PERIYAR UNIVERSITY

NAAC 'A++' Grade with CGPA 3.61 (Cycle - 3)

Salem-636011, Tamilnadu, India.

SYLLABUS FOR M.Sc. ANALYTICAL CHEMISTRY

DEGREE OF MASTER OF SCIENCE

CHOICE BASED CREDIT SYSTEM

(For candidates admitted in the colleges affiliated to Periyar University from 2023-2024 onwards)

TANSCHE REGULATIONS ON LEARNING OUTCOMES-BASED CURRICULUM FRAMEWORK FOR POSTGRADUATE EDUCATION	
Programme	**M.Sc. ANALYTICAL CHEMISTRY**
Programme Code	
Duration	PG - YEARS
Programme Outcomes (Pos)	PO1 (Scientific knowledge): Apply the knowledge of chemical science to find solutions to various academic and research problems. PO2 (Problem analysis): Identify a research problem, review research literature, and design innovative solutions for scientific problems. PO3 (Skill enhancement): Recognize and practice the required skill-sets to enhance them for future employability. PO4 (Modern tool usage): Adopt appropriate modern techniques, resources, and tools to execute the experiments and analyze and interpret the data. PO5 (Society and ethics): Implement contextual knowledge and ethical principles to assess various societal issues related to common scientific and industrial practices. PO6 (Environment and sustainability): Assess the impact of scientific approaches in environment with special emphasis on the need for sustainable development. PO7 (Individual and teamwork): Function as an individual or as a member or leader in diverse teams, and in multidisciplinary settings. PO8 (Communication): Communicate effectively, write reports and design documentation, make effective presentations, and give and receive clear instructions. PO9 (Project management): Utilize knowledge and understanding of the chemical principles to manage projects of various magnitudes in multidisciplinary environments. PO10 (Life-long learning): Identify the important aspects of Chemistry and other allied subjects for independent and life-long learning in the broader context of scientific and technological development.

Programme Specific Outcomes (PSOs)	PSO 1 understands the existence of matter in the universe as solids, liquids, and gases which are composed of molecules, atoms and sub atomic particles. PSO 2 learns to estimate inorganic salt mixtures and organic compounds both qualitatively and quantitatively using the classical methods of analysis in practical classes. PSO 3 grasps the mechanisms of different types of reactions both organic and inorganic and will try to predict the products of unknown reactions. PSO 4 synthesizes the chemical compounds by maneuvering the addition of reagents under optimum reaction conditions. PSO 5 gets aware and handles the sophisticated instruments/equipment and Develop research oriented skills.

Template for P.G., Programmes

Semester–I	Credit	Hours	Semester-II	Credit	Hours	Semester-III	Credit	Hours	Semester–IV	Credit	Hours
Core-I	5	7	. Core-IV	5	6	Core-VII	5	6	Core-XI	5	6
Core-II	5	7	Core-V	5	6	Core-VIII	5	6	Core-XII	5	6
Core – III	4	6	Core – VI	4	6	Core – IX	5	6	Project with viva voce	7	10
Elective -I Discipline Centric	3	5	Elective – III Discipline Centric	3	4	Core – X	4	6	Elective - VI (Industry / Entrepreneurship) 20% Theory 80% Practical	3	4
Elective-II Generic:	3	5	Elective -IV Generic:	3	3	Elective - V Discipline Centric	3	3	Skill Enhancement course / Professional Competency Skill SEC-III	2	4
			SEC-I	2	3	SEC-II	2	3	Extension Activity	1	
			Human rights	1	2	Internship/ Industrial Activity	2	-			
	20	**30**		**23**	**30**		**26**	**30**		**23**	**30**
Total Credit Points -92											

Choice Based Credit System (CBCS), Learning Outcomes Based Curriculum Framework (LOCF)
Guideline Based Credits and Hours Distribution System
For all Post – Graduate Courses including Lab Hours

First Year – Semester – I

Part	List of Courses	Credits	No. of Hours
	Core – I	5	7
	Core – II	5	7
	Core – III	4	6
	Elective – I	3	5
	Elective – II	3	5
		20	30

Semester-II

Part	List of Courses	Credits	No. of Hours
	Core – IV	5	6
	Core – V	5	6
	Core – VI	4	6
	Elective – III	3	4
	Elective – IV	3	3
	Skill Enhancement Course [SEC] - I	2	3
	Human rights	1	2
		23	30

Second Year – Semester – III

Part	List of Courses	Credits	No. of Hours
	Core – VII	5	6
	Core – VIII	5	6
	Core – IX	5	6
	Core (Industry Module) – X	4	6
	Elective – V	3	3
	Skill Enhancement Course - II	2	3
	Internship / Industrial Activity [Credits]	2	-
		26	30

Semester-IV

Part	List of Courses	Credits	No. of Hours
	Core – XI	5	6
	Core – XII	5	6
	Project with VIVA VOCE	7	10
	Elective – VI (Industry Entrepreneurship)	3	4
	Skill Enhancement Course – III / Professional Competency Skill	2	4
	Extension Activity	1	-
		23	30

Total 92 Credits for PG Courses

FIRST SEMESTER

COURSE COMPONENTS	NAME OF THE COURSE	CREDITS.	INST. HRS	MAX MARKS	
				CIA	EXT.
Core-I	Fundamentals of Analytical Chemistry	5	7	25	75
Core-II	Coordination and Nuclear Chemistry	5	7	25	75
Core – III	Stereochemistry and Organic ReactionMechanism Organic Chemistry Practical-I Physical Chemistry Practical-I	4	6	25	75
Elective –I: Discipline Centric	Any One 1. Inorganic Reaction Mechanism 2. Lab Safety and First Aid 3. Chemistry Databases-SciFinder, Mendeleev,Scopus, 4. Web of Science and Google Scholar	3	5	25	75
Elective-II: Generic	Thermodynamics and Chemical Kinetics	3	5	25	75
		20	30		

SECOND SEMESTER

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COURSE COMPONENTS	NAME OF THE COURSE	CREDITS	INST. HRS	MAX MARKS	
				CIA	EXT.
Core-IV	Analytical Instrumentation	5	6	25	75
Core-V	Main Group Elements and Inorganic Polymers	5	6	25	75
Core –VI:	Organic Reaction Mechanism Analytical Chemistry Practical-I Inorganic Chemistry Practical-I	4	6	25	75
Elective- III	Quantum Chemistry and Group Theory	3	4	25	75
Elective – IV	Any One 1. Macromolecular Chemistry 2. Fire Safety and Firefighting	3	3	25	75
NME	Software packages for Chemists-MATLAB,ORIGIN and CHEMDRAW	2	3	25	75
	Human rights	1	2	25	75
		23	30		

THIRD SEMESTER

COURSE COMPONENTS	NAME OF COURSE	CREDITS	INST. HRS	EXAM HRS.	MAX MARKS	
					CIA	EXT.
Core-VII	Physical Methods in Chemistry	5	6	3	25	75
Core-VII	Analysis of complex materials and separation techniques Practical – II	5	6	3	25	75
Core – IX	Instrumental Methods Practical – III	5	6	3	25	75
Core – X	Biological Chemistry	4	6	3	25	75
Elective - V Discipline Centric	Classical & Radio analytical methods of analysis	3	3	3	25	75
NME II	Fundamentals of Molecular Spectroscopy	2	3	3	25	75
Internship	Internship	2	-	-	-	-
		26	30			

Internship will be carried out during the summer vacation of the first year and marks will be included in the Third Semester Marks Statement.

FOURTH SEMESTER

COURSE COMPONENTS	NAME OF COURSE	CREDITS	INST. HRS	EXAM HRS.	MAX MARKS	
					CIA	EXT.
Core-XI	Optical and Surface analytical techniques	5	6	3	25	75
Core-XII	Separation techniques	5	6	4	25	75
Project	Project with *Viva Voce*	7	10	4	25	75
Elective - VI	Energy Conversion Phenomena	3	4	3	25	75
Skill Enhancement course / Professional Competency Skill	Electro analytical Chemistry	2	4	-	-	-
Extension Activity		1				
		23	30			

METHOD OF EVALUATION:

Continuous Internal Assessment	External Examination	Total
25	**75**	**100**

Methods of assessment:

Recall (K1) - Simple definitions, MCQ, Recall steps, Concept definitions

Understand/ Comprehend (K2) - MCQ, True/False, Short essays, Concept explanations, Short summary or overview

Application (K3) - Suggest idea/concept with examples, Suggest formulae, Solve problems, Observe, Explain

Analyse (K4) - Problem-solving questions, Finish a procedure in many steps, Differentiate between various ideas, Map knowledge

Evaluate (K5) - Longer essay/ Evaluation essay, Critique or justify with pros and cons.

Create (K6) - Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations

SEMESTER-I

Course code	**Core-I**	**FUNDAMENTLS OF ANALYTICAL CHEMISTRY**	L	T	P
Core/Elective/Supportive		Core	5	2	0
Pre-requisite		Student must have an idea about chemical analysis			

Course Objectives:

The main objectives of this course are to:

- To interpret and analyze data acquired during testing of samples
- To differentiate the nature of samples and choose the correct sampling technique
- To understand the nature of chemical reactions
- To compare and contrast the various titration methods with sound theoretical knowledge for estimation of ions.

Expected Course Outcomes:

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

•	The students will be able to understand and apply the correct method to analyzeanalytical data
•	They will be able to employ the correct technique to collect samples of anynature for analysis
•	Can evaluate the accuracy and summaries the methods adapted for certainpractical activities.
•	Can explain and summarize the various titrimetric techniques used for analysis
•	To understand the chemical equilibria to predict the solution chemistry
•	Compare and contrast the various methods of titration based on the nature ofsamples

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

Unit:1	TREATMENT OF ANALYTICAL DATA AND SAMPLING	15 hours

Nature of quantitative measurements and treatment of data. Basic statistical concepts – Errors- random and systematic, mean, median, precision and accuracy, significant figures, Gaussian distribution curves, Null Hypothesis, Confidence interval of mean, Rejection of data (Q test),Student's t, F tests. Reliability of results, Regression and correlation. Quality control and control chart.

Analytical Chemical standards, types and traceability, Evaluation of Analytical process, Analytical Method Calibration. Chemical Measurement Process (CMP) – concept and steps.

Principles of sampling methods for solid, liquids and gases. Gross sampling, Sampler's responsibility and pitfalls, hazards of sampling.

Unit:2	CHEMICAL EQUILIBRIA AND NEUTRALIZATIONREACTIONS 15 hours

Chemical Equilibria - Activity concept, equilibrium constant and applications, ionisation constants of acids and bases. Concept of pH, hydrolysis of salts, hydrolysis constant and degree of hydrolysis,Buffers – types, range and capacity, dissociation of polyprotic acids, common ion effect, salt effect.

Neutralization reactions – Theory of acid-base titrations, theory and choice of indicators, mono and polyprotic systems, titration curves and feasibility of reactions, calculation of pH during titrations

Unit:3	REDOX TITRATION, PRECIPITATION TITRATIONSAND COMPLEXOMETRIC TITRATIONS 15hours

Redox titration – Redox potentials, theory and feasibility of redox titration, calculation of potentialsat different stages of titrations, redox indicators, their choice and applications.

Precipitation titrations – Theory and types, Mohr, Volhard and Fajan's methods. Adsorption indicators – theory, choice and applications.

Complexometric titrations – Theory, Stepwise and overall formation constants, Titrations involving chelates (EDTA). Metallochromic indicators – Theory and Choice. Masking and demasking and extractive methods. Direct, indirect (including substitution) titration and applications.

Unit:4 Datahandling (15 Hours)

Classification of Analytical methods- Types of samples, preparation of sample for analysis, sample treatment, moisture in sample, procedure of sampling of solids, liquids and gases, Errors and Evaluation- Accuracy, precision, sensitivity, detection limits, significant figures, rounding off. Types of errors-determinateand indeterminate errors. Ways of expressing accuracy, absolute and relative errors. Significant figures and propagation of errors. Confidence limit, Test of significance- the F- test and T- test. The statistical Q- test for rejection of a result, statistics for small data sets. Linear least squares method. The correlation coefficient. Calculation for the above parameters.

Unit:5 Titrimetric Analyses (15 Hours)

Redox titrations-Redox potentials, theory and feasibility of redox titrations, calculation of potential at different stages of titrations, redox indicators, their choice and application. Complexometric titrations- Theory, stepwise and overall formation constants, titrations involving monodendate (Cl-,CN-) and multi dentate ligands (EDTA), Metallochromic indicators- theory and choice. Masking anddemasking methods. Direct, indirect (including substitution) titrations andapplications

	Contemporary Issues	

Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, and online seminars –webinars for strengthening the subject matters.

	Total Lecture hours	**75 hours**

Text Book(s)

1.	Fundamentals of Analytical Chemistry - Skoog, West and Holler, Saunders College Publishing,VI Edition, 1991, and VII Edition, 1996.
2.	Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985
3.	Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, Pearson Education Ltd, VI Edition, 2001
4.	Analytical Chemistry – Gary D. Christian, John Wiley & Sons, INC, V Edition, 2001
5.	Statistics for Analytical Chemistry – J.C. Miller and J.N. Miller, Ellis Harwood, Chichester,1984.

Reference Books

1	Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, II Edition, 1986
2	Analytical Chemistry – J.G. Dick, McGraw Hill Publishers, 1975
3	Analytical Chemistry- An Introduction – Skoog, West & Holler, Saunders College PublishingVI Edition,1994.
4	Instrumental Methods of Chemical Analysis – G.W. Ewing, McGraw Hill Publishers, 1975.
5	Statistics for Analytical Chemists – R. Caulcutt and R. Boddy, Chapmann and HallPublications, London, 1982

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

1.	https://youtu.be/dlDnzswhTsU-Data Analysis and decision making
2.	https://youtu.be/ozEWJAk4JCc-Acid Base Reactions
3.	https://www.youtube.com/watch?v=n9wUdgxCLMQ-Neutralizations Reactions
4	https://www.youtube.com/watch?v=flCQz0QjPmA-Redox Reactions
5.	https://youtu.be/dtTx5f9zdm0- Quantitative Methods in Chemistry

Course Designed By: Dr. K. Ravichandran, Dr. T.M. Sridhar, Dr. K. Venkatachalam and Dr. DeepaP Nambiar

Mapping with Programme Outcomes*

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

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

<table>
<tr><td>Title of the Course</td><td colspan="8">COORDINATION AND NUCLEAR CHEMISTRY</td></tr>
<tr><td>Paper No.</td><td colspan="8">Core II</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core-II</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td colspan="2" rowspan="2"></td></tr>
<tr><td>Semester</td><td>I</td></tr>
<tr><td rowspan="2">Instructional hours per week</td><td>Lecture</td><td>Tutorial</td><td colspan="3">Lab Practice</td><td colspan="3">Total</td></tr>
<tr><td>5</td><td>2</td><td colspan="3">-</td><td colspan="3">7</td></tr>
<tr><td>Prerequisites</td><td colspan="8">Basic knowledge of inorganic chemistry and Nuclear Chemistry</td></tr>
<tr><td>Objectives of the course</td><td colspan="8">To gain insights into the modern theories of bonding in coordination compounds.
To learn various methods to determine the stability constants of complexes.
To understand and construct correlation diagrams and predict the electronic transitions those are taking place in the complexes.
To describe the nucleus-subatomic particles and their properties
To describe the Nuclear Reactions</td></tr>
<tr><td rowspan="2">Course Outline</td><td colspan="8">UNIT-I:Modern theories of coordination compounds:
Crystal field theory - splitting of d orbitals in octahedral, tetrahedral and square planar symmetries - measurement of 10Dq - factors affecting 10Dq - spectrochemical series - crystal field stabilisation energy for high spin and low spin complexes- evidences for crystal field splitting - site selections in spinels and antispinels - Jahn Teller distortions and its consequences.Molecular Orbital Theory and energy level diagrams concept of Weak and strong fields, Sigma and pi bonding in octahedral, square planar and tetrahedral complexes.</td></tr>
<tr><td colspan="8">UNIT-II:Spectral characteristics of complexes:
Term states for d ions - characteristics of d-d transitions - charge transfer spectra - selection rules for electronic spectra - Orgel correlation diagrams - Sugano-Tanabe energy level diagrams - nephelauxetic series - Racha parameter and calculation of inter-</td></tr>
</table>

	electronic repulsion parameter.
	UNIT-III:Stability and Magnetic property of the complexes: Stability of complexes: Factors affecting stability of complexes, Thermodynamic aspects of complex formation, Stepwise and overall formation constants, Stability correlations, statistical factors and chelate effect, Determination of stability constant and composition of the complexes: Formation curves and Bjerrum's half method, Potentiometric method, Spectrophotometric method, Ion exchange method, Polorographic method and Continuous variation method (Job's method)Magnetic property of complexes: Spin-orbit coupling, effect of spin-orbit coupling on magnetic moments, quenching of orbital magnetic moments.
	UNIT IV Nuclear Chemistry– I (15 Hours) The nucleus-subatomic particles and their properties-mass defect - binding energy - n/ p ratio in stable and metastable nuclei-Different types of nuclear forces-Liquid drop model and shell model. Modes of radioactive decay-Theory of alpha decay, beta decay and gamma radiation, Orbital electron capture, nuclear isomerism-internal conversion. Detection and determination of activity-GM, Scintillation and Cherenkov counters Particle Accelerators: Linear accelerator-cyclotron, synchrotron, betatron and bevatron
	UNIT V Nuclear Chemistry - II (15 Hours) Nuclear Reactions: Q-value,columbic barrier-nuclear cross section-different types of Nuclear reactions-projectile capture-particle emission, spallation, fission and fusion-product distributions - Theories of fission, use of fission products, fissile and fertile isotopes - U-238, U-235, PU-239, Th232 -stellar energy-synthesis of new elements. Radio-Isotopes: Applications-isotopes as tracers - neutron activation analysis and isotopic dilution analysis - uses in structure and

	mechanistic studies - Carbon dating – Radio pharmacology, Radiation protection and safety precautions - Disposal of nuclear waste.
Extended Professional Component (is a part of internal component only, Not to be included in the external examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET/ UGC-CSIR / GATE /TNPSC others to be solved (To be discussed during the Tutorial hours)
Skills acquired from this course	Knowledge, Problem solving, Analytical ability, Professional Competency, Professional Communication and Transferable skills.
Recommended Text	1. J E Huheey, EA Keiter, RL Keiter and OK Medhi, Inorganic Chemistry – Principles of structure and reactivity, 4th Edition, Pearson Education Inc., 2006 2. G L Meissler and D ATarr, Inorganic Chemistry, 3rd Edition, Pearson Education Inc., 2008 3. D. Bannerjea, Co-ordination Chemistry, TATA Mcgraw Hill, 1993. 4. B. N. Figgis, Introduction to Ligand Fields, Wiley Eastern Ltd, 1976. 5. F. A. Cotton, G. Wilkinson.; C. A. Murillo; M. Bochmann, Advanced Inorganic Chemistry, 6thed.; Wiley Inter-science: New York, 1988.
Reference Books	1. Keith F. Purcell and John C. Kotz, Inorganic Chemistry, Saunders Publications, USA, 1977. 2. Peter Atkins and Tina Overton, Shriver and Atkins' Inorganic Chemistry, 5th Edition, Oxford University Press, 2010. 3. Basic Inorganic Chemistry, F. A. Cotton, G. Wilkinson, P. L. Guas, John Wiley, 2002, 3rd edn. 4. Concepts and Models of Inorganic Chemistry, B. Douglas, D. McDaniel, J. Alexander, John Wiley, 1994, 3rd edn. 5. Inorganic Chemistry, D. F. Shriver, P. W. Atkins, W. H. Freeman and Co, London, 2010.
Website and e-learning source	https://ocw.mit.edu/courses/5-04-principles-of-inorganic-chemistry-ii-fall-2008/pages/syllabus/
Course Learning Outcomes (for Mapping with POs and PSOs) Students will be able: CO1:Understand and comprehend various theories of coordination compounds. CO2:Understand the spectroscopic and magnetic properties of coordination complexes. CO3:Explain the stability of complexes and various experimental methods to determine the stability of complexes. CO4:Predict the electronic transitions in a complex based on correlation diagrams and UV-visible spectral details. CO5:Comprehend the kinetics and mechanism of substitution reactions in octahedral and square planar complexes.	

CO-PO Mapping (Course Articulation Matrix)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	S	S	S	S	M	S	S	S	S	M
CO 2	M	S	S	S	S	M	S	S	S	S
CO 3	S	S	M	S	S	S	S	M	S	S
CO 4	M	S	S	S	S	M	S	S	S	S
CO 5	M	S	M	S	S	M	S	M	S	S

3 – Strong, 2 – Medium, 1 - Low

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

3 – Strong, 2 – Medium, 1 – Low

Title of the Course	CORE PRACTICAL-I ORGANIC CHEMISTRY PRACTICAL-I						
Paper No.	Core III						
Category	Core-III	Year	I	Credits	4	Course Code	
		Semester	I				
Instructional hours per week	Lecture	Tutorial	Lab Practice			Total	
	-	-	-			6	

ORGANIC CHEMISTRY PRACTICAL-I

OBJECTIVES

To develop analytical skill in

1. Separation of organic mixture
2. Organic qualitative analysis
3. Preparation of organic compound involving in single stage.

I. Identification of components in a two component mixture and preparation of their derivatives. Determination of boiling point/melting point for components and melting point for their derivatives.

II. Preparation.

1. Beta naphthyl methyl ether from betanaphthol
2. s-Benzyl isothiuronium chloride from benzylchloride
3. Beta glucose penta acetate from glucose
4. ortho-Benzoyl benzoic acid from phthalicanhydride
5. Resacetophenone from resorcinol
6. para-nitrobenzoic acid from para-nitrotoluene
7. meta-nitroaniline from meta-dinitrobenzene
8. Methyl orange from sulphanilic acid
9. Anthraquinone from anthracene 10.Benzhydrol from benzophenone

REFERENCE BOOKS:

1. B.S.Furniss, A.J.Hannaford, P.W.G.Smith and A.R.Tatchell, Vogel's Practical Organic Chemistry.5th Edn., ELBS,1989.
2. Raj K.Bansal, Laboratory manual of Organic Chemistry, III Edn., New Age International (P)Ltd.1996.
3. Gnanpragasam, Ramamurthy, Organic lab Manual, Viswanathan, S., Printers & Publishers Pvt Ltd, 2009.

Title of the Course	CORE PRACTICAL-I PHYSICAL CHEMISTRY PRACTICAL-I						
Paper No.	Core III						
Category	Core-III	Year	I	Credits	4	Course Code	
		Semester	I				
Instructional hours per week	Lecture	Tutorial	Lab Practice			Total	
	-	-	6			6	

OBJECTIVES

To develop analytical skill in Kinetics, Phase diagram, Distribution method,Polarimetry, Viscosity and Adsorption experiments.

Chemical kinetics

1. Study the kinetics of acid hydrolysis of ethyl acetate and determine the temperature coefficient and activation energy of thereaction
2. Study the kinetics of the reaction between acetone and iodine in acid medium and determine the order with respect to iodine and acetone.
3. Study the kinetics of the reaction between potassium persulphate and potassium iodide and determine order, temperature coefficient and activation energy of the reaction.
4. Study the primary salt effect on the kinetics of ionic reactions and test the Bronsted relationship (iodide ion is oxidized by persulphate ion).

Phase diagram

5. Construct a phase diagram for a simple binary system (naphthalene - phenanthrene or benzophenone -diphenylamine).

Distribution method

6. Determine association factor of benzoicacidinbenzeneandwater.

Polarimetry

7. Study the inversion of cane sugar in the presence of acid.

Viscosity

8. Study the variation of viscosity of liquids with temperatures.
9. Determine the partial molar volume of glycine/ methanol/ formic acid/ sulphuric acid by graphical method and determine densities of the solutions of different concentrations.
10. Study the surface tension - concentration relation of solutions (Gibb'sequation).

REFERENCE BOOKS

1. B.P.Levitt (Ed.). Findlay's Practical Physical Chemistry, 9th Edn., Longman, London,1985.
2. J.N.Gurtu and R.Kapoor, Advanced Experimental Chemistry, Vol I.S.Chand& Co.Ltd., New Delhi,1980.

Title of the Course	LAB SAFETY AND FIRST AID						
Paper No.	Elective I						
Category	Elective	Year	I	Credits	5	Course Code	
		Semester	I				
Instructional hours per week	Lecture	Tutorial	Lab Practice			Total	
	3	-	-			5	

Unit 1

Lab safety:

Chemistry lab layout and safety procedures practiced in the Chemical laboratory that pertains to general laboratory safety and awareness including eye shower to fume hoods. Safety kits, devices, uses and storage. SOP for personal safety.

Unit: II

Universal precautions:

Material Safety Data Sheet (MSDS), chemical, radiation, fire, electrical and gas safety; Clean room facility, Universal Precautions and its importance in the handling of hazardous chemicals in the lab; handling radioactive materials and biohazards materials

Unit: III

General Safety and Operational Rules

Chemical Storage Safe Handling of Chemicals and Gases, Acid/Alkali splashes on the skin, Acid/Alkali splashes in the eye, Swallowing acid/ Alkali, General safety, Safety Practices, Good Housekeeping Practices, Personal Care, Personal Protective Equipment (PPE), Glassware safety.

Unit: IV

Chemical & Biological Safety

Basics, Special Precautions for Hazardous Chemical Usage, Chemical Hood Usage, Chemical Transport, Storage, and Usage, Waste Segregation & Disposal,

Unit: V

Fire and Electrical Safety

Precautionary procedures, Electrical Safety, Heated Devices , Fire Extinguisher , Fire Safety Emergency Response, Fires, Accident Reporting, Emergency Contact numbers

Text Book(s)

1. Laboratory Safety Theory and Practice 1st Edition Anthony Fuscaldo December 1980
2. The Foundations of Laboratory Safety Stephen R. Rayburn 1990 Springer-Verlag New York
3. Research Laboratory Safety,By Daniel Reid Kuespert · 2016

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Reference Books

1. Prudent practices in the laboratory: handling and management of chemical Hazards, updated version. National Academies Press, 25-Mar-2011 - Science - 360 pages
2. Guidelines for Chemical Laboratory Safety in Academic Institutions American Chemical Society Washington, DC 2016.
3. Guidelines for Laboratory Design: Health, Safety, and Environmental Considerations, Fourth Edition Louis 15 March 2013 John Wiley & Sons,

Title of the Course	CHEMISTRY DATABASES – SCIFINDER, MANDELEEF, SCOPUS, WEB OF SCIENCE AND GOOGLE SCHOLAR						
Paper No.	Elective I						
Category	Elective	Year	I	Credits	5	Course Code	
		Semester	I				
Instructional hours per week	Lecture	Tutorial	Lab Practice			Total	
	3	-	-			3	

UNIT - I: SciFinder Database

Components of SciFinder, Analyzing, Categorizing and Refining the Scifinder database based on Research topic, Author name, Company name, Molecular formula, Molecular structure, Chemical reaction, Journals, Patents, Physical Properties. Importance of Scifinder database in planning a research problem.

UNIT – II: MANDELEEF

Mandeleef Reference Manager – Application; Reference file - Collection, Insertion, Library organization, Notebook; Citation database - analyze- visualize - research. h- Index, h- graph Cite Score, SJR (SCImago Journal Rank) and SNIP (Source Normalized Impact Paper). ORCHID, Citable documents, Citations, Self Citations - Document types- Alternative Metrics. Overview, citations, Scholarly commentary, Citation Benchmarking, Advanced Search,.

UNIT - III: Scopus

Components of Scopus, Analyzing, Categorizing and Refining the Scopus database based on different options. Importance of Scopus database in planning a research problem. Proximity characters in Scopus.

UNIT - IV: Web of Science

Web of Science – History, Components of Web of Science, Analyzing, Categorizing and Refining the Web of Science database based on different options. Importance of Web of Science database in planning a research problem.

UNIT-V: Google Scholar

Google Scholar – History, Features and specifications, Ranking algorithm, Groups and access to literature - Limitations and citations, Search engine. Citations, H-index and i10 index – Keywords search - Steps to create Google scholar ID and Addition/Removal of articles – Profile updates – My library- Metrics- Alerts -Merits and Demerits of Google Scholar ID.

References:

1. https://www.cas.org/support/training/scifinder
2. https://www.cas.org/sites/default/files/documents/scifinder_search_references_workbook.pdf
3. https://www.mendeley.com/reference-management/mendeley-cite
4. https://www.elsevier.com/solutions/scopus
5. https://clarivate.libguides.com/webofscienceplatform/alldb
6. Jensenius, F., Htun, M., Samuels, D., Singer, D., Lawrence, A., &Chwe, M. (2018). "The Benefits and Pitfalls of Google Scholar" PS: Political Science & Politics, 51(4), 820-824.

<table>
<tr><td>Title of the Course</td><td colspan="7">THERMODYNAMICS AND CHEMICAL KINETICS</td></tr>
<tr><td>Paper No.</td><td colspan="7">Elective II</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">5</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td rowspan="2">Instructional hours per week</td><td>Lecture</td><td>Tutorial</td><td colspan="3">Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td>3</td><td>-</td><td colspan="3">-</td><td colspan="2">3</td></tr>
<tr><td>Prerequisites</td><td colspan="7">Basic Concepts Of Physical Chemistry</td></tr>
<tr><td>Objectives of the course</td><td colspan="7">To recall the fundamentals of thermodynamics and the composition of partial molar quantities.
To understand the classical and statistical approach of the functions
To compare the significance of Maxwell-Boltzman, Fermi-Dirac and Bose-Einstein
To correlate the theories of reaction rates for the evaluation of thermodynamic parameters.
To study the mechanism and kinetics of reactions.</td></tr>
<tr><td rowspan="4">Course Outline</td><td colspan="7">UNIT-I:Classical Thermodynamics:
Partial molar properties-Chemical potential,. Determination of partial molar quantities. Thermodynamics of real gases - Fugacity- - Thermodynamics of ideal and non-ideal binary mixtures, Duhem - Margulus equation applications of ideal and non-ideal mixtures. Activity and activity coefficients-standard states -determination-vapour pressure,</td></tr>
<tr><td colspan="7">UNIT-II:Statistical thermodynamics:
Introduction of statistical thermodynamics concepts of thermodynamic and mathematical probabilities- Maxwell - Boltzmann, Fermi Dirac & Bose-Einstein Statistics- comparison and applications. Partition functions-. Thermodynamic functions in terms of partition functions-calculation of equilibrium constants. Statistical approach to Thermodynamic properties: pressure, internal energy, entropy, enthalpy.</td></tr>
<tr><td colspan="7">UNIT-III:Irreversible Thermodynamics:
Theories of conservation of mass and energyentropy production in open systems by heat, matter and current flow, force and flux concepts.Onsager theory-validity and verification- Onsager reciprocal relationships. Electro kinetic and thermo mechanical effects-Application of irreversible thermodynamics to biological systems.</td></tr>
<tr><td colspan="7">UNIT-IV:Kinetics of Reactions:</td></tr>
</table>

	Theories of reactions-effect of temperature on reaction rates, collision theory of reaction rates, Transition state theory-evaluation of thermodynamic parameters of activation-applications of ARRT to reactions between atoms and molecules, time andtrue order-kinetic parameter evaluation., Homogeneous catalysis- acid- base catalysis-mechanism of acid base catalyzed reactions-Bronsted catalysis law, enzyme catalysis-Michelis-Menton catalysis.
	UNIT-V:Kinetics of complex and fast reactions: Kinetics of complex reactions, reversiblereactions, consecutive reactions, parallel reactions, - Rice Herzfeldmechanism.Study of fast reactions-relaxation methods- temperature and pressure jump methods electric and magnetic field jump methods -stopped flow flash photolysis methods and pulse radiolysis. Kinetics of polymerization-free radical, cationic, anionic polymerization - Polycondensation.
Extended Professional Component	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET/ UGC-CSIR / GATE /TNPSC others to be solved (To be discussed during the Tutorial hours)
Skills acquired from this course	Knowledge, Problem solving, Analytical ability, Professional Competency, Professional Communication and Transferable skills.
Recommended Text	1. J. Rajaram and J.C. Kuriacose, Thermodynamics for Students of Chemistry, 2nd edition,S.L.N.Chand and Co., Jalandhar, 1986. 2. I.M. Klotz and R.M. Rosenberg, Chemical thermodynamics, 6th edition, W.A.BenjaminPublishers, California, 1972. 3. M.C. Gupta, Statistical Thermodynamics, New Age International, Pvt. Ltd., New Delhi,1995. 4. K.J. Laidler, Chemical Kinetics, 3rd edition, Pearson, Reprint - 2013. 5. J. Rajaram and J.C. Kuriokose, Kinetics and Mechanisms of chemical transformation,Macmillan India Ltd, Reprint - 2011.
Reference Books	1. D.A. Mcqurrie And J.D. Simon, Physical Chemistry - A Molecular Approach, Viva Books Pvt. Ltd., New Delhi, 1999. 2.R.P. Rastogi and R.R. Misra, Classical Thermodynamics, Vikas Publishing, Pvt. Ltd., New Delhi, 1990. 3. S.H. Maron and J.B. Lando, Fundamentals of Physical Chemistry, Macmillan Publishers, New York, 1974 4. K.B. Ytsiimiriski, "Kinetic Methods of Analysis", Pergamom Press,1996. 5. Gurdeep Raj, Phase rule, Goel Publishing House, 2011.
Website and e-learning source	1. https://nptel.ac.in/courses/104/103/104103112/ 2. https://bit.ly/3tL3GdN
Course Learning Outcomes (for Mapping with POs and PSOs)	

Students will be able:
CO1: To explain the classical and statistical concepts of thermodynamics.
CO2: To compare and correlate the thermodynamic concepts to study the kinetics of chemical reactions.
CO3: To discuss the various thermodynamic and kinetic determination.
CO4: To evaluate the thermodynamic methods for real gases ad mixtures.
CO5:To compare the theories of reactions rates and fast reactions.

CO-PO Mapping (Course Articulation Matrix)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	S	S	S	S	M	S	S	S	S	M
CO 2	M	S	S	S	S	M	S	S	S	S
CO 3	S	S	M	S	S	S	S	M	S	S
CO 4	M	S	S	S	S	M	S	S	S	S
CO 5	M	S	M	S	S	M	S	M	S	S

3 – Strong, 2 – Medium, 1 - Low

Level of Correlation between PSO's and CO's

CO /PO	**PSO1**	**PSO2**	**PSO3**	**PSO4**	**PSO5**
CO1	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**3**	**3**
CO3	**3**	**3**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**
Weightage	**15**	**15**	**15**	**15**	**15**
Weighted percentage of Course Contribution to Pos	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**

3 – Strong, 2 – Medium, 1 - Low

SEMESTER-II

Title of the Course	ANALYTICAL INSTRUMENTATION						
Paper No.	CORE-IV						
Category	Core	Year	I	Credits	5	Course Code	
		Semester	II				
Instructional hours per week	Lecture	Tutorial	Lab Practice			Total	
	5	1	-			6	
Prerequisites	Basic Concepts Of Chemistry						

The main objectives of this course are to:

- To introduce the students to basic electronics in instrumentation
- Introduce EMR and study the principle of Electronic and Molecular absorption in molecules
- Estimation of molecular species using spectrophotometers
- To understand the principle of absorption and emission using flame
- Selection of the chromatographic technique to separate and identify molecules and ions
- Demonstrate the role of modern instrumentation in chromatography
- To evaluate and critically assess the organization and functioning of spectroscopicinstruments
- To conceive different ideas and conceptualize different hypotheses for qualitative andquantitative analysis of chemical compounds using modern instrumentation.

Expected Course Outcomes:

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

The student can interpret the electromagnetic spectra	K1-K4
Understand the electronics and block diagram of spectroscopic instruments.	K2-K4
Principle of absorption / emission and their molecular interaction with light and flame.	
Separation and identification of molecules and ions using chromatography.	K2-K5
Construction and operation of modern chromatographic equipment's	K3-K4
Collection and interpretation of data from spectroscopic and chromatographic instruments	K5 & K6

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

Unit:1
Molecular Spectroscopy-1

Basic Electronics - Resistors, capacitors, transistors, operational amplifiers, integrated circuits,semiconductor devices

Beer-Lambert's law, Filter photometry, Types of electronic excitation. Chromophore and Auxochrome-Bathochromic and Hypsochromic shift,

Unit-2 Molecular Spectroscopy-2

UV-visible Spectrophotometry – Photometric titrations, Reaction rates, Complex studies. Fluorimetry – Principles of fluorescence, Instrumentation and Applications. Turbidimetry and Nephelometry – Theory, Instrumentation and Applications

Unit:3
Emission Techniques

Flame Photometry – Theory, Instrumentation and a few important applications.
Emission Techniques – Theory, techniques of excitation, electrodes and their shapes, flame andplasma emission spectrometry – instrumentation and application.

Unit:4 Atomic Absorption Spectrometry

Atomic Absorption Spectrometry – Theory, instrumentation (flame and flameless atomization) andapplications.
Types of interfaces, background correction and applications

Unit:5
Chromatography

Classical forms of chromatography – Introduction, principle and applications of column, thin layerchromatography and paper chromatography.
Modern chromatographic techniques – Principle and applications of flash vacuum columnchromatography, Gas chromatography and High performance liquid chromatography.

	Contemporary Issues	

Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars –webinars for strengthening the subject matters.

	Total Lecture hours	60 hours

Text Book(s)

Principles of Instrumental Analysis – Douglas A. Skoog, Saunders College Publ. III Edition,1985.

Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IVEdition, 1985.

Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, Pearson Education Ltd, VIEdition, 2001

Principles of Instrumental Analysis – Skoog and Leary, Saunders College Publ. IV Edition,1992.

Analytical Chemistry – Gary D. Christian, Wiley, New York, V Edition, 2001.

Handbook of Instrumental Techniques for Analytical chemistry – F. Settle, Prentice Hallinc, 1997

Reference Books

Instrumental Methods of Analysis – Willard, Merit, Dean and Settle, CBS Publ. &Distributors, VI Edition, 1986.

Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, IIEdition, 1986.

Analytical Chemistry – J.G. Dick, McGraw Hill Publishers, 1975

Instrumental Methods of Chemical Analysis – G.W. Ewing, McGraw Hill Publishers, 1975.

Quantitative Chemical Analysis – D.C. Harris, W.H. Freeman Publication, IV Edition, 1995.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]
https://youtu.be/9KkcioAoO-Y- Gas chromatography
https://youtu.be/DAwXk77DXUM- Introduction to Industrial Instrumentation
https://youtu.be/5wR9H1FryLs-Fluoroscence Spectroscopy
https://youtu.be/Yzan11nP6Ls-Atomic Absorption Spectroscopy
https://youtu.be/SnbXQTTHGs4-Chromatographic Techniques
https://youtu.be/1F6CxVF5I9g-Flame Photometer
Course Designed By: Dr. K. Ravichandran, Dr. Deepa P Nambiar and Dr. K. Venkatachalam

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	M	S	S	S	S	M	S	S
CO2	S	S	S	S	M	S	M	M	M	L
CO3	S	S	S	S	L	S	S	S	S	S
CO4	S	M	S	S	L	S	S	L	S	M
CO5	S	S	S	M	S	S	S	S	S	M

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

Title of the Course	MAIN GROUP ELEMENTS AND INORGANIC POLYMERS						
Paper No.	Core V						
Category	Core	Year	I	Credits	5	Course Code	
		Semester	II				
Instructional hours per week	Lecture	Tutorial	Lab Practice			Total	
	5	1	-			6	
Prerequisites	Basic knowledge of Chemistry						

UNIT-I

Chemistry of the p-Block elements: Hydrogen and its compounds; classification and structure of compounds; reactivity of hydrogen compounds; metal hydrides and dihydrogen complexes. The boron and carbon groups: The boron group; chemistry of boron hydrides, carboranes, and related compounds. Boron-nitrogen compounds. The carbon group with special emphasis on silicon chemistry.

UNIT-II

The nitrogen and oxygen groups: The nitrogen group with special emphasis on nitrogen and phosphorus chemistry; boron nitrogen compounds; nitrogen-metal complexes and bonding; phosphorus-metal bonds and complexes. The oxygen group with special emphasis on the chemistry of sulfur. p-block ring and cluster compounds.

UNIT-III

The halogens and the noble gases: Polyhalogen and interhalogen compounds; compounds of halogens and oxygen. The noble gases.Special topics and recent developments: Catenation and multiple bonding between heavier elements, particularly, RE=ER (E = P, As, Sb, Bi), R2E=ER2 and R2E (E = Si, Ge, Sn, Pb) systems. Phospha-alkynes and phospha-alkenes. Chemistry of alkali and alkaline earth metals; their uses in homogeneous catalysis and material chemistry. Main group organometallic chemistry. Unusual oxidation states of main group elements with special emphasis on recently developed Al(I) and Si(II)-silylene chemistry.

UNIT-IV

Free Radical Co-Polymerization : Introduction, Copolymer composition, Copolymerisation equations, Methods of determination of reactivity ratios, Reactivity ratio and copolymerization behavior,experimental determination of r1 and r2; Q-e scheme. Microstructure of copolymers, Important examples of copolymers.

UNIT-V

Cationic, Anionic And Ring Opening Polymerization: (15) Basic concepts of cationic and anionic methods of polymerization, distinguishing betweenradical and ionic polymerization. Kinetics of cationic and anionic polymerization. Group transfer polymerization. Ring opening polymerization,mechanism of ROP of cyclic ethers, cyclic amides and cyclosiloxanes; Ring opening metathesispolymerization.

Commercial importance of cationic and anionic polymerization.

References

1.Chemistry of the Elements, by N.N. Greenwood and A. Earnshaw, Butterworth-Heinmann, London, (1997).

2. Advanced Inorganic Chemistry by F. A. Cotton, G. Wilkinson, C. A. Murillo and M. Bochmann, John Wiley, Chichester, (1999).

3. Inorganic Chemistry by N. Wiberg, A. Holleman, and E. Wiberg, Academic Press, New York, (2001).

4. Concepts and models of Inorganic Chemistry by B. Douglas, D. McDaniel and J. Alexander, John Wiley, New York, (1994).

A List of Recommended Books.

1. Polymer Chemistry – M. P. Stevens, 2ndEd., Oxford University Press, 1990.
2. Polymer Synthesis Theory and Practice, D. Braun, H. Cherdrown and H. RitterSpringer, Heidelberg (2001) ISBN 3-540 –41697-8
3. Principles of Polymer Chemistry, 2Nd Ed.A Ravve, Kluwer Academic Publisher (2000) ISBN 0-306- 48368-7.
4. Organic Chemistry of Synthetic High Polymers, R.W. Lenz, Interscience Publishers, New York (1967)
5. Polymer Science and Technology, J.R. Fried, Prentice Hall (1995).
6. Polymer Chemistry – An Introduction, R. B. Seymour and C. E. Carraher, Jr.Marcel Dekker, Inc. New York
7. Polymer Science, V.R. Gowariker, V.N. Vishwanathan and J.Sreedhar, Wiley- Eastern Limited (1995) 8. Contemporary Polymer Chemistry, H.R. Allcock and F.W.Lampe.
9. Introduction to Polymer Science and Technology An SPE Textbook, H. S. Kaufman and J. J. Falcetta, John- Wiley and Sons, New York.
10. Introduction to Synthetic Polymers, I. M. Campbell, 1stEd., Oxford Press (1994)

<table>
<tr><td>Title of the Course</td><td colspan="7">ORGANIC REACTION MECHANISM</td></tr>
<tr><td>Paper No.</td><td colspan="7">Core VI</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Core</td><td>Year</td><td>I</td><td>Credits</td><td>4</td><td>Course Code</td><td></td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td rowspan="2">Instructional hours per week</td><td>Lecture</td><td>Tutorial</td><td colspan="3">Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td>5</td><td>1</td><td colspan="3">-</td><td colspan="2">6</td></tr>
<tr><td>Prerequisites</td><td colspan="7">Basic concepts of organic chemistry</td></tr>
<tr><td>Objectives of the course</td><td colspan="7">To understand the feasibility and the mechanism of various organic reactions.
To comprehend the techniques in the determination of reaction mechanisms.
To understand the concept of stereochemistry involved in organic compounds.
To correlate and appreciate the differences involved in the various types of organic reaction mechanisms.
To design feasible synthetic routes for the preparation of organic compounds.</td></tr>
<tr><td rowspan="2">Course Out line</td><td colspan="7">UNIT-I:Methods of Determination of Reaction Mechanism: Reaction intermediates, The transition state, Reaction coordinate diagrams, Thermodynamic and kinetic requirements of reactions: Hammond postulate.Methods of determining mechanism: non-kinetic methods - product analysis, determination of intermediates-isolation, detection, and trapping. Cross-over experiments, isotopic labelling, isotope effects and stereo chemical evidences. Kinetic methods - relation of rate and mechanism.Effect of structure on reactivity: Hammett and Taft equations. Linear free energy relationship, partial rate factor, substituent and reaction constants.</td></tr>
<tr><td colspan="7">UNIT-II:Aromatic and Aliphatic Electrophilic Substitution: Aromaticity: Aromaticity in benzenoid, non-benzenoid, heterocyclic compounds and annulenes. Aromatic electrophilic substitution: Orientation and reactivity of di- and polysubstituted phenol, nitrobenzene and halobenzene. Reactions involving nitrogen electrophiles: nitration, nitrosation and diazonium coupling; Sulphur electrophiles: sulphonation; Halogen electrophiles: chlorination and bromination; Carbon electrophiles: Friedel-Crafts alkylation, acylation and arylation reactions.Aliphatic electrophilic substitution Mechanisms: SE2 and</td></tr>
</table>

	SEi, SE1- Mechanism and evidences.
	UNIT-III:Aromatic and Aliphatic Nucleophilic Substitution:Aromatic nucleophilic substitution: Mechanisms - S_NAr, S_N1 and Benzyne mechanisms - Evidences - Reactivity, Effect of structure, leaving group and attackingnucleophile. Reactions: Oxygen and Sulphur-nucleophiles, Bucherer and Rosenmund reactions, von Richter, Sommelet- Hauser and Smiles rearrangements. S_N1, ion pair, S_N2 mechanisms and evidences. Aliphatic nucleophilic substitutions at an allylic carbon, aliphatic trigonal carbon and vinyl carbon.S_N1, S_N2, S_Ni, and S_E1 mechanism and evidences, Swain- Scott, Grunwald-Winstein relationship - Ambident nucleophiles.
	UNIT-IV:Stereochemistry-I: Introduction to molecular symmetry and chirality – axis, plane, center, alternating axis of symmetry. Optical isomerism due to asymmetric and dissymmetric molecules with C, N, S based chiral centers. Optical purity, prochirality, enantiotopic and diastereotopic atoms, groups, faces, axial and planar chirality, chirality due to helical shape, methods of determining theconfiguration. Racemic modifications: Racemization by thermal, anion, cation, reversible formation, epimerization, mutarotation.D, L system, Cram's and Prelog's rules: R, S-notations, proR, proS, side phase and re phase Cahn-Ingold-Prelog rules, absolute and relative configurations. Configurations of allenes, spiranes, biphenyls, cyclooctene, helicene, binaphthyls, ansa and cyclophanic compounds, exo-cyclic alkylidene-cycloalkanes. Topicity and prostereoisomerism, chiral shift reagents and chiral solvating reagents.Criteria for optical purity: Resolution of racemic modifications, asymmetric transformations, asymmetric synthesis, destruction. Stereoselective and stereospecific synthesis.
	UNIT-V:Stereochemistry-II: Conformation and reactivity of acyclic systems, intramolecular rearrangements, neighbouring group participation, chemical consequence of conformational equilibrium - Curtin-Hammett Principle.Stability of five and six-membered rings: mono-, di- and polysubstituted cyclohexanes, conformation and reactivity in cyclohexane systems. Fused and bridged rings: bicyclic, poly cyclic systems, decalins and Brett's rule.Optical rotation and optical rotatory dispersion, conformational asymmetry, ORD curves, octant rule, configuration and conformation, Cotton effect, axial haloketone rule and determination of configuration.

Extended Professional Component (is a part of internal component only, Not to be included in the external examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET/ UGC-CSIR / GATE /TNPSC others to be solved (To be discussed during the Tutorial hours)
Skills acquired from this course	Knowledge, Problem solving, Analytical ability, Professional Competency, Professional Communication and Transferable skills.
Recommended Text	1. J. March and M. Smith, Advanced Organic Chemistry, 5th edition, John-Wiley and Sons.2001. 2. E. S. Gould, Mechanism and Structure in Organic Chemistry, Holt, Rinehart and Winston Inc., 1959. 3. P.S.Kalsi, Stereochemistry of carbon compounds, 8th edition, New Age International Publishers, 2015. 4. P. Y. Bruice, Organic Chemistry, 7th edn, Prentice Hall, 2013. 5. J.Clayden, N. Greeves, S. Warren, Organic Compounds, 2nd edition, Oxford University Press, 2014.
Reference Books	**1. F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry Part-A and B, 5th edition, Kluwer Academic / Plenum Publishers, 2007.** **2. D. G. Morris, Stereochemistry, RSC Tutorial Chemistry Text 1, 2001.** **3. N.S. Isaacs, Physical Organic Chemistry, ELBS, Longman, UK, 1987.** **4. E. L. Eliel, Stereochemistry of Carbon Compounds, Tata-McGraw Hill, 2000.** **5. I. L. Finar, Organic chemistry, Vol-1&2, 6th edition, Pearson Education Asia, 2004.**
Website and e-learning source	**1.https://sites.google.com/site/chemistryebookscollection02/home/organic-chemistry/organic** **2. https://www.organic-chemistry.org/**

Course Learning Outcomes (for Mapping with POs and PSOs)

Students will be able

CLO1: To recall the basic principles of organic chemistry.

CLO2: To understand the formation and detection of reaction intermediates of organicreactions.

CLO3: To predict the reaction mechanism of organic reactions and stereochemistry of organic compounds.

CLO4: To apply the principles of kinetic and non-kinetic methods to determine the

mechanism of reactions.
CLO5:To design and synthesize new organic compounds by correlating the stereochemistryof organic compounds.

CO-PO Mapping (Course Articulation Matrix)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	S	S	S	S	M	S	S	S	S	M
CO 2	M	S	S	S	S	M	S	S	S	S
CO 3	S	S	M	S	S	S	S	M	S	S
CO 4	M	S	S	S	S	M	S	S	S	S
CO 5	M	S	M	S	S	M	S	M	S	S

Strong - 3 **Medium-2** **Low-1**

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	3	3	3	3	3
CO2	3	3	3	3	3
CO3	3	3	3	3	3
CO4	3	3	3	3	3
CO5	3	3	3	3	3
Weightage	15	15	15	15	15
Weighted percentage of Course Contribution to Pos	3.0	3.0	3.0	3.0	3.0

3 – Strong, 2 – Medium, 1 – Low

Title of the Course	ANALYTICAL CHEMISTRY PRACTICAL-I						
Paper No.	Core VI						
Category	Core	Year	I	Credits	4	Course Code	
		Semester	II				
Instructional hours per week	Lecture	Tutorial	Lab Practice			Total	
	-	-	6			6	
Prerequisites	Basic concepts of organic chemistry						

The main objectives of this course are to:

- To learn the practical knowledge about the conductivity and potentiometric titrations, nephelometry and fluorometry using lab scale experimental methods.
- To motivate the students to understand the basic principles of spectrophotometry and carry out quantitative analysis.
- To train them in analytical instrumental analysis
- To learn proper maintenance of records, observations and data interpretation

Expected Course Outcomes:

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

1.	To prepare for each experiment by studying lab handouts and links therein	K1-K4
2.	To appreciate the modern problems and scientific controversies in analytical chemistry	K2-K4
3.	To design and perform experiments to estimate the amount of species using instrumentation techniques.	
4.	To verify Beer-Lambert's law and determine the unknown concentration	K2-K5
5.	To validate the theory of electrochemistry and the measurement of electrical conductance through the practical seasons.	K3-K4
6.	To understand the basic concepts of conductometric and potentiometric titrations and the quantitative analysis of unknown solutions using the corresponding instruments.	K5 & K6

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

List of Experiments

	Spectrophotometry: 1. Determination of Iron /Cobalt. 2. Determination of dissociation constant of an indicator. 3. Determination of Binary mixtures. 4. Determination of Mn in steel. Gas Chromatography: 1. Determination of efficiency of a column. 2. Determination of Rt values for various organic compounds. 3. Resolution of mixtures - Hydrocarbons, alcohols Potentiometry/ pHmetry: 1. Determination of pKa of an acid. 2. Determination of zinc with ferrocyanide. 3. Determination of ferrous ion with dichromate. 4. Determination of carbonate/bicarbonate and mixtures. Conductomentry Conductormetric titrations Nephelometry: Determination of sulphate. Fluorimeter: Determination of Quinine. Flash Point - analysis CV, FTIR, AAS, HPLC - demonstration	
	Contemporary Issues	

YouTubes Videos, Animations, NPTEL, MOOC videos,

Reference Books

1	Instrumental Methods of Analysis – Willard, Merit, Dean and Settle, CBS Publ. & Distributors, VI Edition, 1986.
2	Text Book of Quantitative Inorganic Analysis – A. I. Vogel, ELBS, III and IV Edition
3	Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, II Edition, 1986
4	Principles of Instrumental Analysis D. A. Skoog, Saunders College Pub. Co., III Edition, 1985
5	Instrumental Methods of Chemical Analysis – G.W. Ewing, McGraw Hill Publishers, 1975.

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

1.	https://youtu.be/xHQM4BbR040-Spectrophotomettry
2.	https://youtu.be/anlIEj4xWhU-Potentiometry
3.	https://youtu.be/u9t4vBF0h9k-Conductometry

Course Designed By: Dr. K. Venkatachalam

Mapping with Programme Outcomes*

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

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

<table>
<tr><td>Title of the Course</td><td colspan="7">QUANTUM CHEMISTRY AND GROUP THEORY</td></tr>
<tr><td>Paper No.</td><td colspan="7">ELECTIVE-III</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td>Credits</td><td>4</td><td>Course Code</td><td></td></tr>
<tr><td>Semester</td><td>II</td><td colspan="4"></td></tr>
<tr><td rowspan="2">Instructional hours per week</td><td>Lecture</td><td>Tutorial</td><td colspan="3">Lab Practice</td><td colspan="2">Total</td></tr>
<tr><td>4</td><td>1</td><td colspan="3">-</td><td colspan="2">5</td></tr>
<tr><td>Prerequisites</td><td colspan="7">Basic knowledge of physical chemistry</td></tr>
<tr><td>Objectives of the course</td><td colspan="7">To understand the essential characteristics of wave functions and need for the quantum mechanics.
To know the importance of quantum mechanical models of particle in a box, rigid rotor and harmonic oscillator.
To apply the quantum mechanics to hydrogen and polyelectronic systems.
To familiarize the symmetry in molecules and predict the point groups.
To predict the vibrational modes, hybridization using he concepts of group theory.</td></tr>
<tr><td>Course Outline</td><td colspan="7">UNIT-I: Introduction
Wave particle duality, Uncertainty principle, Particle wave and Schrodinger wave equation, wave function, properties of wave function. Properties of wave function, Normalized, Orthogonal, orthonormal, Eigen values, Eigen functions, Hermitian properties of operators.Introduction to quantum mechanics-black body radiation, photoelectric effect, hydrogen spectrum.Need for quantum mechanics, Postulates of Quantum Mechanics, Schrodinger wave equation, Time independent and time dependent</td></tr>
<tr><td></td><td colspan="7">UNIT-II: Quantum models: Particle in a box-1D, two dimensional and three-dimensional, degeneracy, application to linear conjugated molecular system, free particles, ring systems.Harmonic Oscillator-wave equation and solution, anharmonicity, force constant and its significance.Rigid Rotor-wave equation and solution, calculation of rotational constants and bond length of diatomic molecules.</td></tr>
<tr><td></td><td colspan="7">UNIT-III: Applications to Hydrogen and Poly electron atoms: Hydrogen atom and hydrogen like ions, Hamiltonian-wave equation and solutions, radial and angular functions, representation of radial distribution functions.Approximation methods –variation methods: trial wave function, variation integral and application to particle in 1D box. Perturbation method - first order applications.Hatrefock self-consistent field method, Hohenberg-Kohn theorem and Kohn-Sham equation, Helium atom-electron spin, paulis exclusion principle and Slater determination.</td></tr>
<tr><td></td><td colspan="7">UNIT-IV: Group theory: Groups, sub groups, symmetry elements, operations, classification-axial and non-axial. Dihedral point groups-C_n,C_{nh}, D_n, D_{nh}, D_{nd}, Tdand Oh.Matrix representation and classes of symmetry operations, reducible irreducible and direct product representation. The Great orthogonality theorem –irreduciblerepresentation and reduction formula, construction of</td></tr>
</table>

	character table for C_{2v}, C_{2h}, C_{3v} and D_{2h} point groups.
	UNIT-V: Applications of quantum and group theory: Hydrogen Molecule-Molecular orbital theory and Heitler London (VB) treatment, Energy level diagram, Hydrogen molecule ion; Use of linear variation function and LCAO methods.Electronic conjugated system:Huckel method to Ethylene butadiene, cyclopropenyl, cyclo butadiene and Benzene. Applications of group theory to molecular vibrations, electronic spectra of ethylene.
Extended Professional Component (is a part of internal component only, Not to be included in the external examination question paper)	Questions related to the above topics, from various competitive examinations UPSC / TRB / NET/ UGC-CSIR / GATE /TNPSC others to be solved (To be discussed during the Tutorial hours)
Skills acquired from this course	Knowledge, Problem solving, Analytical ability, Professional Competency, Professional Communication and Transferable skills.
Recommended Text	1. R.K. Prasad, Quantum Chemistry, New Age International Publishers, New Delhi, 2010, 4th revised edition. 2. F. A. Cotton, Chemical Applications of Group Theory, John Wiley & Sons, 2003, 2nd edition. 3. A. Vincent, Molecular Symmetry and Group Theory. A Programmed Introduction to Chemical Applications, John and Willy & Sons Ltd., 2013, 2nd Edition. 4. T. Engel & Philip Reid, Quantum Chemistry and Spectroscopy, Pearson, New Delhi, 2018, 4th edition. 5. G. K. Vemulapalli, Physical Chemistry, Prentice Hall of India Pvt. Ltd. 2001. 6. D.A. McQuarrie, Quantum Chemistry, Viva Books PW. Ltd, 2013, 2nd edition.
Reference Books	1. N. Levine, Quantum Chemistry, Allyn& Bacon Inc, 1983, 4th edition. 2. D.A. McQuarrie and J. D. Simon, Physical Chemistry, A Molecular Approach, Viva Books Pvt. Ltd, New Delhi, 2012. 3. R. P. Rastogi & V. K. Srivastava, An Introduction to Quantum Mechanics of Chemical Systems, Oxford & IBH Publishing Co., New Delhi, 1999. 4. R.L. Flurry. Jr, Symmetry Group Theory and Chemical applications, Prentice Hall. Inc, 1980 5. J. M. Hollas, Symmetry in Molecules, Chapman and Hall, London, 2011, Reprint.

Website and e-learning source	1. https://nptel.ac.in/courses/104101124 2. https://ipc.iisc.ac.in/~kls/teaching.html

Course Learning Outcomes (for Mapping with POs and PSOs)
Students will be able:
CO1: To discuss the characteristics of wave functions and symmetry functions.
CO2: To classify the symmetry operation and wave equations.
CO3: To apply the concept of quantum mechanics and group theory to predict the electronic structure.
CO4: To specify the appropriate irreducible representations for theoretical applications.
CO5: To develop skills in evaluating the energies of molecular spectra.

CO-PO Mapping (Course Articulation Matrix)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO 1	**S**	**S**	**S**	**S**	**M**	**S**	**S**	**S**	**S**	**M**
CO 2	**M**	**S**	**S**	**S**	**S**	**M**	**S**	**S**	**S**	**S**
CO 3	**S**	**S**	**M**	**S**	**S**	**S**	**S**	**M**	**S**	**S**
CO 4	**M**	**S**	**S**	**S**	**S**	**M**	**S**	**S**	**S**	**S**
CO 5	**M**	**S**	**M**	**S**	**S**	**M**	**S**	**M**	**S**	**S**

3 – Strong, 2 – Medium, 1 - Low

Level of Correlation between PSO's and CO's

CO /PO	PSO1	PSO2	PSO3	PSO4	PSO5
CO1	**3**	**3**	**3**	**3**	**3**
CO2	**3**	**3**	**3**	**3**	**3**
CO3	**3**	**3**	**3**	**3**	**3**
CO4	**3**	**3**	**3**	**3**	**3**
CO5	**3**	**3**	**3**	**3**	**3**
Weightage	**15**	**15**	**15**	**15**	**15**
Weighted percentage of Course Contribution to POs	**3.0**	**3.0**	**3.0**	**3.0**	**3.0**

3 – Strong, 2 – Medium, 1 - Low

<table>
<tr><td>Title of the Course</td><td colspan="7">FIRE SAFETY AND FIRE FIGHTING</td></tr>
<tr><td>Paper No.</td><td colspan="7">ELECTIVE-IV</td></tr>
<tr><td rowspan="2">Category</td><td rowspan="2">Elective</td><td>Year</td><td>I</td><td rowspan="2">Credits</td><td rowspan="2">3</td><td rowspan="2">Course Code</td><td rowspan="2"></td></tr>
<tr><td>Semester</td><td>II</td></tr>
<tr><td rowspan="2">Instructional hours per week</td><td>Lecture</td><td>Tutorial</td><td colspan="2">Lab Practice</td><td colspan="3">Total</td></tr>
<tr><td>4</td><td></td><td colspan="2">-</td><td colspan="3">4</td></tr>
<tr><td>Prerequisites</td><td colspan="7">Basic concepts of Lab Safety and first aid</td></tr>
<tr><td>Objectives of the course</td><td colspan="7">To learn important about the safety procedures practiced in the Chemical laboratory
To learn how to Chemical Storage, Safe Handling of Chemicals and Gases</td></tr>
<tr><td>Course Outline</td><td colspan="7">Unit-I
Classification of fire, General Causes of fire, Detection of fire, Extinguishing methods, First aid fire fighting equipments, Fire bucket, Fire beater, hose real hose, Portable extinguisher, depends on weight, depends on operating method, depends on content, Depends on position of nozzle, Construction, Operation, Maintenance, Refilling
Unit-II
Recognition of possible fire sources and emergency procedures in the event of a fire, the course also offers an in-depth study of fire investigation and the construction techniques for eliminating fires, History of fires, types of detecting devices and extinguishing agents and systems, construction techniques, and fire investigation, National Fire Protection Association and Occupational Safety and Health Administration standards
Unit-III
Devising procedures in the event of fire, How people perceive and react to fire danger, The measures needed to overcome behavioral problems and to ensure the safe evacuation of people in the event of fire, Assisting disabled people to escape
Unit-IV
Safety goals and objectives, Monitoring safety progress, Identifying hazards and risks, Safety and financial benefits, Safety and the balanced scorecard, Setting targets and ensuring commitment, Developing safe work systems, Policies and procedures, Safety values and principles
Unit-V
Emergency Plans & Staff Training, Highly Flammables & LPG, Firefighting equipment requirements, Fire resisting construction .Active fire safety for building protection: Sprinklers & Automatic roof vents

Text Book(s)
1. Laboratory Safety Theory and Practice 1st Edition Anthony Fuscaldo December 1980
2. The Foundations of Laboratory Safety Stephen R. Rayburn 1990 Springer-Verlag New York

3. Research Laboratory Safety,By Daniel Reid Kuespert · 2016
.
Reference Books
1. Prudent practices in the laboratory: handling and management of chemical Hazards, updated version. National Academies Press, 25-Mar-2011 - Science - 360 pages</td></tr>
</table>

	2. Guidelines for Chemical Laboratory Safety in Academic Institutions American Chemical Society Washington, DC 2016. 3. Guidelines for Laboratory Design: Health, Safety, and Environmental Considerations, Fourth Edition Louis 15 March 2013 John Wiley & Sons,

Title of the Course	**SOFTWARE PACKAGE FOR CHEMISTS – MATLAB, ORIGIN AND CHEMDRAW**						
Paper No.	**ELECTIVE-IV**						
Category	**Elective**	**Year**	**I**	**Credits**	**2**	**Course Code**	
		Semester	**II**				
Instructional hours per week	**Lecture**	**Tutorial**	**Lab Practice**			**Total**	
	4		**-**			**4**	
Prerequisites	**Basic concepts of Software Package**						
Objectives of the course	**To provide basic knowledge in Software Package chemistry and Matlab, Origin And Chemdraw**						
Course Outline	**UNIT I** **Handling of Variable, Comments and Functions:** Basic concepts of MATLAB and its applications in various filed – History and its various Basic operation – Important functions – understanding variables – different types of variables – creating Scripts and understanding commends – operation on matrix – File handling and text processing **UNIT-II** **Programming and Data Conversion:** Programming in MATLAB – Plot functions and programming – 2-D plots (two vectors) and 3-D plots with three vectors – Additional 2D plots – working with structure and map container data types – cell data types – converting between different data types **UNIT-III** **Basics of Origin:** Spread sheets – Basic of origin – various mathematical functions for plotting, statistical calculations – Drawing of various plots and its functions – Background correction for various plots **UNIT-IV** **Origin for Data Analysis** Curve fitting using polynomial, exponential, Gaussian, Lorrentzian, Boltzmann, reciprocal functions, Computing area under a curve, peak finding, deconvolution of curve– Bar chats- 3D plotting – error bars in plotting **UNIT-V** **Chemdraw:** Basic concepts of chemdraw – Functions – various arrows used in the chemical equations – concept of drawing of chemical equations – Concepts of valance of atoms in a molecules– Drawing of simple molecules, macro molecules, inorganic complex, organometallic complex, peptides and dendrimers – drawing of catalytic cycles and organic reaction mechanism.							

	Text book: **1. Amos Gilat, MATLAB: An Introduction with Applications, 4ed , 2012** **2. S.N. Alam, S.S. Alam, Understanding Matlab: A Textbook for Beginners, 2019, Dreamtech Press** **3. Jake Woods, Chemdraw Professional (Tutorial User Guide) Kindle Edition, 2019.**

SEMESTER-III

Title of the Course	PHYSICAL METHODS IN CHEMISTRY						
Paper No.	CORE-VII						
Category	Core	Year	II	Credits	5	Course Code	
		Semester	III				
Instructional hours per week	Lecture	Tutorial	Lab Practice		Total		
	5	1	-		6		
Prerequisites	Basic concepts of UV, IR, NMR and Mass spectra						
Objectives of the course	To provide basic knowledge UV, IR, NMR and Mass spectra						

The main objectives of this course are to:

- To provide the deep understanding of electronic structural changes of metal coordination complexes upon interaction with visible light.
- To understand basic theory and instrumentation involved in the origin of spectroscopy.
- Understand UV, IR, NMR and Mass spectra and their significance in the characterization of organic compounds.

- Illustrate the basic principle of splitting of spectral line of inorganic complexes in the presence of magnetic field upon interaction with electromagnetic radiation.
- To understand role of spectroscopy (UV, IR, NMR & Mass spectroscopy) to determine the structure of organic compounds.
- To learn ESR and their importance in the characterization of radicals.
- To understand basic theory & instrumentation involved with analytical techniques for characterization and imaging

Expected Course Outcomes:

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

1.	Interpretation of various absorption band in the visible, IR and microwave region to understand the structural bonding, geometry and reactivity of inorganic coordination complexes (K1-K4)	K1-K4

2.	To understand the basic concept, interpretation and application of electronic spectra of hydrogen and many electron atoms also to derive angular momentum of many electron atoms and term symbols of atoms (K2-K4)	K2-K4
3.	Knowledge of crystal, vibrational, thermal, ATR and imaging modes to characterize chemical compounds (K3-K4)	K3-K4
4.	Understand basic theory as well as instrumentation techniques for recording UV, IR, NMR, ESR, MS, XRD, Raman, Mossbauer and Thermal spectra of chemical compounds (K2-K5)	K2-K5
5.	Interpretation of UV, IR, NMR, TGA, DSC, XRD, Raman, Mossbauer, ESR and MS spectra of compounds to understand their structural characteristics (K2-K6)	K2-K6
K1 - Remember; K2 - Understand; K3 - Apply; K4 - Analyze; K5 - Evaluate; K6 - Create		

Unit:1	**ELECTRONIC SPECTROSCOPY (PHYSICAL & INORGANIC CHEMISTRY)**	**20 hours**

Spectra of hydrogen and many electron atoms, angular momentum of many electron atoms, term symbols, spectra of many electron atoms- Zeeman effect. Spectra of diatomic molecules, Representation of electronic states through potential energy diagrams-Frank Condon principle.

Intensities of electronic transitions- theoretical treatment of absorption intensities, transition dipole moment integral, oscillator strength, selection rules parity, spin and symmetry considerations, Factors inducing forbidden transitions vibronic and spin orbit coupling, polarization bands.

Spectra of formaldehyde, butadiene and benzene –group theoretical discussion.

Electronic spectra of inorganic complexes – Selection rules (Laporte, orbital and spin selection rules), band intensities, band widths, spectra in solids, spectra of aqueous solutions of d^1-d^9 ions in O_h and T_d environments.

Unit:2	**MOSSBAUER & RAMAN SPECTROSCOPY, X-RAY AND THERMAL METHODS OF ANALYSES (ANALYTICAL CHEMISTRY)**	**20 hours**

Mossbauer spectroscopy: Introduction, principle, instrumentation, recoil energy, Doppler effect, number of MB signals, isomer shift, quadrupole splitting, magnetic hyperfine splitting applications to ^{57}Fe, ^{119}Sn and ^{129}I compounds

Raman Spectroscopy: SERS, SERRS. ATR techniques – UV, IR, Raman. Principle & application of ORD and CD in the identification of complexes.

3D, 4D & 5D NMR imaging techniques

X-ray diffraction – Bragg equation, space groups and point groups, diffraction methods. Thermal methods of analysis – TGA, DTA and DSC – Principle and applications.

Unit;3	**NUCLEAR MAGNETIC RESONANCE (ORGANIC CHEMISTRY)**	**20 hours**

Origin of NMR spectrum-Nuclear spin states – NMR active nuclei – Nuclear magnetic moment– Larmor equation – Absorption of energy and Resonance – Population density of nuclear spin states. Saturation phenomena – Relaxation mechanisms, Bloch equation (only significance and derivation not required). Comparison of CW and FT instrument–Chemical shift - Standards in NMR – Shielding and De-shielding – Factors affecting chemical shift – electronegativity, hybridization, hydrogen bonding - anisotropic effect – double, triple bond, aromatic compounds and carbonyl compounds. Spin-spin coupling – splitting origin and rules – factors affecting coupling constant: cis, trans, gem, ortho, meta, para coupling – exchange with deuterium. Vicinity of the proton, Long range coupling, Karplus equation and curve. ^{1}J, ^{2}J, ^{3}J, ^{4}J and ^{5}J coupling in NMR, order of NMR spectrum. Spin systems: Two interacting nuclei: A2, AB, AX, AA'BB', dd, pair of doublet, AB quartet. Three interacting nuclei: AMX, ABX, ABC systems (only pattern is required). Simplification of complex NMR spectra-Lanthanide shift reagents, CIDNP and NOE. Basic principles and applications of VT NMR & MRI.

^{13}C NMR – difficulties in recording ^{13}C NMR: Homo nuclear and heteronuclear coupling. Decoupling technique: SFORD and Off Resonance decoupled spectrum identification of various types of carbon using ^{13}C NMR. APT & DEPT spectra (DEPT-45, DEPT-90 and DEPT-135).

^{19}F NMR Precessional frequency and heteronuclear coupling. Identification of organofluoro compounds (CF3CO2Et and CF3CH2OH) using NMR. ^{31}P NMR – Chemicalshift and heteronuclear coupling. Identification of organophosphorus compounds suchas (CH3)3P, (C2H5O)2P=O and Ph3P. P-P bond in NMR. Basic principles of 2D NMR (COSY, NOSEY, HSQC & HMBC).

Unit:4	**UV, IR, MS (ORGANIC CHEMSITRY) & ESR (INORGANIC CHEMSITRY)**	**20 hours**

Electronic absorption-Beer-Lamberts law, Types of electronic excitation. Chromophore and Auxochrome-Bathochromic and Hypsochromic shifts. UV-vis spectra of simple organic compounds such as alkenes, phenols, anilines, carbonyl compounds and 1,3-diketones. Woodward and Fieser rule for calculation of λ-max values of dienes and unsaturated ketones.

Infrared Spectra: Identification of functional groups in Organic Compounds, Finger print region. Inter and Intramolecular hydrogen bonding

Origin, basics and bloc diagram of Mass spectrum-Various types of Ionization techniques-Stability of Molecular ions, Meta stable ions. Base peaks and Isotope peaks. Fragmentation patterns of organic molecules such as benzenes, phenyl halides, phenols, benzyl alcohols, benzyl halides, aliphatic alcohols, aliphatic as well as aromatic aldehydes, ketones, acids, esters and amides. Fragmentation patterns of aliphatic/aromatic nitro and amine compounds. Fragmentation patterns of heterocyclic compounds (furan, pyrrole and pyridine only). McLafferty rearrangements of organic molecules.

Structural determination of Organic Compounds using UV, IR, NMR and Mass Spectra.

ESR Spectra of d^1-d^9 Transition Metal Complexes with examples. Interpretation of g in cubic, axial and rhombohedral geometries. Calculation of g values with simple examples. Intensities of '$g_{\parallel}$ and $g_{\perp}$ peaks. Evidence for Metal-Ligand Bond Covalency- Cu(II)- Bis –Salicylaldimine, Bis-Salilcylaldoximato copper(II) $[(NH_3)_5CoO_2CoNH_3)_5]^{5+,}$ Cu(II)-diethyldithiophosphinate, Vanadyldithiophsphinate, Copper(II) tetraphenylporphyrin, Co(II)- phthalocyanine, $K_2[IrCl_6]$. Interpretation of 'g' and 'A' values from ESRspectral data in- i) MnF_6^{4-}, ii) CoF_6^{4-}, and CrF_6^{3-}.

	Contemporary Issues	

Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters.

	Total Lecture hours	80 hours

Text Book(s)

1.	Chang, R (1971); Basic Principles of Spectroscopy, McGraw Hill, ISBN-13: 978-007010517
2.	Banwell, C. N.; McCash, E. M (1994); Fundamentals of Molecular Spectroscopy, IVth Ed, McGraw Hill, ISBN 0-07-707976-0

3.	Kemp, W. (2016); Organic Spectroscopy, 3rd Ed, Palgrave
4.	Kalsi, P. S (2016); Spectroscopy of Organic Compounds, 7th Ed, New Age International
5.	Silverstein, R. M, Webster, F. X, Kiemble, D. J, Bryce, D. L (2015); Spectrometric Identification of Organic Compounds, 8th Ed, Wiley
6	Jag Mohan (2016); Organic Spectroscopy Principles & Applications, 3rd Ed, Narosa Publishing House
7	Pavia, L, Lapman, G. M, Kriz, S, Vyvyan, J.-R (2015); Introduction to Spectroscopy, Cengage Learning, ISBN 13: 978-81-315-2916-4
8	Russell S. Drago, R. S (2016), Physical Methods for Chemists, II Ed
9	Huheey, J. E.; Keiter, E. A.; Keiter, R. L.; Medhi, O. K (2006); Inorganic Chemistry: Principles of Structure and Reactivity, IVth Ed, Pearson Education
10	Skoog, D. A; Holler, F.; Crouch, S (2017); Principles of Instrumental Analysis, 7th Ed, Brooks/Cole publisher
11	Ebsworth, E. A. V.; Rankin, D. W. H.; Craddock, S (1986); Structural Methods in Inorganic Chemistry, Wiley-Blackwell, ISBN-13: 978-0632015924
12	Willard, H. H.; Merritt, L.L. Jr.; Dean, J.A.; Settle, F. A. Jr. (2004); Instrumental methods of analysis CBS Publishers & Distributors; 7th Ed, ISBN 13: 9780534081423
13	Macomber, R. S (1998); A complete introduction to Modern NMR Spectroscopy, John Wiley, ISBN: 0-471-15736-8

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

- https://nptel.ac.in/content/storage2/courses/102103044/pdf/mod2.pdf
- https://www2.chemistry.msu.edu/courses/cem351/FS16_HUANG/Lecture_Presentation/Ch_10_Lecture_Presentation.pdf
- https://www.slideshare.net/siraj174/sir-aj-nmr-spectroscopy-lecture
- http://web.iyte.edu.tr/~serifeyalcin/lectures/chem305/cn_1.pdf
- https://www.youtube.com/watch?v=qtpVfccYEHE&t=98s
- http://www.digimat.in/nptel/courses/video/104106122/L54.html
- https://pubs.rsc.org/en/content/articlelanding/2018/cs/c6cs00565a

https://chem.libretexts.org/Bookshelves/Physical_and_Theoretical_Chemistry_Textbook_Maps/Supplemental_Modules_(Physical_and_Theoretical_Chemistry)/Spectroscopy/Magnetic_Resonance_Spectroscopies/Electron_Paramagnetic_Resonance/EPR%3A_Application

Course Designed By: Prof. A. K. Mohanakrishnan, Dr. K. Parthasarathy, Dr. A. Murugadoss, Dr. R. Sasikumar, Dr. T.M. Sridhar, Dr. K. Venkatachalam and Dr. Deepa P Nambiar.

Mapping with Programme Outcomes*

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

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

Title of the Course	ANALYSIS OF COMPLEX MATERIALS AND SEPARATION TECHNIQUES PRACTICAL – II						
Paper No.	**CORE-VIII**						
Category	**Core**	**Year**	**II**	**Credits**	**5**	**Course Code**	
		Semester	**III**				
Instructional hours per week	**Lecture**	**Tutorial**	**Lab Practice**			**Total**	
	5	**1**	**-**			**6**	
Prerequisites	**Basic concepts of separation techniques**						
Objectives of the course	**To provide basic knowledge separation techniques**						

The main objectives of this course are to:

- Ability to analyze ores and alloys
- Knowledge of procedures to be used for different types of ores and alloys
- Analysis of organic compounds using chemical analysis
- Identification of molecules and ions present in organic compounds.
- Classification and properties of fuels
- Analysis of fuels to determine their properties

Expected Course Outcomes:

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

1.	Basic knowledge of methods used in analysis of complex materials	K1-K2
2.	Toidentify the procedure to analyze the chemical nature of Ore and alloy samples	K2-K4
3.	To summaries the chemical reactions involved in analysis of materials	K3-K4
4.	To understand the principle and assimilate the various steps involved in chemical analysis	K3-K5
5.	To estimate and critically assess properties of complex materials	K4-K5
6.	To device a protocol to analyze any ores, alloys, organic compounds and fuels that is provided using classical analytical procedures	K5 - K6

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

Unit:1	**Ore and Alloy Analysis**	15 hours

Ore and Alloy Analysis – Sample preparation – Decomposition and dissolution of the sample, Fusion process, use of fluxes – acid and alkaline fluxes.

General procedure of complete analysis of Ores and Alloys – Oxide Ore- Haematite, Carbonate Ore – Dolomite, Alloys – Solder and Brass.

Unit:2	**Analysis of Organic Compounds**	15 hours

Elemental analysis – Decomposition of organic compounds – Dry and wet ashing. Fusion - alkali metal fusion. Analysis of carbon, nitrogen and hydrogen in organic compounds.

Determination of traces of water in liquids and solids. Direct and indirect methods – use of Karl-Fischer's reagent, Dean and Stark method.

Functional group analysis: Amine, phenolic – OH, alcoholic – OH, vicinal hydroxyl, aldehyde and ketonic group analysis. Unsaturation in oils and fats – Bromination and iodine number. Rancidity Atomic Absorption Spectrometry – Theory, instrumentation (flame and flameless atomization) and applications.

Unit:3	**Fuel Analysis**	15 hours
Fuel Analysis - Solids, liquids and gaseous fuels – Sampling procedure, ultimate and proximate analysis, specific volatile index, ash content, Calorific value by bomb calorimeter and Junker's gas calorimeter. Liquid fuels – Flash point, viscosity, carbon residue, aniline point, pour point – Determination and significance		
	Contemporary Issues	
Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters.		

Title of the Course	**INSTRUMENTAL METHODS PRACTICAL-III**						
Paper No.	**CORE-IX**						
Category	**Core**	**Year**	**II**	**Credits**	**5**	**Course Code**	
		Semester	**III**				
Instructional hours per week	**Lecture**	**Tutorial**	**Lab Practice**			**Total**	
	5	**1**	**-**			**6**	
Prerequisites	**Students should know about analytical techniques**						
Objectives of the course	**To provide basic knowledge of the fundamentals and applications of spectroscopic techniques**						

Course Objectives:
The main objectives of this course are to:

- To enumerate the crystalline and thermal properties of materials
- To outline the principles of various surface analytical tools.
- To understand the fundamentals and applications of spectroscopic techniques
- To summarise the various microscopic techniques used in research
- To probe the topography of the surfaces at nanometric levels

Expected Course Outcomes:

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

1.	To identify the crystal structure and purity of newly synthesized compounds	K1-K4
2.	To understand the principle and application of spectroscopic techniques	K2-K4
3.	To predict the thermal behaviors of the newly developed compounds and composites	K3-K4
4.	To determine the oxidation states of elements and their composition using surface analytical techniques	K5-K6
5.	Compare and contrast the instrumentation used for SEM and TEM	K4-K5
6.	To obtain the structure of atoms and molecules as images using scanning probe techniques	K5 & K6

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

Unit:1		15 hours

X-RAY DIFFRACTION

X-ray powder diffraction–single crystal diffraction techniques - Determination of accurate lattice parameters-structure analysis - profile analysis - particle size analysis using Scherer formula

THERMAL ANALYSIS METHODS

Principle and Instrumentation of TGA, DTA and DSC- application of thermal analysis for nanostructures.

Unit:2	**QUALITATIVE AND QUANTATIVE ANALYSIS**	15 hours

Principle, instrumentation and applications for nanomaterials- XPS, Auger and EDAX

Unit:3	**SPECTROSCOPIC TECHNIQUES**	15 hours

Principle, instrumentation and applications for nanomaterials –UV-Vis, FT-IR and Raman Spectroscopy

Unit:4	**MICROSCOPIC TECHNIQUES**	15 hours

SCANNING ELECTRON MICROSCOPY

Scanning electron microscopy Principle – Modes of operation – Specimen Preparation, application of SEM for nano materials.

TRANSMISSION ELECTRON MICROSCOPY:

Basic principles - Modes of operation – Specimen preparation – Diffraction in imperfect crystals – Dislocations – precipitates – Structure of Grain boundaries and interfaces- HRTEM use in nanostructures.

Unit:5	**SPM**	15 hours

SPM – types, principle, instrumentation and applications for scanning of surfaces

	Contemporary Issues	

Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters.

	Total Lecture hours	75 hours

Text Book(s)

1	B. D.Cullity, “Elements of X-ray Diffraction”, 4th Edition, Addison Wiley, 1978.
2	M. H.Loretto, “Electron Beam Analysis of Materials”, Chapman and Hall, 1984.
3	J.Goldstein, D. E. Newbury, D.C. Joy, and C.E. Lym, “Scanning Electron Microscopy and X-ray Microanalysis”, 2003.
4.	S.L. Flegler, J.W. Heckman and K.L. Klomparens, “Scanning and Transmission Electron Microscopy: An Introduction”, WH Freeman & Co, 1993.

Reference Books

1.	Michael Brown and Patrick Gallagher, “Handbook of Thermal Analysis and Calorimetry :Recent Advances, Techniques and Applications” Elsevier 2007.
2.	Douglass A. Skoog and Donald M.West “Principles of Instrumental Analysis” illustrated edition, 1971
3.	Daniel C. Haris, “Quantitative Chemical Analysis”, Sixth Edition, 2002

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

1.	https://www.youtube.com/watch?v=IeH0lhn7uHY-X Ray Diffraction
2.	https://www.youtube.com/watch?v=bENSsj4rfJc-TGA
3.	https://www.youtube.com/watch?v=jRAqhFdwt20-AFM

Course Designed By: Dr. K. Venkatachalam

Mapping with Programme Outcomes*

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10

CO1	M	S	M	S	L	M	S	M	M	S
CO2	S	M	S	M	M	S	S	S	M	S
CO3	S	M	M	S	M	M	S	L	S	S
CO4	M	M	M	S	L	L	M	L	S	S
CO5	M	S	M	S	S	L	M	L	L	S

Title of the Course	**BIOLOGICAL CHEMISTRY**						
Paper No.	**CORE-IX**						
Category	**Core**	**Year**	**I**	**Credits**	**5**	**Course Code**	
		Semester	**II**				
Instructional hours per week	**Lecture**	**Tutorial**	**Lab Practice**			**Total**	
	5	**1**	**-**			**6**	
Prerequisites	**Students should understand the role of bio- organic compounds.**						
Objectives of the course	**To provide basic knowledge of the fundamental aspects on biological system, mechanism, kinetics and analytical tools.**						

The main objectives of this course are to:

- To understand the function of carbohydrate in biological chemistry, determination of ring size and study of starch and cellulose.
- To understand the significances of amino acids, proteins nucleic acids in biological system.
- Illustrate the importance of the various elements in the biological system and to gain more insights into the binding of metal complexes with biomacrmolecules and transport and storage mechanism involving in the metaloenzymes.
- To understand the role of heavy metals in the human body- therapeutic and toxicity levels.

Expected Course Outcomes:

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

1.	To learn about structural and functions of carbohydrates, lipids, membranes, amino acids, proteins, antibiotics and vitamins	K1-K5
2.	Understand structure and biological importance of RNA and DNA	K2-K4
3.	Understand the key function of metal ions such as Fe, Co, Ni Zn and Cu in living system, particularly in transports (energy and O_2), storage, electron- and proton transfer, hydrolysis, etc. which are taking place at the active site of metalloproteins and enzymes	K1-K4
4.	Toxicity of metals and their effects in the biological system	K1-K4
5.	To evaluate toxicity of drugs used in cancer and radiodiagnosis	K5 & K6

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

Unit:1	Bio-Organic Chemistry	20 hours
Carbohydrates: Pyranose and furanose forms of aldo-hexose and ketohexose-methods used for the determination of ring size-conformation of aldo-hexopyranose-structure and synthesis of lactose and sucrose. A brief study of starch and cellulose. Lipids and Membranes: Molecular structure of lipids. Fatty Acids, TriglyceridesTypes of membrane lipids Amino acids and Proteins: Amino acids and Protein structure, Analysis of N-terminal and C-terminals in a polypeptide. Sanger method, Edman degradation and Enzymatic analysis. Primary, secondary and tertiary structure of proteins. Structure of collagen, myoglobin and haemoglobin. Nucleic acids: Chemistry of nucleic acids, nucleosides and nucleotides – Structure RNA and DNA and their biological importance. Biomolecules: Antibiotics and vitamins: A detailed study of structure, and stereochemistry of penicillin, cephalosporin. Chemistry and physiological action of ascorbic acid, thiamin, riboflavin and pyridoxine – Elementary aspect of vitamin A, E, K and B12.		
Unit:2	**Bio-Inorganic Chemistry**	**15 hours**
Essential and trace metal ions: Enzymes - Nomenclature and classification – Coenzymes - Vitamin B12, Carboxypeptidase and Superoxide dismutase – Heme-enzyme - Peroxidase and catalases. Oxygen carriers: Hemeproteins - Hemoglobin, myoglobin - Structure Oxygenation and stereochemistry - Bohr effect. Non-heme oxygen carriers - Hemerythrin and hemocyanin. Nitrogen fixation: Introduction, types of nitrogen fixing microorganisms. Nitrogenase enzyme - Metal clusters in nitrogenase - redox property - Dinitrogen complexes - transition metal complexes of dinitrogen - nitrogen fixation via nitride formation and reduction of dinitrogen to ammonia. Biological redox systems: Cytochromes -Classification, cytochrome a, b and c. Cytochrome P- 450. Transport of electrons: Iron-Sulphur Proteins: Rubredoxins and Ferredoxins, Structural and Spectral features of Iron-Sulphur Proteins. Photosynthesis and chlorophyll's.		
Unit:3	**Bio-Physical Chemistry**	**15 hours**
Thermodynamics and biology-Basic concepts of structure and functionality-membranes-structure, function transport properties, aspects of electrochemical phenomena – active transport, ionophores, biological energy storage systems – stepwise mechanism of photosynthesis versus potential. Enzymes - Nomenclature and classification, chemical kinetics, the free energy of activation and the effects of catalysts, kinetics of enzyme catalyzed reactions – Michaelis - Menten equation - Effect of pH, temperature on enzyme reactions, Factors contributing to the catalytic efficiency of enzymes. Membranes - Phase Equilibria, Donnan effect, Donnan Potential, Phase transition in Lipid bilayers, Free energy determination for ATP hydrolysis from sodium-potassium pump, Allosteric effects – Monod-Wyman-Changeux Theory, Assigning of Statistical weights for Helix-Coil transition in proteins, Study by spectroscopic methods.		
Unit:4	**Bio-Analytical Chemistry**	**15 hours**
Essentials of trace elements and chemical toxicology: Trace elements in biological system. Metal ion toxicity - classes of toxic metal compounds– detoxification. Metals in medicine: Anti-arthritis drugs – Au and Cu in rheumatoid arthritis – Li in psychiatry – Pt, Au and metallocenes in anti-cancer drugs- metals in radio diagnosis, radio therapy and magnetic resonance imaging. Transport and storage of metals: Mechanism – Fe, Cu, Zn and V storage and transport – metallothioeins. Molecular mechanism of iron transport across the membrane – sodium and potassium ion pumps. Pollution studies – Effluent and water treatment..		
	Contemporary Issues	
Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars – webinars for strengthening the subject matters.		
	Total Lecture hours	60 hours
Text Book(s)		

1.	Zubay, G, L. (1997); Biochemistry, 4th edition, Brown (William C.) Co
2.	Nelson, D, L Lehninger, A, L Cox M, M. (2008); Principles of Biochemistry, 5th Edition, New York: W.H. Freeman.
3.	John McMurray, (2008); Organic Chemistry, 8th edition, Brooks/Cole.
4.	Finar, I. L. Vol 2 (2018); Organic Chemistry: Stereochemistry and the Chemistry of Natural product, IIIrd Ed, Pearson
5.	Williams D. R. (1976); Introduction to Bioinorganic Chemistry, Thomas, ISBN-13 : 978-0398034221.
6.	Kaim, W, Schwederski, B, Klein, A. (2013); Bioinorganic chemistry: Inorganic Elements in the chemistry of life, 2nd edition, Wiley.
7.	Das Asim K. (2007); Bioinorganic Chemistry, 1st edition, Books and Allied (P) Limited.
8.	Mugherjee G. N, Arabinda D, (1993); Elements of Bioinorganic Chemistry, 4th Edition, U. N. Dhur & Sons Pvt. Ltd.
9.	Satake M. Mido Y. (1996); Bioinorganic Chemistry, ISBN 81-7141-301-1, Discovery Publishing House, New Delhi.
10.	Eichorn, G, (1973); Inorganic Bio-Chemistry Vol. I and II, IV Ed, Elsevier.
11.	Zhimin, T, (2008); Analysis of Cytotoxicity of Anticancer Drugs, VDM Verlag Dr. Mueller E.K.ISBN: 9783639063486, 3639063481

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
	• https://www.youtube.com/watch?v=iuW3nk5EADg https://www.youtube.com/watch?v=aeC7M9PDjQw https://www.youtube.com/watch?v=DhwAp6yQHQI https://www.youtube.com/watch?v=ZqoX2W1N6l0 • https://www.youtube.com/watch?v=lsNalwRnaq0&list=PLbMVogVj5nJSHhL_cMKfzLv556ddrIT90 https://www.youtube.com/watch?v=pXztk04J7u0&list=PLFW6lRTa1g83-gUOcT3ay875UG3a9Mu11
Course Designed By: Dr. T.M. Sridhar, Dr. K. Parthasarthy and Dr. P. Prabhu	

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	S	M	M	S	M	M	L	L
CO2	S	M	S	S	M	M	S	M	L	L
CO3	S	M	S	M	L	M	S	L	L	L
CO4	M	S	S	S	L	S	M	L	L	L
CO5	S	S	S	M	L	L	S	L	L	L

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

Title of the Course	CLASSICAL AND RADIO ANALYTICAL METHODS OF ANALYSIS						
Paper No.	ELECTIVE-V						
Category	Elective	Year	II	Credits	3	Course Code	
		Semester	III				
Instructional hours per week	Lecture	Tutorial	Lab Practice			Total	
	3	-	-			3	
Prerequisites	Students should know about classical methods of analysis						
Objectives of the course	To provide basic knowledge of the computer programming languages in chemistry applications.						

Course Objectives:

The main objectives of this course are to:

- Ability to analyze ores and alloys and organic compounds
- Knowledge of procedures to be used for analyzing different types of complex materials
- To understand the working of electronic components used in instruments
- To state the development and requirements of programing languages
- To critically access the application of computer programming languages in chemistry applications.
- Application of principles of nuclear chemistry in sample analysis
- Role of radio analytical techniques in analytical estimations

Expected Course Outcomes:

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

1.	Knowledge of methods used in complete analysis of complex materials	K1-K4
2.	To identify the procedure to analyze the chemical nature of Ores, alloys andorganic compounds samples	K2-K4
3.	To summaries the chemical reactions involved in analysis of materials usingradio analytical techniques	
4.	To understand the upto date developments in computer programing languagesand techniques	K2-K5
5.	Ability to choose the required programming language to write a program for theirchemistry application.	K3-K4
6.	To device a protocol to analyze any ores, alloys and organic compounds that isprovided using classical analytical procedures	K5 & K6

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

Unit:1	**Analysis of Complex Materials and Organic Compounds**	**15 hours**

nalysis of Complex Materials:
Ore Analysis – Sample preparation – Decomposition and dissolution of sample, fusion process, use of fluxes – acid and alkaline fluxes.
General procedure of complete analysis of ores – oxides, sulphide and carbonate ores,one/two examples of each, cement, silicate, glass and industrial glasses.
Alloy analysis – Sample preparation, Ferrous and non-ferrous alloys :steel, solder, brass and bronze, aluminium alloy, etc.
Analysis of Organic Compounds:
Elemental analysis – Decomposition of organic compounds – Dry, and wet ashing. Fusion – lime, alkali metal fusion. Analysis of carbon, nitrogen, hydrogen, sulphur and halogens in organic compounds, equipment and methods, instrumental, Pregal method, Automatic CHN analysers.
Determination of traces of water in liquids and solids. Direct and indirect methods – use of Karl-Fischer's reagent, Dean and Stark method and instrumental methods.
Functional group analysis - Amine, phenolic-OH, alcoholic-OH, vicinal hydroxyl, methoxyl, ketonic, aldehyde group analysis. Unsaturation in organic compounds including oils and fats – Bromination, hydrogenation, iodine number, Rancidity

Unit:2	**Basic Electronics**	**15 hours**

Basic electronics –operational amplifiers in chemical instrumentation, integrated circuits, integrators, differentiators, rectifiers and battery eliminators, analog and digital circuits, signal to noise ratio, sources of noise in instrumental analysis, optimization and limit of detection

Computer Programing: Principles and techniques of programming, High and low level languages, operating systems, algorithms essentials of BASIC. C, C++, Java, Visual Basic, Fortran. Pascal, SQL.
Concepts of Python, Could computing, Artificial Intelligence

Unit:3	**Radioanalytical Techniques**	**15 hours**

Characteristics of radiation, Nuclear instrumentation, measurements of radioactivity – Gas ionisation, semiconductor, Nuclear emulsion and autoradiography.
Sample preparation for analysis, Neutron Activation analysis, Isotopic dilution analysis, Radioimmunoassay. Direct, reverse and special radiometric titrations. Applications of Radiochromatography and Radioelectrophoresis, Tracer Application of radioisotopes in agriculture, industry and medicine.

	Contemporary Issues	

Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars –webinars for strengthening the subject matters.

	Total Lecture hours	45 hours

Text Book(s)

1	Instrumental Methods of Analysis – Willard, Merit, Dean and Settle , CBS Publ. &

	Distributors, VI Edition, 1986
2	Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, II Edition, 1986
3	Principles of Instrumental Analysis – Douglas A. Skoog, Saunders College Publ. III Edition, 1985.
4.	Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985
5.	Fundamentals of Analytical Chemistry – D.A. Skoog and D.M. West, Holt Rinehart and Winston Publications, IV Edition, 1982..
6	Quantitative Organic Analysis – S. Siggia and J.G. Hanna, Wiley –Intersci. Publ. IV Edition, 1979.
Reference Books	
1	Fuel Testing – G.W. Himus, Leonard Hill, 1954
2	Technical Methods of Analysis – R.C. Griffin, McGraw Hill, 1965.
3	Chemistry of Engineering Materials – C.V.Agarwal, TARA Publications, II Edition, 1965
4	Principles of Radiochemistry – D.D. Sood, N. Ramamoorthy and A.V.R. Reddy, Eds., IANCAS, Bombay, 1993.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://www.youtube.com/watch?v=ZQQVlGCtEns- Ore Analysis
2.	https://www.youtube.com/watch?v=XxA-wwYnNjc-Dean and Stark method
3.	https://www.youtube.com/watch?v=iMg_U5n1ZXo- Autoradiography
3.	https://www.youtube.com/watch?v=GJWXUrE2ma4-Neutron Activation Analysis
Course Designed By: Dr. K. Ravichandran, Dr. T.M. Sridhar, Dr. K. Venkatachalam and Dr. Deepa P Nambiar	

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	S	S	S	M	M	L	M
CO2	S	S	S	S	M	S	S	S	M	S
CO3	S	S	S	M	L	M	S	L	L	S
CO4	S	M	S	S	M	L	S	L	S	L
CO5	M	S	M	S	S	S	S	M	S	S

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

Title of the Course	FUNDAMENTALS OF MOLECULAR SPECTROSCOPY						
Paper No.	SEC-II						
Category	SEC	Year	II	Credits	2	Course Code	
		Semester	III				
Instructional hours per week	Lecture	Tutorial	Lab Practice			Total	
	3	-	-			3	
Prerequisites	Students should know about spectroscopy.						
Objectives of the course	to provide basic knowledge of the principles and – instrumentation of spectroscopy.						

UNIT-I

UV Spectroscopy: (6 Hours)

Principles – Instrumentation – hands on training-sample handling techniques – Application of UV-Visible spectroscopy.

UNIT-II

IR Spectroscopy: (6 Hours)

Principles – Instrumentation, sample handling techniques, Application of IR spectroscopy

UNIT-III

NMR Spectrometry: (6 Hours)

Principles – Instrumentation – advantages of NMR techniques – Application of NMR

UNIT-IV

Mass Spectrometry: (6 Hours)

Basic Principles – Instrumentation – advantages of and Application of mass spectrometry

UNIT-V

ESR Spectrometry: (6 Hours)

Basic Principles – Instrumentation – advantages and Application of ESR spectrometry

Text/Reference Books

1. Silverstein, R. M, Webster, F. X, Kiemble, D. J, Bryce, D. L (2015); Spectrometric Identification of Organic Compounds, 8th Ed, Wiley
2. Kalsi, P. S (2016); Spectroscopy of Organic Compounds, 7th Ed, New Age International
3. Pavia, L, Lapman, G. M, Kriz, S, Vyvyan, J.-R (2015); Introduction to Spectroscopy, Cengage Learning, ISBN 13: 978-81-315-2916-4
4. Jag Mohan (2016); Organic Spectroscopy Principles & Applications, 3rd Ed, Narosa Publishing House.

SEMESTER-IV

Title of the Course	OPTICAL AND SURFACE ANALYTICAL TECHNIQUES						
Paper No.	CORE-Xi						
Category	Core	Year	II	Credits	5	Course Code	
		Semester	IV				
Instructional hours per week	Lecture	Tutorial	Lab Practice			Total	
	5	1	-			6	
Prerequisites	Students should understand the theory and instrumentation						
Objectives of the course	To provide basic knowledge of the structure of atoms and molecules as images using scanning probe techniques						

The main objectives of this course are to:

- To describe the theory and instrumentation for analysis by interaction with light.
- To identify the procedure to analyze the chemical nature and properties of fuels
- To understand the principle of microscopy and apply them to sample analysis.
- To obtain the structure of atoms and molecules as images using scanning probe techniques
- To differentiate the various types of crystals and analyze their properties using X-rays
- To critically assess the composition of surfaces using state of the art technologicallyadvanced instrumentation

Expected Course Outcomes:

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

1.	Determination of optical properties of the given samples	K1-K4
2.	Knowledge of procedures to be used for analysis of different types fuels	K2-K5
3.	Determine the microstructure and chemical composition of samples	K2-K4
4.	Imaging of atoms and molecules of surfaces.	K2-K5
5.	Identification of crystal stricture and properties of compounds	K3-K4
6.	To determine the oxidation states of elements and their composition using surface analytical techniques	K5 & K6

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

Unit:1	Optical Instruments and Fuel Analysis	20 hours

Polarimetry – Theory and instrumentation specific and molecular rotations, applications, spectropolarimetry.

Refractometry – Theory, instrumentation, specific and molecular refraction, Abbe, Pulfrich and immersion types, applications.

Fuel Analysis: Solids, liquids and gaseous fuels – sampling procedure, ultimate and proximate analysis, specific volatile index, ash content, Calorific value by bomb calorimeter and Junker's gas calorimeter.

Liquid fuels – Flash point, viscosity, carbon residue, aniline point, pour point.

Gaseous fuels – Analysis of producer gas, water gas and industrial gases. Chemical and physical methods of analysis.

Unit:2	Microscopic Techniques	20 hours

Chemical Microscopy – Microscope – parts and optical path, numerical aperture and significance. Techniques – Kofler's hot stage microscope, other techniques of microscopy, application and qualitative study.

Electron Microscopy – Principle, Microscope and its operation, sample preparations, applications to analysis, electron probe analyser, ion microscopy, SEM, TEM, EDS
Fluorescence microscopy: Confocal, Phase contrastSPM
– AFM, STM, MFM, EFM- all types

Unit:3	**X-Ray Spectroscopy**	**20 hours**

– Fundamental principles of absorption, emission, fluorescence and diffraction of X-rays, instrumentation – sources, filters, monochromator, detectors and signal processors, qualitative and quantitative applications of X-ray spectroscopy.

Unit:4	**XPS**	**20 hours**

Electron spectroscopy for Chemical Analysis (ESCA) – Principle, Instrumentation – X-ray source, detectors, magnetic shielding and its applications – Quantitative analysis, chemical shifts, oxidationstate and structure.
Auger electron spectroscopy – Theory, Principle, instrumentation and general applications – qualitative analysis and depth profiling of solid surfaces.

	Contemporary Issues	

Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars –webinars for strengthening the subject matters.

	Total Lecture hours	80 hours

Text Book(s)

1	Instrumental Methods of Analysis – Willard, Merit, Dean and Settle, CBS Publ. & Distributors, VI Edition, 1986
2	Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, II Edition, 1986
3	Principles of Instrumental Analysis – Douglas A. Skoog, Saunders College Publ. III Edition, 1985
4.	Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985
5.	Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, Pearson Education Ltd, VI Edition, 2001
6.	Fundamentals of Analytical Chemistry – D.A. Skoog and D.M. West, Holt Rinehart and Winston Publications, IV Edition, 1982
7.	Fundamentals of Analytical Chemistry - Skoog, West and Holler, Saunders College Publishing, VI Edition, 1991, and VII Edition, 1996.

Reference Books

1.	Chemical Instrumentation – H.A. Stuobel, Addison – Wesley Publ. Co., 1976.
2.	Handbook of Chemical Microscopy – E.M. Chamot and C.W. Mason, John Wiley, Vol. I – II, 1944
3.	Treatise on Analytical Chemistry – Kolthoff and Elwing (all series).
4.	Comprehensive Analytical Chemistry – Wilson and Wilson (all series).
5.	Handbook of Instrumental Techniques for Analytical chemistry – F. Settle, Prentice Hall inc, 1997
6.	Principles of Instrumental Analysis – Skoog, Holler & Nieman, Saunders College Publishing, V Edition, 2000

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

1.	https://www.youtube.com/watch?v=1mhcLO8LLoI-Polarimetry
2.	https://www.youtube.com/watch?v=DBiEc8KM1e0-Scanning Electron Microscopy
3.	https://www.youtube.com/watch?v=D3JY4LgyX6Q-Transmission Electron Microscopy
4.	https://www.youtube.com/watch?v=jozx6dOoyxA-XPS
Course Designed By: Dr. Deepa P Nambiar and Dr. K. Venkatachalam	

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	S	S	M	M	L	M	S	L	S
CO2	S	M	S	M	S	M	S	S	M	S
CO3	S	S	S	L	L	M	S	S	S	S
CO4	M	S	S	M	M	M	M	S	L	S
CO5	S	S	S	S	M	L	M	S	M	S

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

Title of the Course	**SEPARATION TECHNIQUES**						
Paper No.	**CORE-XII**						
Category	**Core**	**Year**	**II**	**Credits**	**5**	**Course Code**	
		Semester	**IV**				
Instructional hours per week	**Lecture**	**Tutorial**	**Lab Practice**			**Total**	
	5	**1**	**-**			**6**	
Prerequisites	**Students should know about the separation techniques**						
Objectives of the course	**To provide basic knowledge of the natural compounds to chemicals and estimate them using chromatographic techniques.**						

The main objectives of this course are to:

- To understand the principle and theory of simple separation process employed in the lab theory and instrumentation for analysis by interaction with light.
- To outline the principles of various chromatographic techniques along with the methodology used.
- To display the role of size of a molecule involved in separation using size exclusion chromatography

- To successfully obtain separation of natural compounds to chemicals and estimate them using chromatographic techniques.
- To understand the principle, instrumentation of separation of gaseous mixtures using Gas chromatography
- To differentiate, isolate and characterize the various types of compounds present in liquids using
- HPLC

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

1.	Separation of compounds using distillation, floatation, dialysis and solvent extraction	K1-K4
2.	Selection of procedures to separate compounds using chromatography	K2-K4
3.	Demonstrate the working of instruments with block diagrams	
4.	Compare and contrast the role of various separation techniques used in analysisof specialty compounds	K2-K5
5.	Separation and estimation of ions in solution using ion chromatography	K3-K4
6.	To identify and determine the molecules after separation using GC & HPLC	K5 & K6

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

Unit:1	**Techniques**	**20 hours**

Distillation – Principle – theoretical plates and HFTP, Applications
Solvent Extraction – Distribution law, Batch and continuous extraction. Extraction of solids-applications.
Floatation – Theory, cell and its operation and applications.
Dialysis – Theory, membranes and their choice, Electro dialysis- applications.

Unit:2	**Chromatographic Techniques**	**20 hours**

Chromatographic Methods - General aspects of chromatography, classification, mechanism, Band broadening and column efficiency.
Column chromatography – Construction and operation of column, choice of adsorbents, eluents and applications.
Paper chromatography – Mechanism of separation, qualitative and quantitative applications.
Thin layer Chromatography –Choice of adsorbent, solvents and applications. High performance thin layer chromatography (HPTLC).
Ion-exchange chromatography – Techniques and applications.

Unit:3	**Gas Chromatography**	**20 hours**

– Types, nature and selection of stationary and mobile phases, solid supports and their choice, columns – packed, open and capillary, sampling methods, instrumentation, detectors – types, sensitivity, limit of detection, operative principles of TCD, FID and ECD, comparison of detectors, temperature programming, derivative chromatography, hyphenated techniques qualitative and quantitative applications GC-MS and GC-IR

Unit:4	**High Performance Liquid Chromatography**	**20 hours**
Theory and equipments, types of pumps and their choice, types of columns and choice of column materials, detectors and applications. Size exclusion chromatography – Theory, gel filtration and gel permeation Supercritical fluid chromatography.		
	Contemporary Issues	
Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars –webinars for strengthening the subject matters.		
	Total Lecture hours	60 hours

Text Book(s)	
1	Thin Layer Chromatograph – Egon Stahl, Toppan Printing Co., Pvt, Ltd., II Edn., 1969
2	Physical and Chemical Methods of Separation – E.W. Beg. McGraw Hill, 1963.
3	Gas Chromatography (Analytical Chemistry by Open Learning) – John Willet, John Wiley &Sons, 1991
4.	Instrumental Methods of Analysis – Willard, Merrit, Dean and Settle, VI Edition, CBS Publishers and Distributors, 1986.
5.	Principles of Instrumental Analysis – Skoog and Leary, IV Edition, Saunders College Publishing, 1992
6	Principles of Instrumental Analysis – Skoog, Holler & Nieman, Saunders College Publishing,V Edition, 2000

Reference Books	
1	Treatise on Analytical Chemistry – Kolthoff and Elwing (all series).
2	Quantitative Analysis – Day and Underwood
3	Comprehensive Analytical Chemistry – Wilson and Wilson (all series).
4	Physico – Chemical Techniques of Analysis – P.B. Janardhan, Vol. I & II.
5	Principles and Methods of Chemical Analysis – F. Walton, Prentice Hall, II Edn., 1966
6	Modern Analytical Chemistry – W.F. Pickering, Maroel Dec, 1971.
7	Gas Analysis and Testing of Gaseous Materials – Alteri, Mmer. Gas Asso. 1965.
8	Chromatography –Harry and Calvin, Van Nostrand Reinhold Company, II Edition, 1967
9	Quantitative Analysis Using Chromatographic Techniques – E.Katz, John Wiley & Sons Ltd,1987

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://www.youtube.com/watch?v=Ia8yrBL2Xwc-HPLC
2.	https://www.youtube.com/watch?v=iHrKsfw827c-Chromatographic Techniques
3.	https://www.youtube.com/watch?v=N96JaRnE7n0-Extraction Methods
4.	https://www.youtube.com/watch?v=8Q0VfIbhEmM-Ion Exchange Chromatography
Course Designed By: Dr. T.M. Sridhar	

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	S	M	S	S	M	S	S	M	S	S
CO2	S	S	S	S	L	M	S	M	L	S
CO3	M	S	M	M	L	M	S	L	M	L
CO4	S	S	S	S	S	M	M	S	L	S
CO5	S	S	S	S	M	S	M	M	S	S

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

Title of the Course	**ENERGY CONVERSION PHENOMENA**						
Paper No.	**ELECTIVE-VI**						
Category	**Elective**	**Year**	**I**	**Credits**	**3**	**Course Code**	
		Semester	**II**				
Instructional hours per week	**Lecture**	**Tutorial**	**Lab Practice**			**Total**	
	4	**-**	**-**			**4**	
Prerequisites	**Students should know about the separation techniques**						
Objectives of the course	**To provide basic knowledge of the natural compounds to chemicals and estimate them using chromatographic techniques.**						

Course Description

This course provides fundamentals of thermodynamics,chemistry, and transport physics applied to energy conversion systems. Analysis ofenergy conversion and storage in thermal, mechanical, nuclear, chemical, andelectrochemical processes in power systems, with emphasis on efficiency, performance and environmental impact. Topics include fossil and nuclear powersystems, solar energy, wind energy, geothermal energy, biomass energy, fuel cell andthermoelectric systems, CO2 separation and capture.

Course Objectives

The purpose of this course is to critically examine the technologyof energy systems that will be acceptable in a world faced with global warming, local pollution, and declining supplies of oil. The focus is on renewable energy sources(wind, solar, biomass), but other non-carbon emitting sources (nuclear) and reducedcarbon sources (co-generative gas turbine plants, fuel cells) are also studied. Both thedevices and the overall systems are analyzed.

Title of the Course	ELECTRO ANALYTICAL CHEMISTRY						
Paper No.	SEC-III						
Category	SEC	Year	II	Credits	2	Course Code	
		Semester	IV				
Instructional hours per week	Lecture	Tutorial	Lab Practice			Total	
	4	-	-			4	
Prerequisites	Students should know about the Basic knowledge of electrochemistry isessential						
Objectives of the course	• To provide basic knowledge of the theory and basics of electrochemical techniques and their applications						

The main objectives of this course are to:

- To learn the theory and basics of electrochemical techniques and their applications
- Design and functioning of electrochemical sensors
- Introduction to Electrochemical Impedance Spectroscopy
- Describe the theory and practical applications of voltametric techniques and polarography

Understand the principles and applications of coulometry and electrogravimetry

- V

Expected Course Outcomes:

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

1.	Working knowledge on sensors and electrochemical impedance spectroscopy	K1-K4
2.	Types of electrodes and their functions	K3-K5
3.	Electrical double layer and electrokinetic properties	K2-K4
4.	Distinguish different types of voltametric and polarographic techniques	K2-K5
5.	Interpret and apply electroanalytical techniques in research	K3-K4
6.	Fundamentals of corrosion and its prevention	K5 & K6

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

Unit:1	Electrical Double Layer, Corrosion and Electrokineticapplications	15 hours

Electrical double layer – Electrode - electrolyte interface, Types of interfaces, thermodynamics of electrified interfaces, derivation of electrocapillary phenomena, Point of Zero Charge (PZC), Lippmann equation, estimation of surface charge and surface excess and Gibbs adsorption. Structure of electrified interfaces, Helmholtz-Perrin, Gouy – Chapman and Stern models, specific adsorption. Corrosion - Thermodynamic criteria of corrosion of metals – Dry and wet corrosion, homogenous (Wagner and Traud's) and heterogenous theories, classification of corrosion –Uniform, Galvanic, Crevice, Pitting and Intergranular corrosion- Povrbaix diagram. Corrosion prevention - passivation and inhibitors. Electrokinetic phenomena - overview of Zeta Potential – Principles, Mechanism and applications. Conversion and storage of electrochemical energy. Fuel cells and Lithium-ion battery.

Unit:2	Potentiometric and sensing techniques	15 hours

Potentiometry - standard and formal potentials - Nernst equation. Types of electrodes - indicator and reference electrodes. Ion selective electrodes - crystalline and non-crystalline electrodes - glass electrode for pH measurements, mechanism of electrode response and evaluation of selectivity coefficient, asymmetry potential, alkaline and acid errors, applications of ion selective electrodes. Chronoamperometry and Chronopotentiometry. Potentiometric titrations - manual and

automatic titrators, titrations including differential methods titrations in non-aqueous systems, titrations with polarized electrodes. Bipoteniometry - principle, instrumentation and applications. Amperometric and Potentiometric sensors - Gas Sensors, Bio sensors. Impedance spectroscopy, RDE, RRDE, sensors		
Unit:3	**Voltametric Techniques**	**15 hours**
Voltammetry–Polarography- DME, polarograms, currents in polarography, polarographic maxima, effect of dissolved oxygen and application to chemical analysis, amperometeric titrations, pulse polarography – normal and differential pulse, square wave polarography, stripping methods – cathodic and anodic stripping, linear sweep voltammetry, cyclic voltammetry, types of electrodes and chemically modified electrodes. Coulometric analysis - Theory, Faraday's laws, types of coulometres, coulometric titrations; Electrogravimetry – Theory, electrogravimetry, order of deposition, constant potential, constant current deposition and deposition of complex ions.		
	Contemporary Issues	
Expert lectures, YouTubes Videos, Animations, NPTEL, MOOC videos, online seminars –webinars for strengthening the subject matters.		
	Total Lecture hours	45 hours

Text Book(s)	
1.	Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, Fundamentals ofAnalytical Chemistry, 8th Edition
2.	A. M. Bond, Modern polarographic methods in Analytical Chemistry, Marcel Decker Inc.,1980
3.	Principles of Instrumental Analysis – Douglas A. Skoog, F. Holler, Stanley Crouch, 7th EdnBrooks/Cole publish; 7th edition, 2017
4.	E. Gileadi, E. Kirowa- Eisner and J. Penciner, 3. Interfacial Electrochemistry: AnExperimental Approach, Addison-Wesley Publishing Company, Massachusetts,1975.
5.	P.T. Kissinger and W.R. Heineman, 8. Laboratory Techniques in Electroanalyticalchemistry, Marcel Decker Inc., 1984
Reference Books	
1	John O'M. Bockris, Amulya K. N. Reddy, "Modern Electrochemistry", Vol. I and II, PlenumPublishing, 2008
2	John O' M.Bockris & A.K.N.Reddy, Modern Electrochemistry – Fundamentals of Electrodics,Plenum Publishers, New York, 2000.
3	Willard, H.H.; Merritt, L.L. Jr.; Dean, J.A.; Settle, F.A. Jr., CBS Publishers & Distributors; 7thedition (2004).
4	Modern polarographic methods in Analytical Chemistry- A. M Bond, Marcel Decker Inc., 1980
5	Laboratory Techniques in Electroanalytical chemistry – P.T. Kissinger and W.R. Heineman,Marcel Decker Inc., 1984
6	Chemical Instrumentation – H.A. Stoubel, Addison- Wesley, 1976 Stripping analysis – J.Wang, VCH Publication, 1985
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://www.youtube.com/watch?v=WsDTDiwmHVw-Coulometric Titrations
2	https://www.youtube.com/watch?v=AbemMe19fF4-Polarography Basics

3	https://www.youtube.com/watch?v=o1jytXWBiUc-Electrogravimetry
Course Designed By: Dr. Deepa P Nambiar, Dr. P. Prabhu and Dr A. Murugadoss	

Mapping with Programme Outcomes*										
COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10
CO1	M	S	M	L	M	S	L	M	L	L
CO2	S	S	S	S	M	M	S	M	S	S
CO3	S	S	S	M	L	M	S	S	M	S
CO4	S	S	S	M	S	S	M	M	M	S
CO5	S	S	S	L	M	M	M	S	S	M