22MM: Co-ordination Chemistry

Unit No.	Title with Contents	No. of Lectures
I	**Concept and Scope of Ligand Fields:** Quantum numbers, Free ion Configuration, Terms and States, Energy levels of transition metal ions, free ion terms, microstates, term wave functions, spin-orbits coupling.	07
II	**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, Orgel diagrams, strong field effect, correlation diagrams, Tanabe-Sugano Diagrams, Spin-Pairing energies.	07
III	**Electronic spectra of Transition Metal Complexes:** Introduction, band intensities, band energies, band width and shapes, transition metal spectra of 1st, 2nd and 3rd row ions and complexes, electronic spectra of Lanthanide and Actinide, spectrochemical and nephelauxetic series, charge transfer and luminescence spectra, calculations of Dq, B, β parameters, percentage of covalent character for metal-ligand bond.	08
IV	**Magnetic Properties of Coordination Complexes:** Origin magnetism, types of magnetism, Curie law, Curie-Weiss Law, Magnetic properties of complexes, Para magnetism, 1st and 2nd order Zeeman effect, quenching of orbital angular momentum by Ligand fields, Magnetic properties of A, E and T ground terms in complexes, spin free and spin paired equilibria, temperature dependence of magnetism.	08

Reference Books:

1. Ligand field theory and its applications by B. N. Figgis and M.A. Hitachman
2. Symmetry and spectroscopy of molecules by K. Veera Reddy
3. Elements of Magnetochemistry by A. Syamuel R. L. Dutta

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Course/ Paper Title	**Organic Spectroscopy**
Course Code	**23SMCH23MM**
Semester	**II**
No. of Credits	**2 (30 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
Student should understand and learn;	
1.	Understand basic principles of different spectroscopy
2.	The spectroscopic methods in Organic Chemistry including U.V., I.R., NMR, and CMR and solve problems on structure determination.
3.	To deduce the structure from spectral data.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Students should be able to;	
1.	The basic principles of spectroscopic methods in structure elucidation of organic compounds and elucidate structures from spectroscopic data or spectra
2.	The explain appropriate key factors responsible for the spectroscopic data acquisition and solve problems based on combined data of UV, IR, MS, 1HNMR, 13C-NMR

Syllabus

23SMCH23MM: Organic Spectroscopy

Unit No.	Title with Contents	No. of Lectures
I	**UV spectroscopy:** Introduction and principle of UV spectroscopy, Shift in absorption, solvent effect on UV, Woodward rules, calculation of λmax of dienes, enones and aromatic compounds.	**04**
II	**IR spectroscopy:** Introduction of IR spectroscopy, Principle, Instrumentation, fundamental mode of vibrations, IR spectra of different functional group, factors affecting IR frequencies - effect of conjugation, effect of ring size, H-bonding, inductive effect, resonance effect on IR frequency, problem based on IR frequency.	**05**
III	**^{1}H-NMR spectroscopy:** Basic principle, NMR active nuclei, chemical and magnetic nonequivalence, Chemical shifts, and factors influencing chemical shift: electronegativity, NMR solvent polarity, temperature, anisotropic effect. Multiplicity patterns and Coupling Constants: Pascal's triangle, understanding of tree diagram, complex splitting patterns in aromatic, vinylic, saturated monocyclic compounds, bicyclic compounds. Integration and uses of it in mixture, molar and ee% calculation.	**12**
IV	**^{13}C-NMR:** Introduction of CMR, Basic of CMR: Chemical shift and factors affecting chemical shifts in ^{13}C-NMR, off resonance, and proton decoupled spectra. Example based of ^{13}C-NMR signals.	**06**
V	**Introduction to Mass Spectrometry (MS):** Basic principle of MS, m/z in mass, type of mass spectra, significance of M+ (m/z) in determination of molecular formula, Rule of 13, Nitrogen rule, isotope peaks, problem bases on HRMS.	**03**

Reference Books:

1. Introduction to Spectroscopy by Donald L. Pavia and Gary M. Lampman.
2. Spectrometric Identification of Organic Compounds by Robert M. Silverstein, Francis X. Webster, David J. Kiemle, David L. Bryce.
3. NMR Spectroscopy: Basic Principles, Concepts and Applications in Chemistry by Harald Günther.
4. Organic Spectroscopy, P. S. Kalsi.

Course/ Paper Title	**Instrumental Methods of Analysis**
Course Code	**23SMCH24MM**
Semester	**II**
No. of Credits	**2 (30 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
1.	Student should understand and learn the concept of electro analytical methods.
2.	Student should understand and learn principle and working of analytical instrument
3.	Understand the principles and applications of surface analytical techniques.
4.	Learn the principles and usage of Electroanalytical techniques.
5.	To introduce the student to principles and theory of instrument analysis.
6.	Understand importance of different instrumental methods in chemical analysis of materials.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
1.	Student should be able to apply different advanced voltammetric techniques for understanding the electrode processes
2.	Student should be able to understand the concepts of X-ray spectroscopy and electron microscopy for qualitative and quantitative analysis of solid samples.
3.	Student should be able to interpret X-ray and particle diffraction pattern in assigning the crystallographic aspects of materials
4.	Student should be able to perform quantitative & qualitative analysis of drugs using various analytical instruments.
5.	Student should be able to differentiate and identify the technique of analysis for a sample.
6.	With the knowledge basic techniques used for qualitative and quantitative estimation students should be in a position to choose for appropriate technique.

Syllabus

23SMCH24MM: Instrumental Methods of Analysis

Unit No.	Title with Contents	No. of Lectures
I	**Electro Analytical methods: (Ref. 1 to 3)** 1. **Conductometry:** Principle, Fundamental equations, measurement of conductance, Conductometric titrations. 2. **Potentiometry:** Principle, apparatus and technique, potential (emf), Nernst equation, reference electrodes, measurement of potential, applications to neutralization, redox, precipitation, complexometric titrations, location of end points, differential titrations, advantages of potentiometric titrations. 3. **pH metry:** Principle, Instrumentation, The Glass pH electrode – theory, construction, standard buffers, pH titrations. 4. **Electrogravimetry:** Principle and method. Determination of Copper. Separation of metal ions. 5. **Coulometry:** Principle and method. Coulometric titrations. 6. Numerical problems based on these techniques.	**15**
II	**Diffraction Techniques: (Ref. 4 to 6)** 1. **X- ray Methods of Analysis:** Principle, Theory- X-ray spectral lines, X-ray tube, X-ray emission, and Absorptive apparatus: Sources, Collimation, sample handling, wavelength dispersive devices, Energy dispersive devices, detectors, readout device. Chemical analysis using X-ray absorption. 2. **X-ray Fluorescence:** Instrumentation and chemical analysis. 3. **X-ray Diffraction:** Electron diffraction and Neutron diffraction, Chemical analysis with X-ray diffraction. Reflection high energy electron diffraction (RHEED). 4. **Small angle neutron diffraction** (SANS) analysis: Principle, Instrumentation, and applications. Small angle X-ray diffraction. 5. Numerical problems based on these techniques.	**15**

Reference Books:

1. Christian, G. D., Analytical Chemistry, 7th Ed., Wiley India, New Delhi, 2003.
2. Harvey David, Modern analytical chemistry, The McGraw-Hill Companies, Inc., 2000
3. Analytical Chemistry, Ed. by Kellner, Mermet, Otto, Valcarcel, Widmer, 2nd Ed., Wiley – VCH.
4. Chemical Analysis – Modern Instrumentation Methods and Techniques, Rouessac and Rouessac, John Wiley, 2010, 6th edition.
5. Surface Analysis: The Principal Techniques, John C Vikerman, Ian Gilmore (Eds.), Wiley 2009, 2nd Edition.
6. Materials Characterization, introduction to microscopic and spectroscopic techniques, Yang Leng, 2nd Wiley-VCH
7. Skoog, D. A.; Holler F. J.; Crouch, S. R., Principles of Instrumental Analysis, 6th Ed., Cengage Learning India, New Delhi, 2014.
8. Introduction to Instrumental Analysis by R. D. Broun, Mc-Graw Hill, 1987.
9. Chatwal G. R., Anand Sham K., Instrumental Methods of Chemical Analysis, 5th Edition, Himalaya Publishing House, 2005.
10. Instrumental Methods of Chemical Analysis, Dr. B. K. Sharma, Krishna Prakashan Media, 1981.

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Course/ Paper Title	**Physical Chemistry Practical-II**
Course Code	**21SMCH25MM**
Semester	**II**
No. of Credits	**2 (60 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
	Students should understand and learn;
1.	Principle and working of conductometer, polarograph, potentiometer and polarimeter.
2.	Standard operating procedures, calibration, and application of all these instruments.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
	Student will have;
1.	Understanding of principle and working of conductometer, polarograph, potentiometer and polarimeter.
2.	Sufficient exposure in independent handling of instruments, calibration and collection of data and readings from these instruments.
3.	Conceptual understanding of experimental applications, formulae and calculations.

Syllabus for 21SMCH25MM: Physical Chemistry Practical-II

Total 12 practical sessions to be conducted from following

Unit No.	Title with Contents	Practical Sessions
I	**Conductometry (Any four):** 1. Hydrolysis of NH_4Cl or CH_3COONa or aniline hydrochloride. 2. Determination of λ_0 or λ_α and dissociation constant of acetic acid. 3. Hydrolysis of ethyl acetate by NaOH. 4. Determination of ΔG, ΔH, and ΔS of silver benzoate by conductometry. 5. Determination of critical micellar concentration (CMC) and ΔG of micellization of sodium Lauryl Sulphate / Detergent.	**04**
II	**Polarography (Any one):** 1. Determination of half wave potential $E_{1/2}$ and unknown concentration of Cu or Pb or Zn ion. 2. Amperometric titration of $Pb(NO_3)_2$ with $K_2Cr_2O_7$.	**01**
III	**Potentiometry (Any three):** 1. Stability Constant of a complex ion. 2. Solubility of a sparingly soluble salt. 3. To determine the ionic product of H2O. 4. Estimation of halide in mixture.	**03**
IV	**Polarimetry (Any two):** 1. To study the rate equation for the muta-rotation of D-glucose in water. 2. Determination the percentage of two optically active substances in a mixture by polarimetry. 3. To study the inversion of cane sugar by polarimetry.	**02**

V	**Table Work (Any two):** 1. Analysis of powder XRD of SrTiO3 and Ag metal or any two compounds (Calculation, lattice constant, crystal volume and density, and assigning planes to peaks using JCPDS data). 2. Cyclic voltammogram of $K_3Fe(CN)_6$ in KCl / H_2O / Ferrocene in TEAP/MeCN. 3. Detailed interpretation of Raman spectra of diatomic molecules.	**02**

Reference Books:

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. Experimental Physical Chemistry, R. C. Das and B. Behera, Tata McGraw Hill, 1983.
5. Advanced Experimental Chemistry, Vol. I -Physical by Gurtu& R. Kapoor, S Chand & Co.
6. Systematic Experimental Physical Chemistry by S. W. Rajbhoj and T. K. Chondhekar, Anjali Publication.

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Course/ Paper Title	**Inorganic Chemistry Practical –II**
Course Code	**23SMCH26MM**
Semester	**II**
No. of Credits	**2 (60 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
	Student should understand and learn;
1.	Student should understand and learn pre-requisite & basic steps, involved in the Ore and Alloy analysis
2.	Student should understand and learn the practical aspects of synthesis of co-ordination compounds to that of the theory.
3.	Students are expected to learn and develop basic idea of the characterization of compound based on the mentioned characterization techniques.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
	Students should be able to;
1.	Students will get acquainted with basic principle of metal ions extraction techniques from a mixture
2.	Students will understand and apply theoretical aspects in the synthesis of complex formation and their stability constant by mentioned techniques

Syllabus

23SMCH126: Inorganic Chemistry Practical –II

Unit No.	Title with Contents	Practical sessions
I	**1**. Determination of iron and chromium from stainless steel alloy. **2**. Determination of tin and lead from solder alloy. **3**. Synthesis and Purity of Potassium tri-oxalato aluminate. **4.** Synthesis and Purity of Tris (ethylene di ammine) Ni(II) thiosulphate. **5**. To study complex formation between Fe(III) with sulfosalicylic acid by conductometry. **6**. To verify the Debye Huckel theory of ionic conductance for strong electrolytes KCl, BaCl2, K_2SO_4 and $[K_3Fe(CN)_6]$. **7**. Determination of equilibrium constant of M – L systems Fe(III)–Sulphosalicylic acid or Fe(III)–β–resorcilic acid by Job's continuous variation method. 8. Determination of equilibrium constant of M – L systems Fe (III)– Salicylic acid or by Job's continuous variation method. **9**. Determination of Cu(II) by solvent extraction as Dithiocarbamate complex. **10**. Determination of iron by solvent extraction techniques in a mixture of Fe(III) +Al(III) or Fe(III) + Ni(III) using 8–hydroxyquinoline reagent. **11**. Solution state preparation of $[Ni(en)_3]S_2O_3$, $[Ni(H_2O)_6]Cl_2$, $[Ni(NH_3)_6]Cl_2$. Record absorption spectra in solution of all three complexes and calculate 10Dq. Arrange three ligands according to their increasing strength depending on your observations. **12**. Estimation of hyperfine splitting pattern for the given ESR spectrum. (Any two compound). **13.** Data analysis of XRD or CV spectrum (any two compounds). **14.** Determination of magnetic susceptibility (χg and χm) of mercury tetracyanato cobalt or Fe (acac)3 or Ferrous ammonium sulfate by Faraday or Gouy Method.	**12**

Reference Books:

1. Vogel's Textbook of Inorganic quantitative analysis.

2. Experimental Inorganic Chemistry, Mounir A. Malati, Horwood Series in Chemical Science (Horwood Publishing, Chichester) 1999.

3. Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publishing House.

4. General Chemistry Experiments, Anil. J Elias, University Press (2002).

5. Practical physical Chemistry, B. Vishwanathan and P. S. Raghwan, Viva Books.

6. Physical methods in Inorganic chemistry, R. S. Drago.

Course/ Paper Title	**Organic Chemistry Practical – II**
Course Code	**23SMCH27MM**
Semester	**II**
No. of Credits	**2 (60 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
Student should understand and learn;	
1.	The course aims are not only the continuation study of basic principles of organic chemistry, but it will also provide the important topics in Organic chemistry functional groups including (aromatic compounds, phenols, carboxylic acids and its derivatives, aldehydes & ketones, amines, and malonic ester synthesis).
2.	This helps students to gain experience to predict the functional group transformations, simple reaction mechanisms, and the synthesis of organic molecules by multi-step synthesis strategies.
3.	In addition of that, the course will also help students to understand the reaction mechanism subjects in later stages of their study.
4.	The selection and differences of procedures used for synthesis.
5.	The practical skill and hands skill during practical.
6.	Students should understand and learn drawing of molecules on chemistry drawing applications.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Student should be able to;	
1.	Acquire skills to observe and record scientific experiments.
2.	Students able to familiarize their self with the laboratory equipment, various chemicals, and set up chemical reactions to ensure safe and diligent laboratory practice.

Syllabus for 23SMCH27MM: Organic Chemistry Practical – II

Total 12 practical sessions to be conducted from following

Unit No.	Title with Contents	Practical Sessions
I	**Double stages preparation (Any three Experiments)** At least six two stage preparations from the following should be carried out. The preparations should be carried out on microscale. 1. Benzaldehyde ---------- Benzalacetophenone ---------- Epoxide 2. Resorcinol -------- 4-methyl-7-hydroxy coumarin --------4-Methyl-7-acetoxy coumarin 3. Cyclohexanone ----- Phenyl hydrazine ------- 1, 2, 3, 4-tetrahydrocarbazole 4. Hydroquinone ---------- Hydroquinone diacetate --------- 1, 2, 4-Triacetoxy benzene 5. Phthalic acid ------- Phthalimide-------- Anthranilic acid 6. Benzyl cyanide---------- p-Nitrobenzyl cyanide ---------- p-Nitro phenyl acetic acid	**06**
II	**Solvent free synthesis (Any six Experiments)** 1. Pinacol coupling reaction (Page 36) 2. Knoevenagel condensation (Page 40) 3. Biginelli reaction (Page 46) 4. Claisen reaction (Page 47) 5. Pechmann reaction (Page 50) 6. Azomethine synthesis (Page 213) 7. Beckmann rearrangement (Page 346)	**06**

Reference Books:

1. Practical Organic Chemistry A. I. Vogel (Longmans).

2. Text Book of practical organic Chemistry F. G. Mann & B.C. Sanders.

3. Solvent-free Organic Synthesis by Koichi Tanaka (Copyright © 2009 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim, ISBN: 978-3-527-32264).

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Course/ Paper Title	**Organic Reaction Mechanism – I**
Course Code	**23SMCH21MEA**
Semester	**II**
No. of Credits	**2 (30 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
Student should understand and learn;	
1.	The student is expected to learn the basic theory of aliphatic nucleophilic substitution reaction, NGP
2.	Through this course, student is also expected to thoroughly learn advanced concepts and various reactions of carbocation, free radicals, organometallic, ylid with their applications in organic syntheses.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Student should be able to;	
1.	To inculcate mechanistic approach for advanced organic reactions.
2.	Understand the role of various reaction intermediates like carbocation, carbanion, carbenes and radicals in organic reactions; concept of NGP.

Syllabus
23SMCH21MEA: Organic Reaction Mechanism – I

Unit No.	Title with Contents	No. of Lectures
I	**Aliphatic Nucleophilic Substitution** The SN_2, SN_1, mixed SN_1 and SN_2 and SET mechanism. The SNi mechanism. Nucleophile Substitution at an allylic, aliphatic trigonal and vinylic carbon. Factors affecting these reactions: substrate, nucleophilicity, solvent, steric effect, hard-soft interaction, leaving group, ambident nucleophile and regioselectivity.	**08**
II	**Neighboring Group Mechanism** The neighboring group participation mechanism, The Neighboring Group Participation by π & σ bonds, anchimeric assistance, classical and nonclassical carbocations, phenonium ions, norbornyl system, carbocation rearrangements in neighboring group participation.	**06**
III	**Reactions of Carbene and Free Radicals** Reaction of Halocarbenes, Photolysis of Cyclopropanes, Bamford-Stevens Reaction, carbene reactions of diazoalkanes-Addition to Alkenes, Addition to Aromatic Derivatives, Cyclization Reactions of α-Diazo Ketones, C-H Insertion Reactions of α-Diazo Ketones, Carbenoids-Simmons-Smith reaction. Free Radical Reactions- Coupling, Addition reactions, Substitution reactions, Reduction reaction, Barton-McCombie reaction, Barton reaction, Intermolecular Radical Coupling of Alkyl Halides and Alkenes, Intramolecular radical reactions (radical cyclization).	**08**
IV	**Reactions of Organometallic and Ylides** Addition of Grignard Reagent, Organo lithium, Organo Zinc, and Organo Copper reagents to Carbonyl and unsaturated Carbonyl compounds. Reactions of Phosphorous, Nitrogen and Sulphur Ylids.	**08**

Reference Books:

1. Advanced Organic Chemistry –by J. March 6th Edition.
2. Organic Synthesis-by Michael B. Smith Third Edition.
3. A guidebook to mechanism in organic chemistry – Peter Sykes 6th Ed. Orient Longman.
4. Mechanism and structure in Organic Chemistry – E. S. Gould (Holt, Rinehart and Winston).
5. Organic Chemistry – J. Clayden, N. Greeves, S. Warren and P. Wothers. Oxford University Press (2001)

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Course/ Paper Title	**Quantum Chemistry**
Course Code	**23SMCH21MEB**
Semester	**II**
No. of Credits	**2 (30 Hours)**

Aims & Objectives of the Course

Sr. No.	**Objectives**
	Students should;
1.	Understand quantum mechanical principles as well as the different microscopic phenomena.
2.	Understand the covalent nature of bonding and their theoretical background and correlation to practical aspects.
3.	Have a sound understanding of different spectroscopic techniques and photochemistry.

Expected Course Specific Learning Outcomes

Sr. No.	**Learning Outcome**
	Student should be able to;
1.	Describe specific examples where classical mechanics fails completely to account for experimental observations, and describe how the predictions of quantum mechanics agree with those observations.
2.	Carry out simple calculations involving complex numbers, functions and operators.
3.	Describe how the size and shape of a box, and the mass of a particle in it, influence the allowed energy states; calculate realistic energies for particle-in-a-box systems.
4.	Explain the concepts of a basis of vectors, a basis of functions, orthogonality and normalization of functions.

5.	Describe the Huckel hamiltonian matrix model, and give realistic numerical values, in eV, for the matrix elements of the Huckel hamiltonian in simple π-conjugated molecules.

Syllabus

23SMCH21MEB: Quantum Chemistry

Unit No.	Title with Contents	No. of Lectures
I	**Fundamental Background:** Failure of classical mechanics: blackbody radiation, photoelectric effect, de Broglie hypothesis and uncertainty principle and its experimental evidence.	**08**
II	**Application of Quantum Chemistry in Translation motion:** Schrödinger wave equation, particle in one dimensional box, Normalization and orthogonality of wave function, particle in three-dimensional box, hydrogen like atoms (no derivation).	**06**
III	**The Postulates and General Principles of Quantum Mechanics:** Postulates of Quantum Mechanics, Operators: algebra of operators, commutative property, linear operators, commutator operator, the operator ∇ and ∇^2, Problems.	**06**
IV	**Chemical Bonding:** Valence bond theory, hybrid orbitals, geometry and hybridization, molecular orbital theory for di and tri atomic molecule, linear variation method, approximations underlying Huckel theory, applications to simple π-systems, problems.	**10**

Reference Books:

1. Physical Chemistry by P. W. Atkin and De Paul.
2. Physical Chemistry by T. Engel and P. Reid.
3. Physical Chemistry and molecular approach by D. Mequarie and J. Siman.
4. Quantum Chemistry by I. Levine.
5. Quantum Chemistry by R.K. Prasad.

Course/ Paper Title	**Bio-inorganic Chemistry**
Course Code	**23SMCH22MEA**
Semester	**II**
No. of Credits	**2 (30 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
Student should understand and learn;	
1.	The role of metal ions in biological system.
2.	The bioinorganic chemistry of hemoglobin.
3.	The bioinorganic chemistry of myoglobin.
4.	The bioinorganic chemistry of Iron in Ferritin, Transferrin, Fe-S clusters, Porphyrin based system, the role of Ca in blood coagulation.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
Students should be able to;	
1.	Students will be able to explain concept of bioinorganic chemistry.
2.	Students will be able to explain and apply HSAB rule chelation, macro cyclic, cryptate effect.
3.	Students will be able to explain functions and transport of Alkali and Alkaline Earth Metal ions.
4	Students will be able to explain the role of Ca in blood coagulation, role of iron in Ferritin and Transferrin. Students will be able to understand the structures of Fe-S clusters, Porphyrin based system

Syllabus
23SMCH22MEA: Bio-Inorganic Chemistry

Unit No.	Title with Contents	No. of Lectures
I	**Metal ions in biological system:** Occurrence and availability of Inorganic elements in organisms, Essential and trace metal ions in biological system. Deficiency/excess of Mn, Co, and Zn metal ions, structure of chlorophyll, Photosynthesis, Photo system I and Photo system II. Metalloenzymes; cytochromes and iron-sulphur proteins, nitrogen fixation, Zinc enzymes; carboxypeptidase, carbonic anhydrase. Iron enzymes-catalase and peroxidase. Copper enzyme –superoxide dismutase. Cobalt enzyme; cyanocobalamin.	**11**
II	**Concepts of Inorganic Chemistry in Bioinorganic Chemistry:** Thermodynamic aspects - HSAB concept, chelate effect and IrvingWilliam series, pKa values of coordinated ligands, Tuning of redox potential, Biopolymer effects. Kinetic aspects- Electron transfer reaction, Electronic substitution reaction. Reactions of coordinated ligands and Template effect, concept of spontaneous self-assembly model compounds.	**10**
III	**Functions and Transport of Alkali and Alkaline Earth Metal Ions:** Roll of Alkali and alkaline earth metals in neuro sensation, Na+ /K+ - ATPase ion pump for active transport of Na+ and K Ionophores: Natural and Synthetic, Application of ionophores.	**05**
IV	**Biochemistry of following Elements:** Ca in blood coagulation, Iron in Ferritin, Transferrin, Fe-S clusters, Porphyrin based system	**04**

Reference Books:

1. Principle of Bioinorganic Chemistry by S. J. Lippard and J. M. Berg 38
2. Bioinorganic Chemistry: Inorganic Elements in Chemistry of Life by W. Kaim and B. Schwederski
3. Bioinorganic Chemistry, I. Bertini, H.B. Gray, S. J. Lippard and J.S. Valentine.
4. Inorganic Biochemistry, G. L. Eichhorn, vol. I and II., Elsevier.
5. Progress in Inorganic Chemistry, Vols. 18 and 38, S. J. Lippard, Eiley.

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Course/ Paper Title	**Molecular and Cell Biology**
Course Code	**23SMCH22MEB**
Semester	**II**
No. of Credits	**2 (30 Hours)**

Aims & Objectives of the Course

Sr. No.	Objectives
1.	To provide a solid foundation in the fundamental principles of molecular and cell biology.
2.	To familiarize students with the molecular mechanisms underlying cellular processes and functions.
3.	To explore the interdisciplinary aspects of molecular biology and its relevance to chemistry.
4.	To develop critical thinking and analytical skills for understanding and interpreting molecular and cell biology research.
5.	To introduce students to emerging topics and technologies in molecular and cell biology.

Expected Course Specific Learning Outcomes

Sr. No.	Learning Outcome
1.	Demonstrate a thorough understanding of the principles and mechanisms of molecular and cell biology.
2.	Explain the molecular processes underlying cellular functions, including DNA replication, gene expression, and protein synthesis.
3.	Analyze and interpret molecular and cell biology research findings, critically evaluating experimental data and scientific literature.
4.	Apply chemical principles to understand and investigate biochemical pathways and drug targets.
5.	Perform molecular and cell biology techniques accurately and safely in a laboratory setting.
6.	Communicate effectively about molecular and cell biology concepts, research findings, and ethical considerations.

Syllabus

23SMCH22MEB: Molecular and Cell Biology

Unit No.	Title with Contents	No. of Lectures
I	**Introduction to Molecular and Cell Biology** 1. Basic concepts in molecular and cell biology: • Introduction to the fundamental principles and concepts in molecular and cell biology. • Includes the study of biological molecules (DNA, RNA, proteins), cell structures, and cellular processes. • Emphasizes the importance of understanding molecular and cellular mechanisms in biological systems. 2. Central dogma of molecular biology: • The central dogma describes the flow of genetic information in cells. • DNA is replicated, transcribed into RNA, and translated into proteins. • Emphasizes the essential role of genetic information in determining cellular functions and characteristics. 3. Overview of cell structure and function: • Cells are the basic structural and functional units of living organisms. • Different types of cells exist, including prokaryotic and eukaryotic cells. • Covers the components of cells (e.g., cell membranes, organelles) and their functions in maintaining life processes.	**6**
II	**Nucleic Acids and Genetic Information** 1. DNA structure and replication: • Introduction to the structure of DNA as a double-stranded molecule composed of nucleotides.	**8**

	• Explanation of the base pairing rules (A-T, G-C) and the double helix structure of DNA. • Overview of DNA replication, the process of copying DNA to produce two identical DNA molecules. 2. RNA structure and transcription: • Introduction to RNA as a single-stranded molecule involved in gene expression. • Description of different types of RNA, including messenger RNA (mRNA), transfer RNA (tRNA), and ribosomal RNA (rRNA). • Explanation of transcription, the process by which DNA is transcribed into RNA molecules. 3. Genetic code and translation: • Understanding the genetic code, a set of rules that determines the correspondence between RNA codons and amino acids. • Explanation of translation, the process of synthesizing proteins based on the information encoded in mRNA. • Discussion of the roles of ribosomes and transfer RNA (tRNA) in the translation process. 4. Gene regulation and expression: • Overview of gene regulation, the control of gene expression in response to cellular needs. • Exploration of transcription factors, enhancers, and repressors as mechanisms of gene regulation. • Understanding gene expression, the process by which genetic information is used to synthesize proteins. 5. Recombinant DNA technology: • Introduction to recombinant DNA technology, which involves combining DNA from different sources to create novel DNA molecules.	

	• Description of techniques such as DNA cloning, PCR (polymerase chain reaction), and genetic engineering. • Discussion of the applications of recombinant DNA technology in medicine, agriculture, and biotechnology. 6. Genomics and proteomics: • Introduction to genomics, the study of the entire set of genes in an organism (genome). • Overview of proteomics, which focuses on the study of proteins, including their structure, function, and interactions. • Understanding the significance of genomics and proteomics in advancing our knowledge of biological processes and diseases.	
III	**Cellular Processes** 1. Cell cycle and cell division: • Overview of the cell cycle, including the phases (interphase, mitosis, and cytokinesis) and their regulation. • Explanation of the key events in each phase, such as DNA replication, chromosome segregation, and cell division. 2. Protein synthesis and secretion: • Introduction to the process of protein synthesis, including transcription and translation. • Understanding the role of the endoplasmic reticulum (ER) and Golgi apparatus in protein processing and secretion. 3. Membrane transport and signal transduction: • Explanation of membrane transport mechanisms, including passive diffusion, facilitated diffusion, and active transport.	**8**

	• Introduction to signal transduction, the process by which extracellular signals are transmitted into intracellular responses. 4. Cell adhesion and communication: • Overview of cell adhesion molecules and their roles in cell-cell and cell-matrix interactions. • Understanding intercellular communication mechanisms, such as gap junctions, tight junctions, and chemical signaling. 5. Cell differentiation and development: • Exploration of cell differentiation, the process by which cells acquire specialized functions. • Understanding the principles of embryonic development and organogenesis. 6. Apoptosis and cell death: • Introduction to apoptosis, programmed cell death, and its role in normal development and homeostasis. • Discussion of the molecular mechanisms involved in apoptosis and its importance in disease processes.	
IV	**Special Topics in Molecular and Cell Biology** 1. Molecular basis of drug discovery and development: • Introduction to the process of drug discovery and development, including target identification and validation. • Understanding molecular targets for drug intervention and their significance in therapeutic approaches. 2. Biochemical pathways and drug targets: • Overview of biochemical pathways and their regulation in cellular processes.	**8**

	• Identification and characterization of drug targets within biochemical pathways for effective drug design. 3. Pharmacokinetics and drug metabolism: • Understanding the absorption, distribution, metabolism, and excretion (ADME) of drugs in the body. • Exploring the role of enzymes and factors influencing drug metabolism and pharmacokinetics. 4. Drug delivery systems and nanomedicine: • Introduction to drug delivery systems and the importance of effective drug delivery in therapeutics. • Applications of nanotechnology in drug delivery and its impact on improving drug efficacy and targeted delivery. 5. Drug resistance and mechanisms of resistance: • Exploring the mechanisms underlying drug resistance in various diseases. • Discussing strategies to overcome drug resistance and enhance therapeutic outcomes.	

Reference Books:

1. "Molecular Biology of the Cell" by Bruce Alberts, Alexander Johnson, Julian Lewis, David Morgan, Martin Raff, Keith Roberts, and Peter Walter.
2. "Essential Cell Biology" by Bruce Alberts, Dennis Bray, Karen Hopkin, Alexander Johnson, Julian Lewis, Martin Raff, Keith Roberts, and Peter Walter.
3. "Molecular Cell Biology" by Harvey Lodish, Arnold Berk, Chris A. Kaiser, Monty Krieger, Matthew P. Scott, Anthony Bretscher, Hidde Ploegh, and Paul Matsudaira.
4. "Cell and Molecular Biology: Concepts and Experiments" by Gerald Karp.
5. "Lehninger Principles of Biochemistry" by David L. Nelson and Michael M. Cox.

Course/ Paper Title	**Field Work / On Job training (OJT)**
Course Code	**23SMCH12FP**
Semester	**II**
No. of Credits	**4**

The students, as a part of their course, will be given opportunities to enroll for Field Project(s) or on job training.

The student must undergo field work project which related to chemistry.

The students must undergo industrial on job training/internship in the 2nd semester in any of the reputed industry, Government-sponsored Research & Development Organization, and reputed academic institution/foreign universities.

In a fieldwork report or On Job training, it is important to include relevant information and observations in following format.

- Introduction:
- Methodology:
- Fieldwork Activities:
- Data Collection:
- Findings, data analysis and Results:
- Discussion:
- Recommendations:
- Conclusion:
- References:
- Supplementary material

In a report on job training, it is important to provide a comprehensive overview of the training program and highlight key learnings and outcomes.

some points to consider when creating a report on job training:

- Introduction:
- Training Program Overview:
- Learning Objectives:
- Training Activities:
- Skills and Knowledge Acquired:
- Challenges and Solutions:
- Feedback and Evaluation:
- Impact and Benefits:
- Recommendations:
- Conclusion:
- Summarize the key findings and outcomes of the training program.