M. Sc. CHEMISTRY

(SEMESTER PATTERN)
CHOICE BASED CREDIT SYSTEM (CBCS)

TWO YEARS FULL TIME PROGRAMME

COURSE OF STUDIES AR-24

GIET UNIVERSITY, GUNUPUR ODISHA

All the precautions have been taken to print the course curriculum accurate. However, mistakes if any will be corrected as and when noticed. The university reserves the right to include/exclude any content at any point of time during the progression of the course.

M.Sc. CHEMISTRY R24

Course and Credit Structure

SEMESTER-I (1st Year)

Sl. No.	Course Category	Course Code	Course Title	L	T	P	Credits
THEORY							
1	CHPC	24CHPC1001	Organic Chemistry-I	4	0	0	4
2	CHPC	24CHPC1002	Inorganic Chemistry-I	4	0	0	4
3	CHPC	24CHPC1003	Physical Chemistry-I	3	1	0	4
4	CHPC	24CHPC1004	Molecular Spectroscopy	3	1	0	4
PRACTICAL/SESSIONAL							
5	CHPC	24CHPC1005	Organic Practical	0	0	8	4
6	CHPC	24CHPC1006	Project-I	0	0	4	2
TOTAL				**14**	**2**	**12**	**22**

SEMESTER-II (1st Year)

Sl. No.	Course Category	Course Code	Course Title	L	T	P	Credits
THEORY							
1	CHPC	24CHPC2001	Organic Chemistry-II	4	0	0	4
2	CHPC	24CHPC2002	Inorganic Chemistry-II	4	0	0	4
3	CHPC	24CHPC2003	Physical Chemistry-II	3	1	0	4
4	CHPC	24CHPC2004	Organic Spectroscopy	3	1	0	4
PRACTICAL/SESSIONAL							
5	CHPC	24CHPC2005	Inorganic Practical	0	0	8	4
6	CHPC	24CHPC2006	Project-II	0	0	4	2
7	CHPC	24CHPC2007	MATLAB	0	0	1	1
TOTAL				**14**	**2**	**12**	**23**

BoS Members:

1. Dr. Prativa Kar
2. Dr. Ganesh Chandra Nayak
3. Dr. Bankim Chandra Tripathy
4. Dr. Jitendra Kumar Sahoo
5. Dr. Uttam Kumar Sahu
6. Mrs. Juhi Rath
7. Mr. Debasis Panda

BOS Approved
Date:17/05/2024

SEMESTER-III (2nd Year)

Sl. No.	Course Category	Course Code	Course Title	L	T	P	Credits
THEORY							
1	CHPC	24CHPC3001	Analytical Chemistry-I	3	1	0	4
2	CHPE	24CHPE3002	Organic Chemistry-III	3	1	0	4
		24CHPE3003	Agro Chemistry				
3	CHPE	24CHPE3004	Environmental and Analytical Chemistry	4	0	0	4
		24CHPE3005	Nano Chemistry				
4	CHCBOE	24CHCBOE3006	Chemistry of Materials	4	0	0	4
		24CHCBOE3007	Advanced Organometallic Chemistry				
PRACTICAL/SESSIONAL							
5	CHPC	24CHPC3008	Analytical Practical	0	0	8	4
6	CHPC	24CHPC3009	Summer Internship / Project - III	0	0	4	2
TOTAL				**14**	**2**	**12**	**22**

SEMESTER-IV (2nd Year)

Sl. No.	Course Category	Course Code	Course Title	L	T	P	Credits
THEORY							
1	CHPC	24CHPC4001	Physical Chemistry-III	3	1	0	4
2	CHPE	24CHPE4002	Organic Chemistry-IV	4	0	0	4
		24CHPE4003	Bio-inorganic and Supra Molecular Chemistry				
		24CHPE4004	Polymer Chemistry				
		24CHPE4005	Industrial Chemistry				
3	CHOE	24CHPE4006	Ethics & IPR	3	0	0	3
PRACTICAL / SESSIONAL							
4	CHPE	24CHPE4007	Physical Practical	0	0	8	4
5	CHEC	24CHEC4008	Major Project/ Dissertation	0	0	16	8
6	VAC	24VAC4009	Value added course/ MOOCS	-	-	-	-
TOTAL				**11**	**1**	**24**	**23**

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SCHEME OF INSTRUCTION SUMMARY

SL. NO.	COURSE WORK - SUBJECTS AREA	CREDITS / SEMESTER				TOTAL CREDITS	%
		I (550 marks)	II (600 marks)	III (550 marks)	IV (600 marks)	Total (2300 marks)	
1	Professional Course (PC)	20	21	8	4	53	59
2	Professional Electives (PE)	-	-	8	8	16	18
3	Choice Based Open Elective (CBOE) / Open Elective (OE)	-	-	4	3	7	8
4	Project Work, Seminar and/or Internship in Industry or elsewhere (PC)	2	2	2	8	14	15
5	Value added Courses	0	0	-	-	0	0
	TOTAL	**22**	**23**	**22**	**23**	**90**	**100**

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(Credits-Hours-Marks Distribution)

Semester	Course	Course Title	Hrs per week L-T-P	Credits L-T-P	Exam Hrs L-T-P	Marks		Total
						Mid Sem	End Sem	
I	24CHPC1001	Organic Chemistry-I	4	4	3	40	60	100
	24CHPC1002	Inorganic Chemistry-I	4	4	3	40	60	100
	24CHPC1003	Physical Chemistry-I	4	4	3	40	60	100
	24CHPC1004	Molecular Spectroscopy	4	4	3	40	60	100
	24CHPC1005	Organic Practical	8	4	6	0	100	100
	24CHPC1006	Project-I	4	2	2	0	50	50
			28	**22**				**550**
II	24CHPC2001	Organic Chemistry-II	4	4	3	40	60	100
	24CHPC2002	Inorganic Chemistry-II	4	4	3	40	60	100
	24CHPC2003	Physical Chemistry-II	4	4	3	40	60	100
	24CHPC2004	Organic Spectroscopy	4	4	3	40	60	100
	24CHPC2005	Inorganic Practical	8	4	6	0	100	100
	24CHPC2006	Project-II	4	2	2	0	50	50
	24CHPC2007	MATLAB	1	1	2	0	50	50
			29	**23**				**600**

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(Credits-Hours-Marks Distribution)

Semester	Course	Course Title	Hrs per week L-T-P	Credits L-T-P	Exam Hrs L-T-P	Marks		Total
						Mid Sem	End Sem	
III	24CHPC3001	Analytical Chemistry-I	4	4	3	40	60	100
	24CHPE3002	Organic Chemistry-III	4	4	3	40	60	100
	24CHPE3003	Agro Chemistry						
	24CHPE3004	Environmental and Analytical Chemistry	4	4	3	40	60	100
	24CHPE3005	Nano Chemistry						
	24CHCBOE3006	Chemistry of Materials	4	4	3	40	60	100
	24CHCBOE3007	Advanced Organometallic Chemistry						
	24CHPC3008	Analytical Practical	8	4	6	0	100	100
	24CHEC3009	Summer Internship/ Project - III	4	2	-	-	50	50
			28	**22**				**550**
IV	24CHPC4001	Physical Chemistry-III	4	4	3	40	60	100
	24CHPE4002	Organic Chemistry-IV	4	4	3	40	60	100
	24CHPE4003	Bio-inorganic and Supra Molecular Chemistry						
	24CHPE4004	Polymer Chemistry						
	24CHPE4005	Industrial Chemistry						
	24CHOE4006	Ethics & IPR	3	3	3	40	60	100
	24CHPE4007	Physical Practical	8	4	6		100	100
	24CHPC4008	Major Project / Dissertation	16	8			200	200
	24VAC4009	Value Added Course / MOOCS	**0**	**0**	0	0	0	**0**
			35	**23**				**600**

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BOS Approved
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SEMESTER-I

Course Code:	24CHPC1001	No. of Credits:	4
Course Name:	ORGANIC CHEMISTRY-I	Sem End Exam & Cycle Test:	60+40

Course Educational Objectives:

This course enables the students

CEO1: To impart advanced knowledge of reactive intermediates.

CEO2: To learn the control of reactions progress and concepts of stereochemistry.

CEO3: To study and understand the name reactions and molecular rearrangements.

Course Outcomes:

Upon successful completion of this course, students should be able to:

CO1: Interpret the concept of aromaticity and Addition Compounds.

CO2: Compare the Reaction intermediates based on various parameters.

CO3: Apply the concepts of kinetic and thermodynamic control for different reactions and principles of HSAB.

CO4: Analyse the stereochemistry of different organic molecules.

CO5: Derive the mechanism and probable applications of different Name reactions.

CO6: Derive mechanism and probable applications of the molecular rearrangements.

Mapping of COs with POs

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-										
CO2	2	2										
CO3	3	3										
CO4	3	1										
CO5	3	2										
CO6	2	3										

COURSE CONTENT

Unit-I: Basic Concepts **(12 hours)**

A) Aromaticity in benzenoid and nonbenzenoid compounds, Huckel‘s rule, Addition Compounds: Crown ether complexes and cryptands, Inclusion complexes, Cyclodextrins, Catenanes and Rotaxanes.

B) Reaction intermediates: Classification, Structure, Stability, Generation and Fate of intermediates-carboanion, carbocation, carbenes, carbenoids, free radicals, ylides and N-Heterocyclic Carbenes.

Unit-II: Structure and reactivity **(12 hours)**

Types of reaction mechanisms, types of reactions, Thermodynamic and Kinetic requirements, Kinetic and Thermodynamic control, Hammond’s postulate, Curtin-Hammett principle, Potential energy diagram, Methods of determining mechanism, Isotope effect, Hard-soft concept of acid base, HSAB principle, Hammett equation, Hammett equation and linear free energy relationships, substituent and reaction constants, Taft equation.

Unit-III: Stereochemistry (12 hours)

Conformation of cycloalkanes and decalins. Effect of conformation on reactivity, conformation of sugars, Optical activity in absence of chiral carbon (biphenyls, allenes and spirans), Chirality due to helical shape, Asymmetric synthesis. Racemic modification, Resolution of racemic modification, Absolute and relative configuration, R-S nomenclature, Optical purity, E-Z-notation.

Unit-IV: Name Reactions (12 hours)

A: Name reaction: Chichibabin reaction, Clasien-Schmidth reaction, Bayer villager reaction, Hoffman reaction, Shapiro reaction, Stobbe condensation, Wittig reaction. Aldol condensation, knoevenagel condensation, Claisen condensation, Mannich Reaction, Benzoin condensation, Perkin Reaction, Michael reaction, Reformatsky reaction ,Vilsmeier- Hack reaction. Gattermann – Koch reaction, Reimer- Tiemann reaction, Friedel Craft reaction, Diazonium coupling, Hunsdiecker reaction, Kochi reaction, sandmeyer reaction.

Unit-V: Molecular rearrangement (12 hours)

Molecular rearrangement:Beckmann rearrangement, Benzilic acid rearrangement, Pinacol-Pinacolone rearrangement, Wagner-Meerwein rearrangement, Dienone-Phenol rearrangement, Favorskii rearrangement, Fries rearrangement, Lossen rearrangement, Neber rearrangement, Steven rearrangement, Benzidine rearrangement, Von-Richter rearrangement, Sommelet –Hauser rearrangement, Smiles Rearrangement

Reference Books:

1. Organic synthesis: Clayden, Greeves, Warren and Wouthers, Oxford Univ. Press, 2nd Ed (2012).
2. Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Part A and B Springer, 5th Ed.(2005)
3. A Guide Book of Mechanism in Organic Chemistry, Peter Sykes, Longman.6th Ed.(1999)
4. Structure and Mechanism in Organic Chemistry, C. K. Ingold, Cornell University Press,3rd (1957).
5. Organic Chemistry, R. T. Morrison and R. N. Boyd, Prentice-Hall, 6th Ed.(1992)
6. Modern Organic Reactions, H. O. House, W.A. Benjamin. 2nd Ed.(1972)
7. Principles of Organic Synthesis, R.O.C. Norman and J. M. Cox, CRC Press 3rd (2014).
8. Reaction Mechanism in Organic Chemistry, S. M. Mukherjee and S. P. Singh, Macmillan.3rd Ed. (2009).
9. Stereochemistry of Organic Compounds, E. L. Eliel, S. H. Wilen, L.N. Mander, John Wiley & Sons, Inc., New York, NY. (1994).
10. Organic reaction mechanism (Benjamin) R. Breslow
11. Organic chemistry (McGraw-Hill) Hendrickson, Cram and Hammond.
12. Basic principles of Organic chemistry (Benjamin) J. D.Roberts and M. C. Caserio.
13. Organic reaction mechanism (McGraw-Hill) R. K. Bansal.
14. Organic Chemistry By I.L Finar (Volume 1 & 2) Pearson Publication
15. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley, 6th Ed.(2006)

Course Code:	**24CHPC1002**	**No. of Credits:**	**4**
Course Name:	**INORGANIC CHEMISTRY-I**	**Sem End Exam & Cycle Test:**	**60+40**

Course Educational Objective:

This course enables the students

CEO1: To impart advanced knowledge of chemical bonding

CEO2: To learn concepts of CFT and MOT

CEO3: To study and understand the nuclear reaction and radioactive element

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: To understand the hybridization of polyatomic molecules, Valence bond and Molecular orbital theories

CO2: Students should learn applications in crystal field theory and molecular spectroscopy. Determine the exact shape of co-ordination complex compound.

CO3: To learn the concept of electronic structure and magnetic properties of coordination complexes to identify the occurrence, active site structure and functions of some transition metal ions.

CO4: Students will be able to describe of Orgel and Jahn-Teller diagrams, structure of mixed metal oxides and chemistry of inner transition elements.

CO5: Students will be able to identify the CFSE of various metal complexes.

CO6: To understand the composition of the nuclear structure, its stability and induce the students to take up nuclear research in their higher studies.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-										-
CO2	1	2										-
CO3	2	3										-
CO4	2	3										2
CO5	2	3										
CO6	1	3										

COURSE CONTENT

Unit-I: Covalent Bond **(12 hours)**

Valence bond theory: Qualitative discussion on valence bond theory-formation of hydrogen molecule, energy distribution and stability, bent theory, VSEPR theory, shapes of simple molecules and ions, Linnet's double quartet theory and spectra of simple molecules. Hybridization and wave mechanical description for sp, sp^2 and sp^3 hybrid orbitals, qualitative idea about dsp^2, dsp^3 and d^2sp^3 hybrid orbitals.

Unit-II: Bonding in Co-ordination Compounds (12 hours)

Valence bond theory-strength and short coming, Crystal field theory-effect spin types, CFSE, factors affecting the magnitude of 10Dq, Evidence for crystal stabilization energy in octahedral, tetrahedral, tetragonal, square pyramidal and square planner fields, Jahn-Teller distortion, Applications of Crystal Field Splitting, Structures of Mixed Metal Oxides: Spinel & Inverse Spinel, Nephelauxetic series.

Unit-III: Molecular Orbital Theory (12 hours)

Molecular orbital theory (qualitative), Qualitative discussion on molecular orbital theory, bonding and antibonding orbitals, MO energy level diagrams of simple diatomic and polyatomic molecules, Walsh diagram, formation of ligand group orbitals (LGOs) of sigma symmetry, Formation of molecular orbitals of sigma symmetry, construction of molecular orbital energy level diagram involving only sigma bond contribution from ligands, Sigma–pi bonding and their importance in co-ordination compounds.

Unit-IV: Spectral and Magnetic Properties of Transition Metal Complexes (12 hours)

Spectroscopic ground states, Correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1-d^9 states), Charge transfer spectra, Elementary idea about magneto chemistry of metal complexes, Diamagnetism, Para magnetism, Temperature independent paramagnetism, Magnetic susceptibility and its measurement, Paramagnetism applied to metal complexes, Ferromagnetism Ferrimagnetism and Anti-ferromagnetism.

Unit-V: Nuclear Chemistry (12 hours)

Mass and charge, nuclear moments, binding energy, mass defect, packing fraction, stability, magic numbers. Modes of radioactive decay and rate of radioactive decay - half-life, average life, radioactive equilibrium, Energetics and types - nuclear fission- liquid drop model - nuclear fusion - essential features of nuclear reactors - tracer techniques, neutron activation analysis - carbon and rock dating - application of tracers in chemical analysis, reaction mechanisms, medicine and industry.

Reference Books

1. Advanced Inorganic Chemistry: F. A. Cotton, G. Wilkinson, C. A. Murillo, M. Bochmann, John Wiley and Sons Press, 3rd Ed. (1995).
2. Inorganic Chemistry-Principles of Structure and Reactivity: J. E. Huheey, E. A. Keiter, R. L. Keiter, Harper-Collins, NY, 4th Ed. (1993).
3. Inorganic Chemistry: G. L. Missler and D. A. Tarr, Prentice Hall, 3rd Ed. (2003).
4. Inorganic Chemistry: D. F. Shriver, and P. W. Atkins, Oxford University, Oxford, 3rd Ed. (1999).
5. Chemistry of the Elements. N. N. Greenwood, and A. Earnshaw, Elsevier, 2nd Ed. (1997).
6. Essential of Nuclear Chemistry: H. J. Arnikar, Wiley,NY, 2nd Ed.(1987).
7. Principles of In-organicChemistry:Puri,Sharma,Kalia,VPC

Course Code:	**24CHPC1003**	**No. of Credits:**	**4**
Course Name:	**PHYSICAL CHEMISTRY-I**	**Sem End Exam & Cycle Test:**	**60+40**

Course Educational Objective:

This course enables the students

CEO1: The aim of this course is to provide a systematic treatment of symmetry in chemical systems

within the mathematical framework known as group theory.

CEO2: To understand equilibrium which exists within different states of matter (solid, liquid and gas)

CEO3: To understand the concept of quantum chemistry

CEO4: To understand C-programming language and it's use in chemistry

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1 Apply the knowledge of symmetry and point group of molecules

CO2: Apply in industries including allotropes of carbon, purification of components by distillation,

and uses of emulsions in food productions

CO3: Use symmetry arguments to understand bonding and geometry of molecules

CO4: Uses of phase equilibrium to control the concentration of component and its concept also used in various types of separation process.

CO5: Explain the postulates and general principles of quantum mechanics.

CO6: Apply the Computer programming skills in C programming language and develop small computer codes involving simple formula in chemistry.

Mapping of COs with Pos

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	CO10	CO11	CO12
CO1	2	3										
CO2	1	3										
CO3	1	2										
CO4	2	2										
CO5	1	3										
CO6	2	2										

COURSE CONTENT

Unit-I: Symmetry and group theory **(12 hours)**

Symmetry operation, symmetry element, classification of symmetry elements, Definition of group, subgroup, Classes, Relationship between orders of a finite group and its subgroup, Mathematical requirement of point group, symmetry Point group, group multiplication table(C3, C2v, C4,C2h, D2, S4) conjugacy relation and classes, matrix representation of symmetry elements, reducible and irreducible representation, the great orthogonality theorem (without proof) and its explanation, Standard reduction, Character table (C2v, C3v, C4v,C2h, D2, D2d Point group), Direct product.

Unit-II: Phase Equilibrium (12 hours)

Concept of phase, components and degree of freedom, derivation of Gibbs phase rule for nonreactive and reactive system, clausius claperon equation and its application to solid-liquid, liquid-vapour and solid-vapour equilibria, phase diagram for one component system with application (H_2O and Sulphur system). Three component systems, water-chloroform-acetic acid system, triangular plots, Gibbs-Duhem margagules equation, its derivation and application to fractional distillation of binary miscible liquids (ideal and non-ideal), Nernst distribution (its derivation and applications).

Unit-III: Quantum Chemistry (12 hours)

The Schrodinger equation and the postulates of quantum mechanics, Elementary application of the Schrodinger equation, Particle in one and three dimensional boxes, Hydrogenatom, Transformation of co-ordinate, Separation of variables, φ-equation, θ-equation, The radial equation, Shapes of s,p and d orbitals. Postulates of quantum mechanics, Simple harmonic oscillator, Rigid rotator, The variation theorem, Linear variation theorem, Linear variation principle.

Unit-IV Quantum Chemistry-II (12 hours)

Perturbation theory (first order and non-degenerate), Application of various methods and perturbation theory to Helium atom, Angular momentum, Ordinary angular momentum, generalized angular momentum, Eigen functions for angular momentum, addition of angular momentum, Huckel theory of conjugated systems, Bond order and charge density calculation, Application to ethylene, butadine, cyclobutadiene.

Unit-V: Computer for Chemists (12 hours)

Computer programming in C: Elements of computer language, Constant and Variables, Operation and symbols, Expressions, Arithmetic assignment, Input and output, Conditional statement, Loops, Logical variables. C Programming in chemistry: Development of small computer codes involving simple formulae in chemistry such as vander Waal‘s equation, Radioactive decay constant, Rate constant, Evaluation of energy level and radius of an orbit.

Reference Books

1. K. Veera Reddy, Symmetry and Spectroscopy of Molecules, New Age International, Delhi

2. I.N. Levine, Quantum Chemistry, 5th edition (2000), Pearson Educ. Inc., New Delhi.

3. A.K. Chandra, Introductory Quantum Chemistry, 4th edition, Tata McGraw Hill, New Delhi.

4. L. Pauling and E. B. Wilson, Introduction to Quantum Mechanics with Applications to Chemistry (1935), McGraw Hill, New York.

5. R.K.Prasad,‖ Quantum Chemistry‖, Wiley.

6. F.A. Cotton, Chemical Applications of Group Theory, Wiley 7. Ramesh Kumari, Computers and their Applications to Chemistry, Narosa, New Delhi

7. Physical Chemistry by P.W Atkins’ ,Oxford Publication

8. AText book of Physical Chemistry Volume-III By KL Kapoor, 5th edition,2020

9. Group Theory In Chemistry By Alok K Mukherjee, B.C Ghosh ,University Press

10. R. Ameta, Symmetry and Group Theory in Chemistry, New Age International Ltd., 1st edn, 2013, New Delhi.

Course Code:	24CHPC1004	No. of Credits:	4
Course Name:	MOLECULAR SPECTROSCOPY	Sem End Exam & Cycle Test:	60+40

Course Educational Objective:

This course enables the students

CEO: To provide knowledge of advanced spectroscopic techniques for identification and elucidation of structures of molecules.

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: To understand electronic and molecular spectroscopy of different elements and simple molecules.

CO2: To introduce vibrational-rotational energy levels, selection rules and their applications in IR and Raman spectroscopy.

CO3: To learn the fundamental and advanced concepts of Microwave and photo electron spectroscopy and their applications for chemical analysis.

CO4: To study the concepts and principles of Mössbauer Spectroscopy and electron spin resonance spectroscopy and their applications.

CO5: Students will be able to define and discuss about various spectroscopic techniques.

CO6: Students are able to predict the structure of different molecules.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3										
CO2	2	2										
CO3	2	3										
CO4	3	3										
CO5	3	2										
CO6	3	3										

COURSE CONTENT

Unit-I: Electronic & Molecular Spectroscopy (12 hours)

A. **Atomic spectroscopy**: The electromagnetic spectrum, Energies of atomic orbital, Spectra of hydrogen atom and hydrogen like atom, alkali metals spectra.

B. Molecular spectroscopy: Energy levels, Molecular orbitals, Vibrational progression and geometry of excited state, Frank-Condon principle. Electronic spectra of polyatomic molecules.

C. Rotational or Microwave spectroscopy: Classification of molecules, Rigid rotator model, Intensities of spectral lines, Effect of isotopic substitution on transition frequencies, Non- rigid rotator. , Stark effect, applications.

Unit-II: Vibrational Spectroscopy (12 hours)

A. Infra-red spectroscopy: Introduction, Vibrational energy of diatomic molecules, zero point energy, force constant and bond strength, Morse potential energy diagram, vibrational- rotational spectroscopy, P,Q,R branches, break–down of Oppenheimer approximation, vibration of polyatomic molecules, Selection rules, Normal mode of vibration, Group frequencies, Overtones, Hot bands, Factors affecting the band positions and intensities, far IR-region.

Unit-III: **(12 hours)**

A. Raman Spectroscopy: Introduction, Classical and quantum theories of Raman effect, Pure rotational, vibrational and rotational Raman spectra, Selection rule, Mutual exclusion principle, Coherent anti Stoke's-Raman spectroscopy.

B. Mossbauer spectroscopy: Basic principles, Spectral parameters and spectral display, Quadrupole splitting, Magnetic hyperfine interaction, Application of the techniques to study the bonding and structure of Fe^{2+} and Fe^{3+} compounds including those of intermediate spins.

Unit-IV: Photoelectron spectroscopy **(12 hours)**

Introduction, Basic principles, Photo electric effect, Ionisation process, Koopmans's theorem, photoelectron spectra of simple molecules, ESCA, Chemical information from ESCA, Auger electron spectroscopy-basic idea.

Unit-V: Electron spin resonance spectroscopy **(12 hours)**

Basic principles, Zero- field splitting and Kramer's degeneracy, Factors affecting the "g" value, hyperfine splitting in isotropic systems involving more than one nucleus, Isotopic and anisotropic hyperfine coupling constant, Measurement techniques, Application.

Reference Books

1. Modern Spectroscopy, J.M. Hollas, John Wiley, 2004, 4th edition, Sussex.
2. Physical Methods in Chemistry, R.S. Drago, Sauders College.
3. Chemical Applications of Group Theory, F.A. Cotton.
4. Introduction to Molecular Spectroscopy, G.M. Barrow, McGraw Hill
5. Basic Principles of Spectroscopy, R. Chang, McGraw Hill.
6. Theory and Applications of UV Spectroscopy, H.H.Jaffe and M.Orchin, IBH-Oxford.
7. Introduction to Photoelectron Spectroscopy, P.K.Ghosh, John Wiley.
8. Introduction to Magnetic Resonance, A. Carrington and A.D. Maclachalan, Harper & Row.
9. Spectroscopy, S. Walker and H. Straw, Chapman and Hall ltd.
10. Energy levels in atom and molecules, W.G. Richards and P.R. Scott, Oxford University Press, Oxford Chemistry Primer vol. 26, 1994, New York.
11. Introduction to Spectroscopy, Pavia, Brooks/Cole Cenage, 4th edition, 2009, Belmont.
12. Electronic Absorption Spectroscopy and Related Techniques, D. Sathyanarayana, University Press (India) Ltd., 2001, Hyderabad.
13. Molecular Spectroscopy, P.S. Sindhu, Tata McGraw Hill , 1985, New Delhi.
14. Fundamental of Molecular Spectroscopy, C. N. Banwell and E. McCash, Tata McGraw Hill, 4th edition, 1994, New Delhi.
15. Physical chemistry by P.W.Atkins,ELBS. 1986
16. Molecular Spectrocopy by I.N.Levins,Wiley Interscience

Course Code:	**24CHPC1005**	**No. of Credits:**	**4**
Course Name:	**ORGANIC PRACTICAL**	**End Exam:**	**100**

(6hrs per week)

Course Educational Objective:

This course enables the students

CEO1: To apply the skill in two stage preparation, purification and recrystallisation.

CEO2: To focus on Synthesis of organic compounds

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: To familiarize the solubility nature of organic substances of different functional group.

CO2 To expertise the various techniques of preparation and analysis of organic substances

CO3: To learn two stage preparation involving molecular rearrangement.

CO4: To learn the preparations of derivative of all functional groups

CO5: To understand the techniques involving drying and recrystalliation by various method.

CO6: To understand the identification of various organic compounds.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**2**				**1**							
CO2	**2**				**1**				**1**			
CO3	**2**				**1**							
CO4	**2**				**1**				**1**			
CO5	**2**				**1**				**1**			
CO6	**2**				**1**							

1. Qualitative Analysis

i. Identification of organic compounds having at least two functional group. Submission of derivatives.

ii. Identification of organic compounds of binary mixture by (Thin Layer Chromatography) and determination of Rf value

iii. Purification of organic compounds of binary mixture by Column Chromatography

iv. Characterization of functional group by IR spectra/NMR/Mass

2. Quantitative Analysis

i. Estimation of Acetyl group

ii. Estimation Phenolic group

iii. Estimation of Keto group

3. Synthesis of organic compounds:

i. p- Nitroacetanilide.
ii. p- Nitroaniline.
iii. Ethylbenzoate.
iv. m-Dinitrobenzene.
v. Dibenzyl acetone and its derivatives
vi. Anthranilic acid
vii. Methyl Orange
viii. Adipic acid by chromic acid oxidation of cyclohexanol
ix. Triphenyl methanol from benzoic acid (Grignard reaction)
x. Benzaldehyde to cinnamic acid

Reference Books

1. Quantitative and Qualitative analysis By A.I. Vogel, John Wiley.
2. Experiments and Techniques in Organic Chemistry, D.Pasto, C.Johnson, & M.Miller, Prentice Hall.
3. Systematic Qualitative Organic Analysis, H. Middleton, Edward Arnold (Publisher).
4. Hand Book of Organic Analysis, Qualitative & Quantitative, M.T. Clarke, Edward Arnold (Publisher).
5. Macroscale and Microscale Organic Experiments, K. L. Williamson, D. C. Heath.

SEMESTER–II

Course Code:	24CHPC2001	No. of Credits:	4
Course Name:	ORGANIC CHEMISTRY-II	Sem End Exam & Cycle Test:	60+40

Course Educational Objective:

This course enables the students

CEO1: To learn the mechanism of nucleophilic substitutions in aromatic molecules and aliphatic molecules.

CEO2: To learn the concepts of free radical mechanism.

CEO2: To learn the mechanism of electrophilic substitutions in aromatic molecules and aliphatic molecules.

CEO3: To learn the mechanism of addition and elimination reaction.

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: Understand the mechanism of electrophilic substitution in aliphatic and aromatic molecules.

CO2: Analysis of free radical mechanism in organic reactions.

CO3: Understand the mechanism of nucleophilic substitutions in aromatic and aliphatic molecules.

CO4: Explain the concept, types, reaction mechanism and example of addition reactions.

CO5: Know the concept, types, reaction mechanism and example of elimination reactions.

CO6: Comparison of reagent type: electrophiles and nucleophiles (elementary idea).

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	3										
CO2	3	2										
CO3	2	3										
CO4	3	-										
CO5	2	1										
CO6	3	3										

COURSE CONTENT

Unit-I: **(12 hours)**

A. Aromatic electrophilic substitutions: Arenium ion mechanism, Pi – complex mechanism, Orientation and reactivity, Energy profile diagram, Ortho/para ratio , Ipso attack , Electrophilic substitutions at allylic substrate, Orientation of benzene with more than one substituent.

B. Aliphatic electrophilic substitution: Bimolecular mechanisms: SE2 and SEi. The SE1 mechanism, electrophilic substitution accompanied by double bond shifts. Effect of substrates, leaving ground and the solvent polarity on the reactivity.

Unit-II: Free radical substitutions (12 hours)

Free radical reactions, Mechanism of free radical substitutions, Neighbouring group assistance in free radical reactions, Free radical substitutions at bridge head, Allylic halogenations, Benzylic halogenation, Coupling of alkynes, Arylation of aromatic compounds by diazonium salt.

Unit-III: (12 hours)

A. Aromatic nucleophilic substitutions :

$ArSN_2$– mechanism, $ArSN_1$– mechanism, Benzyne mechanism, SRN_1– mechanism, Reactivity effect of substrate structure, leaving group ,attacking nucleophile.

B. Aliphatic nucleophilic substitutions:

SN_2 and SN_1 mechanisms , Ion pairs in SN_1- mechanisms , Mixed SN_2 and SN_1 - mechanisms, SET mechanism, SN_i- mechanism, Nucleophilic substitution in allylic , vinylic and aliphatic trigonal carbon , Neighbouring group participation mechanism, Non-classical carbocation, Effect of structure of the substrate , attacking nucleophile , solvent and leaving group on reactivity of nucleophilic substitution.

Unit –IV: Addition reaction: (12 hours)

Mechanistic and stereochemical aspects of addition reactions involving electrophiles, nucleophiles and free radicals, regio- and chemoselecticvity, orientation and reactivity, Addition to cyclopropane ring. Hydrogenation of double and triple bonds, hydrogenation of aromatic rings. Hydroboration, Oxymercuration, Epoxidation, Sulfonium Ylides, Halohydrin addition, Michael reaction, Sharpless asymmetric epoxidation and dihydroxylation.

Unit –V: Elimination reaction: (12 hours)

The E2, E1 and E1cB -mechanisms, salient feature, evidences, Comparison in between E2, E1 and E1cb, Orientation of the double bond. Reactivity – effects of substrate structures, attacking base, the leaving group and the medium. Mechanism and orientation in pyrolytic elimination. Saytzeff and Hofmann Elimination, Bredt's rule.

Reference Books

1. Organic synthesis: Clayden, Greeves, Warren and Wouthers, Oxford Univ. Press, 2nd Ed (2012).
2. Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Part A and B Springer, 5th Ed.(2005)
3. A Guide Book of Mechanism in Organic Chemistry, Peter Sykes, Longman.6th Ed.(1999)
4. Structure and Mechanism in Organic Chemistry, C. K. Ingold, Cornell University Press, 3rd (1957).
5. Organic Chemistry, R. T. Morrison and R. N. Boyd, Prentice-Hall, 6th Ed.(1992)
6. Organic reaction mechanism (Benjamin) R. Breslow
7. Mechanism and structure in Organic chemistry (Holt Reinh.) B. S. Gould.
8. Organic chemistry (McGraw-Hill) Hendrikson, Cram and Hammond.
9. Organic reaction mechanism (McGraw-Hill) R. K. Bansal.
10. Principle of organic synthesis- R.O.C. Norman and J. M. Coxon.(ELBS)
11. Reaction mechanism in organic chemistry- S. M. Mukharji and S. P. Singh.
12. Advanced organic chemistry (McGraw-Hill) J. March.
13. Some Modern Methods of Organic synthesis. W. Carruthers, Cambridge Univ. Press.
14. Modern Synthetic Reactions, H. O. House, W.A. Benjamin.

Course Code:	**24CHPC2002**	**No. of Credits:**	**4**
Course Name:	**INORGANIC CHEMISTRY-II**	**Sem End Exam & Cycle Test:**	**60+40**

Course Educational Objective:

This course enables the students

CEO1: The objective of the course is to appraise the students about the Metal cluster.
CEO2: To learn about the 18 electron rule and its violation
CEO3: To learn methods, including spectroscopy techniques used to determine the structure of metal carbonyl complexes and to probe reaction mechanism.
CEO4: The students should be able to give appropriate definitions of the terms inert and labile and state which d-electron configurations are associated with inertness.
CEO5: The students should be able to explain the use of terms Hard and Soft in relation to metal ions and ligands and discuss the stability of complexes in terms of hard and soft interactions.

Course Outcome:
Upon successful completion of this course, students should be able to:
CO1: Understand the chemistry of cluster compounds. Structure of carboranes, metallo boranes, hetero boranes, metal carboranes, etc. Apply the concept for future research in this field.
CO2: Student can predict the structure of carboranes, metallo boranes, hetero boranes, metal carboranes.
CO3: Student should learn the role of the metal ion as catalyst and its important various catalytic pathway of the synthetic procedure. Industrial application of this catalytic cycle will also be informed.
CO4: This course is very important for the learners. This course gives them idea about the way a reaction precedes and kinetics in details, specially for inorganic substitution reactions.
CO5: Students will be able to analyze the stability of metal complex.
CO6: Students will understand the various bonding in metal-ligand complexes.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2										-
CO2	2	2										-
CO3	2	3										-
CO4	1	3										2
CO5	3	1										
CO6	3	1										

COURSE CONTENT

Unit-I: Metal II-Complexes (12 hours)

Chemistry of metal carbonyls, Constitution of metal carbonyls: mononuclear, poly nuclear clusters with terminal and bridge carbon monoxide ligand units, 18 electron rule, Effective atomic number rule, vibrational spectra of metal carbonyls for bonding and structural elucidation, Carbonylate anions, carbonyl halides and related compounds.

Unit-II: Complex of Carbon Monoxide Analogs (12 hours)

A. Preparation, bonding and important reaction of transition metal complexes with isocyanide, cyanide, dinitrogen, carbon disulphide and nitrogen monoxides.

B. Transition metal to carbon multiple bonded: compounds chemistry of carbenes, carbynes.

Unit-III: Rings, Cages and Metal Clusters (12 hours)

Classification of Metal carbonyl clusters (Low and High nuclearitry carbonyl cluster), Inorganic catenation and hetero catenation, Inorganic ring: borazine, phosphazine and their derivatives, Inorganic cages: borides and carbides, higher boranes, carboranes, metallaboranes and metallacarboranes, compounds with metal-metal multiple bonds.

Unit-IV: Metal-Ligand Equilibria in Solution (12 hours)

Stepwise and overall formation constants and their interaction, Trends in stepwise constants, Inert and labile complexes, Kinetic application of valence bond and crystal field theories, Kinetics of octahedral substitution, Factors affecting stability of metal complexes with reference to the nature of metal ion and ligand, Chelate effect and its thermodynamic origin, Determination of binary formation constants by potentiometric and spectrophotometric methods.

Unit-V: Reaction Mechanism of Transition Metal Complexes (12 hours)

Acid hydrolysis, Factors affecting acid hydrolysis, Base hydrolysis, Conjugate base mechanism, Direct and indirect evidences in favour of conjugate mechanism, Anation reactions, Reactions without metal ligand bond cleavage, Substitution reactions in square planar complexes, Trans effect, Mechanism of one electron reactions, Outer-sphere type reactions, Cross reactions and Marcus-Hush theory, Inner sphere type reactions.

Reference Books

1. Mechanism of Inorganic Reactions: F. Basalo and R. G. Pearson, Wiley Eastern publication 1967.
2. Advanced Inorganic Chemistry: F. A. Cotton and G. Wilkinson, Wiley Estern 1988
3. Inorganic Chemistry: J. E. Huheey, E. A. Keiter, R. L. Keiter, Pearson Education.
4. Inorganic Electronic Spectroscopy: A. B. P. Lever, Elsevier.
5. Magnetochemistry: R. L. Carlin, Springer Verlag.
6. Chemistry of the Elements: N. N. B. Greenwood and A. Earnshow, Pergamon.
7. Mechanism of Inorganic Reactions: F. Basalo and R. G. Pearson, Wiley Eastern publication 1967.
8. Basic Inorganic chemistry By F.A cotton

Course Code:	24CHPC2003	No. of Credits:	4
Course Name:	PHYSICAL CHEMISTRY-II	Sem End Exam & Cycle Test:	60+40

Course Educational Objective:

This course enables the students

CEO1: To understand the concept of different laws of thermodynamics.

CEO2: To evaluate most probable distribution state for all type of statics i.e. for Maxwell-Boltzmann, Fermi dirac and Bose –Einstein statistics

CEO3: To understand the concept of partition function, its physical significance and calculation of molar and atomic partition function.

CEO4: To understand Entropy production

CEO5: To understand the different theories of chemical kinetics.

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: State and apply the Zeroth law, first law, second law and third law of thermodynamics to the real system..

CO2: Define and determine Partial molar properties, Chemical potential and fugacity.

CO3: Explain statistical thermodynamics as logical consequences of the postulates of statistical mechanics, learn the Maxwell –Boltzmann, Fermi –Dirac and Bohr's Einstein statistics

CO4: Comparison and applications know about the Partition functions and apply the principles of statistical mechanics to selected problems.

CO5: Explain the entropy production, entropy flow and entropy balance equation for the different reversible processes.

CO6: Explain the steady state approximation, Lindemann-hinshelwood mechanism, RRKM theories, chain reaction, General features of fast reaction, Belousov-Zhabotinsky reaction, Photochemical reactions.

Mapping of COs with Pos

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	CO10	CO11	CO12
CO1	1	2										1
CO2	1	3										
CO3	2	3										
CO4	2	2										
CO5	1	3										
CO6:	1	2										

COURSE CONTENT

Unit-I: Classical Thermodynamics-I **(12 hours)**

Brief resume of the concept of enthalpy, entropy, free energy and laws of thermodynamics, Gibbs-helmholtz equation, Gibbs-Duhem equation, clausius claperon equation, Molar properties: (partial free energy, molar volume and molar heat content), Equipartition theorem, Carnot cycle, Determination of partial molar properties by: (1) Direct Method, (ii) Apparent method, (iii) Method of intercept.

Unit-II: Classical Thermodynamics-II **(12 hours)**

Chemical potential, Effect of temperature and pressure, Concept of fugacity and its determination by (i) Graphical method, (ii) From equation of state (iii) Approximation method, Nernst heat theorem and its application to solid, Third law of thermodynamics, Experimental determination of entropy by third law. Entropy and probability, Boltzmann-Planck equation.

Unit-III: Statistical thermodynamics **(12 hours)**

Thermodynamic probability and entropy, Maxwell-Boltzmann statistics, Partition function (translational, vibrational, rotational and electronic) for diatomic molecules, relationship between partition and thermodynamic function (internal energy, enthalpy, entropy and free energy), Calculation of equilibrium constant, Fermi-Dirac statistics, Bose-Einstein statistics, Distribution law and its application to metal.

Unit-IV: Non-equilibrium thermodynamics **(12 hours)**

Thermodynamic criteria for non-equilibrium states, Entropy production and entropy flow, Entropy balance equation for the different reversible processes: (Entopy Production in chemical reaction, Entropy production/Entropy flow in Open system), Different types of forces and fluxes, Transformation Properties of fluxes and forces, Non-equilibrium stationary state, Microscopic reversibility, Onsager's reciprocity relation, Verification of Onsager's reciprocity relation.

Unit-V: Chemical Dynamics **(12 hours)**

Methods of determining rate laws, Collision theory of reaction rate, Activated complex theory, Arrhenius equation, Ionic reaction, Kinetic salt effect, Steady state kinetics, Photochemical reaction (Hydrogen-Bromine and Hydrogen-Chlorine reactions), Oscillatory reactions (Belousov- Zhabotinsky reaction), Homogeneous catalysis, General features of fast reaction, Study of fast reaction by flow method and relaxation method. Treatment of Unimolecular reactions (Lindemann-Hinshel wood and Rice-Ramsperger-Kassel-Marcus theories (RRKM).

Reference Books:

1. K.L. Kapoor, Text book on Physical Chemistry, Volume 2, Macmillan India Ltd. Delhi

2. P. W. Atkins, Physical Chemistry, 7th Edition, (2002) Oxford University Press, New York.

3. Andrew Maczek, Statistical Thermodynamics, (1998) Oxford University Press Inc., New York.

4. F.W. Billmayer, Jr., Text Book of Polymer Science, 3rd Edition (1984), Wiley- Interscience, New York.

5. K. J. Laidler, Chemical Kinetics, Third Edition (1987), Harper & Row, New York.

6. P. W. Atkins, Physical Chemistry, Seventh Edition (2002), Oxford University Press, New York

7. I.N. Levine, Physical Chemistry, 5th Edition (2002), Tata McGraw Hill Pub. Co. Ltd., New Delhi.

8. J. Raja Ram and J.C. Kuriacose, Kinetics and Mechanism of Chemical Transformations (1993), MacMillan Indian Ltd., New Delhi.

9. S. K. Dogra ,S. Dogra, Physical Chemistry Through Problems, New Age International (P)Limited.

10. R.P. Rastogi & R.R Mishra An introduction to Chemical Thermodynamics, Vikas Publishing House Pvt Ltd; Sixth edition (2018)

Course Code:	**24CHPC2004**	**No. of Credits:**	**4**
Course Name:	**ORGANIC SPECTROSCOPY**	**Sem End Exam & Cycle Test:**	**60+40**

Course Educational Objective:

This course enables the students

To learn various techniques of spectrometric identification of organic compounds and characterizes organic compounds by applying various techniques together.

Course Outcome:

Upon successful completion of this course, students should be able to: **CO1:** To understand about electronic transitions, UV of carbonyl compounds, dienes and heterocyclic compounds.

CO2: To study the instrumentation, components of IR and identify different functional groups in compounds.

CO3: To understand processes responsible for NMR chemical shifts and splitting patterns by interaction of ^{1}H and ^{13}C nuclei.

CO4: To study the concepts, principles, splitting patterns of Mass Spectroscopy and their applications to structural determination of organic molecules.

CO5: To analyze the structure of various organic compounds**.**

CO6: Students are will be able to create some novel organic compounds and analyze.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	3										
CO2	2	2										
CO3	3	3										
CO4	3	3										
CO5	3	3										
CO6	3	2										

COURSE CONTENT

Unit-1: Ultraviolet and Visible spectroscopy (12 hours)

Various electronic transitions(185-800nm), Beer-Lambert Law,molar extinction coefficient, Effect of solvent on electronic transitions, relationship of potential energy curves to electronic spectra, Chromophores, auxochromes, blue shift, red shift, hypo and hyperchromic effect, Ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes and conjugated dienes, Woodward rulesfor conjugated dienes, Ultraviolet spectra of aromatic and heterocyclic compounds, Steric effect in biphenyls.

Unit–II: Infra-red spectroscopy (12 hours)

Infra-red spectroscopy :,Instrumentation , Characteristics vibrational frequencies of simple organic molecules like alkanes, alkene, alkyne , aromatic compounds , alcohols, phenol, amines, aldehydes, ketones, acids and acid derivatives, Effect of hydrogen bonding and Solvent effect on IR –spectra, Over tones and combination bands, Fermi resonance, FT-IR.

Unit-III: Nuclear Magnetic Resonance Spectroscopy (12 hours)

Basic principle, Chemical shift, Spin-spin interaction, Shielding mechanism, Chemical shift values and correlation to protons bonded to carbon and other nuclei, coupling constant and factors affecting the coupling constant, Chemical exchange, Effect of deuteration, Complex spin-spin interaction between two, three, four and five nuclei, Hindered rotation, Shift reagent, Nuclear-over hauser effect(NOE).

Unit-IV: Carbon-13NMR spectroscopy (12 hours)

General consideration, Chemical shift (aliphatic, olefinic, alkyne, aromatic, hetero aromatic and carbonyl carbon), Coupling constant, 1H-decoupling, noise decoupling, broad banded coupling; Introduction to two dimension NMR spectroscopy: COSY, DEPT, INDEQUATE techniques.

Unit-V: Mass Spectroscopy (12 hours)

Introduction , methods of ionization - EI, CI, Brief description of FD and FAB, Factors affecting fragmentation, Ion analysis, Ion abundance fragmentation of organic compounds with common functional groups, Molecular ion peak, Meta stable ions, Mc- Lafferty rearrangement , Nitrogen rule, High resolution mass spectrometry, Examples of mass spectra fragmentation for the determination of structure of simple organic molecules.

Reference Books:

1. Instrumental Methods of analysis by Willard, Merrit, Dean and Settle
2. Spectroscopic identification of organic compounds- R.M. Silverstein and G.C. Bassler
3. Applications of spectroscopic techniques in Organic chemistry- P.S. Kalsi
4. Absorption spectroscopy of organic molecules- V.M. Parikh
5. Introduction to Spectroscopy, Pavia, Brooks/Cole Cenage, 4th edition, 2009, Belmont
6. Organic Spectroscopy, W. Kemp, Palgrave
7. Symmetry ans Spectroscopy of Molecules, , K.V. Reddy, New Age International (P) Ltd., Ist edition, 1998, New Delhi.
8. Modern NMR Spectroscopy: A Guide for Chemists. J. K. M. Sanders, B. K. Hunter. Oxford UniversityPress, 1993
9. Principles of nuclear magnetic resonance in one and two dimensions. R. R. Ernst, Geoffrey Bodenhausen, and Alexander Wokaun. Oxford University Press, 1987
10. Spectrometric Identification of Organic Compounds, R. M. Silverstein, F. X. Webster, D. J. Kiemle, D. L. Bryce, Willey, 8th Edition (2015).
11. Mössbauer Spectroscopy, N.N. Greenwood and T.C. Gibb, , Chapman and Hall 1971, London.
12. Mössbauer Spectroscopy and Transition Metal Chemistry, P. Gütlich, R. Link, A. Trautwein, , Springer, 1978, Verlag, Berlin-Heidelberg-New York.
13. Analytical Method By R Gopal & K S Viswanatthan ,University Press

Course Code:	**24CHPC2005**	**No. of Credits:**	**4**
Course Name:	**INORGANIC PRACTICAL**	**End Exam:**	**100**

(6hrs per week)

Course Educational Objective:

This course enables the students

CEO: To explore the basic chemistry in aqueous medium, solubility product, color, texture, solubility, group chemistry etc. of some common inorganic salts (both cations and anions).

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: Students will discuss the knowledge inorganic salts and insoluble inorganic samples.

CO2: Students will be able to identify the tests used to detect inorganic salts and insoluble inorganic samples.

CO3: Students will be able to analyze mixture of inorganic salts and insoluble inorganic samples.

CO4: Students will able to identify acid and basic radicals in a sample of unknown mixtures.

CO5: Students will able to apply and handle air and moisture sensitive chemicals for the synthesis and study of complexes and inorganic reactions.

CO6: Analyze unknown inorganic samples containing 3 acid and 3 basic radicals including rare elements.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1			1				1			
CO2	2	2			1				1			
CO3	2	3										
CO4	2	2										
CO5	3	2										
CO6	3	3										

1. Qualitative analysis of mixtures containing not less than six radicals. Anyone of the following rare metal ions may be included.

   a) V b) Mo c) W d) Ti

2. A) Volumetric analysis involving EDTA as reagent.

   I. Determination of Ca^{2+} and Mg^{2+} in Dolomite.

   II. Determination of Nickel in Stainless steel.

   B) Complete analysis of:

   i) Brass ii) Cement iii) chromo iron ore.

   C) Preparation of Hexamine Cobalt(III) chloride.

Reference Books

Quantitative and Qualitative analysis By A.I. Vogel Semester-III

Course Code:	24CHEC2006	No. of Credits:	2
Course Name:	SEMINAR AND PROJECT-II	End Exam:	50

Course Educational Objective:

- Assist students with understanding more about a particular item.
- Teach student the skills needed to successfully communicate in a modern world through written materials.
- Achieve a greater awareness of the importance of selecting and integrating graphics with written communication.
- Improve ability to differentiate among and to use facts, inferences and judgments.
- Acquaint student with the concept of a writer-reader relationship and identify the need for active participation from both writer and reader.

Course Outcome:

- Students will demonstrate the ability to speak and debate with an appreciation for complex social and cultural sensibilities.
- Students will demonstrate the ability to collaborate with others as they work on intellectual projects(reading, writing, speaking, researching...).
- Students will demonstrate the ability to ask disciplinarily appropriate questions of the material and recognize when lines of inquiry of all outside of disciplinary boundaries.
- Students will demonstrate the ability to evaluate, credit, and synthesize sources.
- Every student will present a seminar on a topic related to theoretical or experimental, advanced topic, industrial project, training in a research institute, training of handling of sophisticated equipment etc. Each student will submit a technical report.

CRITERIA	Max. Marks
Presentation	10
Communication	15
Seminar contents	25
Total Marks	**50**

Course Code:	**24CHPC2007**	**No. of Credits:**	**1**
Course Name:	MATLAB	**End Exam:**	**50**

List of the Experiments

1. MATLAB variables and data selection using colon operator.
2. Arithmetic, Trigonometric, and logical operations using MATLAB.
3. Numbers with different bases and their conversion technique using MATLAB.
4. Matrix operations using MATLAB.
5. Solving n^{th} order linear equations using MATLAB.
6. Solving integration, differential equations and partial differential equations using MATLAB.
7. Graphics in MATLAB, 2D plots, 3D plots, bar plots.
8. Programming in MATLAB 1: if-else statement, for loop.
9. Programming in MATLAB 2: while loop, switch case statements.
10. Functions in MATLAB: built-in functions and user defined functions with single and multiple variables.

References

1. Understanding MATLAB: A Textbook for Beginners by S. N. Alam S. S. Alam.
2. Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers by Rudra Pratap.
3. MATLAB: An Introduction with Applications, 4ed by Amos Gilat.

SEMESTER-III

Course Code:	**24CHPC3001**	**No. of Credits:**	**4**
Course Name:	**ANALYTICAL CHEMISTRY-I**	**Sem End Exam & Cycle Test:**	**60+40**

Course Educational Objective:

This course enables the students

CEO1: To learn the different techniques for characterization of organic and inorganic materials.

CEO2: To understand crystal structure, morphology, microstructure, different types of phases present in a material, purity of the material.

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: To understand the instrumentation, applications of TGA, DTGA and DTA.

CO2: To explain the electrodes, processes, suitable method for the analysis of a particular sample and analytical applications of Voltametry.

CO3: To educate in structure identification, topology, morphology, composition and crystallographic information by using XRD, SEM, TEM and even the data analysis. **CO4:** To understand the classification and various analyses of fuel and drugs.

CO5: Able to discuss analyse sampling techniques.

CO6: Student will gain an insight on data collection methods and data analysis.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2										
CO2	3	2										
CO3	3	2										
CO4	2	2										
CO5	3	3										
CO6	2	3										

COURSECONTENT

Unit- I: Analysis of data (10 hours)

Types of errors, determinate error, indeterminate error, minimization of error, Accuracy and precession. Mean (Average Deviation), Standard deviation, Median, Methods of repeating analytical data, statistical evaluation of data, statistical analysis. Problems.

Unit-II: Thermal methods of analysis (12 hours)

Thermo analytical methods: Thermo gravimetric analysis (TGA): Principle, instrumentation, factors affecting TGA curve, derivative thermogravimetric analysis (DTGA) and application of thermogravimetric analysis to physical studies (reaction kinetics and information for the constitution of phase diagram), Differential thermal Analysis (DTA), instrumentation of DTA and application of DTA, Simultaneous study of TGA, DTA with examples. Differential scanning calorimetry (DSC) Principle, instrumentation, sample preparation, types of DSC and factors affecting DSC and thermometric titration.

Unit-III: Electrical methods of analysis (12 hours)

A. **Electroanalyctical Method Polarography:** Basic principle, instrumentation, theory of current-voltage curve, Theory of diffusion current, Dropping mercury electrode, Ilkovic equation, polarography wave and half wave potential. Application of polarography.

B. **Voltametry:** Reversible reactions, The residual current, Current maxima, Principle, Application, advantage and disadvantage of Cyclic voltammetry anodic stripping voltammetry, amperometry, conductrometry and ion selective electrodes.

Unit-IV: X-Ray Diffraction Method (16 hours)

Principle, Instrumentation and applications of XRD, XRF (EDS, WDS) and XPS. Crystal Structure determination by XRD.

Electron Spectroscopy: Photoelectron Spectroscopy (PES), concepts. Principle, Instrumentation and applications of Scanning electron microscopy, Transmission electron microscopy, Scanning Tunnelling Microscopy, Atomic Force Microscopy.

Unit-V: Analysis of Fuel and Drugs (10 hours)

A. Fuel analysis: Solid, liquid and gas. Ultimate and proximate analysis—heating values grading of coal. Liquid fuels-flash point, Aniline point, octane number and carbon residue. Gaseous fuels-producer gas and water gas-calorific value.

B. Drug analysis: Narcotics and dangerous drugs. Classification of drugs. Screening by gas and thin layer chromatography and separation of Amino acids by gas chromatography method.

Reference Books

1. Analytical chemistry by Gurdeep Chatwal

2. Instrumental methods of Chemical Analysis ny H.Kaur

3. Instrumental Method of Analysis by H. Willard, L. Merritt, J. Dean & F. Settle

4. Analytical Chemistry (Theory and Practical) by U.N. Dash

5. Basic Principle of Analytical Chemistry by S.M. Khopkar

6. Standard Methods of chemical Analysis Vol.3, Part A & B, By F. J. Welcher,

7. Instrumental Methods of Analysis 4th and 5th editions By G.W. Ewing,

8. Vogel's Textbook of Quantitative Inorganic Analysis By Bassett, Denney-Jeffer and Mendham,.

9. Electro-analytical chemistry, edited by H.W.Nurnberg.

10. A Textbook of Electrochemistry By Kortum and Bockris

11. Principles of Electrochemistry by D.A. Maclines.

Course Code:	**24CHPE3002**	**No. of Credits:**	**4**
Course Name:	**ORGANIC CHEMISTRY- III**	**Sem End Exam & Cycle Test:**	**60+40**

Course Educational Objective:

This course enables the students

CEO1: To learn the mechanism and stereochemistry of pericyclic reaction.

CEO2: To provide knowledge of photochemistry and it's applications.

CEO3: To provide the idea about structural activity relationship of different class of drugs**.**

CEO4: To learn about the retrosynthesis and synthetic strategies of different drugs.

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: Understand the orbital symmetry and different approaches of pericyclic reactions.

CO2: Understand the concept of photochemistry and various photochemical reactions of in organic molecules.

CO3: L earn the synthesis of drug molecules using the reactions of synthetic organic chemistry**.**

CO4: Deals with the synthesis, structure, properties chemical biological reactions of various biomolecules.

CO5: Understand industrial applications of oils and fats.

CO6: Analyze the retrosynthesis approach of various drugs.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**2**	**3**										
CO2	**2**	**3**										
CO3	**3**	**2**										
CO4	**2**	**3**										
CO5	**1**	**2**										
CO6	**2**	**3**										

COURSE CONTENT

Unit-I: Pericyclic Reaction (12 hours)

Molecular orbital symmetry, Frontier orbital of ethene, 1,3- Butadiene,1,3,5- Hexatriene, Allyl system, Classification of pericyclic reaction, Methods of explaining pericyclic reactions- Woodward-Hoffmann method, Frontier molecular orbital theory approach, Huckel-Mobius approach. Electrocyclic reactions: Dis and Con rotation, 4n, 4n+2 and allylic system, Explanation through correlation diagram and Huckel-Mobius approach, Cycloaddition reaction: 2+2 and 4+2 cycloaddition, 1, 3-Dipolar cycloaddition, Cheletropic reactions, Sigmatropic rearrangements, Claisen Rearrangement, Cope rearrangement, Ene reaction.

Unit-II: Organic Photochemistry **(12 hours)**

Electronic excitations, Fate of excited molecules (Jablonski diagram), Fluorescence, Phosphorescence, Photo dissociation reactions: Norrish Type-I &II cleavage, Photo isomerisation, Photo-Fries rearrangement, Paterno-Buchi reaction, Barton reaction, Di-Pi methane rearrangement, Photochemistry of aromatic compounds, Photo-Oxidation of alkenes, Photochemistry of vision.

Unit-III: Medicinal chemistry **(12 hours)**

A. Structure and activity: Relationship between chemical structure and biological activity, receptor site theory, approaches to drug design.

B. Interpretation of Drugs: Structural elucidation, synthesis of the biologically active compounds: Pencillin G, biosynthesis of Prostaglandin, stereochemistry and biosynthesis of Santonin, Cholesterol, Morphine, Reserpine, Aspirin.

Unit-IV: Biomolecules **(12 hours)**

Structure, properties and reactions of mono- and di-saccharides, physicochemical properties of amino acids, chemical synthesis of peptides, chemical structure determination of peptides and proteins, structural features of proteins, nucleic acids, lipids, steroids, terpenoids, carotenoids and alkaloids.

Unit-V: Retrosyntheisis and disconnection approach **(12 hours)**

Retrosynthesis the disconnection approach: Introduction, terminology, principles convergent and linear synthesis, One group C–X (X = hetero atom), C-C disconnections and two groups C–X and C-C disconnections with reference to 1,1; 1,2; 1,3; 1,4 and 1,5 difunctionalised compounds. Reterosynthesis and synthetic strategies with examples - salbutamol, benzocaine, paracetamol.

Reference Books

1. Photo chemistry and Pericyclic reaction by Jagadamba Singh & Jaya Singh , New Age International Publication

2. Organic synthesis: Clayden, Greeves, Warren and Wouthers, Oxford Univ. Press, 2nd Ed (2012).

3. Fundamentals of Photochemistry, K. K. Rohtagi-Mukherji, Wilcy-Eastern.

4. Molecular Photochemistry, N. J. Turro, W. A. Benjamin.

5. Introductory Photochemistry, A. Cox and T. Camp. McGraw-Hill.

6. Photochemistry, R. P. Kundall and A. Gibert, Thomson Nelson.

7. Organic reaction mechanism (Benjamin) R. Breslow

8. Organic reaction mechanism (McGraw-Hill) R. K. Bansal.

9. Organic chemistry By Dy Sunakar Panda

10. Organometallic chemistry By Indrajit Sharma

11. Reaction ,Rearrangement and Reagents By S N Sanyal, Bharati bhawan (P&D)

Course Code:	**24CHPE3003**	**No. of Credits:**	**4**
Course Name:	**AGRO CHEMISTRY**	**Sem End Exam & Cycle Test:**	**60+40**

Course Educational Objective:

This course enables the students

CEO1: To introduce the classical concepts of soil chemistry and to familiarize students with modern developments in chemistry of soils.

CEO2: To elaborate understandings of the causes and effects of biochemical reactions taking place due to application of agrochemicals.

CEO3: To analyse the chemistry behind synthesis of agrochemicals.

CEO4: To make the students familiar regarding various chemical reactions behind preparation of organic amendments.

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: Acquire knowledge on chemistry behind reaction of various agrochemicals in soil.

CO2: To understand the misuse of insecticides or pesticides on the Fate of environment

CO3: Could get applied knowledge on application of various agrochemicals as well as organics in proper and judicious way.

CO4: Students could gain expertise in differentiating different chemical fertilizers based on their composition and properties.

CO5: Explain the chemical nature and interaction of the soil.

CO6: To determine the amount of fertilizer needed to achieve a commercial crop yield.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	1					1					
CO2	2	1					1					
CO3	2	1					1					
CO4	2	1					1					
CO5	1	3										
CO6	2	3										

COURSE CONTENT

Unit-I Soil Chemistry (12 hours)

Soil , Soil Profile, components of soil; Soil physical properties: soil-texture, structure, density and porosity, soil colour, consistence and plasticity; Elementary knowledge of soil taxonomy classification and soils of India; Soil water retention, movement and availability; soil air, composition, ; Soil reaction-pH, soil acidity and alkalinity, buffering, effect of pH on nutrient availability; sources of charge ion exchange, cation exchange capacity, base saturation.

Unit-II: Soil organic matter (12 hours)

composition, properties and its influence on soil properties; humic substances - nature and properties; Soil pollution - behaviour of pesticides and inorganic contaminants, prevention and mitigation of soil pollution.

Unit-III: Insecticides and Pesticides (12 hours)

Definition of insecticides, Classification of insecticides, Effect of insecticides, Synthesis of insecticides, toxicity of insecticides, use of novel insecticides, Phytotoxicity of insecticides, Definition of pesticides, Classification of pesticides, Effect of pesticides, Synthesis & Applications of pesticides, Recent methods of pest control. Formulations of insecticides, Misuse of insecticides or pesticides, Residues of pesticides, Fate of environment upon the use of pesticides

Unit-IV: Pheromones and Bio Manures (12 hours)

Classification–pheromones, definition, Pheromones in yeast, bacteria and protozoa, their role in pest management, Merits and demerits in using pheromones for pest management, synthesis. Definition, Classification of Bulky Organic Manures (BOM) and Concentrated Organic Manures (COM), Preparation of different types of compost including industrial waste, coir waste, press mud, Vermicompost, Green manures (GM)and Green Leaf Manures(GLM), their Benefits and significance . Biofertilizers and their types, Application of Biofertilizers.

Unit-V: Fertilizers (12 hours)

Chemical fertilizers: classification (Straight, mixed and complex fertilizers), composition and properties of major nitrogenous, phosphatic, potassic fertilizers, secondary & micronutrient fertilizers, Complex fertilizers, nano fertilizers Soil amendments- –Synthesis of fertilisers–slow release N fertilizers – Nitrification inhibitors - Fertilizer Storage-Chemistry of soil nitrogen.

Reference Books

1. Bolt GH & Bruggenwert MGM. 1978. Soil Chemistry. Elsevier.

2. Greenland DJ & Hayes MHB. Chemistry of Soil Constituents. John Wiley & Sons.

3. McBride MB. 1994. Environmental Chemistry of Soils. Oxford Univ. Press.

4. Sposito G. 1989. The Chemistry of Soils. Oxford Univ. Press. Stevenson FJ. 1994.

5. Das DK. 2020.Introductory Soil Science. Kalyani Publishers.

6. Tan Kim H. Principles of Soil Chemistry. 2010. CRC Press.

7. D.S.Reddy. Applied Entomology. 2019. Science technology.

8. Basant Raj David. Elements of Economic Entomology.2016.Brillion Publishing.

9. The Nature and Properties of Soil - N. C. Brady and R. Ray, Weill, Pearson Education Inc. New Delhi (2002).

10. A Text Book of Soil Science - T.D. Biswas and S. K. Mukherjee, Tata McGraw-Hill Publishing Co. Ltd. (1987).

11. Fundamentals of Soil Science - Indian Society of Soil Science, IARI, New Delhi (2002).

Course Code:	**24CHPE3004**	**No. of Credits:**	**4**
Course Name:	**ENVIRONMENTAL AND ANALYTICAL CHEMISTRY**	**Sem End Exam & Cycle Test:**	**60+40**

Course Educational Objective:

This course enables the students

CEO1: To explain the types of air pollutants, casuses and consequences of air pollution.

CEO2: To explain the concepts behind wastewater characterization, treatment.

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: Students will be able to define air pollution, explain the sources of air pollution, discuss and describe types of air pollution.

CO2: To describe the main sources of water pollution, the main types of pollutant.

CO3: Application of analytical tools to determine and measure pollutants in various environmental samples.

CO4: Understand about green chemistry principles and their applications.

CO5: To understand the principle, instrumentation, differences between absorption and emission of spectroscopy

CO6: To get acquainted with the sources, properties and ill-effects of important radioactive pollutants and apply analytical tools to determine and measure pollutants.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2					1					1
CO2	2	2					1					1
CO3	1	3										
CO4	1	2										1
CO5	1	3										
CO6	1	2		1			2					

COURSE CONTENT

Unit-I: Air pollution **(12 hours)**

Primary pollutants like Carbon monoxide, nitrogen oxides, hydro carbons, sulphur dioxide, particulate matter, Biogeochemical cycles of C, N, P, S and O, Consequences of air pollution : Acid rain, Green house effect, Ozone layer depletion, Smog formation, Sampling, monitoring and analysis of Carbon monoxide, Nitrogen oxide, Sulphur dioxide, Hydrocarbons, Aromatic hydrocarbons. Aromatic hydrocarbons in exhaust petrol and acid.

Unit-II: Hydrosphere: (12 hours)

Chemical composition of water bodies: lakes, streams, rivers and wet lands etc. Hydrological cycle. Water pollutants, type of water pollutants: Ground water, surface water, lake water, river water and sea water. Sources of water pollution: Domestic source, industrial effluents, agricultural discharge, radioactive material. General effect of water pollution.

Unit-III: water analysis (12 hours)

Analysis of Water pollutants: important parameters like colour turbidity, electrical conductivity, total suspended solids, hardness, alkalinity, fluoride, dissolved oxygen, chemical oxygen demand, biochemical oxygen demand. Detrimental effect of some toxic elements like Cd, Cr, Pb, Zn and Hg. Waste water treatment.

Unit-IV: Absorption and Emission Spectroscopy: (12 hours)

Principle, difference between atomic absorption spectroscopy and flame emission spectroscopy, advantages and disadvantages of atomic absorption spectroscopy. Instrumentation, detection limit and sensitivity. Fluorimetry and Phosphorimetry, Comparision of Fluorimetry and Phosphormetry, Some Flurometric applications and some phosphorimetric applications.

Unit-V: Radio isotopes in Analysis: (12 hours)

Applications of radio isotopes to physico-chemical problems: solubility of sparingly soluble salt, surface area of powder or precipitate, rate of diffusion and study of reaction mechanism. Analytical applications of radioactivity: Radio chromatography, isotopic dilution analysis, Neutron activation analysis and radiometric titration. Use of radio isotopes for dating, in medicine, agriculture and industry.

Reference Books

1. Environment and Ecology by Sunakar Panda, 2nd edition, 2008
2. Text book of Environmental chemistry by A.K. De, 9th edition,2018
3. Analytical chemistry by Gurdeep Chatwal, Sham K Anand, 2018 , Himalaya Publishing House
4. Environmental Chemistry by B.K.Sharma, 2014, Krishan Prakashan

Course Code:	**24CHPE3005**	**No. of Credits:**	**4**
Course Name:	**NANOCHEMISTRY**	**Sem End Exam & Cycle Test:**	**60+40**

Course Educational Objective:

This course enables the students

CEO1: To provide introduction to nanoscience and technology.

CEO2: To learn the various approaches for the synthesis of nanoscale materials/nanoparticles.

CEO3: To understand crystal structure, morphology, microstructure, different types of phases present in a material.

CEO4: To study applications of nanoparticles.

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: To understand about nanostructure.

CO2: To obtain knowledge about synthesis of nanoparticles.

CO3: To understand the Nanoremediation

CO4: To understand various applications of nanomaterials.

CO5: Classify nano and smart materials.

CO6: Explain the importance of different types of nanoremedies.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2										
CO2	2	3										
CO3	3	2										
CO4	1	3										
CO5:	3	2										
CO6:	1	3										

COURSE CONTENT

Unit- I: Introduction to nano scale Science and Technology (12 hours)

Introduction and classification -What is nanotechnology? - Classification of nanostructures - Nanoscale architecture; Summary of the electronic properties of atoms and solids - The isolated atom - Bonding between atoms - Giant molecular solids - The free electron model and energy bands - Crystalline solids - Periodicity of crystal lattices - Electronic conduction; Effects of the nanometer length scale - Changes to the system total energy - Changes to the system structure - How nanoscale dimensions affect properties- Fabrication methods: Top-down processes, Bottom-up processes, Methods for templating the growth of nanomaterials, Ordering of nanosystems.

Unit II: Synthesis and Stabilization of Nano particles: (12 hours)

Chemical Reduction; Reactions in Micelles, Emulsions; Photochemical and Radiation Cryochemical Synthesis: Physical Methods; Particles of Various Shapes and Films.

Unit-III: Nanomaterials for Environmental Protection (12 hours)

Nano technology processes – Nano Engineering materials for Pollution Prevention, Green Chemistry, Energy efficient resources and materials, Nano technology products- Nanomaterials (nanostructures) Nanodevices and nanosystems.

Unit-IV: Nanoremediation (12 hours)

Identification and characterization of Hazardous waste, Nano Pollution, Air- Water - Soil Contaminants, Identification and Characterization of Organic and inorganics, Environmental cleanup technologies.

Unit-V: Applications of Nanoparticle (12 hours)

Catalysis on Nano particles, Semiconductors, Sensor, Electronic Devices, Photochemistry and nanophotonics, Application of Carbon Nano tubes, Nanochemistry in Biology and Medicine.

Reference Books

1. Nanomaterials and Nanochemistry, Br‘echignac C., Houdy., and Lahmani M. (Eds.) Springer Berlin Heidelberg New York. 2007.
2. Nanoscale Science and Technology, Robert W. Kelsall, Ian W. Hamley and Mark Geoghegan, John Wiley & Sons, Ltd., UK, 2005.
3. Introduction to Nanotechnology, Charles P. Poole Jr and Frank J. Owens, Wiley Interscience, 2003.
4. Bio-Inspired Nanomaterials and Nanotechnology, Edited by Yong Zhou, Nova Publishers.
5. Nano:The Essentials: Understanding Nanoscience and Nanotecnology, T.Pradeep, Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008.
6. Nanoparticle Technology Handbook. M. Hosokawa, K. Nogi, M. Naito and T. Yokoyama (Eds.) First edition 2007. Elsevier
7. Nanotechnology Basic Calculations for Engineers and Scientists. Louis Theodore, John wiley & sons, inc., publication, 2006.
8. Environanotechnology by Mao Hong fan, Chin-pao Huang, Alan E Bland, Z Honglin Wang, Rachid Sliman, Ian Wright. Elsevier, 2010.
9. Nanotechnlogy: Health and Environmental risk by Jo Anne Shatkin. CRC press, 2008

Course Code:	**24CHCBOE3006**	**No. of Credits:**	**4**
Course Name:	**CHEMISTRY OF MATERIALS**	**Sem End Exam & Cycle Test:**	**60+40**

Course Educational Objective:

This course enables the students

CEO1: Develop understanding of the structure of ceramic materials, knowledge of mechanical properties including examples of ceramics and glass applications.

CEO2: To learn preparation, properties and applications of composites.

CEO3: To study the properties and applications of ionic conductors and films.

CEO4: To study about the conducting and magnetic properties of Fullerenes and optical materials**.**

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: To obtain knowledge of the structure of clays, ceramics, and glasses.

CO2: To understand the preparation, properties and applications of composites

CO3: To understand the types, properties, defects and applications of ionic conductors and films.

CO4: To understand the synthesis and characterization methods of nano materials.

CO5: To understand the technique of thin film coating.

CO6: To recognize conducting and magnetic properties of Fullerenes and optical materials.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-										
CO2	2	2										
CO3	3	3										
CO4	2	3										
CO5	3				2							
CO6	2	1										

COURSE CONTENT

Unit-I Glasses, Ceramics, Clay and Refractories: (12 hours)

Glassy State, Glass Formers and Glass Modifiers, Applications. Ceramic Structures, Mechanical Properties, Clay Products. Refractories, Characterizations, Properties and Applications.

Unit-II Composites, and Nanomaterials: (12 hours)

Macroscopic Composites, Dispersion-Strengthened and Particle-Reinforced, Fibre- Reinforced Composites, Macroscopic Composites. Nanoclusters, carbon nanotubes (CNT) and nanowires, Nanocrystalline Phase, Preparation, Procedures, Special Properties, Applications of nanomaterials in wastewater treatment.

Unit-III: Ionic Conductors (12 hours)

Types of Ionic Conductors, Mechanism of Ionic Conduction, Interstitial Jumps (Frenkel), Vacancy Mechanism, Diffusion Superionic Conductors, Phase Transition and Mechanism of Conduction in Superionic Conductors, Examples and Applications of Ionic Conductors.

Unit-IV: Thin Films and Langmuir-Blodgett Films (12 hours)

Preparation Techniques, Evaporation/Sputtering, Chemical Processes, Sol-Gel, Langmuir-Blodgett (LB) Film, Growth Techniques, Photolithography, Properties and Application of Thin and LB Films, Reverse micellar method.

Unit-V: Organic Solids, Fullerenes, and Molecular Devices (12 hours)

Conducting Organics, Organic Superconductors, Magnetism in Organic Materials. Fullerenes-Doped, Fullerenes as Superconductors. Molecular Rectifiers and Transistors, Artificial Photosynthetic Devices, Optical Storage Memory and Switches-Sensors. Nonlinear Optical Materials: Nonlinear Optical Effects, Second and Third Order, Molecular Hyperpolarisability and Second Order Electric Susceptibility, Materials for Second and Third Harmonic Generation.

Reference Books:

1. N.W. Ashcroft and N.D. Mermin, Solid State Physics, 33rd Edition, Holt, Rinehart and Winston, 1976.
2. W.D. Callister and D.G. Rethwisch, Materials Science and Engineering: An Introduction, 9th Edition, John Wiley & Sons, 2014.
3. H.V. Keer, Principles of Solid State, 1st Edition, New Age International, 1993.
4. J.C. Anderson, K.D. Leaver, R.D. Rawlings, and J.M. Alexander, Materials Science, 4th Edition, Springer, 2013.
5. G.W. Gray, Thermotropic Liquid Crystals, 1st Edition, John Wiley & Sons, 1987.
6. H. Kelker and R. Hatz, Handbook of Liquid Crystals, 1st Edition, VerlagChemie, 1980.
7. D. Singh, D. Zhu, W.M. Kriven, S. Mathur, H.-T. Lin, Design, Development, and Applications of Structural Ceramics, Composites, and Nanomaterials, 1st Edition, John Wiley & Sons, 2014.
8. C. S. Sunandana, Introduction to Solid State Ionics: Phenomenology and Applications, 1st Edition, CRC Press, 2016.

Course Code:	**24CHCBOE3007**	**No. of Credits:**	**4**
Course Name:	**ADVANCED ORGANOMETALLIC CHEMISTRY**	**Sem End Exam & Cycle Test:**	**60+40**

Course Educational Objective:

This course enables the students

CEO1: The objective of the course is to appraise the students about the organometallic Chemistry.

CEO2: To identify the basic concept, terms, and important events in the development of organometallic chemistry.

CEO3: To learn methods, including spectroscopy techniques, used to determine the structure of organometallic complexes and to probe reaction mechanism.

CEO4: To develop an appreciation for the scope, diversity, and application of organometallic chemistry.

CEO5: To learn about the common organometallic reactions and to be able to draw reasonable reaction mechanisms

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: To understand the preparation, properties and structure of main group organometallic chemistry.

CO2: Be able to use knowledge about structure and bonding issues to understand the stability and reactivity of simple organometallic complexes.

CO3: It is use full for industrial processes include olefin metathesis, alkene polymerization, alkene

CO4: Know important applications of organometallic homogeneous catalysis in the production of large-scale (bulk) and smaller-scale (fine chemicals) production.

CO5: Describe the structure and bonding aspects of different organotransition metal compounds.

CO6: Describe the important applications of organometallic homogeneous catalysis in the production of organic chemicals.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**1**	**2**										-
CO2	**1**	**2**										-
CO3	**2**	**3**										-
CO4	**2**	**3**										2
CO5	**3**	**2**										
CO6	**1**	**3**										

COURSE CONTENT

Unit I: Main Group Organometallics **(12 hours)**

Synthesis and reactions of organolithium compounds; Synthesis and reactions of organomagnesium compounds; Organometallics of zinc and mercury: preparation, structure, bonding and reactions of aluminum organyls; Silicon organyl of coordination number 4.

Unit II: Transition Metal–Carbon Bond (12 hours)

A. Transition Metal–Carbon σ-Bond: Brief review of metal alkyl compounds; transition metalcarbene and transition metal-carbyne compounds; transition metal vinylidene and transition metal allenylidene compounds.

B. Transition Metal-Carbon π-Bond: Cyclopropenyl cation ($C R^+$) as a ligand; CR as a ligand (R = H, Me, Ph), cyclopentadienyls as ligand.

Unit III: Metal π complexes (12 hours)

Alkyls and aryls of transition metals, compounds having metal carbon multiple bond, transition metal π – complexes. Metal carbonyls: Preparation, properties and structure. 18 electron rule and its basis. Homogeneous catalysis, Reaction of organometallic compounds.

Unit IV: Syntheses of Cyclopentadienyl and Arene Metal Analogues (12 hours)

Synthesis and reactions of cyclopentadienyl metal carbonyls, arene metal carbonyls, η^6-arene-chromium tricarbonyl in organic synthesis. η6 -cycloheptatriene and η6 -cyclooctatriene ligands: synthesis and reactions.

Unit V: Organometallic Compounds in Catalysis (12 hours)

Stiochiometric reactions for Organometallic catalysts: Dissociation & Substitution, Oxidative addition & carbonylation, Oxygen transfer from Peroxo and Oxo Species, Reductive & Hydride elimination, Insertion, Displacement and Isomerization reaction, Hydrogenation , Hydrosilation and Hydrocynation of unsaturated compounds, Hydroformylation of alkenes (Using cobalt and rhodium catalyst), Wacker (Smidt) Process, Olefin Metathesis, Fischer-Tropsch synthesis, Zeigler-Natta polymerization of olefins, Water gas reaction.

Reference Books

1. Molecular Chemistry of the Transition Elements: F. Mathey & A. Sevin, John Wiley.
2. Organometallic Chemistry: A Unified Approach (2nd edn.), R. C. Mehrotra & A. Singh, New Age International.
3. The Organometallic Chemistry of the Transition Metals (4th edn.): R. H. Crabtree John Wiley.
4. Basic Organometallic Chemistry: Concepts, Synthesis and Applications (2nd edn.), B. D. Gupta & A. J. Elias, Springer Science.
5. Basic organometallic Chemistry by B. D. Gupta, A. J. Elias, University Press (India) Pvt. Ltd., 2nd edn, Hyderabad, 2013
6. Organometallic Chemistry by R. C. Mehrotra, A. Singh, New Age International Ltd., 1st edn, 2011, New Delhi
7. Organometallic Compounds by Indrajeet Kumar, 4th edn, 2013, Pragati Prakashan, Meerut

Course Code:	**24CHPC3008**	**No. of Credits:**	**4**
Course Name:	**ANALYTICAL CHEMISTRY PRACTICAL**	**End Exam:**	**100**

Course Educational Objective:
This course enables the students
CEO1: To determine relative strength of acids, rate constant & order of reactions PKa value of a weak acid potentiometric titration and conductometric titration.

Course Outcome:
Upon successful completion of this course, students should be able to:
CO1: An appreciation for modern problems and scientific controversies in physical chemistry.
CO2: How to design and perform experiments to determine the rate, order, and activation energy of chemical reactions by varying concentrations and/or temperature
CO3: Methods to measure equilibrium concentrations and equilibrium constants for acid-base, solubility, and complexation reactions given initial concentrations of reactant
CO4: To the preparation of buffer solutions at a required pH, given a choice of solutions of acid/conjugate base pairs
CO5: To know the principle and mechanism of Conductormetric and potentiometric titrations.
CO6: Students will gain a hands-on experience.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1											
CO2	2	1										
CO3	2											
CO4	2											
CO5	2											
CO6	1											

6Hrs duration **F.M.-100**

1. To find out the dissociation constant of the given tribasic acid, i.e. phosphoric acid by treating it against NaOH using a pH Meter
2. Determination of hydrolytic constant (Kh) of ammonium chloride solution pH-metrically.
3. To estimate the iron content in the given ferrous ammonium sulphate solution by Colorimetry
4. To determine the composition and stability constant of Fe(III) –salicylic acid complex colorimetrically by Job‘s method of continuous variation.
5. To determine the Λo and Ka of weak electrolyte at a definite temperature by Debye Huckel Onsagar equation.

6. To determine the stoichoimetric ratio in the complex metric titration of HgCl2 against potassium iodide conductometrically.
7. To determine the total cation concentration in natural water.
8. To estimate the amount of Na^+ ion in a given sample using ionisation resin column.
9. Potentiometric estimation of Mohr salt solution with standard potassium dichromate solution and also determination of formal potential (reduction) of ferric-ferrous system.
10. Determination of activity solubility product of silver chloride by emf measurement
11. Adsorption of CH_3COOH on activated charcoal and verification of Freundlich's & Langumir's adsorption isotherm.
12. Simultaneous estimation of Mn and Cr in a solution of $KMnO_4$ and $K_2Cr_2O_7$

Reference Books

1. Physical Chemistry Practical by Saroj Kr Maity and Naba Kr Ghosh
2. Experimental Physical Chemistry by R.C. Das and B. Behera
3. Text book of Quantitative Inorganic Analysis by A.I. Vogel,ELBS(1978)
4. Experimental Physical chemistry by J B Yadav, Goel Pub. House,(1981)
5. Senior Practical Physical Chemistry by B. C. Kosla, Simla Printers New Delhi (1987).
6. Experimental Physical Chemistry by Daniel et al., McGraw Hill, New York (1962).

Course Code:	**24CHPC3009**	**No. of Credits:**	**2**
Course Name:	**SUMMER INTERNSHIP/ SEMINAR & PROJECT-III**	**Sem End Exam & Cycle Test:**	**50**

Course Educational Objective:

This course enables the students

CEO1: To gain practical experience by working in a professional chemistry –related environment.
CEO2: To demonstrate an ability to work independently and utilize principles of chemistry to solve real-world problems

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: To know the various types of industries, nature of job involved, entire work area of the industry/institution and to adapt with the working people.

CO2: To learn the procedure of identifying, approaching, applying and getting approval of internship from a leading industry/institutions.

CO3: To identify the manufacturing procedures and technical skills involved and correlate the manufacturing procedures with simple laboratory synthesis

CO4: To learn the environment aspects, pollution their control involved in the manufacturing unit.

CO5: To prepare a final evalution report and presentation for the internship carried out for minimum 30 days.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**2**								**1**			
CO2	**2**	**1**										
CO3	**2**											
CO4	**2**						**1**					
CO5	**2**								**1**			

A student has to work in a reputed industry for the period of minimum 30days during summer vacation after the completion of 2nd semester and he/she has to submit a thesis report and give a power point presentation about the work done in the industry.

SEMESTER IV

Course Code:	24CHPC4001	No. of Credits:	4
Course Name:	PHYSICAL CHEMISTRY-III	Sem End Exam & Cycle Test:	60+40

Course Educational Objective:

This course enables the students

CEO1: To understand the Debye Huckel Theory of ion-ion interactions.

CEO2: To understand Semiconductor interfaces, Fuel cell, Corrosion

CEO3: This course is intended as an introduction to surface chemistry and cover fundamental and applied aspects of surface chemical processes; theories of molecular adsorption/desorption, surface active agent

CEO4: To provide an introduction to the concepts underlying solid state chemistry.

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: Discuss electrical properties of ionic solutions, describe Debye –Huckel equation: limiting and extended forms, calculate effect of ionic strength on ion reaction rates and determine the activity coefficient by different methods,

CO2: Fuel cell and its applications, Corrosion monitoring and prevention, solve the cell reactions and calculate EMF.

CO3: To study the semiconductor material and their wide range of application in electronic components such as diodes, transistor and photovoltaic cell.

CO4: Understand the adsorption of gases by solid type of isotherms, estimate the surface area,

CO5: study of the various types of surfactants, micelles and their various applications namely diagnostic imaging and drugs delivery.

CO6: Classify Crystal systems and lattices, describe specific crystal structures by applying basic crystallographic concepts.

Mapping of COs with Pos

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	CO10	CO11	CO12
CO1	2	3										1
CO2	2	3										
CO3	2	2										
CO4	1	3										
CO5	2	2										
CO6	1	3										

COURSE CONTENT

Unit-I: Electrochemistry-I (12 hours)

Electrochemistry of solution: Ion-solvent interactions, Born Model, Ion-ion interactions: Debye-Huckel (ion-cloud), Bjerrum Model, Thermodynamics of electrified interface equations; Ion transport in solution: Debye Huckel-Onsager equation, Derivation of electrocapillarity, Lippmann equations, Structure of electrified interfaces, Over potential, Derivation of Butler Volmer equation, Tafel plot.

Unit-II: Electrochemistry-II **(12 hours)**

Activity and activity coefficient, Ionic strength, Debye-Huckel limiting law and its verification, Degree of dissociation and its determination, Determination of activity coefficient by freezing point, Vapour pressure and solubility measurement, Ion association, Association constant, Determination of dissociation constant of electrolyte.

Unit-III Electrochemistry-III **(12 hours)**

Semiconductor interfaces, Theory of double layer at semiconductor, Electrolytic solution interfaces, Structure of double layer interfaces, Effect of light at semiconductor solution interface, Fuel cell, Corrosion: Homogeneous theory forms of corrosion, corrosion monitoring and prevention, Passivity of metals. Electromotive force, Measurement of EMF, Relationship between EMF and thermodynamics parameters (free energy change, enthalpy change and entropy change), Thermodynamics of reversible cells, Electrode potential in terms of osmotic pressure and solution pressure. Nernst equation relating electrode potential and concentration.

Unit-IV Surface Chemistry and Catalysis **(12 hours)**

A. Adsorption, Surface tension, Capillary action, Pressure difference across curved surface(Laplaceequation), Vapour pressure of droplets (Kelvin equation), Gibb‘s adsorption isotherm, Estimation of surface area (BET equation), Surface films on liquids (electro kinetic phenomenon), Catalytic activity at surfaces.

B. Micelles

Surface active agents, Classification, Micellization, Hydrophobic interaction, Critical micellar Concentration (CMC), Factors affecting CMC of surfactants,Counter ion Binding to micelles. Thermodynamics of micellization, Phase separation and mass action models, Solubulisation, Microemulsion, Reverse micelles.

Unit-V Solid State **(12 hours)**

Crystal systems and lattices, Miller Indices, wises indices, Miller planes, Crystal packing, Crystal defects; Point Defects (Schottky and Frenkel Defects), Line defects, Surface defect, Volume defects, X-Ray Crystallography, Bragg ‘s Law, Ionic crystals, Band theory, Metals and semiconductors, Types of solid state reactions.

Reference Books

1. Modern Electrochemistry, J.O‘M. Bockris and A.K.N. Reddy, Vol. 1 & 2A and 2 B, (1998) Plenum Press, New York.
2. Micelles : Theoretical and Applied Aspects, Y. Moroi, (1992) Plenum Press, New York.
3. Text Book of Polymer Science, F.W. Billmayer, Jr., 3rd Edition (1984), Wiley-Interscience, New York.
4. Solid State Chemistry and its Applications, A.R. West, (1984) John Wiley & Sons, Singapore.
5. New Directions in Solid State Chemistry, C.N R. Rao and J. Gopalkrishnan, (1997) Cambridge Univ. Press.
6. Introduction to Electrochemistry, S. Glasstone, Affiliated East-West Press.

Course Code:	**24CHPE4002**	**No. of Credits:**	**4**
Course Name:	**ORGANIC CHEMISTRY- IV**	**Sem End Exam & Cycle Test:**	**60+40**

Course Educational Objective:

This course enables the students

CEO1: To understand the synthetic application of various reagents

CEO2: To acquire the knowledge of heterocyclic Chemistry.and polymers.

CEO3: To study about various natural products and their synthesis

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: Understand about oxidation and phenomenon of oxidation in different organic molecules by various reagents.

CO2: Understand about reduction and phenomenon of reduction in alkenes, carbonyl compounds, carboxylic acids by various reagents.

CO3: Study the mechanism, properties and synthesis of heterocyclic compounds.

CO4: Understand the basic knowledge, classification and synthesis of polymers.

CO5: Demonstration of acquired knowledge about the chemical properties, structure and application of organic dyes.

CO6: Formulating conclusions about the possible applications of natural and synthetic organic dyes.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**1**	**2**										**-**
CO2	**1**	**2**										**-**
CO3	**3**	**-**										**-**
CO4	**3**	**-**					1					**1**
CO5	**3**	**-**										
CO6	**2**	**-**										

COURSE CONTENT

Unit-I: Oxidation Reaction (12 hours)

Different oxidative processes , Oxidation of hydrocarbon , alkanes, alkenes, aromatic ring, alcohol , α, β- diol, allylic and benzylic alcohols, aldehydes ketones, carboxylic acids , amines, Dioxirane, Sharpeless Epoxidation and Dihydroxylation, Fentens oxidation, Ozone, Hydroboration Oxidation, Oxymercuration. Oxidation with RuO_4, PCC, PDC, $KMnO_4$, $K_2Cr_2O_7$, SeO_2, CrO_3,m-CPBA.

Unit-II: Reduction Reaction (12 hours)

Different reductive processes, Reduction of alkenes, alkynes, aromatic rings, cycloalkanes, carbonyl compounds, aldehydes , ketones , acids and their derivatives, reduction of nitro compounds, Catalytic Hydogenation: (Hydrogenolysis, H_2/Pd/C, H_2/Pt, Lindlar reduction) $NaBH_4$, Luche reduction, B_2H_6, $LiAlH_4$, $LiEt_3BH$, Birch Reduction, Baker-Yeast Reduction, Wolf-Kishner Reduction, Noyori Reduction.

Unit-III Synthesis of Heterocycles (12 hours)

Saturated heterocycles, synthesis of 5- membered rings-pyrrol, furan, thiophene, synthesis of 6-membered rings-pyridine, aromatic heterocycles-benzothiophene, benzopyrrol, benzofuran in organic synthesis. Synthesis of Porphyrin, Paal-knorr pyrole synthesis, Fisher-Indole Synthesis, Hantzsch Pyridine Synthesis,

Unit-IV: Organic Polymers (12 hours)

Basic concepts of Polymer, Classification, Number, weight and viscosity average molecular weights. Polydispersity a n d molecular weight distribution. Mechanism of polymerization (Cationic/anionic/Free radical). Synthesis and application of Polyamide, Polyester, Poly carbonate, Living Polymer, Bio- degradable polymer, Zeigler-Natta polymerization, Atactic, Syndiotactic and isotactic Polymer, Solid state peptide synthesis.

Unit-V: Dyes (12 hours)

Classification, colour and constitution; Mordant and Vat dyes; Chemistry of dyeing. Synthesis and applications of: Azo dyes Methyl orange and Congo red (mechanism of Diazo Coupling); Triphenyl methane dyes - Malachite Green, and crystal violet; Phthalein dyes Phenolphthalein and Fluorescein; Natural dyes Alizarin and Indigo; Edible dyes with examples.

Reference Books

1. Organic synthesis: Clayden, Greeves, Warren and Wouthers, Oxford Univ. Press, 2nd Ed (2012).
2. Advanced Organic Chemistry, F. A. Carey and R. J. Sundberg, Part A and B Springer, 5th Ed.(2005)
3. A Guide Book of Mechanism in Organic Chemistry, Peter Sykes, Longman.6th Ed.(1999)
4. Structure and Mechanism in Organic Chemistry, C. K. Ingold, Cornell University Press, 3rd (1957).
5. Organic Chemistry, R. T. Morrison and R. N. Boyd, Prentice-Hall, 6th Ed.(1992)
6. Advanced organic chemistry by F.A.carey and R.M.Saundberg
7. A guide book to mechanism in Organic chemistry (Orient-Longmens)- Peter Sykes
8. Organic reaction mechanism (Benjamin) R. Breslow
9. Mechanism and structure in Organic chemistry (Holt Reinh.)B. S. Gould.
10. Advanced Organic Chemistry-Reactions, Mechanism and Structure, Jerry March, John Wiley, 6th Ed.(2006).
11. Chemistry Of Natural Product N R Krishnaswamy ,University Press

Course Code:	24CHPE4003	No. of Credits:	4
Course Name:	BIO-INORGANIC AND SUPRA MOLECULAR CHEMISTRY	Sem End Exam & Cycle Test:	60+40

Course Educational Objective:

This course enables the students

CEO1: To understand the role of metal ions in biological system

CEO2: To understand the structure of Hb

CEO3: To understand the essential and trace metals

CEO4: To understand the different classes of drugs

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: Able to understand the mechanism of oxygen transport in body and able to understand various pumps in the body and their significance, and Able to know about the phenomenon of muscle contraction.

CO2: Able to understand the different proteins and their structures

CO3: Abe to understand the enzymes with different metal atoms their individual structures, functions in human body with aspects of biological mechanism.

CO4: Able to understand positive and negative impacts of drugs

CO5: Able to understand the biologically relevant metal ions and their functions.

CO6: Able to design metal complexes for their potential use in medicinal chemistry**.**

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	3										-
CO2	2	3										-
CO3	2	3										-
CO4	1	2										-
CO5	1	3										
CO6	2											2

COURSE CONTENT

Unit-I: Bioinorganic Chemistry of Alkali and Alkaline Earth Metals (12 hours)

Essential and trace elements in biological systems, structure and functions of biological membranes; mechanism of ion transport across membranes; sodium pump; ionophores: valinomycin and crown ether complexes of Na^+ and K^+; photosynthesis: chlorophyll a, PS I and PS II; role of calcium in muscle contraction, blood clotting mechanism.

Unit-II: Metalloproteins (12 hours)

Heme proteins and oxygen up take, Structure and functions of haemoglobin, myoglobin, hemocyanin and hemerythrin,Iron-sulphur proteins: rubredoxin and ferredoxins, Xanthine oxidase, Nitrogenase, Bio-inorganic aspects of nitrogen fixation.

Unit-III: Metalloenzyme **(12 hours)**

Zinc enzymes–carboxy peptidase and carbonic anhydrase, Liver alcohol dehydrogenase, IronEnzymes–catalaseperoxidise Cytochrome-c oxidase and cytochrome p-450, Copper enzymes – superoxide dismutase, ceruloplasmin, Mg enzymes –vitamin B_{12}. Iron storage and transport: Ferritin, Transferrin and Siderophores, Blue copper protein: Plastocyanin, and Azuri.

Unit IV: Metal complexes in Medicine **(12 hours)**

Cisplatin: Anticancer drug, Wilson's disease, Anti-Arthritis, Hypercalcemia, Magnetic Resonance Imaging, Siderosis Disease, Use of chelating agents in metal poisoning: the chelate therapy (Lead, Cadmium, and Mercury), Deficiency symptoms of some trace metals.

Unit-V: Supra Molecular Chemistry **(12 hours)**

A. Molecular recognition: Spherical recognition, Recognition of anionic Substrate, Tetrahedral recognition, Co receptor molecules and multiple recognition, Binding and recognition of neutral molecules.

B. Supra molecular reactivity and catalysis.

C. Molecular assembly in supra molecular chemistry.

D. Supra molecular devices: Suitable binding, photochemical and electrochemical sensor wires.

Reference Books

1. Priciple of Biochemistry (Lehninger): D. L. Nelson and M. M. Cox, W. H. Freeman and company, New York.
2. Fundamentals of Biochemistry: D. Voet, J. G. Voet and C. W. Pratt; John wiley and sons.
3. Bioinorganic Chemistry: Bertini, Gray, Lippard, Valentine, Viva Books Private Limited.
4. Organometallic & Bio-inorganic Chemistry: Ajai Kumar, Aaryush Education.
5. Bio-inorganic Chemistry: Asim K. Das, New Central Publisher

Course Code:	**24CHPE4004**	**No. of Credits:**	**4**
Course Name:	**POLYMER CHEMISTRY**	**Sem End Exam & Cycle Test:**	**60+40**

Course Educational Objective:

This course enables the students

CEO1: To introduce the chemistry of high molecular weight polymers, both natural and synthetic.

CEO2: The methods used for their characterization and the structure of polymers.

CEO3: Properties of commercial polymers and biomedical polymers.

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: To understand the basic knowledge, classification and synthesis of polymers.

CO2: To understand about various methods used to characterize polymers.

CO3: To learn about structure and properties of polymers.

CO4: To study the properties and importance of commercial and biomedical polymers.

CO5: To study the effect of Glass transition temperature (Tg).

CO6: Student will able to design manufacturing process of synthetic polymer and their applications.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	2										1
CO2	2											-
CO3	3											-
CO4	3											3
CO5	2	3										
CO6	2		3				1					

COURSE CONTENT

Unit-I: Basics of Polymer (12 hours)

Importance of polymers, Basic concepts: Monomer, repeat units, degree of polymerization, Linear, branched and network polymers, Classification of polymers, Polymerization: Condensation, addition, radical and coordination polymerization, Polymerization conditions and polymer reactions, Polymerization in homogenous and heterogeneous systems.

Unit-II: Polymer Characterization (10 hours)

Polydispersion-average molecular concept, Number, weight and viscocity average molecular weights, Polydispersity and molecular weight distribution, Practical significance of molecular weight, Measurement of molecular weights, End group, viscosity, Light scattering, osmotic and ultracentrifugation methods, stereochemistry of Polymerization.

Unit-III: Structure and Properties (12 hours)

Morphology and order in crystalline polymers-centrifugation of polymer chains, Crystal structure of polymers, Morphology of crystalline polymers, strain induced morphology, crystallization and melting, Polymer structure and physical properties-crystalline melting point, melting points of homogenous series, effect of chain flexibility and other steric factors, entropy and heat of fusion, Glass transition temperature, Tg, Relationship between Tm and Tg, effects of molecular weight, diluents, chemical structure, chain topology, branching and cross linking, Property requirements and polymer utilization- elastomers, fibres and plastics.

Unit-IV: Properties of Commercial Polymers (14 hours)

Commercial polymers-importance, properties of Polyethylene, poly vinyl chloride, polyamides, phenolic resins, epoxy resins and silicone polymers, Functional polymers- Fire retarding polymers and electrically conducting polymers, Biomedical polymers–classification, properties of contact lens, dental polymers, artificial heart, kidney, skin and blood cells, Smart Polymers, Shape Memory Polymers, Self-Healing Polymers, LCP, Branched polymers (star, dendritic and hyper branched polymers).

Unit-V: Determination of molecular weight of polymers (12 hours)

(Mn, Mw, etc.) by end group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Polydispersity index. Glass transition temperature (Tg) and determination of Tg WLF equation, Factors affecting glass transition temperature (Tg).

Reference Books

1. Textbook of Polymer Science: F. W. Billmeyer Jr, Wiley
2. Polymer Science: V. R. Gowariker, N. V. Biswanathan and J. Sreedhar, Wiley, Eastern.
3. Physics and Chemistry of Polymers: J. M. G. Cowie, Blackie Academic and Professional.

Course Code:	**24CHPE4005**	**No. of Credits:**	**4**
Course Name:	**INDUSTRIAL CHEMISTRY**	**Sem End Exam & Cycle Test:**	**60+40**

Course Educational Objective:

This course enables the students

CEO1: To introduce the technologies of petroleum refining and processing to obtain the more valuable lighter fractions and intermediates for petrochemicals

CEO2: To understand the theory of surfactant behavior and commercial production technology of important surfactants.

CEO3: To highlight various important regulations like GMP and GLP practiced in pharmaceutical industry.

CEO4: To introduce concept of stoichiometry, mass and energy balances and other fundamental aspects of chemistry.

Course Outcome:

Upon successful completion of this course, students should be able to:

CO1: To understand the commercial production technology of various important petrochemicals and polymerization mechanisms.

CO2: To understand the importance of fats and oils and analyse the role of surfactant in various value added applications and the fermentation process.

CO3: To understand the manufacture of pesticides and importance of pharmacological industries.

CO4: To analyse the mass transfer systems and identify and understand the unit operations involved in a process.

CO5: Students will be able to anlsyse about chemical and biological catalysts.

CO6: To understand the importance of energy production, consumption and environmental impact.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1											1
CO2	2											2
CO3	3											-
CO4	3											-
CO5	1	3										
CO6	1						2					1

COURSE CONTENT

Unit-I Petroleum and coal based chemicals: (12 hours)

Composition of petroleum, cracking processes, commercial production of Ethylene, Acetylene, Polymerisation mechanism, addition, condensation, step growth, chain growth, method of polymerisation, distillation of coal.

Unit-II Oil based industries: **(12 hours)**

A) Oils and fats, solvent extraction of oils, hydrogenation of oils, use of oil in the manufacturing of soap, paints and varnishes.

B) Surface active agents:

Classification and manufacturing of detergents used for cleaning purpose.

C) Fermentation industries:

A general discussion of Fermentation conditions, manufacturing of Penicillin.

Unit-III Pesticides and Pharmacological industries: **(12 hours)**

Manufacture of DDT, BHC.2,4-D manufacture, Parathion manufacture. Pharmaceutical industries.

Unit-IV Stoichiometry and unit operation: **(12 hours)**

Distillation, Absorption and Stripping, Extraction and leaching, crystallisation, Psychometric, Drying, Evaporation, less conventional operation.

Unit-V: **(12 hours)**

A. Energy & Environment: Sources of energy: Coal, petrol and natural gas. Nuclear fusion/fission, solar energy, hydrogen, geothermal, tidal and hydel. Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management.

B. Biocatalysis: Introduction to biocatalysis: Importance in green chemistry and chemical industry.

Reference Books

1. Analytical Chemistry by G. D. Christain
2. Introduction to chromatography : Bobbit
3. Instrumental Methods of analysis (CBS) - H.H. Willard, L.L. Mirrit, J.A. Dean
4. Instrumental Methods of Analysis : Chatwal and Anand
5. Instrumental Methods of Inorganic Analysis(ELBS) : A.I. Vogel
6. Chemical Instrumentation: A Systematic approch- H.A. Strobel
7. The principals of ion-selective electrodes and membrane transport: W.E.Morf
8. Physical Chemistry – P.W. Atkins
9. Principal of Instrumental Analysis- D. Skoog and D.We st

Course Code:	**24CHOE4006**	**No. of Credits:**	**4**
Course Name:	**ETHICS & INTELLECTUAL PROPERTY RIGHTS**	**Sem End Exam & Cycle Test:**	**60+40**

Course Educational Objectives

This course enables the students:

CEO1: To provide thorough understanding on ethics, moral values, moral development theories, personal and professional ethics.

CEO2: To provide students with a deep insight about Profession and Professionalism, Professional accountability and ethical theories.

CEO3: To impart knowledge on intellectual properties, intellectual property rights and their need in research.

CEO4: To learn about patentable requirements, various IPRs and patent filling procedure.

Course Outcomes

At the end of the course, a student should be able to:

CO1: Recognize the philosophical assumptions that are embedded in moral ideas and in philosophical works in order to define one's moral responsibility in contemporary society.

CO2: To enable the students to internalize the ethical behaviour in the personal and professional lives

CO3: To facilitate the development of a holistic perspective among students towards their life and profession.

CO4: Reflect on and evaluate ethical arguments from diverse sources in order to communicate effectively with others who might have a different opinion from one's own.

CO5: Gain awareness about Intellectual Property Rights (IPRs) to take measure for the protecting their ideas and devise business strategies by taking account of IPRs.

CO6: Acquire more insights into the regulatory affair and assists in technology up-gradation for enhancing competitiveness.

COs/POs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	1	-							
CO2	-	2	1	1	-							
CO3	2	3	-	2	1							
CO4	1	-	-	1	-			2	1			
CO5								1	1		3	
CO6					2	1						2

Unit-I

Introduction to Ethics: 1.1 Basic terms- Moral, Ethics, Ethical dilemma, Emotional intelligence 1.2 Moral development theories of Kohlberg and Piaget 1.3 View on ethics by Aristotle 1.4 Governing factors of an individual's value system 1.5 Personal and professional ethics.

Unit-II

Profession and Professionalism: 2.1 Clarification of the concepts: Profession, Professional, Professionalism, Professional accountability, Professional risks, Profession and Craftsmanship, Conflict of interest 2.2 Distinguishing features of a professional 2.3 Role and responsibilities of professionals 2.4 Professionals' duties towards the organization and vice-a-versa.

Unit-III

Ethical Theories: 3.1 Various ethical theories and their application- Consequentialism, Deontology, Virtue theory, Rights Theory, Casuist theory 3.2 Ethical terms: Moral absolutism, Moral Relativism, Moral Pluralism etc. 3.3 Resolving Ethical Dilemma.

Unit-IV

Concept of property, rights, duties and their correlation; Intellectual property rights and its types-Patents, Trademarks, Copyright & Related Rights, Industrial Design, Traditional Knowledge, Geographical Indications, Protection of new GMOs; Process patent vs product patent; International framework for the protection of IP; IP as a factor in R&D; IPs of relevance to Biotechnology and few Case Studies.

Unit-V

Basic requirement of a patentable invention- novelty, inventive step, Prior art and Stae of art;Patent databases; Searching International Databases; Analysis and report formation; Filing of a patent application; Role of a Country Patent Office; Precautions before patenting-disclosure/non-disclosure; International patenting-requirement; Introduction to History of GATT, WTO, WIPO, TRIPS, PCT and Implications; Patent infringement- meaning, scope, litigation, remedies; Case studies and examples-Rice, Neemetc.

Reference Books:

1. R. Subramanian, "Professional Ethics" , Oxford University Press, New Delhi, 2013
2. Edmund G. Seebauer and Robert L. Barry, "Fundamentals of Ethics", Oxford University Press, New Delhi, 2012.
3. Stanley SA, Bioethics, Wisdom educational services
4. Sateesh MK, Bioethics and Biosafety, IK International Pvt. Ltd.

Course Code:	**24CHPE4007**	**No. of Credits:**	**4**
Course Name:	**PHYSICAL CHEMISTRY PRACTICAL**	**End Exam:**	**100**

(6hrs per week)

Course Educational Objective:

This course enables the students

CEO1. knowledge of physical chemistry. (Surface tension and solubility product etc.)

CEO2. To provide practical knowledge and skills about various topics taught in theory class of physical chemistry.

Course Outcome:

CO1. Understand the basic procedures for carrying out a physical chemistry practical like preparation and standardization of solutions, handling aspects and know about the limits of the experimental error.
CO2. knowledge of physical chemistry practical of Surface tension and solubility product
CO3. Determine the various physical parameters for the various problems under study which in turn will enhance their problem solving and analytical skills.
CO4. Verify various laws studied in the theory part.
CO5: An appreciation for modern problems and scientific controversies in physical chemistry.
CO6: Students will gain a hands-on experience.

Mapping of COs with Pos

COs/Pos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3								1			
CO2	2											
CO3	2	3										
CO4	3											
CO5	2	2										
CO6	2	3										

COURSE CONTENT

1) To determine the critical Micelle Concentration (CMC) of surfactant from the measurement of surface tension.
2) To determine the Molecular weight of a polymer from viscosity measurements.
3) Determination of critical solution temperature (CST) of phenol-water system
4) A study of phase diagram of three-component liquid (ternary) system at room temperature: (Benzene-accetic acid-water system)
5) To determine the strength of HCL and acetic acid (AcOH) from the mixture of acids by strong alkali (NaOH) conductmetrically.
6) Potentiometric titration of a weak acid (acetic acid) with caustic soda solution and determination of the dissociation constant of the acid using quinhydrone electrode at room temperature
7) To determine the rate constant of base hydrolysis of ester titrometrically.

8) To study the simultaneous equilibria in benzoic acid - benzene water system.

9) To determine the energy of activation from the Kinetic measurement of hydrolysis of ester

10) Study of inversion of cane sugar in acid medium by polarimetry

11) Determination of solubility product of $BaSO_4$.

12) To study of an equilibrium $KI + I_2 = KI_3$.

Reference Books

1. Experimental Physical Chemistry by Das and Behera
2. Practical Physical Chemistry by B. Vishwanathan & P.S. Raghavan
3. Experimental Physical Chemistry by V.D. Athawale

Course Code:	24CHPC4008	No. of Credits:	10
Course Name:	MAJOR PROJECT AND SEMINAR	End Exam:	200

Course Educational Objective:

- To explore the inter connectedness of subject knowledge.
- To acquire skills to use ICT tools effectively.
- Ability to work independently.

Course Outcome:

- To provide problem solving skill to the students.
- Strengthening Practices for Critical Thinking, Reading, and Writing.

Each student has to work for at least 300hours in a reputed research laboratory or industry on a specific project under the guidance of a Professor/Associate Professor/Assistant Professor/Reader/lecturer or a Scientist. The project can be a theoretical or experimental related to advanced topic, industrial project, training in a research institute, training of handling of sophisticated equipments etc. The research work will be submitted in the form of a dissertation within 15 days of last theory examination. The student has to present his work in power point before an External examiner and an internal examiner for evaluation. The project report should be hard bound and the students will have to submit four ***copies*** of the project report for final evaluation of 100marks based on the following criteria.

CRITERIA	Max. Marks
Literature Survey/Reference	20
Objectives/Plan of the project	20
Experimental/Theoretical Methodology	40
Significance and originality of the study	20
Depth of knowledge in the subject	20
Results and Discussions	20
Presentation/seminar	60
Total Marks	**200**