M.Sc. Chemistry

Syllabus

AFFILIATED COLLEGES

Program Code: 32D

2023 – 2024 onwards

BHARATHIAR UNIVERSITY

(A State University, Accredited with "A++" Grade by NAAC,
Ranked 21st among Indian Universities by MHRD-NIRF)

Coimbatore - 641 046, Tamil Nadu, India

Program Educational Objectives (PEOs)	
The **M. Sc. Chemistry**program aims that the graduates will become successful professional by indicating rational and analytical thinking abilities. The graduates will be mould to communicate efficiently and work in interdisciplinary research, and demonstrate scientific leadership in academia and industries.	
PEO1	Studentsacquireknowledge on major fields in Chemistry namely Organic, Inorganic Physicaland AnalyticalChemistry which would make them to recognise the key role played by chemistry in all the fields.
PEO2	Be motivated to prepare the students to pursue higher studies and research to meet out academic demands of the country.
PEO3	Have knowledge in wide range of chemistry techniques and application in scientific and engineering domains.
PEO4	Students will be stimulated to interchange their knowledge and skills for developing independent writing in their field of study
PEO5	Students will be allowed to design their own research project based on their firm theoretical understanding.

Program Specific Outcomes (PSOs)	
After the successful completion of **M.Sc. Chemistry** program, the students are expected to	
PSO1	To build the firm foundation in the fundamentals and correlate the application with the current developments in chemistry.
PSO2	To emphasize on integrating various disciplines of Science and encourage for interdisciplinary approach.
PSO3	To make current awareness on social, economic, and environmental problems facing globally.
PSO4	To motivate the students to prepare for competitive examinations, job carriers and get trained for industrial entrepreneurship.
PSO5	To acquire problem solving capacity, interpretation of results with the use of sophisticated instruments and devises new preparation techniques.
PSO6	To get sufficient expertise in the operational knowledge and laboratory skills in all major fields of chemistry.

Program Outcomes (POs)	
On successful completion of the **M. Sc. Chemistry**program	
PO1	To equip students to meet current industrial need
PO2	To equip students with advanced knowledge and insight in general and green chemistry
PO3	To enhance professional skills in chemistry by providing hands on training to operate the sophisticated instruments.
PO4	Acquire the knowledge on the role of chemistry in industries and to become entrepreneur
PO5	To equip students with different types of problem solving related to academic and industrial domain
PO6	Demonstrate, solve and understanding of major concepts in all disciplines of chemistry.
PO7	Develop analytical skills and problem solving skills requiring application of chemical principles.
PO8	The students can understand the role of chemistry in day to day life.
PO9	Create an awareness of the impact of chemistry on the environment, society, and development outside the scientific community.
PO10	Acquires the ability to synthesis, separate and characterize compounds using laboratory and instrumentation techniques.

BHARATHIAR UNIVERSITY: COIMBATORE 641 046

M. Sc. Chemistry Curriculum (Affiliated Colleges)

(For the students admitted during the academic year 2023 – 24 onwards)

Course Code	Title of the Course	Credits	Hours		Maximum Marks		
			Theory	Practical	CIA	ESE	Total
FIRST SEMESTER							
Paper - I	Organic Chemistry - I	4	5		25	75	100
Paper - II	Inorganic Chemistry - I	4	5		25	75	100
Paper - III	Physical Chemistry - I	4	5		25	75	100
Elective - I	Elective - I	4	3		25	75	100
Practical - I	Organic Chemistry -I			4	---	--	---
Practical - II	Inorganic Chemistry -I			4	--	--	---
Practical - III	Physical Chemistry -I			4	--	--	--
	Total	16	18	12	100	300	400
SECOND SEMESTER							
Paper - IV	Organic Chemistry - II	4	5		25	75	100
Paper - V	Physical Chemistry - II	4	5		25	75	100
Paper - VI	Physical Methods in Chemistry - I	4	5		25	75	100
Elective - II	Elective II	4	3		25	75	100
Practical - I	Organic Chemistry -I	4		4	25	75	100
Practical - II	Inorganic Chemistry -I	4		4	25	75	100
Practical - III	Physical Chemistry -I	4		4	25	75	100
Total		28	18	12	175	525	700
THIRD SEMESTER							
Paper - VII	Organic Chemistry - III	4	5		25	75	100
Paper - VIII	Physical Chemistry - III	4	5		25	75	100
Paper - IX	Physical Methods in Chemistry - II	4	5		25	75	100
Elective - III	Elective - III	4	3		25	75	100
Practical - IV	Organic Chemistry - II			4	---	--	---
Practical - V	Inorganic Chemistry - II			4	--	--	---
Practical - VI	Physical Chemistry - II			4	--	--	--
	Total	16	18	12	100	300	400
FOURTH SEMESTER							
Paper - X	Inorganic Chemistry - II	4	5		25	75	100
Paper - XI	Physical Chemistry - IV	4	5		25	75	100
Paper - XII	Polymer Technology	4	5		25	75	100
Elective - IV	Option given to choose either Elective Paper (OR) Project Work	4	3		25	75	100*
Practical Viva		2			50		50
Practical - IV	Organic Chemistry - II	4		4	25	75	100
Practical - V	Inorganic Chemistry - II	4		4	25	75	100
Practical - VI	Physical Chemistry - II	4		4	25	75	100
	Total	30	18	12	225	525	750
Grand Total		90			600	1650	2250


First Semester

Course code	Paper I	TITLE OF THE COURSE	L	T	P	C
Core		Organic Chemistry –I (Organic Reaction Mechanisms)	4	1	-	4
Pre-requisite		Chemical reactions & their mechanism	Syllabus Versio			

Course Objectives:

The main objectives of this course are to:

1. To understand the concept of aromaticity, antiaromaticity and nonaromaticity in organic compounds.
2. To know about the basics of aromatic and aliphatic electrophilic substitution reactions and its mechanism.
3. To understand the reaction pathway of the aliphatic, aromatic nucleophilic substitution reactions.
4. To know about the basic concept of various elimination reactions and reactive intermediates.
5. To acquire basic knowledge about the free radical generation, stability and few typical free radical name reactions.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Acquired the knowledge to distinguish about benzenoid and non-benzenoid aromatic compounds and their ions.	K2
2	To understand the basics of aromatic and aliphatic electrophilic substitution reactions; aromatic and aliphatic electrophilic substitution.	K2
3	Understood and got-in depth knowledge about reaction mechanisms	K5
4	Motivated and enabled the students to comprehend the possible chemical routes by which new pharmaceutically important compounds can be synthesized.	K3
5	Recognized the difference between electrophilic and nucleophilic substitution reactions on aromatic and aliphatic compounds, and to know about various aspects of elimination and free radical reactions.	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1		**13-- hours**

1. Aromaticity: Criteria, Non-benzenoid aromatics – annulenes, Azulenes and ferrocenes (synthesis not necessary). Anti-aromatic and non-aromatic compounds –Homoaromaticity.

2. Kinetic and nonkinetic methods of study of reaction mechanisms - Primary and secondary kinetic isotopic effects, non-kinetic methods of study of reaction mechanism – study of intermediates, isotopic labeling, stereochemical studies and cross over experiments. Hammond‘s postulate. Kinetic and thermodynamic control.

3. Linear free energy relationship - Hammett equation (Taft equation not necessary).		
Unit:2		**13-- hours**
Aromatic electrophilic substitution reactions: Mechanism, orientation and reactivity in mono substituted benzene rings. Activating and deactivating groups. Ortho/para ratio- *ipso* attack, orientation in disubstituted benzene rings. Typical reactions such as Friedel Crafts alkylation & acylation, Reimer-Tiemann, Vilsmeier- Haack reaction, Hofmann-Martius and Jacobsons reaction. Aliphatic electrophilic substitution reactions, Mechanism of SE^1, SE^2 and SE^i reaction. Stork- enamine reaction.		
Unit:3		**13-- hours**
Aliphatic nucleophilic substitution reactions and mechanisms: SN1, SN2, SNi mechanisms. Factors affecting nucleephilic substitution reaction – nature of the substrate, solvent, nucleophile and leaving group. Neighbouring group participation. Ambident nucleophiles and ambident substrates. Stereochemistry of nucleophilic substitution reactions. Substitution at vinyl carbon allylic carbon and bridge head carbon. Typical substitution reactions such as Von Braun reaction, Claisen condensation and hydrolysis of esters. Aromatic Nucleophilic Substitution reactions: SN1, SNAr and Benzyne mechanisms (Ziegler alkylation and Chichibabin reaction).		
Unit:4		**12-- hours**
1. Elimination reactions: El, E2, Ei, E1CB mechanisms, Hoffman and Sayetzeff rules, Stereochemistry of elimination reactions. Elimination Vs substitution. Typical elimination reactions such as Chugaev reaction. Hofmann degradation. Cope elimination. 2. Carbenes and nitrenes — structure, generation and reactions.		
Unit:5		**12-- hours**
Free radical reactions: Introduction -structure, stability and geometry of free radicals. Generations of long lived and short lived free radicals. Characteristics of free radical reactions - substitutions - additions and eliminations, rearrangements. of free radicals. Typical reactions such as Sandmeyar, Gamberg, Pechmann, Ullman, Pschorr and Hunsdiecker reactions.		
Unit:6		**2 hours**
Seminar, Webinar, Workshop, Training		
	Total Lecture hours	**65-- hours**
Text Book(s)		
1. Jerry March, Advanced Organic Chemistry - Reactions, Mechanism and Structure, Wiley-		

Interscience, 1992.
2. I.L. Finar, Organic Chemistry, Volume I and II, The fundamental principles, Sixth edition, Pearson education Ltd., 2014.

Reference Books

1	R.T. Morrison and R.N. Boyd — Organic chemistry.
2	E.S. Gould — Mechanism and Structure in Organic Chemistry
3	E. R. Alexander — Principles of ionic organicreactions
4	Fieser and Fieser — Advanced organic chemistry
5	J.B. Hendrickson, D.J.Gram and G.S.Hammond — Organic Chemistry
6	P.J. Garrat — Aromaticity
7	Badger — Aromaticity and aromatic character
8	D.V. Banthorpe — Eliminations

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/104/101/104101115/
2	https://nptel.ac.in/courses/104/103/104103110/
3	https://nptel.ac.in/courses/104/101/104101005/

Mapping with Programme outcomes

POs / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	S	S	S	S
CO2	M	S	S	S	S	M	S	S	S	S
CO3	M	S	S	S	M	S	S	M	S	M
CO4	M	S	S	S	M	S	S	M	S	M
CO5	S	S	M	S	S	S	M	S	S	S

*S-Strong; M-Medium; L-Low

Course code	Paper –II	Inorganic Chemistry –I	L	T	P	C
Core		Inorganic Rings and Nuclear chemistry	4	1	0	4
Pre-requisite		Theories on Inorganic rings and nuclear chemistry	Syllabus Version			

Course Objectives:

The main objectives of this course are to:

1. On successful completion of the course the students should have an idea about the Inorganic clusters
2. Learn about the electricals, thermoelectric and magnetic properties of solids.
3. After finishing this course the students will get an exposure to nuclear chemistry.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand the difference between rings, chains, cages, clusters and their types.	K2
2	To create a new borazines, phosphonitrilic compounds and sulphur-nitrogen ring compounds.	K6
3	To distinguish between stochiometry and non-stochiometry defects in solids.	K4
4	To acquire the knowledge in electrical, magnetic and thermoelectric properties of solids	K2
5	To analyse the concepts involved in nuclear chemistry, various types of nuclear reactionsand applications of radioactive isotopes.	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1 **12 hours**

Heterocatenation- Silicate minerals-classification-Ortho, Pyro, Cyclic, Chain, Sheet, Three dimensional silicates- Zeolites - Isopoly and Heteropoly anions – Cages – boranes – Carboranes - Clusters – Metal clusters – Classification - Carbonyl clusters–Low Nuclearity carbonyl clusters (Dinuclear, trinuclear and tetranuclear carbonyl clusters)-High Nuclearity carbonyl clusters- Wades rule-Halide type clusters ($[Re_2X_8]^{2-}$, $[Re_3X_9]$, $[W_4(OR)_{12}]$, $[Mo_6Cl_8]^{4+}$, $[Nb_6Cl_{12}]^{2+}$- Cheveral phases and naked clusters-Organometallic clusters

Unit:2 **12 hours**

Borazines – phosphonitrilic compounds – sulphur - nitrogen ring compounds. Metallic state – free electron and band theories – non stochiometry – point defects in solids – Schotty - Frenkel defects – linear and dislocation effects.

Unit:3 **12 hours**

Electrical properties of solids: Conductors and nonconductors Conductivity in pure metals and alloys– superconductors –Occurrence of superconductivity- BCS theory-Type-I and Type-II, and High temperature (HT) superconductors- Preparation of HT superconductors-critical temperature – persistent currents- Meissner effect. Magnetic properties-Diamagnetism, Paramagnetism and Ferromagnetism-

Langevin equation-- Carie‘s law-Zener‘s theory-Domain Structure. Thermoelectric properties – Phenomenon thermoelectricity- Seeback, Peltier and Thomson effects – Synthesis of Thermoelectric materials- Applications of thermoelectric materials.

Unit:4		**11 hours**

Nuclear chemistry-the nuclues-subatomic particles and their properties –Stability of nucleus- binding energy- N/P ratio, packing fraction-nuclear forces-Meson theory-Nuclear models-Liquid drop model-shell model-mode of radioactive decay-α,β,γ decay-Half life period-nuclear isomerism-internal conversion.

Unit:5		**11 hours**

Nuclear reactions (Capture, Particle-particle, spallation, photodisintegration)- Q-value, coulombic barrier, cross section. Fission, fusion & theories of fission- Pinch Effect-Atom bomb, Hydrogen and Plutonium bomb-Fissile and fertile isotopes– U^{233}, U^{235}, Pu^{239}, Th^{232} Radioactive series (U, Th, Ac and Np series)- Atomic power projects in India, stellar energy-Application of radio isotopes-hot atom chemistry.

Unit:6		**2 hours**

Seminar, Webinar, Workshop, Training

	Total Lecture hours	**60 hours**

Text book(s) :

1. *Advanced Inorganic Chemistry*Wiley Eastern (P), Ltd., 1968- F. A. Cotton and G. Wilkinson
2 S. Glasstone, Source book of atomic Energy, Van Nonstrand Co.,1969..
3. U.K.Malik, G.D.Tuli, and R.D. Madan, (2010). *Selected Topics in Inorganic Chemistry*, S. Chand Publication.

Reference Books

1	Gurdeep Raj. (2014). *Advanced Inorganic Chemistry*. 12th Edition. Geol Publishing House.
2	G.M.Arora : Solid State Chemistry
3	R.A.Alberty and Silbey : Solid State Chemistry
4	J.P.Srivastava : Elements of Solid State Physics
5	H.J. Arniker, Essentials of nuclear chemistry, 2nd edition Wiley easternCo.,1987.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/104/104/104104101/
2	https://nptel.ac.in/courses/104/108/104108098/
3	https://nptel.ac.in/courses/104/103/104103069/

Mapping with Programme outcomes

POs / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	S	S	S	M	S	S	S
CO2	M	S	S	M	S	S	S	S	S	M
CO3	M	M	S	M	M	S	M	M	S	M
CO4	S	M	S	S	S	S	M	S	S	S

*S-Strong; M-Medium; L-Low

Course code	PAPER III	Physical chemistry – I	L	T	P	C
Core		Group Theory, Nanoscience and Computers in Chemistry	4	1	0	4
Pre-requisite		Basic principle of group theory, nano chemistry and computers	Syllabus rsion			

Course Objectives:

The main objectives of this course are to:

1. To give a thorough introduction to the study nanoscience.
2. To learn the theories and basics of group theory and its applications.
3. To study the concepts and fundamentals of computers in chemistry

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To evaluate the symmetry elements present in the new molecules	K5
2	To understand the elementary ideas of group theory, point group,	K2
3	To evaluate the applications and relationship between Group theory and vibrational spectroscopy.	K5
4	To acquire the basic knowledge about nanoscience, nanofabrication, preparation and experimental techniques of nano materials and their characterisation.	K3
5	To implement the applications of computers in chemistry	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1		**12 hours**

Symmetry elements and symmetry operations: definition of identical and equivalent elements configurations- symmetry operations and symmetry elements-rotation-axis of symmetry- reflections symmetry planes-inversion center-improper rotations-rotation-reflection axis-effect of performing successive operations (commutative and non - commutative) - inverse operations. Groups and their basic Properties: Definition of a group -basic properties of a group-definition of Abelian group-isomorphic group-similarity transformation and classes-group multiplication tables-symmetry classification of molecules into point groups (Schoenflies symbol only) difference between point group and space group.

Unit:2		**12 hours**

Definition of reducible and irreducible representations-irreducible representations as orthogonal vectors-direct product rule-the great orthogonality theorem and its consequences (statement only proof not needed)-determinations of the characters for irreducible representation of $C_{2v}$and C_{3v} point groups using the orthogonality theorem. Calculation of character values of reducible representations per unshifted atom for each type of symmetry operation (Character table may be provided to the students)-

determination of total Cartesian representation—determination of direct sum from total Cartesian representation. Group theory and vibrational spectroscopy-vibrational modes as basis for group representation symmetry selection rules for IR and Raman spectra (mutual exclusion principle)-classification of vibrational modes. Application of group theory to chemical bonding

- Hybridization schemes for σ bonding in AB_4 (Td) type (methane).
- Hybridization schemes for π bonding in AB_3 (D3h) type (borontrichloride).

Unit:3		**12 hours**

Nanoscience Definition of nanodimensional materials - Historical milestones - Properties at the nanoscale dimension- Physical basis and principles. 0D, 1D, 2D, 3D Structures. Graphite to buckyballs to Carbon nanotubes (CNT). Single and Multiwalled CNT. Synthesis of – Nanotubes (Laser abalation, Electric Arc method, Catalytic Chemical Vapour Deposition-Homogeneous and heterogeneous including mechanism of growth -tip based root based), Functionalisation of nanotubes,

Unit:4		**11 hours**

Nanowires and nanorods (Template assisted synthesis- Pressure, Electrochemical, PVD, CVD and MOCVD methods, Template filling - Melt and solution filling, Electrospinning). Nanofabrication: Top-down approach – Nanolithography - Photo, Deep ultraviolet, X-ray, Electron beam, and Ion beam lithography. Soft lithography - dip pen nanolithography. Bottom- up approach - STM/AFM atomic manipulation. Chemical method (Sol-gel synthesis).

Unit:5		**11 hours**

Introduction to computers and computation in chemistry Basic structure and functioning of computers with PC as an illustrative example- memory. I/O devices secondary storage-computer languages-operating systems with DOS as an example- introduction to UNIX and WINDOWS-data processing, principle of programming- algorithms and flow charts. Data entry devices for sequential processing-data entry devices for direct access processing-data communication concepts: LAN, WAN, e-mail internet concept; computer virus; soft ware packages.

Unit:6		**2 hours**
Seminar, Webinar, Workshop, Training		
	Total Lecture hours	**60 hours**

Text book(s) :

1. F.A.Cotton : Chemical applications of Group theory.
2. M. Orchin and H.H. Jaffe : Symmetry, Orbital and spectra
3. G. Davidson : Introductory Group theory for Chemists 4 K.V. Raman : Computers in Chemistry

Reference Books

1	E. Balagurusamy and Deenadialu : Introduction to Computer
2	E. Balagurusamy : Programming in C
3	Jackie Ying - Nanostructured Materials, Academic Press; 1st edition,2001.
4	Gregory L. Timp – Nanotechnology, American Institute of Physics; 1st edition,1998.
5	Guozhong Cao – Nano structures and nano materials: Synthesis, property esand Applications-Imperial College Press(2004)
5	K. Eric Drexler- Engines of Creation. AnchorBooks/Doubleday
6	K. Eric Drexler- Nanosystems: Molecular Machinery, Manufacturing, and Computation**.** John Wiley & Sons, Inc.: New York,2001.
7	Robert A. Freitas Jr.- Kinematic Self-Replicating Machines**.** LandesBioscience: Georgetown, TX.2004
8	J. Storrs Hall, Nanofuture: What's Next For Nanotechnology, Prometheus Books,2005
9	NorioTaniguchi- Nanotechnology - Oxford University Press,2005

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/104/101/104101094/
2	https://nptel.ac.in/courses/104/104/104104080/
3	https://nptel.ac.in/courses/118/104/118104008/

POs / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	M	M	S	S	S	M	M
CO2	M	S	S	S	S	S	S	S	S	S
CO3	S	M	S	S	M	S	M	S	S	M
CO4	S	S	S	M	M	S	S	S	M	M
CO5	S	M	S	S	M	S	M	S	S	M

*S-Strong; M-Medium; L-Low

Mapping with Programme outcomes

Second Semester

Course code	PAPER IV	Organic Chemistry –II	L	T	P	C
Core		Molecular rearrangements and Photochemistry	4	1		4
Pre-requisite		Basic concept of molecular rearrangements and photochemistry	Syllabus rsion			

Course Objectives:

The main objectives of this course are to:

1. To understand the versatile knowledge about the different addition reactions.
2. To understand the basic concept of conformational analysis and stereochemistry.
3. To know about the principles of molecular rearrangements and it is essentially involving in the namereactions.
4. To acquire basic knowledge about organic photochemistry.
5. On successful completion of the course the students have mastered in synthetically important name reactions in organic chemistry.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand molecular rearrangements that play vital role in the synthesis of new organic molecules	K2
2	To acquire and comprehend knowledge in photochemistry and pericyclic reactions	K2
3	To interpret the mechanism of addition, oxidation and reduction reactions	K3
4	To understand and analyse the concepts, types and nomenclature instereoisomerism	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1		**13 hours**

Molecular rearrangements: Introduction - Wagner - Meerwein rearrangements, Neber rearrangement, Baeyer —Villiger rearrangement. Rearrangements to electron deficient nitrogen and oxygen — Dienone phenol, Favorski, Fries, Wolf, Benzidine and Stevens rearrangements. Chapman, Neber, ArdntEister Synthesis, Fischer Indole Synthesis, Schmidt rearrangement, Lossen and Wallach rearrangements.

Unit:2		**13 hours**

Concerted reactions: Conservation of orbital symmetry – Woodward-Hoffman rules. Electrocyclic reactions – 1,3-dienes and 1,3,5-trienes. Analysis of reaction stereochemistry using correlation diagrams method and FMO method. Cycloadditions [2+2] and [4+2] – analysis using correlation diagram and FMO methods. Sigmatropic rearrangements – FMO method- Cope and Claisen rearrangements, di-pi-methane rearrangement. PMO Approach.

Unit:3		**13 hours**

1. Organic photochemistry: Introductory theory of light absorption, photophysical processes – Jablonski diagram, energy transfer photochemical reaction of ketones - Norrish type I and type II reactions. Paterno – Buchi reaction and cis and trans isomerisation.
2. Oxidation and reductions: Mechanisms — oxidation of olefins, alcohols, glycols, ozonolysis and aromatization reaction and Sommelet reaction.
3. Reduction reactions and selectivity in reduction. Reduction reactions involving metalhydrides ($LiAlH_4$ and $NaBH_4$). Reduction of nitro compounds, carbonyl compounds and aromatic compounds. Typical reactions such as Birch reduction, Clemmensen, Wolff – Kishner and MPV reduction.

Unit:4		**12 hours**

1. Additon reactions: Electrophilic and nucleophilic. Addition to double and triple bonds — Hydration. hydroxylation. Michael addition. hydroboration and epoxidation.

2. Addition to carbonyl compounds: Mannich reaction, Dieckmann, Stobbe, Knovenagel, Darzen, Wittig, Thorpe and Benzoin reactions.

Unit:5		**12 hours**

Stereoisomerism – Configurational& conformational isomerism**:**
1. Introduction, definition & classification. Molecular representation (Fischer projection, Newmann projection formula). Basic requirements of optical isomerism. Optical isomerism exhibited by a few nitrogen and sulphur compounds – the role of nitrogen inversion.
2. Configurational nomenclature: D & L, R & S and E &Z (olefins) nomenclatures.
3. Conformations of acyclic and cyclic molecules: Configurations and conformations of cyclohexane, mono and disubstitutedcyclohexanes (conformational equilibrium – delta G). Configurations and conformations of fused polycyclic systems – decalin, perhydrophenanthrene, perhydroanthracene. Stereoselective and stereospecific reactions.

Unit:6		**2 hours**

Seminar, Webinar, Workshop, Training

	Total Lecture hours	**75 hours**

Text Book(s):
1. Jerry March : Advanced Organic Chemistry

2. Pant Dc Mayo : Molecular rearrangements vol. 1 &II

Reference Books

1	Jaffee and Drchin : Orbitalsymmetry
2	L.N.Ferguson — The modern structural theory of organic chemistry
3	Entwistle : Orbital symmetry correlations in organicchemistry
4	Lehr and Marchand : Orbitalsymmetry
5	Pant Dc Mayo : Molecular rearrangements vol. 1 &II

6	N.J. Turro : Molecularphotochemistry
7	C.H. Depuy and O.S. Chapman : Molecular reactions andphotochemistry
8	W.A. Pnyer : Introduction to free radicalchemistry
9	S.M.Munergee and S.P.Singh : Reaction mechanisms in organicchemistry
10	J.M. Coxon and B.Halton : Organicchemistry
11	C.A.Buntcn -- Nucleophilic substitution at the saturated carbon atom
12	J .Miller -— Atomic nucleophiclic substitution
13	C.K. lngold — Structure and mechanism in organic chemistry
14	K.Milson — Introduction to stereochemistry
15	E. L.Eliel — Stereochemistry of carbon compounds
16	Whitaker David — Stereochemistry
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/104/106/104106077/
2	https://nptel.ac.in/courses/104/101/104101005/
3	https://nptel.ac.in/courses/104/105/104105038/
4	https://nptel.ac.in/courses/104/105/104105086/

Mapping with Programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	S	S	S	M	S	S	S	M
CO2	M	M	S	S	S	M	S	S	S	M
CO3	M	S	S	S	S	S	S	S	S	S
CO4	S	S	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	PAPER V	PHYSICAL CHEMISTRY – II	L	T	P	C
Core		Quantum chemistry and nanomaterials	4	1	0	4
Pre-requisite		Understanding the physical & mathematical aspects of quantum mechanics	Syllabus Version			

Course Objectives:

The main objectives of this course are to:

1. To present the basic principles of quantum chemistry.
2. To learn the theories and basics of quantum mechanical treatment.
3. To motivate the student to enjoy the application of nanoscience.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Understand the concepts of classical and quantum mechanics, to picture out the failure of classical mechanics.	K4
2	To comprehend the approximate methods in quantum mechanics.	K5
3	To acquire the knowledge about quantum chemistry, heat capacity of solids, Schrodinger equation and various operators	K6
4	To understand the applications of Schrodinger equation to one D box, rigid rotor, harmonic oscillator, H-atom and various theories in quantum chemistry.	K2
5	To implement nanoscalecharacterisation and applications of nanomaterials.	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1		**12 hours**

1. Success of quantum theory and the Failure of classical mechanics in explaining blackbody radiation, heat capacity of solids, photo-electric effect and the H-atom spectrum.(Derivation of Plank‘s distribution law and Einstein‘s heat capacity equation not needed). Heisenberg‘s uncertainity principle.
2. The time-dependent and time-independent schrodinger equations — Born‘sinterpretation of the wave function. Requirements of the acceptable wave function. Postulates of quantum mechanics.
3. Algebra of operators. Sums and products of operators. Commutator. Linear operators. Eigen functions and eigen values. Correspondence between physical quantities in classical mechanics and operators in quantum mechanics. Hamiltonian operator. Angular momentum operator. Quantization of angular momentum and its spatial orientation. Average (expectation) values.

Unit:2		**12 hours**

1. Particle in a one - dimensional box. Quantization of energy. Normalization of wave function. Orthogonality of the particle in a one—dimensional box wave functions.
Illustration of the uncertainty principle and correspondence principle with reference to the particle in a one dimensional box. Particle in a three-dimensional box. Separation of variables.
2. Solving of Schrodinger equation for the one—dimensional harmonic oscillator. Harmonic oscillator

model of a diatomic molecule. Illustration of the uncertainty principle and correspondence principle with reference to harmonic oscillator.
3. Solving of Schrodingcr equation for a rigid rotor. Rigid rotor model of a diatomic molecule.

Unit:3		**12 hours**

1. Schrodinger equation for the H-atom (or H-like species) separation of variables (solving of radial equation is not needed but nature of solution is given), energy levels. Radial factors of the H-atom wave functions. Orbitals and orbital shapes. Probability density and radial distribution functions. The most probable distance of the H-atom (or H-like species) 1S electron.
2. Need for approximation methods. The perturbation theory (first order only). Application of the perturbation method to He-atom.
3. The variation method. Application of variation method to He-atom.

Unit:4		**11 hours**

Nano scale characterisation: Fundamentals of Nano-device measurements. Traditional surface and material analysis techniques- Raman, X-RD, SAXS, Measurements of Nano-devices and Atomic scale characterization – SEM/TEM, SEM with EDX, Scanning probe microscopies (AFM and STM). Chemical Characterization, Optical measuring systems-Surface Plasmon Resonance, pattern recognition and inspection systems.

Unit:5		**11 hours**

Applications of nano materials: Biological applications- Polymeric nanomaterials for drug delivery, Hydroxyapatite. Industrial applications - Nanorobots, Nano electro mechanical systems (NEMS). Computing - Present and future - Quantum methods of information processing. Chemical Applications – Catalysis, Nanosensors, Nanomedicine-Domestic Applications- Self cleaning surfaces, Nano paints, water treatment, cosmetics. Environmental effects of nano.

Unit:6		**2 hours**

Seminar, Webinar, Workshop, Training

	Total Lecture hours	**75 hours**

Text Book(s):

1. Ira. N.Levine, Allyn& Bacon IC: Quantum Chemistry,1974 .
2. Mc. Quarie : Quantum Chemistry

Reference Books

1	Ira.N.Levine, McGrav : Physical Chemistry, Hill Book Company,1971
2	Ira.N.Levine, Wiley : Interscience, N.Y.1975
3	Jackie Ying - Nanostructured Materials, Academic Press; 1st edition, 2001.
4	Gregory L. Timp – Nanotechnology, American Institute of Physics; 1st edition, 1998.

5	Guozhong Cao – Nano structures and nano materials: Synthesis, properties and Applications-Imperial College Press(2004)
6	K. Eric Drexler- Engines of Creation. Anchor Books/Doubleday
7	K. Eric Drexler- Nanosystems: Molecular Machinery, Manufacturing, and Computation**.** John Wiley & Sons, Inc.: New York, 2001.
8	Robert A. Freitas Jr.- Kinematic Self-Replicating Machines**.** Landes Bioscience: Georgetown, TX.2004
9	J. Storrs Hall, Nanofuture: What's Next For Nanotechnology, Prometheus Books, 2005.
10	NorioTaniguchi- Nanotechnology - Oxford University Press, 2005.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/104/101/104101126/
2	https://nptel.ac.in/courses/115/101/115101107/
3	https://nptel.ac.in/courses/115/103/115103104/
4	https://nptel.ac.in/courses/113/106/113106093/

Mapping with Programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	M	M	S	S	M	M	S	S
CO2	S	M	M	M	S	S	M	M	S	S
CO3	M	M	M	M	S	S	M	M	S	S
CO4	M	M	S	S	M	M	S	S	M	M
CO5	S	M	M	M	S	S	M	M	S	S

*S-Strong; M-Medium; L-Low

Course code	PAPER VI	PHYSICAL METHODS IN CHEMISTRY - I	L	T	P	C
Core			4	1		4
Pre-requisite		Basicsof EPR, Mossbauer and neutron and X-ray diffraction	Syllabus rsion			

Course Objectives:

The main objectives of this course are to:

1. To understand the key role of various physical techniques like ORD, CD, DTA, DSC, TGA, ESCA, GLC and HPLC.
2. To understand the basis of mossbauer spectroscopy
3. To understand the basics of ESR and its applications.
4. To acquire the knowledge about of neutron and X – ray diffraction

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand the principle, theory and applications of different chromatography techniques	K2
2	To analyse the concepts and methods used in solid state and chemical crystallography	K4
3	To interpret the principles and applications of ORD, CD, AES andUPS	K4
4	To recognize the principles involved in TGA, DTA, DSC, refractometry, turbidinetry and Nephelometry	K5
5	To acquire deep knowledge about Mossbauer spectroscopy and ESR spectroscopy and utilize to create a new molecule of interest.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1 **12-- hours**

Chromatography – Principles, theory, instrumentation and applications in chemical analysis of the following – column, paper, thin layer and ion-exchange – GC, GLC and HPLC. Purification of common organic solvents. Atomic absorption spectroscopy and Flame emission spectroscopy – basic principles – Instrumentation and applications.

Unit:2 **12-- hours**

Solid state and Chemical Crystallography – Diffraction methods – X-ray , neutron and electron Diffraction – Structure of NaCl , KCl and CsCl – Determination of lattice type and unit Cell dimensions – Power Camera – indexing the powder pattern – An elementary discussion of structural factors and scattering factor – Structures of rutile, fluorite, Antifluorite, zinc blende,wurtzite, diamond and graphite.

Unit:3 **12-- hours**

Circular dichroism and optical rotatory dispersion-basic principles-basic principles of O.R.D.

and C.D.-cotton effects-Octants rule-axial halo ketone rule application of O.R.D. and C.D. Electronspectroscopy: ESCA (XPS): principle, chemical shifts-description of SCA spectrometer, X-ray sources, samples analysis, detectors and recordingdevices-applications. Auger electron spectroscopy (AES) and ultra-violet photo electron spectroscopy (UPS/PES)-principles and applications.		
Unit:4		**11-- hours**
Thermal analysis – Thermogravimetric Analysis (TGA), Differential Thermal Analysis (DTA) and Differential Scanning Calorimetry (DSC) – Basic principles. Refractometry- Refractometer theory – basic principles – Abbey Refractometer – Applications. Turbidimetry and Nephelometry-applications.		
Unit:5		**11-- hours**
Mossbauer Spectroscopy - principles – Spectrometer – Isomer shift – Quadruple interaction – Nuclear Zeeman Splitting – Applications ESR Spectroscopy - theory – Derivative curves – ‗g' shift – hyperfine splitting – Isotropic and anisotropic systems – Zero field splitting and Kramer degeneracy – Identification of free radicals – Applications.		
Unit:6		**2 hours**
Seminar, Webinar, Workshop, Training		
	Total Lecture hours	**60-- hours**

Text Book(s):

1.A. I. Vogel : A text book of quantitative inorganic analysis

2.G. D. Christian : Analytical Chemistry

Reference Books

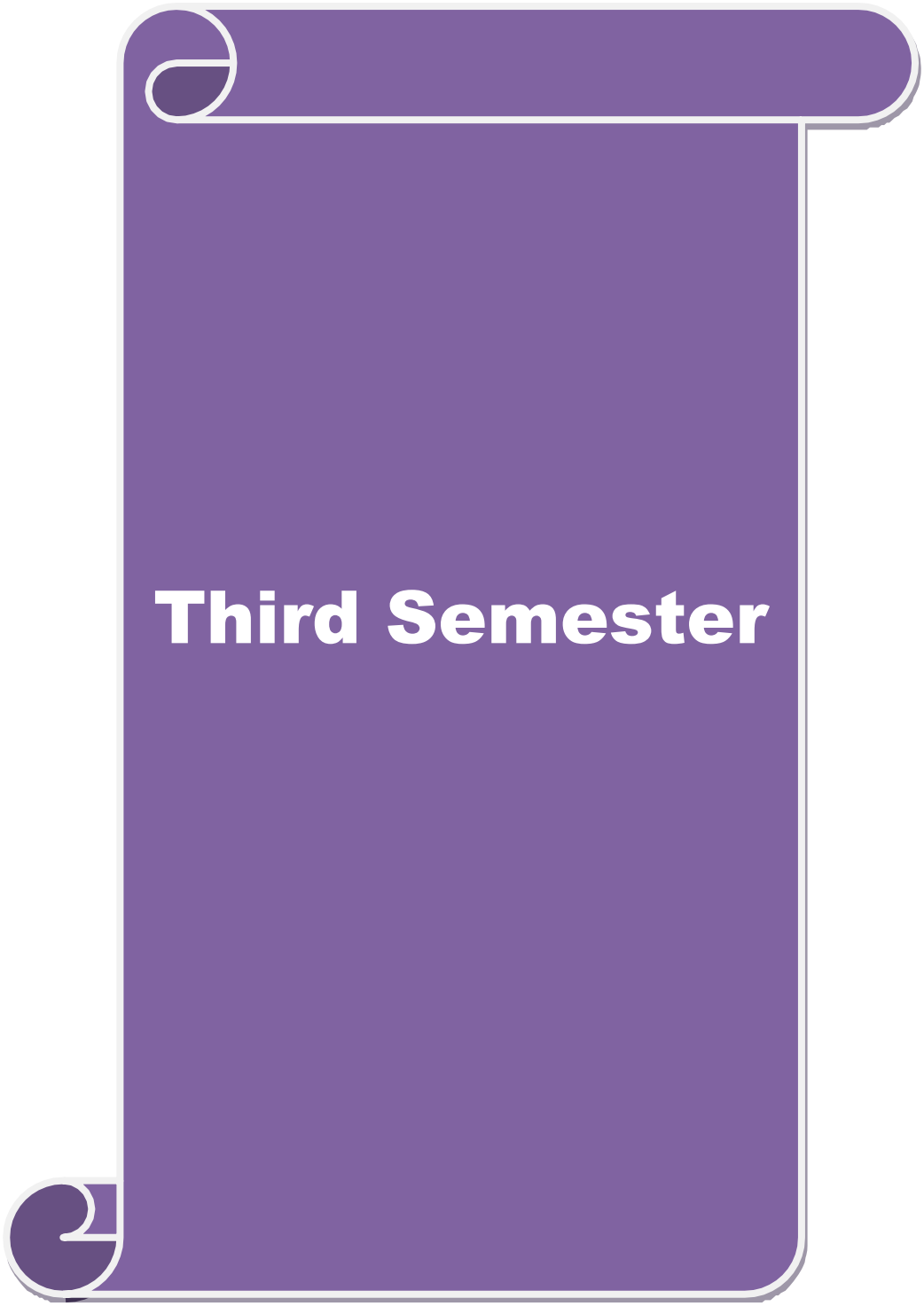
1	G. D. Christian : Analytical Chemistry
2	D. A. Skoog and D. M. West : Fundamentals of AnalyticalChemistry
3	D. A. Skoog : Instrumental methods ofanalysis
4	B. K. Sharma : Instrumental methods ofanalysis
5	H. H. Willard, L.L.Merrit, J.A. Dean: Instrumental methods ofanalysis
6	S.N.Khopkar : Fundamental concepts of AnalyticalChemistry
7	Drago, Physical methods in InorganicChemistry
8	Djerassi, Optical RotatoryDispersion
9	Chatwal, Instrumental Methods ofAnalysis
10	Sharma, Instrumental Methods of ChemicalAnalysis
11	Sharma, Chromatography

12	Arora, Solid StateChemistry
13	Alberty and Silbey, Solid StateChemistry
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/104/104/104104101/
2	https://nptel.ac.in/courses/104/106/104106048/

Mapping with Programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	S	M	S	S	S
CO2	M	S	S	M	S	S	S	M	M	S
CO3	S	M	S	S	M	M	S	S	S	S
CO4	M	S	S	S	S	M	S	S	M	S
CO5	S	M	S	S	M	S	S	S	M	S

*S-Strong; M-Medium; L-Low


Third Semester

Course code	PAPER VII	ORGANIC CHEMISTRY - III	L	T	P	C
Core		Chemistry of Natural Products	4	1	-	4
Pre-requisite		Basic idea on natural products	Syllabus			

Course Objectives:

The main objectives of this course are to:

1. To study about the chemistry in terpeniods
2. To study about the chemistry in steriods
3. To know about the Alkaloids
4. To acquire the knowledge about important organic reagents used synthesis organic natural products.
5. To understand the composition of the important natural materials around them.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To remember the basic reaction involved in the synthesis of various natural products	K1
2	To understand the reactions and reagents that play vital role in the synthesis of new organic molecules.	K4
3	To acquire comprehend knowledge in Terpenoids, Steroids, and Alkaloids.	K4
4	To the evaluate the applications of novel reagents in the synthesis of natural molecules	K2

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1 **13-- hours**

Terpenoids: Isolation and classification of terpenoids — structural elucidation and synthesis of zingiberene, eudesmol, juvenile hormone, abeitic acid and caryophyllene.

Unit:2 **13-- hours**

Steroids: Introduction — structural elucidation of cholesterol (synthesis not required), ergosterol, equilenin, estrone, testosterone and progesterone.

Unit:3 **13-- hours**

Alkaloids: Introduction – isolation of alkaloids, structural elucidation and synthesis of morphine, reserpine. Quinine, atropine and glaucine.

Unit:4 **12-- hours**

1. Proteins and nucleic acids: Classification and characteristics (structure) of proteins — synthesis of polypeptides and oxytocin, enzymes and coenzymes. Structure of RNA and DNA and their biological importance.
2. Heterocyclic compounds: Structure, synthesis and reactions of flavones, isoflavones, purines (adenine and guanine) and anthocyanins (cyanin and pelargonin).

Unit:5		**12-- hours**
Reactions and reagents: Reactions in organic synthesis: Oppanauer oxidation, Barbier – Wieland degradation, Barton reaction, Jones oxidation and Vilsmeier reaction. Reagents in organic synthesis: Preparations and synthetic applications of DDQ (2,3-dichloro-5,6-dicyano-1,4-benzoquinone), DBU (1,5-diazabicyclo[5.4.0]undecene-5), DCC (dicyclohexylcarbodiimide) NBS, PCC, PDC and crown ethers.		
Unit:6		**2 hours**
Seminar, Webinar, Workshop, Training		
	Total Lecture hours	**65-- hours**

Text Book(s):

1. I.L.Finar, Organic Chemistry, Volume I & II, The fundamental principles, Sixth edition, Pearson education Ltd., 2014.
2. O.P.Agarwal : Natural product chemistry

Reference Books	
1	I.L.Finar, Organic Chemistry, Volume I& II, The fundamental principles, Sixth edition, Pearson education Ltd., 2014.
2	P.S.Kalsi : Chemistry of naturalproducts
3	J.N.Guntu and R.Kapoor : Organic reactions and reagents
4	Acheson : Introduction to heterocyclic compounds
5	Katritsky : Principles of heterocyclic chemistry
6	TadeuszAniszewski: Alkaloids
7	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/104/103/104103023/
2	https://nptel.ac.in/courses/104/105/104105040/
3	https://nptel.ac.in/courses/102/101/102101049/

Mapping with Programme outcomes

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	M	S	S	S	S	S	S	S	S	S
CO2	S	S	M	S	S	M	M	S	S	M
CO3	M	S	S	S	S	S	S	S	S	S
CO4	S	S	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	PAPER — VIII	PHYSICAL CHEMISTRY — III	L	T	P	C
Core		Thermodynamics	4	1	0	4
Pre-requisite		Fundamental concepts of thermodynamics	Syllabus rsion			

Course Objectives:

The main objectives of this course are to:

1. To have an exposure to the Thermodynamics.
2. To acquire awareness about the basic concepts of Quantum Statistics.
3. To understand basics of Heat capacities of solids.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand the ideas of Thermodynamics	K2
2	To acquire basic knowledge about Quantum Statistics	K2
3	To analyze the quantum mechanics propblem	K4
4	To implement the evaluation of Thermodynamic properties E, H, S, A, G, Cv and Cp .	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1 **12 hours**

Themodynamics and Non-ideal systems: Chemical potential and the definition of fugacity. Determination of fugacity of gases by graphical method and from equations of state. Variation of fugacity with temperature. fugacity and the standard state for non-ideal gases. Definition of activity. Activity coefficient. Temperature coefficient of activity. Standard states. Applications of activity concept to solutions. The rational and practical approaches. Measurement of activity of solvent from colligative properties. Determination of activity of solute.

Unit:2 **12 hours**

Third Law of Thermodynamics: Probability and third law. Need for third law. Nernst heat theorem and other forms stating third law. Thermodynamic quantities at absolute zero. Statistical meaning of third law and apparent exception. Mathematical Introduction: Theories of permutation & combination, Laws of probability. Distribution laws. Gaussian distribution.

Unit:3 **12 hours**

Quantum statistics: Maxwell - Boltzmann statistics. Thermodynamic probability. Thermodynamic probabilities of systems in equilibrium. Boltzrnann expression for entropy. Stirling‘s approximation. States of maximum thermodynamics probability. Legrangian multipliers, thermodynamic probabilities of systems involving energy levels. Maxwell - Boltzmann distribution law. Evaluation of alpha and beta in M.B. distribution law.

Unit:4		**11 hours**

Partition function: Partition function - definition, justification of nomenclature, microcanonical and canonical ensembles. Molecular partition function and canonical function. The relation between the total partition function of a molecule and the separate partition functions. _Translational partition function, rotational partition function. Effect of molecular symmetry on rotational partition function. Ortho and para hydrogen. Vibrational partition function. Electronic partition function. Evaluation of thermodynamic properties E, H, S, A, G, Cv and Cp from monoatomic and diatomic ideal gas molecule partition functions

Unit:5		**11 hours**

Heat capacities of solids: Einstein‘s and Debye‘s theories of heat capacities of solids. Bose-Einstein and Fermi-Dirac Statistics: Bose-Einstein distribution law. Entropy of Bose- Einstein gas. Plank distribution law for black-body radiation. Fermi – Dirac distribution law. Entropy of a Fermi-Dirac gas.

Unit:6		**2 hours**

Seminar, Webinar, Workshop, Training

	Total Lecture hours	**60 hours**

Text Book(s):

1. Klotz : Chemical thermodynamics .
2. P.W.Atkins : Physical Chemistry

Reference Books

1	S. Glasstone:Thermodynamics
2	M . C. Gupta: Statistical thermodynamics
3	Lee. Sears and Salinger : Statistical thermodynamics

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/104/103/104103112/
2	https://nptel.ac.in/courses/112/105/112105266/
3	https://nptel.ac.in/courses/104/106/104106094/

Mapping with Programme outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	S	S	M	S	S	S	M
CO2	M	S	L	M	L	S	L	M	L	S
CO3	S	M	S	S	S	M	S	S	S	M
CO4	M	S	S	M	S	S	S	M	S	S

*S-Strong; M-Medium; L-Low

Course code	PAPER-IX	PHYSICAL METHODS IN CHEMISTRY -II	L	T	P	C
Core			4	1	0	4
Pre-requisite		Background knowledge on spectroscopy	Syllabus			

Course Objectives:

The main objectives of this course are to:

To understand the basis of visible, IR, UV, ^{1}H NMR, ^{13}C NMR and Mass Spectroscopy

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand the principle, theory, and applications of different spectral techniques.	K2,K3 &K6
2	To interpret the principle and applications of ^{1}H NMR ,^{13}CNMR and Mass Spectroscopy	K4
3	To acquire deep knowledge about characterization of organic molecules using IR, UV,	K5
4	To acquire deep understanding about ^{1}HNMR , ^{13}C NMR and Mass Spectroscopy	K5
5	To acquire deep knowledge about Correlation NMR Spectroscopy	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1		**12 hours**

Infrared Spectroscopy Principle of infrared spectroscopy - description of double beam IR spectrophotometer-IR spectra of polyatomic molecules-factors affecting the vibrational frequencies-application of IR spectroscopy for organic and inorganic compounds-problems.

Unit:2		**12 hours**

Ultraviolet and Visible Spectroscopy-Electronic spectra of diatomic molecules – Laws of photometry – Electronic absorption transitions – Correlation of electronic structure with molecular structure – Simple chromophoric groups – Effects of conjugation – Woodward – Fieser rules – Aromatic system and systems with extended conjugation – applications to organic and inorganic compounds – Instrumentation.

Unit:3		**12 hours**

^{1}H NMR Spectroscopy-magnetic properties of nuclei – theory of nuclear resonance – Chemical shift and its measurement – Factors influencing chemical shift – Chemical equivalence and magnetic equivalence – solvents and NMR spectra – Spin –Spin coupling – Spin-Spin splitting systems – Proton exchange reactions – Heteronuclear coupling – Deuterium exchange – Double resonances–Chemical

shift reagents–Applications to organic and inorganic compounds - Instrumentation –CW and FT NMR.

Unit:4		**11 hours**

^{13}C NMR Spectroscopy- magnetic moment and natural abundance- broad band decoupling- deuterium coupling- NOE effect- Off-resonance decoupling- peak assignments using DEPT spectrum – structural applications of ^{13}C NMR spectroscopy. Correlation NMR Spectroscopy- theory- ^{1}H-^{1}H COSY, ^{1}H-^{13}C COSY:

Unit:5		**11 hours**

Mass Spectrometry-Theory – Instrumentation – Isotopic abundance – Determination of molecular weights and formulae, Ionisation techniques (CI, FD, FAB &ESI) – Nitrogen rule – Metastable ions and peaks – Ion fragmentation mechanisms – Retro Diels-Alder rearrangement – Mclafferty rearrangement – Fragmentation associated with functional groups – aliphatic and aromatic compounds – Elimination due to orthogroups.

Unit:6		**2 hours**

Seminar, Webinar, Workshop, Training

	Total Lecture hours	**60 hours**

Text Books:

1. Silverstein, Basler and Morrill, Spectrometric identification of Organic Compounds.
2. R. S. Drago, Physical Methods in Inorganic Chemistry.
3. Pavia and Lampman, Introduction to Spectroscopy

Reference Books

1	W. Kemp, Organic Spectroscopy
2	P. S. Kalsi, Spectroscopy of Organic Compounds
3	C. N. Banwell, Fundamentals of Spectroscopy
4	Das and James, Mass Spectrometry
5	F. W. McLafferty, Mass Spectrometry
6	Sheinmann, Introduction to Spectroscopic Methods
7	Silverstein and Webster, Spectrometric Identification of Organic Compounds
8	Y. R. Sharma, Elementary Organic Absorption Spectroscopy
9	R. Chang, Basic Principles of Spectroscopy
10	B. Stuart, Infrared Spectroscopy: Fundamentals and Applications, John Wiley & Sons Ltd (2004)

11	Abraham and Lofters: 13C NMR spectroscopy

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/104/108/104108124/
2	https://nptel.ac.in/courses/104/101/104101117/
3	https://nptel.ac.in/courses/104/108/104108097/
4	https://nptel.ac.in/courses/104/101/104101099/

Mapping with Programme outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	M	S	M	S	S
CO2	S	M	S	S	S	S	M	S	S	S
CO3	M	S	S	S	S	S	S	S	S	S
CO4	S	M	S	S	S	S	M	S	S	S
CO5	M	S	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low


Fourth
Semester

Course code	PAPER – X	INORGANIC CHEMISTRY – II	L	T	P	C
Core		COORDINATION CHEMISTRY	4	1	0	4
Pre-requisite		Understanding of basic concept of coordination chemistry	Syllabus Version			

Course Objectives:

The main objectives of this course are to:

1. To know the basic principles of coordination chemistry
2. To know the basic principles of organometallic compounds
3. To understand the important theories of coordination chemistry
4. To utilize the applications of coordination compounds

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand some principles and theories in coordination chemistry	K2
2	To learn about organometallic and bio inorganic chemistry	K3
3	To analyze the concepts, types, and nomenclature of coordination chemistry	K4
4	To evaluate the application of coordination compound in various fields	K5
5	To analyze the concepts, types, and nomenclature of coordination chemistry	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1 **12 hours**

Crystal field theory – spectrochemical series – molecular orbital theory –comparison of MOT and CFT-pi- bonding – magnetic behaviour of the transition metal ions (Paramagentic and diamagnetic properties, cooperative magnetism). Thermochemical correlation.

Unit:2 **12 hours**

Term symbols for the 3d-block elements and their ions – Orgel diagram ($d^3$and d^5only) – Tanabe-Sugano diagram for Co^{3+}system – John-Tellar distortions– spin-orbit coupling – Nephelauxetic effect – charge transfer spectra.-Racah parameters. Substitution reactions in square planar and octahedral complexes – trans effect – redox reactions (Inner and Outer sphere mechanism)

Unit:3 **12 hours**

d-Block metal carbonyls – General preparation, properties structure and Spectroscopic properties (^{13}C and IR) EAN Rule–Preparation, properties and structure of Iron carbonyls – Preparation and Structure of $Fe_2(CO)_9$ and $Co_4(CO)_{12}$ – Carbonyl hydrides $[HMn(CO)_5]$, $[HCo(CO)_4]$, $[H_2Fe(CO)_4]$ (Preparation and chemical reaction only)- Complexes of molecular nitrogen and oxygen (synthesis and reactions). Isolobal analogies.

Unit:4 **11 hours**

Cyclopentadienyl complex - Ferrocene – synthesis, structure and reactions (Acetylation, aminomethylation, metalation, Nitration and Halogenation). Homogeneous catalysis by coordination compounds – hydroformylation using $Co(CO)_4H$– Carboxylation of methanol – hydrogenation of alkenes (Wilkinson's catalyst)- Wacker oxidation of alkenes-Alkene metathesis (Grubb's catalyst)-Reppe synthesis (Nickel based catalyst) -Vasca's compound – Zeise salt.		
Unit:5		**11 hours**
The Inorganic composition of cells- Sodium and potassium transport- Cytochromes (electron transfer)-Zinc enzymes (carbonic anhydrase) – Peroxidases-Oxidases - Oxygenases-Photosynthetic oxygen production-Nitrogen fixation (*in vivo* and *in vitro*). Hemoglobin – myoglobin - cyanocobalamin – chlorophyll (structure and functions). Chelation therapy, antitumour agents - *cis*platin.		
Unit:6		**2 hours**
Seminar, Webinar, Workshop, Training		
	Total Lecture hours	**60 hours**

Text Book(s):

1. Shriver and Atkins, Inorganic Chemistry, Fifth Edition.
2. K.F. Purcell and J.C. Cotz, Inorganic chemistry, , Fifth Edition

Reference Books

1	James E. Huheey, Ellen A. Keiter and Richerd L. Keiter : Inorganic Chemistry, IV Edn., 1993
2	Cotton and Wilkinson : Advanced inorganic Chemistry, Wiley Eastern (P), Ltd.,1968
3	H.J. Emeleus and A.G.Sharp : Modern aspects of Inorganic Chemistry, IV Edn.,1989
4	R.S. Drago : Physical methods in Inorganic Chemistry,1978
5	R.C. Mehrotra and A. Singh : Organometallic Chemistry

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/104/101/104101121/
2	https://nptel.ac.in/courses/104/103/104103069/
3	https://nptel.ac.in/courses/104/104/104104109/
4	https://nptel.ac.in/courses/104/105/104105031/

Mapping with Programme outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	M	M	S	S	S	M	M
CO2	M	S	S	S	S	S	S	S	S	S
CO3	S	M	S	S	M	M	M	S	S	M
CO4	S	S	S	M	L	S	S	S	M	L
CO5	M	S	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	PAPER XI	PHYSICAL CHEMISTRY – IV	L	T	P	C
Core		Reaction Kinetics and Electrochemistry	4	1	-	4
Pre-requisite		Basic knowledge on kinetics	Syllabus			

Course Objectives:

The main objectives of this course are to:

1. To learn about relation between different theories of reaction rate
2. To study of reaction rate in solution and fast reaction
3. To learn about the concept of homogeneous and heterogeneous catalysis
4. To learn about the polarography, coulometric and amperometric methods of estimations.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To analyze the different theories of reaction rates.	K4
2	To understand the kinetic aspects of chemical reactions and the role of catalysts	K2
3	To acquire the knowledge about theories of double layer.	K3
4	To learn polarography, coulometric and amperometric methods of estimations.	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1 **13 hours**

Theories of reaction rates: Arrhenius theory. Hard - sphere collision theory of gas – phase reactions. Activated complex theory or absolute reaction rate theory (ARRT) for ideal gas reactions (in terms of partition functions). Relation between activated - complex theory and hard - sphere collision theory. Thermodynamic formulations of activated complex theory & kinetic isotopic effect.

Unit:2 **13 hours**

1. Reactions in solution: Comparison between gas-phase and solution reactions. The influence of the solvent on the reactions between ions. Influence of ionic strength on rates of reactions in solution - Primary salt effect. Influence of pressure on rates of reactions in solution. Significance of volume and entropy of activations.

2. Study of Fast reactions: Flow methods, pulse methods, relaxation methods, Shock-tube method & nuclear magnetic resonance method.

Unit:3 **13 hours**

1. Homogeneous catalysis: Specific and general acid - base catalysis. Bronsted catalysis law. Hammett acidity function. Enzyme catalysis (single substrate reaction only).
Michaelis-Menton law. Influence of pH and temperature on enzyme catalysis.

2. Surface phenomenon and heterogeneous catalysis: Adsorption and free energy relation at interfaces. Gibb‘s adsorption isotherm. Physisorption and chemisorption. Adsorption isotherms (Freundlich& Langmuir). Kinetics of heterogeneous catalysis. Langmuir - Hinshelwood and Langmuir – Rideal-Eley mechanism.

Unit:4		**12 hours**

1. Interionic attraction theory: Debye – Huckel – Onsager equation. Falkenhagen effect. Wien effect. Activity and activity coefficient. Ionic strength. Debye – Hukel limiting law and its applications.
2. Theories of double layer. Helmholtz – Perrin - Gouychapmann – Stern theories.

Unit:5		**12 hours**

1. Polarography: Current – voltage relationships. The dropping mercury electrode. Diffusion current. Half – wave potentials. Applications of polarography. Amperometric titrations.
2. Fundamental principles of coulometric methods. Constant current and controlled potential methods. Simple applications.

Unit:6		**2 hours**

Seminar, Webinar, Workshop, Training

	Total Lecture hours	**75 hours**

Text Book(s)

1. K.J. Laidler: Chemical kinetics. Tata McGraw Hill
2. Gurdeep Raj: Chemical kinetics. Goel Publishing House

Reference Books

1	Puri, Sharma &Pathania: Principles of Physical Chemistry
2	A. A. Frost & R. G. Pearson: Kinetics and Mechanism. Wiley Eastern, Pvt
3	S. Glasstone: Introduction to electrochemistry.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/104/106/104106094/
2	https://nptel.ac.in/courses/104/106/104106089/

Mapping with Programme outcomes

PO / CO	PO1	PO2	PO3	PSO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	H	S	S	S	H	S	S	S	H
CO2	S	S	S	S	S	S	S	S	S	S
CO3	M	S	S	H	S	S	S	H	S	S
CO4	S	S	S	H	S	S	S	H	S	S

*S-Strong; M-Medium; L-Low

Course code	Paper - XII	POLYMER TECHNOLOGY	L	T	P	C
Core			4	1	-	4
Pre-requisite		Basic of polymer chemistry	Syllabus			

Course Objectives:

The main objectives of this course are to:

1. To understand the plastic materials commonly used.
2. To know about the manufacture and compatibility of polymers.
3. To recognize the additives added to them.
4. To learnt the techniques of converting basic polymers into finished products.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand the manufacturing methods of polymers.	K2
2	To understand the various degradation method for polymers	K2
3	To learn the techniques of adding additives and converting virgin polymer into plastic.	K3
4	To understand Fabrication process, methods of making plastics, fibres and elastomers.	K2
5	To create a new technology for polymer synthesis.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1 **12-- hours**

Polymerization process: Bulk polymerization, solution polymerization, suspension polymerization, emulsion polymerization, meltpolycondensation, solution polycondensation and interfacial polycondensation. Production of polymers: polythene (LDPE and HDPE), polystyrene, PVC, ABS plastics, polyvinyl alcohol, polymethyl methacrylate, phenol formaldehyde, urea formaldehyde and epoxy resins.

Unit:2 **12-- hours**

Polymer degradation: Types of degradation – chain-end and random, thermal degradation, mechanical degradation, photo degradation, oxidative degradation, degradation by high-energy radiation. Polymer additives –fillers, antioxidants, thermal and UV- stabilizers, colorants, flame retardants, blowing agents and plasticizers – effect of plasticizers on polymer properties, compatibility of plasticizers and polymers.

Unit:3 **12-- hours**

Fabrication process – One-dimensional processes: coatings and adhesives – Two-dimensional

processes: Extrusion moulding, flat film extrusion, calendering, blown film extrusion and lamination. Three dimensional processes: Injection moulding, blow moulding, transfer moulding, foaming and forming process.

Unit:4		**11-- hours**

Fibre technology: Production of natural and synthetic fibers: Regenerated cellulose, nylon 6, nylon 6,6, polyethylene terephthalate, and polyacrylonitrile. Properties of textile fibers, criteria for fiber formation. Spinning processes – melt spinning, dry spinning and wet spinning. Treatment of fibers: sizing, dyeing, finishing and lubrication.

Unit:5		**11-- hours**

Elastomer technology: Natural rubber, synthetic rubbers - SBR, butyl rubber, nitrile rubber, urethane rubber, chloroprene rubber and silicone rubber. Vulcanization – chemistry of vulcanization (sulphur and nonsulphur vulcanizations), physical aspects of vulcanization. Reinforcement: Theories of reinforcement, carbon as filler and reinforcing agent, carbon black, effects of carbon black structure on reinforcement.

Unit:6		**2 hours**

Seminar, Webinar, Workshop, Training

	Total Lecture hours	**60-- hours**

Text Book(s):

1. F. Rodriguez : Principles of polymer science, TMH Edition, 1970
2. Dryden : Outlines of chemical technology, East West Press, 1965
3. L.K. Arnold : Introduction to plastics, George Allen Ltd. 1968

.

Reference Books

1	E.W. Duck : Plastics and rubbers, Butterworths, London, 1971
2	F.W. Billmeyer : Text books of polymer science, Wiely, Interscience 1971
3	K.K. Walczak : Formation of synthetic fibres
4	Morton : Introduction to rubber technology
5	W.C. Wake : The analysis of rubber and rubber-like polymers
6	Cagle : Hand-book of adhesive bonding, McGraw Hill
7	D.H. Kecalble : Physical chemistry of adhesion, Wiley-Interscience
8	R.M. Ogorikewiez : Thermoplastics – Properties and design, John Wiley
9	I.I. Rublin : Injection moulding theory and practice, Wiley Inter science

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/104/105/104105124/
2	https://nptel.ac.in/courses/103/106/105106205/

Mapping with Programme outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	M	S	M	S	S
CO2	S	M	S	S	S	S	M	S	S	S
CO3	M	S	S	S	S	S	S	S	S	S
CO4	S	M	S	S	S	S	M	S	S	S
CO5	M	S	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Practical Course

Course code	PRACTICAL – I	Organic Chemistry – I	L	T	P	C
PRACTICALS			0	0	6	4
Pre-requisite		Knowledge on organic synthesis	Syllabus rsion			

Course Objectives:

The main objectives of this course are to:

1. To learn the separation techniques and systematic analysis of organic mixtures.
2. To know how to distinguish between aromatic-aliphatic, saturated-unsaturated compounds and to find out elements present and functional groups.
3. To develop the skill for the preparation of organic compounds involving the following reactions: hydrolysis, acetylation, bromination, nitration, benzoylation and oxidation motivate the students to understand the basic principles of chemical kinetics, potentiometric and conductometric titrations.
4. To execute the idea about recrystallisation

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand the separation techniques and systematic analysis of organic mixtures	K2
2	To distinguish between aromatic-aliphatic, saturated-unsaturated compounds and to find out elements present and functional groups	K3
3	To develop skill for the preparation of organic compounds involving the following reactions: hydrolysis, acetylation, bromination, nitration, benzoylation and oxidation	K4
4	To execute the idea about recrystallisation.	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

	Analysis of two components – component mixtures. Separation and characterization of compounds.	**30 hours**
	About ten preparations involving one or two or three stages comprising of the following processes:	**30 hours**

Nitration, acylation, halogenation, diazotisation, rearrangement, hydrolysis, reduction, alkylation and oxidation and preparations illustrating the following: Benzoin condensation, Cannizzaro reaction, Perkin reaction, Reimer-Tiemann reaction, Sandmeyer reaction, Fries rearrangement, Skraup synthesis.

Note: A minimum of six organic mixtures should be analyzed by each student. A minimum of ten preparations involving one or two stages should be done by each student

	Total Lecture hours	**60 hours**

Text Book(s):

1.Vogel‟s Text book of practical organic chemistry, 5th edition, Prentice Hall, 2008

Reference Books

1	N.S. GnanaPrakasam, G.Ramamurthy, Organic chemistry Manual, S.Viswanathan Co., Ltd
2	Raj K Bansal, Laboratory manual of organic chemistry, III edn, New age international (p) Ltd, 1996

Mapping with Programme outcomes

PO / **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	S	S	M	S	M	S	S
CO2	S	M	S	S	S	S	M	S	S	S
CO3	M	S	S	S	S	S	S	S	S	S
CO4	S	M	S	S	S	S	M	S	S	S

*S-Strong; M-Medium; L-Low

Course code	PRACTICAL – II	Inorganic Chemistry – I	L	T	P	C
PRACTICALS		PRACTICAL – II	0	0	6	4
Pre-requisite		Knowledge on organic synthesis	Syllabus Version			

Course Objectives:

The main objectives of this course are to:

1. To acquire knowledge about the analysis of mixtures of cations each consisting of two familiar metal cations and two less familiar metal cations.
2. To understand the preparation of metal complexes.
3. To know reaction behind the separation of cations.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To analysis of mixtures of cations each consisting of two familiar metal cations and two less familiar metal cations	K4
2	To understand the principles behind analysis of mixtures of cations	K2
3	To apply the knowledge for the preparation of metal complexes.	K3
4	To evaluate the estimation of metal ions using colorimetry.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

	Analysis of two components – component mixtures. Separation and characterization of compounds.	**30 hours**

Qualitative analysis, employing semimicro methods and spot tests of mixtures of common cations and ions of the following less familiar elements. Thallium, Tungsten, Selenium, Tellurium, Molybdenum, Cerium, Thorium, Titanium, Zirconium, Vanadium, Beryllium, Uranium and Lithium.

		30 hours

About ten preparations involving different techniques selected from the following: Lead tetra acetate, dipyridiniumhexachloroplumbate, hydroxylamine hydrochloride,
ortho-and para-hydroxy phenyl mercuric chloride, potassium cupric chloride, chrome alum, copper(I) chloride, trithio urea copper(I), potassium trioxalato-aluminato(III), potassium trioxalato chromate(III), potassium trioxalato ferrate(III), hexamine cobalt(III) chloride, chloropentammine chromium(III), chloroaquopentammine chromium(III) nitrate, tetrammine copper(II) sulphate, ammonium hexachlorostanate(IV).

Note: A minimum of six inorganic mixtures, each of two common and two rare elements should analysed by a student. A minimum of six preparations should be done by a student.

	Colorimetric estimations	

Colorimetric estimations (using Nessler technique and colorimeters) of copper, iron, nickel, manganese, chromium and zirconium.

	Total Lecture hours	**60 hours**

Text Book(s):

1.V.V.Ramanujam, Inorganic Semimicro qualitative analysis, 3rd edition, National Publishing company,1974	
Reference Books	
1	R.Mukhopadhyay&P.Chatlerjee, Advanced Practical Chemistry,Book& Allied (p) ltd 2007. C
2	J.Mendham, R.C. Denney, M.J.K.ThomasDarid&J.Bares, Vogels quantitative chemical analysis, 6h edition prentice hall 2000.
3	Vogel's qualitative Inorganic analysis, 6th edition Longman.

Mapping with Programme outcomes

PO / **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	M	S	S	S	S	M	S	S	S
CO2	M	S	S	S	S	S	S	S	S	S
CO3	S	M	S	S	S	S	M	S	S	S
CO4	M	S	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	PRACTICAL – III	Physical Chemistry – I	L	T	P	C
PRACTICALS			0	0	6	4
Pre-requisite		Knowledge on basis of physical Chemistry	Syllabus Version			

Course Objectives:

The main objectives of this course are to:

1. To understand the simple eutectic system, molecular weight determination by Rast method, partition coefficient.
2. To recognize the principle of acid base titration, redox titration and precipitation titration using potentiometry.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand the simple eutectic system, molecular weight determination by Rastmethod, partition coefficient.	K4
2	Recognized the principle of acid base titration, redox titration and precipitation titration using potentiometry.	K2
3	To evaluate the thermodynamic quantities from e. m. f. data	K5
4	To analyze the refractive index mixture	

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

	Analysis of two components – component mixtures. Separation and characterization of compounds.	**60 hours**

Thermodynamics:
a. Heat of solution from solubility
b. Heat of solution by calorimetry Molecular weight determination by
i. Freezing point depression of solvents (benzene and water) by Beckmannmethod.
ii. By Rastmicromethods

Distribution of activity and activity co-efficients by freezing point method.
Distribution co-efficient and determination of equilibrium constant.
Properties of matter:
Variation of viscosity of liquids with temperature.
Determination of refractive index (Unknown composition of a mixture of liquids).
Heterogeneousequilibria
Thermal analysis of binary systems forming compounds with congruent melting points.
Three component systems (chloroform-acetic acid-water).
Electromotive force Determination of standard potentials (Cu, Zn, Ag)
Evaluation of thermodynamic quantities from e. m. f. data (Daniel cell).
Determination of pH and pka values using hydrogen and quinhydrone electrodes and glass electrode (pH meter), potentiometric acid-base titrations.
Determination of formal redox potential of a redox system, redox titrations.

Determination of instability constant (of silver ammonia complex) and its dependence on temperature. Determination of solubility product of a sparingly soluble salt (concentration cell and chemical cell). Determination of activity co-efficients from e. m. f. data. Precipitation titration of a mixture of halides.		
	Total Lecture hours	**60 hours**
Text Book(s): **1.** P.S. Sindhu ―Practical in Physical Chemistry‖, Macmillan, 2005		
Reference Books		
1	H.R. Crockford, J.W. Nowell, –Laboratory manual of Physical Chemistry‖, John Wiley and Sons, Inc.	

Mapping with Programme outcomes

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	S	S	M	S	M	S	S
CO2	M	S	S	S	S	S	S	S	S	S
CO3	S	M	M	M	S	S	M	S	S	S
CO4	M	S	S	S	S	M	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	PRACTICAL – IV	Organic Chemistry – II	L	T	P	C
PRACTICALS			0	0	6	4
Pre-requisite		Knowledge on organic separation	Syllabus rsion			

Course Objectives:

The main objectives of this course are to:

1. To know about the estimation of phenol, methyl ketone, glucose, nitro, amino, and methoxy groups.
2. To acquire knowledge about the analysis of oils (RM value, iodine value, saponification value and acetyl value), extraction and estimation of active constituents like lactose from milk, caffeine from tea.
3. To understand the preparation of organic compounds.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To evaluate the amount of phenol, methyl ketone, glucose, nitro, amino, and methoxy groups present in organic compounds.	K5
2	To analyze the oil by using various methods	K4
3	To develop skill for the preparation of organic compounds from literatures.	K3
4	To apply the separation skills to extract various compounds from the natural source	K3

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

	Estimation	**20 hours**

Estimation of phenol, methyl ketone, glucose, nitro, amino and methoxy groups, unsaturation.

	Analysis of oils	**20 hours**

Reichart – Meisel value, Iodine value, Saponification value and acetyl value.

	Extraction and estimation of active constituents:	**20 hours**

a. Lactose from milk
b. Caffeine from tea
c. Nicotine from tobacco extract
d. Citric acid or ascorbic acid from a tablet or from a natural source.

About five preparations from literature.

	Total Lecture hours	**60 hours**

Text Book(s):

1.Vogel‟s Text book of practical organic chemistry, 5th edition, Prentice Hall, 2008

Reference Books	
1	N.S. GnanaPrakasam, G.Ramamurthy, Organic chemistry Manual, S.Viswanathan Co., Ltd

Mapping with Programme outcomes

PO / **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	S	S	M	S	M	S	S
CO2	M	S	S	S	S	S	S	S	S	S
CO3	S	M	M	M	S	S	M	S	S	S
CO4	M	S	S	S	S	M	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	PRACTICAL – V	Inorganic Chemistry – II	L	T	P	C
PRACTICALS		PRACTICAL – V	0	0	6	4
Pre-requisite		Knowledge on organic synthesis	Syllabus rsion			

Course Objectives:

The main objectives of this course are to:

1. To acquire knowledge about industrial analysis of brass, bronze, stainless steel, cement and glass.
2. To understand the mechanism behind the preparation of metal complexes
3. To know about the estimation of metal ions using volumetric and gravimetric estimations.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To analyze the industrial samples such as brass, bronze, stainless steel, cement and glass.	K4
2	To understand the mechanism behind the preparation of metal complexes	K2
3	To evaluate the amount of metal ions using volumetric and gravimetric estimations.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

	Industrial analysis:	**20 hours**

a. Analysis of two of the following alloys – brass, bronze, stainless steel, solder type metal.
b. Analysis of any one of the following – cement, dolomite, glass.

	Titrimetry:	**20 hours**

Oxidation using ceric and vanadium salts: Complexometric titrations involving estimation of calcium, magnesium, nickel, zinc and hardness of water.

	Chromatography:	**5 hours**

Column, paper, thin layer and ion exchange.

	Titrations in non-aqueous solvents	**5 hours**
	Preparation, analysis and study of the properties of co-ordination complexes	**10 hours**

Note: Quantitative analysis (involving volumetric and gravimetric estimations) of at least five mixtures of cations should be done by a student. The volumetric procedure may also include EDTA titration for estimation of mixtures of cations.

	Total Lecture hours	**60 hours**

Text Book(s):

1.R.Mukhopadhyay&P.Chatlerjee, Advanced Practical Chemistry,Book& Allied (p) ltd 2007. C	
Reference Books	
1	J.Mendham, R.C. Denney, M.J.K.ThomasDarid&J.Bares, Vogels quantitative chemical analysis, 6h edition prentice hall 2000.

Mapping with Programme outcomes

PO / **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	S	S	M	S	M	S	S
CO2	S	M	S	S	S	S	M	S	S	S
CO3	M	S	S	S	S	S	S	S	S	S
CO4	S	M	S	S	S	S	M	S	S	S

*S-Strong; M-Medium; L-Low

Course code	PRACTICAL – VI	Physical Chemistry – II	L	T	P	C
PRACTICALS			0	0	6	4
Pre-requisite		Knowledge on basis of physical Chemistry	Syllabus Version		2021-	

Course Objectives:

The main objectives of this course are to:

1. To recognize the principle of acid base titration, redox titration, and precipitation titration using conductometry.
2. To study the rate of polymerization of monomer solutions by viscosity.
3. To know about the rate of reaction between persulphate and iodide ions.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand the principle of acid base titration, redox titration, and precipitation titration using conductometry	K2
2	To analyze the rate of polymerization of monomer solutions by viscosity.	K4
3	To evaluate the rate of reaction between persulphate and iodide ions	K5
4	To apply a kinetics to different reactions.	

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

60 hours

Conductivity experiments:
Determination of

i) Equivalent conductance of a strong electrolyte and the verification of Debye-HuckelOnsagar law.
ii) Verification of Ostwald dilution law and kohlrausch law for weak electrolytes.

Conductometric determination of pka of a weak acid.
Hydrolysis constant of aniline hydrochloride.
Determination of the solubility of a sparingly soluble salt.
Conductometric titrations:
Acid-base and precipitation titrations (including mixture of halides).
Colorimetric estimation using Beer-Lambert law (copper, nickel).

Dropping mercury cathodes – half-wave potentials and estimations by differential method of cadmium, copper, zinc and lead.

Chemical kinetics:
i. Evaluation of Arrhenius parameters using acid hydrolysis of an ester.
ii. Base catalyzed hydrolysis of an ester conductometrically.

Rate of reaction between persulphate and iodide ions study of salt effects over the persulphate – iodide reaction.
Study of rate of polymerization of monomer solutions by viscosity.
Evaluation of

i) Catalytic constant of a strong acid for the iodination of acetone or hydrolysis of an ester.

ii)	Catalytic constants for weak acids and verification of Bronsted catalysis law. Adsorption experiments: Adsorption of oxalic, acetic, formic acids on activated charcoal – Freundlish isotherm – surface area determination.	
	Total Lecture hours	**60 hours**
Text Book(s): **1.** P.S. Sindhu ―Practical in Physical Chemistry‖, Macmillan, 2005		
Reference Books		
1	H.R. Crockford, J.W. Nowell, –Laboratory manual of Physical Chemistry‖, John Wiley and Sons, Inc.	

Mapping with Programme outcomes

PO **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	S	S	M	S	M	S	S
CO2	M	S	S	S	S	S	S	S	S	S
CO3	S	M	S	S	S	S	M	S	S	S
CO4	M	S	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low


Elective Course

Course code	GROUP A: Elective PAPER I&GROUP D: Elective PAPER IV	DYE CHEMISTRY	L	T	P	C
Elective		GROUP A: Elective PAPER I&GROUP D: Elective PAPER IV	3	0	0	3
Pre-requisite		Fundamentals about the Dye	Syllabus			

Course Objectives:

The main objectives of this course are to:

1. To understand the chemistry of dyes
2. To interpret the various types of dyes, synthesis, reactions and applications
3. To recognise the pigments, cosmetics and colouring agents

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Learnt the chemistry of dyes	K3
2	Studied the organic intermediate in the dye chemistry	K4
3	Gained the knowledge to interpret the various types of dyes, synthesis, reactions andapplications	K4
4	Expertise in the pigments, cosmetics and colouring agents	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1		**9 hours**

Colour and Constitution: Relationship of colour observed to wavelength of light absorbed – Terms used in colour chemistry – chromophores, Auxochromes, Bathochromic shift, Hypsochrmic shift. Quinonoid theory and modern theories: Valence bond theory, molecular orbital theory.

Unit:2		**9 hours**

Chemistry of organic intermediates used in dye manufacture. Benzene, Naphathalene and Anthroqucnone intermediates. Nitro dyes, Nitrosodyes, Azo dyes – principles governing azo coupling – mechanism of diazotization coupling with amines, coupling with phenols. Classification according to the number of azo groups and application – Tautomerism in azo dyes.

Unit:3		**9 hours**

Synthesis of specifics dyes and uses Orange IV, Diamond Block F, Metanil yellow, Tartrazines Direct Deep Black, Eriochrome Black T, Eriochrome Red B, Cellition Scarlet B, Congo Red, Malachite

green, methylene blue, Safranine – T, Acid Magenta, Cyanin Green G, Alizarine, Benzanthrone, Indigo, Copper phthalo cyanine, Sulphur black – T .		
Unit:4		**8 hours**
Synthesis, reactions and applications of xanthene dyes, _Cyanine dyes, acridine dyes, Sulphur dyes, Anthranquinone dyes: Anthraquinone mordant dyes, Anthroquinone acid dyes and Anthraqyinone disperse dyes.		
Unit:5		**8 hours**
Pigments – Introduction - Requirements of organic pigments Types of Pigments – Applications. Fluorsecent. Brightening agents – application of dyes in other areas – Leather, paper, medicine, chemical analysis, cosmetics, colouring agents Food and Beverages		
Unit:6		**2 hours**
Seminar, Webinar, Workshop, Training		
	Total Lecture hours	**45 hours**

Text Book(s)

1. Organic chemistry volume – I I.L.Finar

2. The chemistry of synthetic dyes volume I, III, III+IV K. Venkataraman.

Reference Books

1	Synthetic Dyes – GurdeepR.Chatwal
2	An Introduction to synthetic drugs and dyes Ra. Chawathe.Shah.
3	An introduction to industrial chemistry B.K.Sharma.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/116/104/116104044/

Mapping with Programme outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	M	S	M	S	S
CO2	S	M	S	S	S	S	M	S	S	S
CO3	M	S	S	S	S	S	S	S	S	S
CO4	S	M	S	S	S	S	M	S	S	S

*S-Strong; M-Medium; L-Low

Course code	GROUP C: Elective PAPER III	Kinetics of polymerization	L	T	P	C
Elective		GROUP C: Elective PAPER III	3	0	0	3
Pre-requisite		Fundamentals about the polymers	Syllabus rsion			

Course Objectives:

The main objectives of this course are to:

1. To understand the kinetics of step polymerisation, radical chain polymerisation and ionic chain polymerisation
2. To acquire the knowledge about chain copolymerisation and its kinetics in detail
3. To recognise the Zigler –Natta catalysis, role of Zigler-natta catalyst in polymerization and basic kinetics

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand the kinetics of step polymerization and radical chain polymerization and ionic chain polymerisation	K2
2	To apply knowledge for polymerization mechanism in industrial need.	K3
3	To apply the Zigler –Natta catalyst in polymerization reaction	K3
4	To acquire the knowledge about chain copolymerisation and its kinetics in detail	K4
5	To understand the different types of copolymer	K2

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1 **9 hours**

Step polymerization: Theory of reactivity of large molecules, reactivity of functional groups and molecular size. kinetics of step polymerization, self catalysedpolymerization,external catalysis of polymerizations. CycizationVs linear polymerization, thermodynamic and kinetic consideration. Molecular weight control and distribution in Linearpolymerization

Unit:2 **9 hours**

Kinetics of‘ radical chain polymerization: Kinetic scheme for polymerization in the presence of an initiator. Thermal decomposition of initiators. redox initiation. Photochemical initiation, propagation and terminations — rate expression. Initiator efficiency, auto acceleration mechanism. Kinetics of chain transfer, chain transfer to monomer, initiation and solvents.

Unit:3 **9 hours**

Ionic chain polymerization: Comparision of radical and ionic polymerizations. Cationic polymerization - initiation, propagation and termination - chain transfer to monomer spontaneous and backbiting. Kinetics expression and validity of steady state assumption. The nature and mechanism of anionic polymerization, effect of monomers, initiators and solvents. Initiation, termination - polymerization

without termination, termination by impurities and added transfer agents. Kinetics of polymerization withterminations.

Unit:4		**8 hours**

Chain copolymerization Types of copolymers, evaluation of monomer reactivity ratio copolymer composition, the copolymer equation. Types — of copolyrnerizationbehaviour — ideal co-polymerization, alternating copolymerization and block — copolymerizations. The Q-e scheme and rate of copolymerization — chemical controlled termination, diffusion controlled termination.

Unit:5		**8 hours**

Ziegler — Natta catalysis and polymerization: Definition Ziegler-Natta catalysts, chemical description of Ziegler-Nattn catalysts for olefins, co-factors determining behaviour of catalysts. modification of Ziegler—Natta catalysts by third components, mechanisms for initiation and propagation mechanisms for stereochemical control of alpha—olefins. isotactic and syndiotacticpropagation. Basic kinetics schemes and rate of polymerization.

Unit:6		**2 hours**

Seminar, Webinar, Workshop, Training

	Total Lecture hours	**45 hours**

Text Book(s)

1. P.J. Flory : Principles of‘ Polymer Chemistry, CornellUnit, Press. New York,1953
2. HR. Allcock and F.W. Lampc : Contemporary Polymer Chemistry, PrenticeHall, Englewood, NJ,1981

Reference Books

1	N.G. Gaylord and H.F.Mark : Linear and StereographerAdditionPolymers, Wiley (lnterscience), New York,1959
2	F.W.Billmeyer : Jr. Textbook of Polymer Science, Wiley,New York,1984
3	R.B. Seymour and CE. Carraher : Polymer Chemistry, An IntroductionDekker, New York,1981
4	T Keii : Kinetics of Ziegler — Natta Polymerization; Chapman and Hall,1972

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/104/105/104105124/
2	https://nptel.ac.in/courses/103/106/105106205/

Mapping with Programme outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	S	S	S	S	S	S	S
CO2	S	M	S	S	S	S	M	S	S	S
CO3	S	S	M	S	S	M	S	M	S	S
CO4	S	M	S	S	S	S	M	S	S	S
CO5	M	S	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	GROUP A: Elective Paper IV	Industrial Chemistry	L	T	P	C
Elective		GROUP A: Elective Paper IV	3	0	0	3
Pre-requisite		Fundamentals of chemistry behind the industry	Syllabus Version			

Course Objectives:

The main objectives of this course are to:

1. To understand the chemistry of fuel petroleum and nuclear fuels
2. To acquire brief knowledge about rubber, glass, cement, ceramics, paints, pigments, fertilisers and explosion.
3. To know about the applications of rubber, glass, cement, ceramics, paints, pigments, fertilisers and explosion.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand the chemistry of fuel petroleum and nuclear fuels.	K2
2	To acquire brief knowledge about rubber, glass, cement, ceramics, paints, pigments, fertilizers and explosion.	K3
3	To understand the chemistry of rupper, glass, cement, ceramics, paints and pigments	K2
4	To create the new paints, ceramics and pigments based the knowledge acquired.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1 **9 hours**

Fuels: Introduction – what is a fuel – calorific value – classification of fuels properties of fuels – petroleum: classification of petroleum – Origin of petroleum – petroleum resources in India – Cracking of petroleum: Thermal cracking – catalytic cracking – knocking – chemical structure and knocking – octane rating. Improvement of anti- knocking characteristics of fuel. Non petroleum fuels. Benzol and power alcohol. Nuclear fuels: Nuclear reactor, Breeder reactor Disposal of radio active wastes.

Unit:2 **9 hours**

Rubber: Importance of rubber – Coagulation of rubber – Draw backs of raw rubber –Vulcanisation of rubber – Properties of vulcanized rubber. Synthetic rubber – Buna – s, Neoprene rubber, Buna – N, Thiokol, silicone rubber, Spong rubber, Foam rubber

Unit:3 **9 hours**

Glass: Introduction – physical and chemical properties of glass –Raw materials – methods of manufacture: Formation of the Batch material, melting, shaping, Annealing and finishing. Cement: Manufacture and setting of cement. Ceramics: Manufacturing process – Application of clolurs to the pottery – Earthenware‘s and stonewares.

Unit:4		**8 hours**
Paints and pigments; Pigments: Introduction – Requirements of a pigment Typical inorganic pigments – Application. Paints: Classification of paints – Distempers- constituents of paints – setting of the paint – Requirements of a good paint – Emulsion paints – Latex paints – paint removers – Varnishes – Solvents and thinners.		
Unit:5		**8 hours**
Unit V Fertilizers: Plant nutrients – Fertilizers type – Essential requirements – Fertility of the soil – PH. value of the soil, classification of fertilizers, straight and mixed fertilizers. Nitrogenous fertilizers: Manufacture of Ammonium nitrate, Ammonium sulphate, Urea, nitrolim, CAN. Phosphatic fertilizers: Normal superphosphate and triple superphosphate. Potassiumfertilizers. Explosives: Introduction - Classification – Characteristics, Nitro Cellulose – TNB - TNT – Dynamite – Cordite, Gun Powder – RDX – HMX - Tetryl – Pentryl – Hexyl.		
Unit:6		**2 hours**
Seminar, Webinar, Workshop, Training		
	Total Lecture hours	**45 hours**

Text Book(s)

1. Industrial Chemistry – B. K.Sharma
2. Engineering Chemistry –Sharma

Reference Books

1	Engineering Chemistry - P.C. Jain & Monika Jain
2	Industrial Chemistry – B. N.Chakarbarty
3	Engineering Chemistry – KuriaKose**&**Chemical technology –Shukla

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/116/104/116104044/
2	https://nptel.ac.in/courses/103/107/103107086/
3	https://nptel.ac.in/courses/105/106/105106178/

Mapping with Programme outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	S	S	S	M	S	S	S
CO2	M	S	S	S	S	S	S	S	S	S
CO3	S	M	S	S	S	S	M	S	S	S
CO4	M	S	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	GROUP A & B: ELECTIVE Paper II	Water Pollution and Industrial Effluents treatment	L	T	P	C
Elective		GROUP A & B: ELECTIVE Paper II	3	0	0	3
Pre-requisite		Fundamentals of pollution	Syllabus rsion			

Course Objectives:

The main objectives of this course are to:

1. To acquire knowledge about characteristics of water in detail.
2. To understand water pollution, complete physico chemical examination of water.
3. To recognize industrial effluents and their treatment in brief.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand characteristics of water indetail.	K2
2	To apply the knowledge on water pollution.	K3
3	To analyse the complete physico chemical features of water.	K5
4	To evaluate the industrial effluents and their treatment in brief.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1 **9 hours**

Characteristics of water – Introduction – sources of water – Hardness of water - Units of hardness – problems on calculation of hardness – Disadvantages of hard water – Scale and sludge formation in boiler – Boiler Corrosion - Softening methods – problems on softening – desalination of Brackish water: Distillation, Electro dialysis and reverse osmosis.

Unit:2 **9 hours**

Water Pollution: Introduction – Definition of water pollution – water Pollutants – physical and chemical pollution of water – ground water pollution – harmful effects of ground water pollution – surface water. River water and sea water pollution, Oil pollution of water. Effects oil pollution in marine water – Radioactive materials in water.

Unit:3 **9 hours**

Complete physico chemical Examination of water: collection of samples – colour – odour Turbidity PH – temperature – Soilds: Total Solids, Dissolved solids, suspended solids, settable solids – Acidity – Free carbon dioxide – Alkalinity – Hardness – calcium, Magnesium, Sodium - Potassium - Iron – Aluminum – Sulphate – Silica – Heavy metal such as Arsenic, Calcium, chromium – copper – lead - Manganese – Mercury – Nickle – Selenium – Tin and Zinc – Dissolved Oxygen, BOD, COD, Permanganate value – Ammonia Nitrogen – Albuminoidal nitrogen – Total Kjeldhal Nitrogen etc.

Unit:4		**8 hours**
Industrial Effluents: Pulp and paper industries Cotton Processing – Cane sugar industry - Distillery – Dairy– Iron production. Electroplating industry – oil field and oil refinery – Fertilizer industry - Pesticide manufacture - Rubber wastes –Slaughter House and Meat packing – Soaps and Detergents manufacture - Soft Drinks Manufactures. Viscose rayon Manufacture – Radio active Pollution.		
Unit:5		**8 hours**
Treatment of Industrial Effluents : Primary Treatment: Screening – Sedimentation – Equalization – Neutralization – Coagulation. Secondary Treatment: Aerated Lagoons – Trickling Filtration – Activated sludge process – Oxidation. Ditch – Oxidation Ponds - Anaerobic digestion. Tertiary Treatment : Evaporation – Reverse osmosis – Dialysis – Ion Exchange – chemical precipitation Activated Carbon Treatment. Tolerance limits for Industrial Effluents.		
Unit:6		**2 hours**
Seminar, Webinar, Workshop, Training		
	Total Lecture hours	**45 hours**

Text Book(s)

1. Industrial Effluents – N.Manivasakam
2. Physico chemical Examination of Water, sewage and Industrial Effluents – N. Manivasakam

Reference Books

1	Water Pollution P.K.Goel
2	Engineering chemistry P.C. Jain & Monika Jain
3	Environmental Chemistry B. K.Sharma
4	Insecticides, Pesticides and Agro based Industries R.C. Falful, K. Goel ,R.K. Gupta

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/123/105/123105001/
2	https://nptel.ac.in/courses/126/105/126105012/

:

Mapping with Programme outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	M	S	M	S	S
CO2	S	M	S	S	S	S	M	S	S	S
CO3	S	M	S	S	S	S	M	S	S	S
CO4	M	S	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	GROUP B & C Elective Paper I	GREEN CHEMISTRY	L	T	P	C
Elective		GROUP B & C Elective Paper I	3	0	0	3
Pre-requisite		Fundamentals of green chemistry	Syllabus rsion			

Course Objectives:

The main objectives of this course are to:

1. To implement the principles and tools of green chemistry
2. To acquire knowledge about microwave assisted organic synthesis and its advantages
3. To understand the terms ionic liquid & PTC and their applications in green chemistry
4. To review the use of supported catalysis, biocatalysts, alternative synthesis, reagents and reaction conditions used in green chemistry.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand and implement the principles and tools of greenchemistry.	K2 & K3
2	To apply the knowledge about microwave assisted organic synthesis and its advantages	K3
3	To understand the terms ionic liquid & PTC and their applications in green chemistry.	K2
4	To evaluate the use of supported catalysis, biocatalysts, alternative synthesis, reagents and reaction conditions used in green chemistry.	K5

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1		**9 hours**

Introduction to green chemistry: Green chemistry-relevance and goals, Anastas‘ twelve basic principles of green chemistry - Tools of green chemistry: alternative starting materials, reagents, catalysts, solvents and processes with suitable examples.

Unit:2		**9 hours**

Microwave mediated organic synthesis (MAOS): Microwave activation – advantage of microwave exposure – specific effects of microwave – Neat reactions – solid supports reactions _ Functional group transformations – condensations reactions – oxidations – reductions reactions – multi-componentreactions.

Unit:3		**9 hours**

Ionic liquids and PTC Introduction – synthesis of ionic liquids – physical properties – applications in alkylation – hydroformylations – expoxidations – synthesis of ethers – Friedel-craft reactions – Diels-Alder reactions – Knoevengal condensations – Wittig reactions – Phase transfer catalyst - Synthesis – applications.

Unit:4		**8 hours**

UNIT IV

Supported catalysts and bio-catalysts for Green chemistry

Introduction – the concept of atom ecomomy – supported metal catalysts – mesoporoussilicas – the use of Biocatalysts for green chemistry - modified bio catalysts – fermentations and biotransformations – fine chemicals by microbial fermentations – vitamins and amino acids - Baker's yeast mediated biotransformations– Bio-catalyst mediated Baeyer-Villiger reactions – Microbial polyester synthesis.

Unit:5		**8 hours**

Alternative synthesis, reagents and reaction conditions: A photochemical alternative to Friedel-crafts reactions - Dimethyl carbonate as a methylating agent – the design and applications of green oxidants – super critical carbon dioxide for synthetic chemistry.

Unit:6		**2 hours**

Seminar, Webinar, Workshop, Training

	Total Lecture hours	**45 hours**

Text Book(s)

1. Green Chemistry – Environmentally benign reactions – V. K. Ahluwalia. AneBooks India (Publisher). (2006).
2. Green Chemistry – Designing Chemistry for the Environment – edited by Paul T. Anastas& Tracy C. Williamson. Second Edition, (1998).

Reference Books

1	**References:** Green Chemistry – Frontiers in benign chemical synthesis and processes- edited by Paul T. Anastas& Tracy C. Williamson. Oxford University Press,(1998).
2	Green Chemistry – Environment friendly alternatives- edited by RashmiSanghi& M. M. Srivastava, Narora Publishing House, (2003).

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/104/105/104105087/
2	https://nptel.ac.in/courses/104/103/104103022/

Mapping with Programme outcomes

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	M	S	S	S	S	M	S	S	S
CO2	M	S	S	S	S	S	S	S	S	S
CO3	S	M	S	S	S	S	M	S	S	S
CO4	M	S	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	GROUP B :Elective Paper III	Medicinal Chemistry	L	T	P	C
Elective		GROUP B :Elective Paper III	3	0	0	3
Pre-requisite		Fundamentals of medicinal chemistry	Syllabus rsion			

Course Objectives:

The main objectives of this course are to:
1. To understand the terminologies used in drug chemistry, common types ofcommunicable diseases, drug mechanism and action
2. To acquire detailed knowledge in drug design and structure activity relationship
3. To know about various types of therapeutic agents

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Understood the terminologies used in drug chemistry, common types of communicable diseases, drug mechanism and action.	K2
2	Acquired detailed knowledge in drug design and structure activityrelationship.	K5
3	To analyze various types of therapeutic agents.	K4
4	To create new drugs for various applications.	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1 **9 hours**

Drugs: Introduction, Terminologies used in drug chemistry. Drugs and Diseases- diseases transmission. Common types of communicable diseases – Cholera, Malaria, Lymphatic Filariasis, Jaundice, Anaemia.

Unit:2 **9 hours**

Drug metabolism and action: Requirements of an ideal drug, drug metabolism, effect of age, species and strain difference, hereditary and genetic factors on drug metabolism, role of cytochromes in drug metabolism, The P-450 Catalytic Cycle, metabolic transformation of Halothane, Phase I-Non-synthetic reactions, Phase II-synthetic reactions,

Unit:3 **9 hours**

Drug design and structure activity relationship: a general treatment of the approachesto drug designs, including the methods of variation, study of the use of biochemicaland physiological information involving new drugs. Basic consideration of drug design – Denovo drug design – lead seeking methods, structural factors in drug design, physical and chemical factors in drug design.

Unit:4 **8 hours**

Quantitative Structure Activity Relationship (QSAR): Fundamentals of QSAR – objectives, expressions of biological activity, parameters related to chemical structure, correlative methods and analysis of results. A study of the SAR of important categories of drugs. Therapeutic targets for drug discovery.

Unit:5		**8 hours**
Therapeutic agents: Antibiotics - β-lactam antibiotics, aminoglycosidal antibiotics, tetracyclines, chloramphenicol and antitumour antibiotics. Analgesic – Endogenous analgetic peptides, Opioid analgetic peptides and their simplified structures. Anti-inflammatory agents. Diuretics. Psychopharmacological drugs, Cardiac drugs, Antihypertensive agents, Cardiac glycosides, Anticancer agents. Antiviral agents.		
Unit:6		**2 hours**
Seminar, Webinar, Workshop, Training		
	Total Lecture hours	**45 hours**

Text Book(s)

1. William Paul Purcell, George E. Bass, John Mark Clayton, Strategy of Drug Design, John Wiley & Sons Inc,1973.
2. Wilson, Charles O. & Ole Gisvold, Textbook of Organic Medicinal and Pharmaceutical Chemistry, Lippincott publishers, 1962.

Reference Books

1	**References:** Graham L. Patrick- An Introduction to Medicinal Chemistry, Oxford University Press, USA; 3rd edition, 2005.
2	K. BagavathiSundari –Applied Chemistry, MJP Publishers, 2006.
3	Alfred Burger & Manfred E. Wolff, Burger's Medicinal Chemistry, John Wiley & Sons Inc; 4th edition, 1981.
4	E. J. Ariens- Drug Design, Academic Press1980.
5	William O. Foye, Thomas L. Lemke, David A. Williams, Principles of Medicinal Chemistry, Williams & Wilkins; 4th edition,1995.
6	H. John Smith, Smith and Williams' Introduction to the Principles of Drug Design and Action, Fourth Edition, CRC; 4th edition, 2004.
7	Stanley M. Roberts & R.F. Newton- Prostaglandins and Thromboxanes, Butterworth- Heinemann Ltd, 1982.
8	Jasjit S. Bindra&RanjnaBindra- Prostaglandin Synthesis, Butterworth-Heinemann, Ltd., 1982.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/104/106/104106106/

Mapping with Programme outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	M	S	M	S	S
CO2	S	M	S	S	S	S	M	S	S	S
CO3	M	S	S	S	S	S	S	S	S	S
CO4	M	S	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	GROUP B: ELECTIVE PAPER IV	APPLIED ELECTROCHEMISTRY	L	T	P	C
Elective		GROUP B: ELECTIVE PAPER IV	3	0	0	3
Pre-requisite		Fundamentals of electrochemistry	Syllabus rsion			

Course Objectives:

The main objectives of this course are to:
1. To understand principles of corrosion, corrosion monitoring and corrosion inhibition..
2. To Learn the electroanalytical techniques like cyclic voltammetry, anodic stripping voltammetry and electrogravimetry

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand the principle and importance of corrosion.	K2
2	Recognized the principles, importance and classification of corrosion and corrosion monitoring methods.	K4
3	Gained the knowledge about corrosion inhibition in detail.	K5
4	Understood the theory, basic instrumentation and applications of various electroanalytical techniques used in corrosion.	K2

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1		**9 hours**

Principles of corrosion Definition – cost of corrosion – importance of corrosion studies – classification of corrosion – expression for corrosion rates – Electrochemical principles of corrosion

Unit:2		**9 hours**

Corrosion monitoring Coupon (weight loss) method – electrical resistance method – gasometric method – potentiodynamic polarization method – impedance method – hydrogen permeation method

Unit:3		**9 hours**

Corrosion inhibition – definition – importance – classification of inhibitors – based on electrode process – based on environment – mechanism of inhibitor action in acidic environment

Unit:4		**8 hours**

Electroanalytical Techniques – I Cyclic voltammetry (CV)– theory – basic instrumentation – applications Anodic stripping voltammetry (ASV)– theory – basic instrumentation –applications.

Unit:5		**8 hours**

Electroanalytical Techniques – II Bulk electrolysis- electrogravimetry – controlled potential (potentiostatic) electrogravimetry – electroseparation – controlled current (coulostatic)

electrogravimetry – current – time behaviour – comparative account of potentiostatic and coulostatic techniques.		
Unit:6		**2 hours**
Seminar, Webinar, Workshop, Training		
	Total Lecture hours	**45 hours**

Text Book(s)

1. An Introduction to metallic corrosion and its prevention by Raj Narayanan.
2. Vogel's Textbook of Quantitative Chemical Analysis by G.H. Jeffery, J. Bassett, J. Mendham, and R.C.Denney , Longman Scientific & Technical, 5th edition,1989.

Reference Books

1	Electrochemical methods – fundamentals and applications – Allen J. Bard and Larry R.Faulkner, Wiley International editions
2	Electroanalytical chemistry – Basil H. Vassons and Galen W. Ewing, Wiley Inter science Publication1983
3	Chemistry Experiments for Instrumental methods – Donald T. Sawyer, William R. Heineman, Janice M. Beebe, John Wiley & Sons, 1984.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/113/104/113104082/
2	https://nptel.ac.in/courses/113/104/113104089/

Mapping with Programme outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	M	S	M	S	S
CO2	S	M	S	S	S	S	M	S	S	S
CO3	S	M	S	S	S	S	M	S	S	S
CO4	M	S	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	GROUP C - ELECTIVE PAPER II	ADVANCED POLYMERIC MATERIALS	L	T	P	C
Elective		GROUP C - ELECTIVE PAPER II	3	0	0	3
Pre-requisite		Fundamentals of polymer chemistry	Syllabus rsion			

Course Objectives:

The main objectives of this course are to:
1. To choose any research work related to the advanced polymeric materials.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Acquire the knowledge about dendrimers, hyper-branched polymers and polymer nano composites.	K4
2	Recognise the importance of synthetic biomedical polymers for drug delivery and conducting polymers.	K5
3	Understand the synthetic route, structure, properties and uses of engineering plastics.	K2

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	**9 hours**

Dendrimers and hyperbranched polymers Properties of Dendrimers and Hyperbranched Polymers and their Blends: Dendrimers and their structure, synthesis of Dendrimers, Hyperbranched Polymers and their structure. Synthesis of hyperbranched polymers, branching and polydispersity, conformation, general concepts of polymer blends. Blends of Dendritic polymers with thermoplastics.

Unit:2	**9 hours**

Polymer nano composites Polyamide/clay nano composites - Synthesis, characterization and properties of Nylon 6- clay hybrid. Polystyrene/clay nano composites – Surface initiated polymerization, syndiotactic polystyrene / clay nano composites, properties. Poly (butylenes terephthalate) (PBT) based nano composites, Epoxy nano composites on layered silicates. Polypropyelene layered silicate nanocomposites.

Unit:3	**9 hours**

Synthesis Biomedical polymers for drug delivery Polymers as biomaterials, biomedical applications of synthetic polymers, synthetic polymers for biomedical applications, poly(α-hydroxy esters), poly (lactic acid), poly (anhydrides), poly (phosphazenes), controlled drug delivery, methods of drug delivery,

Unit:4	**8 hours**

Conducting polymers Correlation of chemical structure and electrical conductivity. Structure of conducting polymers Poly (acetylene), poly (pyrrole)s, poly (thiophene)s, polyanilines, poly (p-phenylenesulphide), poly (p-phenylenevinylene)s. Different methods of synthesis of polyaniline: solution polymerization, interfacial polymerization, electrochemical synthesis, enzyme synthesis and photo induced polymerization of aniline. Applications of conducting polymers: Membranes and ion

exchanger, corrosion protection, gas sensors, biosensors, electrocatalysis.

Unit:5		**8 hours**

Engineering plastics Acrylonitrile butadiene styrene (ABS),Polycarbonates (PC),Polyamides (PA), Polybutylene terephthalate (PBT), Polyethylene terephthalate (PET), Polyphenylene oxide (PPO),Poly sulphone (PSU), Polyether ether ketone (PEEK). Polyimides, Poly phenyleneSulphide (PPS), Synthetic route, structure, properties and uses.

Unit:6		**2 hours**

Seminar, Webinar, Workshop, Training

	Total Lecture hours	**45 hours**

Text Book(s)

1. Advance polymeric materials Editors : Gabriel O. Shonaike& Suresh G. Advani, CRCpress–2003.

Reference Books

1	Progress in preparation, processing and applications of polyaniline. Progress in polymer Science 34 (2009) 783 – 810
2	Monographs in electrochemistry Conducting polymers – a new era in electrochemistry Editor: F. Scholz Springer – Verlag, Germany
3	Polymer nano composites Editor: Y-W Mai, Wood head Publishing Ltd. 2006 M.Sc. Chemistry (Colleges) 2010-11

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/104/105/104105124/

Mapping with Programme outcomes

PO / CO	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	S	S	M	S	M	S	S
CO2	S	M	S	S	S	S	M	S	S	S
CO3	M	S	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	GROUP C - ELECTIVE PAPER IV	PHARMACEUTICAL CHEMISTRY	L	T	P	C
Elective		GROUP C - ELECTIVE PAPER IV	3	0	0	3
Pre-requisite		Fundamentals of pharmaceutical chemistry	Syllabus rsion			

Course Objectives:

The main objectives of this course are to:

1. To compete during their search for jobs in the pharmaceutical companies.
2. To acquire the knowledge about medicinal plants and medicinally important compounds.
3. To recognise the importance of Antibiotics, sulpha drugs, Analgesics
4. To analyze the Antipyretics, Antihypertensive, hypotensive and antineoplastic drugs.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand the important terminologies used in pharmaceutical chemistry, naming ofdrugs and mechanism of drug action	K2
2	To acquire the knowledge about medicinal plants and medicinally important compounds.	K4
3	To recognise the importance of Antibiotics, sulpha drugs, Analgesics,	K5
4	To analyze the Antipyretics, Antihypertensive, hypotensive and antineoplastic drugs.	

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	**9 hours**

Introduction Important terminologies used in pharmaceutical chemistry – pharmacology – drug – pharmocophore – antimetabolites – mutation – grams test – actinomycetes – immunological agents – vaccines – toxoids – immune – human sera – primary immunization – routes of drug administration – additive effect – synergism – antagonism – placebo – important drugs which cause dependence – dosage – mechanism of drug action – factors influencing the metabolism of drugs – principles of bio assay – encapsulation – naming of drugs

Unit:2	**9 hours**

Medicinal plants and medicinally important compounds Indian medicinal plants – medicinal plants in cure of diseases – spices as medicines – medicinal plants in the kitchen garden – plant poisoning – medicinally important compounds of Mg, Al, P, As, Hg and Fe-testing cholesterol in serum-estimation of bilirubin in serum – estimation of urea in serum and estimation of inorganic chlorides in blood serum.

Unit:3	**9 hours**

Antibiotics and Sulpha drugs Antibiotics – penicillin – semisynthetic penicillin – chloramphenicol – streptomycin – cephalosporin – antifungals – nystatin – griseofluvin. Sulpha drugs – sulphathiazole – sulphamerazine – sulphaguanidine – sulphadiazine - mechanism of action – uses.

Unit:4		**8 hours**
Analgesics and Antipyretics Introduction to pharmaceutical chemistry analgesics – Morphine analogues and its modification – Codeine – Synthetic narcotic analgesiscs – Pethidines and methadones – Narcotic antagonists – Nalorphine – Antipyretic analgesics – pyrazoles – salicylic acid – paraaminophenol derivatives – Aspirin and salol hypnotics and sedatives – Barbiturates – Benzodiazipines.		
Unit:5		**8 hours**
Antihypertensive, hypotensive drugs and antineoplastic drugs Antihypertensive and hypotensive drugs – mechanism of lowering blood pressure – α- methyl dopa – pargyline – bertyline – hydralazine – propranolol and antiarrhythmic agents, antitubercular drugs – PAS – INH – ethambutol, rifampicin – pyrazinamide. Antineoplastic drugs – alkylating agents – nitrogen mustards – aziridines – sulphonic acid esters – 1,2 – epoxides – antimetabolites – folic acid and pyrimidine antagonista – vinca alkaloids – hormones – oral contraceptives.		
Unit:6		**2 hours**
Seminar, Webinar, Workshop, Training		
	Total Lecture hours	**45 hours**

Text Book(s)

1. Berger, A medicinal chemistry, Wiley interscience, New York, Volume I and II, 1990.
2. AsutoshKar, Medicinal chemistry, Wiley Eastern Ltd, Chennai, 1992.

Reference Books

1	Bentley and Driver‘s, Textbook of Pharmaceutical Chemistry, 1985.
2	Wilson, O. Giswold and F. George, Textbook of Organic medicinal and pharmaceutical chemistry, Philadelphia, 1991.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/104/106/104106106/

Course Designed By:

Mapping with Programme outcomes

PO / CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	M	S	M	S	S
CO2	S	M	S	S	S	S	M	S	S	S
CO3	M	S	S	S	S	S	S	S	S	S
CO4	S	M	S	S	S	S	M	S	S	S

*S-Strong; M-Medium; L-Low

Course code	GROUP A: ELECTIVE PAPER III	Organic Synthetic Methodology, Oxidation and Reduction	L	T	P	C
Elective		GROUP A: ELECTIVE PAPER III	3	0	0	3
Pre-requisite		Fundamentals of organic chemistry	Syllabus Version			

Course Objectives:

The main objectives of this course are to:

1. To apply the IUPAC nomenclature in naming of acyclic and monocyclic compounds.
2. To acquire brief knowledge about various synthetic methodologies
3. To review the different types of reagents used in oxidation and reduction
4. To implement the applications of UV, IR, NMR and Mass spectral techniques

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To remember the IUPAC nomenclature in naming of acyclic and monocyclic compounds.	K4
2	To evaluate the various synthetic methodologies used for synthetic chemistry.	K5
3	To review the different types of reagents used in oxidation and reduction	K2
4	To implement the applications of UV, IR, NMR and Mass spectral techniques	

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1		**9 hours**

Nomenclature - IUPAC nomenclature of acyclic and monocyclic compounds- Nomenclature of bicyclic system – large ring compounds (muscone, civetone) Novel ring system – adamantane – diadamantane, cubane (strained ring) catenane (interlocked system), bulvalene (fluxional molecule) (Synthesis not necessary) **Reagents in Organic Synthesis -** Hexamethylphosphorictiamide (HMPT), Polyphosphoric acid (PPA), 1,3-dithiane (umpolung), Lithium dimethylcuprate (LDC), Lithium disopropylamide (LDA), crown ethers, Phase transfer catalysts (PTC).

Unit:2		**9 hours**

Synthetic Methodology – Retrosynthesis – disconnection approach – synthons and synthetic equivalents – guidelines for choosing disconnections– linear and convergent synthesis
- functional group interconversions – functional group addition-one group C-X disconnections – two group C-X bond disconnections – one group C-C bond disconnections – regioselectivity – two- group C-C bond disconnections - importance of the order of events – chemoselectivity – reversal of polarity. Protecting groups – protection of alcohols, carbonyl groups, carboxylic group and aminogroup.

Unit:3		**9 hours**

Oxidation – Jone‘s reagent, Chromyl chloride, Dioxiranes, DMSO, DMSO-Ac_2O, DMSO-oxalyl chloride (Swern reaction), Etard reaction, SeO_2, Lemieux reagents ($NaIO_4$ with $KMnO_4$& OsO_4), allylic oxidation (SeO_2& NBS), Fenton‘s reagent.oxidation of amines and sulphides, Wacker process

(ketone from alkene) and ceric ammonium nitrate (CAN).

Unit:4		**8 hours**

Reduction –Metal hydride reduction – typical reactions and conditions used –$NaCNBH_3$ reductions, hydroboration, 9BBN, tri –n- butyl tinhydride (TBH), DIBAL–H, Me_3SiCN, tri tertiarybutoxy aluminum hydride. Dissolving metal reductions –Rosenmund reduction, McMurrays coupling, acyloin condensation, Wilkinson's catalyst, Bakers yeast.

Unit:5		**8 hours**

Applications of UV, IR, ^1H NMR and Mass spectral techniques to solve the structures of simple organic molecules (simple problems based on data)

Unit:6		**2 hours**

Seminar, Webinar, Workshop, Training

	Total Lecture hours	**45 hours**

Text Book(s)

1. Jerry March, Advanced Organic Chemistry
2. House, Modern Synthetic Reactions
3. Carruthers, Some Modern Methods of Organic Synthesis

Reference Books

1	Norman, Principles of Organic Synthesis
2	Pine, Organic Chemistry
3	Ireland, Organic Synthesis
4	Waren, Designing Organic Synthesis-A Programmed Introduction to Synthetic Approach
5	Furthrhop and Penzlin, Organic Synthesis Concepts, Methods and Starting Materials
6	Mackie and Smith, Guide lines to Organic Synthesis
7	Gurtu and Kapoor, Organic Reactions and Reagents.
8	Fieser and Fieser, Reagents in Organic Synthesis.
9	Jagdamba Singh and L.D.S. Yadav, Organic Synthesis
10	Silverstein, Bassler and Morril, Spetrometric identification of Organic Compounds.
11	Kemp, Organic Spectroscopy
12	Kalsi, Spectroscopy of OrganicCompounds.
13	Y. R. Sharma, Elementary Organic Absorption Spectroscopy
14	Silverstein and Webster, Spectrometric Identification of Organic Compounds.

15	S.C. Pal, Nomenclature of Organic Compounds
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1	https://nptel.ac.in/courses/104/108/104108078/
2	https://nptel.ac.in/courses/104/101/104101005/

Mapping with Programme outcomes

PO / **CO**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**
CO1	S	S	M	S	S	M	S	M	S	S
CO2	S	M	S	S	S	S	M	S	S	S
CO3	S	M	S	S	S	S	M	S	S	S
CO4	M	S	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	GROUP D: ELECTIVE PAPER I	Introduction to Industry 4.0	L	T	P	C
Elective		GROUP D: ELECTIVE PAPER I	3	0	0	3
Pre-requisite		Fundamentals on emerging Technology in computer science	Syllabus Version			

Course Objectives:

The main objectives of this course are to:

1. At the end of completing this course, students will have knowledge on Industry 4.0, need for digital transformation and the following Industry 4.0 tools:

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	To understand the concept of Industry 4.0	K2
2	To apply the concept of Artificial Intelligence	K3
3	To analyze the Big Data and IoT	K4
4	To evaluate the Applications and Tools of Industry 4.0	K4
5	To create the awareness regarding the job 2030	K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Industry 4.0	9 hours

Need – Reason for Adopting Industry 4.0 - Definition – Goals and Design Principles -Technologies of Industry 4.0 – Big Data – Artificial Intelligence (AI) – Industrial Internet of Things - Cyber Security – Cloud – Augmented Reality

Unit:2	Artificial Intelligence	9 hours

Artificial Intelligence: Artificial Intelligence (AI) – What & Why? - History of AI - Foundations of AI -The AI - environment - Societal Influences of AI – Application Domains and Tools - Associated Technologies of AI - Future Prospects of AI – Challenges of AI.

Unit:3	Big Data and IoT	9 hours

Big Data : Evolution - Data Evolution - Data : Terminologies - Big Data Definitions - Essential of Big Data in Industry 4.0 - Big Data Merits and Advantages - Big Data Components : Big Data Characteristics - Big Data Processing Frameworks - Big Data Applications - Big Data Tools - Big Data Domain Stack : Big Data in Data Science – Big Data in IoT - Big Data in Machine Learning - Big Data in Databases - Big Data Use cases : Big Data in Social Causes - Big Data for Industry -Big Data Roles and Skills -Big Data Roles - Learning Platforms; Internet of Things (IoT) : Introduction to IoT – Architecture of IoT - Technologies for IoT - Developing IoT Applications - Applications of IoT - Security in IoT.

Unit:4	Applications and Tools of Industry 4.0	9 hours

Applications of IoT – Manufacturing – Healthcare – Education – Aerospace and Defense –

Agriculture – Transportationa and Logistics – Impact of Industry 4.0 on Society: Impact on Business, Government, People. Tools for Artificial Intelligence, Big Data and Data Analytics, Virtual Reality, Augmented Reality, IoT, Robotics.		
Unit:5	**Jobs 2030**	**9 hours**
Industry 4.0 – Education 4.0 – Curriculum 4.0 – Faculty 4.0 – Skills required for Future - Tools for Education – Artificial Intelligence Jobs in 2030 – Jobs 2030 - Framework for aligning Education with Industry 4.0.		
	Total Lecture hours	**45 hours**

Text Book:

P. Kaliraj, T. Devi, Higher Education for Industry 4.0 and Transformation to Education 5.0, 2020

Reference Books

1	P. Kaliraj, T. Devi, Higher Education for Industry 4.0 and Transformation to Education 5.0, 2020

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/106/102/106102220/
2	https://nptel.ac.in/courses/106/104/106104189/

Mapping with Programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	M	S	S	S	M	S
CO2	S	M	M	S	S	M	M	S	S	M
CO3	S	S	S	S	M	S	S	S	M	S
CO4	M	M	S	S	S	S	S	S	S	S
CO5	S	S	S	M	M	S	S	M	M	S

*S-Strong; M-Medium; L-Low

Course code	GROUP D: ELECTIVE PAPER II	ARTIFICIAL INTELLIGENCE	L	T	P	C
Elective		GROUP D: ELECTIVE PAPER II	3	0	-	3
Pre-requisite		Design intelligent agents to solve real world problems	Syllabus Version			

Course Objectives:

The main objectives of this course are to:

1. to introduce Artificial Intelligence & machine learning
2. to facilitate students to learn & apply AI tools for solving research issues
3. to understand the basics of robotic process automation
4. to develop automated solutions for research problems

.

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Gained the knowledge on Artificial Intelligence & machine learnings	K1 & K2
2	Student will apply AI tools for solving research issues	K2 & K3
3	Student will understand the basics of robotic process automation	K4
4	Student can acquired the knowledge on automated solutions for research problems.	K5 & K6

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1	Artificial Intelligence (AI):	9-- hours

Introduction to AI – Fundamentals – Need for AI – Foundations of AI – AI environment – Application domains of AI – AI tools – Challenges and Future of AI

Unit:2	Machine learning (ML) and Deep learning (DL) & Artificial Intelligence in Biology research:	9-- hours

Fundamentals of ML and DL – ML algorithms to find associations across biological data, cellular image classification and identification of genetic variations.

AI in drug design – AI in Phylogeny – AI in next generation sequencing – AI in protein structure prediction – AI in protein folding analysis.

Unit:3	Python programming	9-- hours

Introduction to Python language – Python, Machine learning and AI - Data types, variables and operators – Conditions and loops – Structure of a Python program – Packages and function – Writing simple python codes.

Unit:4	Robotic Process Automation (RPA)	9-- hours

Fundamentals of RPA – Programming basics from RPA perspective – Applying RPA – RPA

development methodology – Architecture of RPA – RPA and emerging ecosystem.		
Unit:5	**UiPath Studio**	**9-- hours**
Introduction - Automation debugging – Automation library – Activities Packages – Basic automation tasks - Text and image automation – Data tables in RPA – Extracting data from data tables and pdf – Building simple Automation projects.		
	Total Lecture hours	**45-- hours**
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1	https://nptel.ac.in/courses/112/103/112103280/	
2	https://nptel.ac.in/courses/106/106/106106145/	

Mapping with Programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	M	S	S	S	S				
CO3	S	S	S	S	S	S	S	S	S	S
CO3	S	M	S	S	S	S	M	S	S	S
CO4	S	S	S	S	S	S	S	S	S	S

*S-Strong; M-Medium; L-Low

Course code	GROUP D: ELECTIVE PAPER III	Data Analytics using R	L	T	P	C
Elective		GROUP D: ELECTIVE PAPER III	3	0	0	3
Pre-requisite		Emphasis on statistical & analytical skills on computer language	Syllabus Version			

Course Objectives:

The main objectives of this course are to:

1. To introduce the concept of Data Analytics
2. To understand the features of R.
3. To utilize the concept of data analytics and R

Expected Course Outcomes:

On the successful completion of the course, student will be able to:

1	Student get the knowledge about data analytics	K2
2	Student can apply the concept of data analytics	K3
3	Student can analyze new tools used in robotics	K4

K1 - Remember; **K2** - Understand; **K3** - Apply; **K4** - Analyze; **K5** - Evaluate; **K6** - Create

Unit:1 — **9 hours**

Introduction Data Analytics – Data Analysis Vs Data Analytics – Data Analytics – Types - Data Analytics – Framework – Data Analytics – Tool - R language - Understanding R features - Installing R and RStudio – Packages and Library – Importing and Exporting Files: CSV File – JSON File – txt File –Excel File – Xml File - Command Line Vs. Scripts. - Data Pre-Processing – Missing Value – Omitting Null Values – Data Transformation – Data Selection – Data Integration.

Unit:2 — **9hours**

Understanding R features - Installing R and RStudio – Packages and Library – Importing and Exporting Files: CSV File – JSON File – txt File –Excel File – Xml File – Command Line Vs. Scripts Data Manipulation: Slicing - Subscripts and Indices – Data Subset – Dplyr Package: Select Function - Filter Function - Mutate Function - Arrange Function.

Unit:3 — **9 hours**

Data Summarization & Visualization - Mean – Median – Mode - Variablity Measures - Variance – Range - IQR – Standard Deviation – Sum of Squares –Identifying Outliers using IQR. Data Visualization – Introduction – Datasets – Exploratory Data Analytics – Univariate Analysis – Histogram - Bivariate Analysis - Box Plot – Multivariate Analysis - Scatter Plot - MASS Package - Categorical Variable –Bar Chart – Mosaic Plot.

Unit:4 — **9 hours**

Reporting Tool – Analysing Gathering Information – Story Telling – R Markdown – R Markdown Framework - rmarkdown package – Knit for Embedded Code: knitr package - Convert File:HTML,

PDF, MS Word - Markdown Formatted Text - ShinyApp – shiny package: Built Shiny app – Control Widgets – Customize Reactions – Reactive Expressions - Customize Appearance - Deploy Shiny app.		
Unit:5		**9 hours**
Data Analytics Case Studies – Marketing – Logistic Management – Insurance – Behavioural Analytics – Data Analytics on Diamond Dataset.		
	Total Lecture hours	**45 hours**

Text Book(s):

1.VigneshPrajapati, ―Big Data Analytics with R and Hadoop‖, Packt Publishing, ISBN-978-1-78216-328-2, 2013.

Reference Books

1	V. Bhuvaneswari, ―Data Analytics with R Step by Step‖, Scitech Publisher, ISBN – 978-81- 929131-2-4, Edition 2016.
2	Roger D.Peng, ―R Programming for Data Science‖, Lean Publishing, 2014.
3	Sholom Weiss, et.al, ―The Text Mining Handbook: Advanced Approaches in Analysing Unstructured Data‖, Springer, Paperback 2010.
4	Emmanuel Paradis, ―R for Beginners‖, 2005.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]

1	https://nptel.ac.in/courses/106/107/106107220/
2	https://nptel.ac.in/courses/110/106/110106072/

Mapping with Programme outcomes

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	M	S	S	S	S	M
CO2	S	M	M	S	S	M	M	M	S	S
CO3	S	S	S	S	M	S	S	S	S	M

*S-Strong; M-Medium; L-Low