M.SC.,
ANALYTICAL CHEMSITRY

MODEL SYLLABUS

AUGUST- 2022

TAMILNADU STATE COUNCIL FOR HIGHER EDUCATION,
CHENNAI – 600 005

DEPARTMENT OF Analytical Chemistry	
Programme:	M. Sc Analytical Chemistry
Programme Code:	CHE 001
Duration:	**2 years**
Programme Outcomes:	**PO 1** To understand the application of the analytical chemistry in today's changing technological world. **PO 2** To deliver an in-depth information to learners in the area of Analytical Chemistry and to empower them to work independently. **PO 3** To possess realistic and experimental knowledge across the principles of analytical chemistry. **PO 4** To learn fundamental tools in analytical chemistry, classical analysis, modern microscopy, thermal, radio analytical, optical and instrumentations tools and their applications to different disciplines of chemical analysis. **PO 5** To advances the acquaintance on the significance of spectroscopy, electrochemical, chromatography and surface analytical techniques. **PO 6** To demonstrate competence in solving industrial and scientific research problems through experiments by selection of the relevant international standard protocols. **PO 7** Professionally skilled towards employment in industries and higher studies in internationally renowned research institutions were they are competent to work as an individual and as a collaborative team member. **PO 8** Execute and implement the analytical chemistry concepts to critical innovative thinking in the laboratory and problem solving to meet current day challenges. **PO 9** To develop an appreciation for the problematic mission of adjudicating the accuracy and precision of data collected from the lab experiments and sharpened to them towards using appropriate computational statistical methods. **PO 10** To apply effectively the concepts of analytical chemistry towards interdisciplinary nature of chemistry, biology, medicine, material science, forensic science and other related fields to meet the ever-growing variety of chemical challenges.

Programme Specific Outcomes:	● 1 Trained to be a responsible analytical chemist and implement safe laboratory practices by handling glassware, equipment and chemical reagents appropriately following international standard operating procedures ● 2 Comprehensive analytical chemistry proficiency and research experience through methodically delivered courses and a mentored master project. ● 3 Competent in applying analytical chemistry to analyze complex materials to any substances using classical and modern separation, isolation and identification techniques. ● 4 Familiarity with spectroscopy, electrochemical, chromatography and surface analytical techniques along with the interpretation of spectra of unknown compounds ● 5 Highly skilled and knowledgeable to clear competitive exams for higher studies in premier research institutions and industrial sector.

List of Courses:

Semester	Course Code	Title of the Course	Core/ Elective/ Soft skill	Credits
I	CHE C001	Fundamentals of Analytical Chemistry	Core	3
	CHE C101	Coordination and Nuclear Chemistry	Core	3
	CHE C201	Stereochemistry and Organic ReactionMechanism	Core	3
	CHE C301	Thermodynamics and Chemical Kinetics	Core	3
	CHE C202	Organic Chemistry Practical-I	Core	3
	CHE C302	Physical Chemistry Practical-I	Core	3
	CHE E101	Inorganic Reaction Mechanism	Elective	3
	UOSM115	Lab Safety and First Aid	Soft skill	2
	UOMS117	Chemistry Databases-SciFinder, Mendeleev,Scopus, Web of Science and Google Scholar	Soft skill	2
II	CHE C002	Analytical Instrumentation	Core	3
	CHE C102	Main Group Elements andInorganic Polymers	Core	3
	CHE C203	Organic Reaction Mechanism	Core	3
	CHE C303	Quantum Chemistry and Group Theory	Core	3
	CHE C003	Analytical Chemistry Practical-I	Core	3
	CHE C103	Inorganic Chemistry Practical-I	Core	3
	CHE E302	Macromolecular Chemistry	Elective	3
	UOMS116	Fire Safety and Firefighting	Soft skill	2
	UOMS147	Software packages for Chemists-MATLAB,ORIGIN and CHEMDRAW	Soft skill	2
	UOM I001	Internship	Internship	2

III	CHE C601	Physical Methods in Chemistry	Core	4
	CHE C004	Analysis of complex materials and separation techniques Practical – II	Core	3
	CHE C005	Instrumental Methods Practical – III	Core	3
	CHE E601	Biological Chemistry	Elective	3
	CHE E003	Classical & Radio analytical methods of analysis	Elective	3
	PHY E008	Fundamentals of Molecular Spectroscopy	Elective	3
IV	CHE C006	Optical and Surface analytical techniques	Core	4
	CHE C007	Separation techniques	Core	4
	CHE C008	Project	Core	6
	CHE E503	Energy Conversion Phenomena	Elective	3
	CHE E004	Electro analytical Chemistry	Elective	3
		Total Credits		91

Method of Evaluation:

Sessional I	Sessional II	End Semester Examination	Total	Grade
20	20	60	100	A, A+, B, D, D+, O

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

Course code	CHE C001	FUNDAMENTLS OF ANALYTICAL CHEMISTRY	L	T	P	C
Core/Elective/Supportive		Core	3	0	0	3
Pre-requisite		Student must have an idea about chemical analysis	Syllabus Version			R2021

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:

1.	The students will be able to understand and apply the correct method to analyze analytical data	K1-K4
2.	They will be able to employ the correct technique to collect samples of any nature for analysis	K2-K4
3.	Can evaluate the accuracy and summaries the methods adapted for certain practical activities.	K3-K4
4.	Can explain and summarize the various titrimetric techniques used for analysis	K2
5.	To understand the chemical equilibria to predict the solution chemistry	K5
6.	Compare and contrast the various methods of titration based on the nature of samples	K5 & K6

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

Unit:1	TREATMENT OF ANALYTICAL DATA AND SAMPLING	20 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 NEUTRALIZATION REACTIONS	20 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 TITRATIONS AND COMPLEXOMETRIC TITRATIONS	20 hours

Redox titration – Redox potentials, theory and feasibility of redox titration, calculation of potentials at 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.

	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.	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 Publishing VI 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 Hall Publications, 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. Deepa P 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

Course code	CHE E001	ELECTRONICS, COMPUTERS AND COMPUTER PROGRAMING FOR CHEMISTS	L	T	P	C
Core/Elective/Supportive		Elective	3	0	0	3
Pre-requisite		Student must have an awareness about computers and electronics	Syllabus Version			R2021

Course Objectives:

The main objectives of this course are to:

- To understand the working of electronic components used in instruments
- To outline the organization and working of a computer
- To state the development and requirements of programing languages
- To introduce modern concepts in computer science
- To critically access the application of computer programming languages in chemistry applications.

Expected Course Outcomes:

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

1.	Student can operate the computer and install hardware and software without any assistance.	K1-K4
2.	They will be able to identify the electronic parts and accordingly maintain them	K2-K4
3.	Possess working knowledge of how to develop computer programs	
4.	They will be able to choose the required programming language to write a program for their chemistry application.	K2-K5
5.	They will be able to develop new programs for their chemistry requirements.	K3-K4
6.	Can evaluate new software developed for chemistry applications	K5 & K6

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

Unit:1	BASIC ELECTRONICS AND COMPUTERS IN CHEMISTRY	15 hours

Basic electronics – Resistors, capacitors, transistors, operational amplifiers, integrated circuits, integrators, differentiators, rectifiers and battery eliminators, signal to noise ratio, optimization and limit of detection.

Computers in chemistry - Basic structure of a computer – input / output devices, memory and storage systems, central processing unit, peripherals, computer codes and arithmetic, binary number systems – floating point representation, floating point arithmetic, computational errors.

Unit:2	COMPUTER PROGRAMING	15 hours

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

Unit:3	PROGRAMS FOR CHEMIST	15 hours

Concepts of Python, Cloud computing, Artificial Intelligence

Programs for chemist – pH calculations – monobasic and polybasic acid systems, buffers, XRD – peak interpretation, conductometry, potentiometry, equilibrium constants, solubility products, standard deviation, F and t tests, regression analysis, half-wave potential calculations.

	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	Principles of Instrumental Analysis – Skoog and Leary, IV Edition, Saunders College Publishing, 1992.
2	Text book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985
3	Electronic Principle – A.P. Malvino, PMH Publishers, III Edition, 1984.
4.	BASIC Programming for Chemists – Peter C. Jurs, T.L. Isenhour and C.L. Wilkins, John Wiley and Sons, 1987
5.	Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, Pearson Education Ltd, VI Edition, 2001.
Reference Books	
1	Instrumental Methods of Analysis – Willard, Merit, Dean and Settle, CBS Publ.& Distributors, VI Edition, 1986
2	BASIC Programming – B.J. Holmes, Galgotia Book source Pub., 1983.
3	Programming for BASIC – M. Subramanian, A.H. Wheeler and Co. Pvt, Ltd., II Edition, 1987.
4	Programming and Computing with Fortran IV - K. P. Sharma, Affiliated East-West Press, Pvt. Ltd., 1976
5	Principles of Instrumental Analysis – Skoog, Holler & Nieman, Saunders College Publishing, V Edition, 2000
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	An Introduction to Programming through C++ https://youtu.be/efXI8anQwXo
2.	An Introduction to Artificial intelligence https://youtu.be/GHpchgLoDvI
3.	https://youtu.be/woVJ4N5nl_s-Phyton Basics
3.	https://youtu.be/JMUxmLyrhSk-Artificial Intelligence
Course Designed By: Dr. T.M. Sridhar	

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

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

Course code	UOMS115	SOFT SKILL Laboratory Safety Skills	L	T	P	C
Core/Elective/Supportive		Supportive	4	0	0	5
Pre-requisite		Students should have an idea about science laboratories	Syllabus Version			R2021

Course Objectives:

The main objectives of this course are to:

- To train the student how to work safely in the lab and protect others
- To outline the organization of a chemistry laboratory
- To state the role of MSDS and universal precautions for disposal and handling of hazardous chemicals

Expected Course Outcomes:

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

1.	To work in a lab safely and prevent human accidents	K1-K4
2.	To practice best lab practices	K2-K4
3.	Student should know how to design a safe chemistry lab	K3-K4
4.	Knowledge of Material Safety Data Sheet (MSDS) and handling of harmful chemicals	K2-K5
5.	Setting up and handling clean room facilities	K5 & K6

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

Unit:1	Lab safety	15 hours

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

Unit:2	Universal precautions	15 hours

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 biohazardous materials

	Contemporary Issues	

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

	Total Lecture hours	30 hours

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

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, Inc.

Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://youtu.be/qrUja_ILrOI - Material safety Data Sheet
2.	https://youtu.be/FD2hXZjgcEM- Problems related to safety and loss statistics
3.	https://youtu.be/8queMM7VVfw- Chemical Hazards / Lab Safety
3.	https://youtu.be/GjAD83B4JaY-PPE and Lab Safety
4.	https://youtu.be/ICz1GUQoiAQ-Fire Extinguishers
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	L	M	S	S	S	M	S	S
CO2	S	S	S	S	S	S	S	S	S	S
CO3	S	S	S	S	M	S	S	M	S	S
CO4	S	S	S	S	M	S	S	S	S	S
CO5	M	S	M	S	L	M	S	M	S	S

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

Course code	CHE C002	ANALYTICAL INSTRUMENTATION	L	T	P	C
Core/Elective/Supportive		Core	4	0	0	4
Pre-requisite		Student is required to have acquaintance with spectroscopic and chromatographic analysis	Syllabus Version			R2021

Course Objectives:

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 spectroscopic instruments
- To conceive different ideas and conceptualize different hypotheses for qualitative and quantitative analysis of chemical compounds using modern instrumentation.

Expected Course Outcomes:

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

1.	The student can interpret the electromagnetic spectra	K1-K4
2.	Understand the electronics and block diagram of spectroscopic instruments.	K2-K4
3.	Principle of absorption / emission and their molecular interaction with light and flame.	
4.	Separation and identification of molecules and ions using chromatography.	K2-K5
5.	Construction and operation of modern chromatographic equipment's	K3-K4
6.	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	20 hours

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, UV-visible Spectrophotometry – Photometric titrations, Reaction rates, Complex studies.

Fluorimetry – Principles of fluorescence, Instrumentation and Applications.

Turbidimetry and Nephelometry – Theory, Instrumentation and Applications

Unit:2	Emission Techniques	20 hours

Flame Photometry – Theory, Instrumentation and a few important applications.

Emission Techniques – Theory, techniques of excitation, electrodes and their shapes, flame and plasma emission spectrometry – instrumentation and application.

Atomic Absorption Spectrometry – Theory, instrumentation (flame and flameless atomization) and applications.

Types of interfaces, background correction and applications

Unit:3	Chromatography	20 hours

Classical forms of chromatography – Introduction, principle and applications of column, thin layer chromatography and paper chromatography.

Modern chromatographic techniques – Principle and applications of flash vacuum column chromatography, 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)	
1	Principles of Instrumental Analysis – Douglas A. Skoog, Saunders College Publ. III Edition, 1985.
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.	Principles of Instrumental Analysis – Skoog and Leary, Saunders College Publ. IV Edition, 1992.
5.	Analytical Chemistry – Gary D. Christian, Wiley, New York, V Edition, 2001.
6	Handbook of Instrumental Techniques for Analytical chemistry – F. Settle, Prentice Hall inc, 1997
Reference Books	
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	Analytical Chemistry – J.G. Dick, McGraw Hill Publishers, 1975
4	Instrumental Methods of Chemical Analysis – G.W. Ewing, McGraw Hill Publishers, 1975.
5	Quantitative Chemical Analysis – D.C. Harris, W.H. Freeman Publication, IV Edition, 1995.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://youtu.be/9KkcioAoO-Y- Gas chromatography
2.	https://youtu.be/DAwXk77DXUM- Introduction to Industrial Instrumentation
3.	https://youtu.be/5wR9H1FryLs-Fluoroscence Spectroscopy
4.	https://youtu.be/Yzan11nP6Ls-Atomic Absorption Spectroscopy
5.	https://youtu.be/SnbXQTTHGs4-Chromatographic Techniques
6.	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

Course code	CHE E002	ANALYSIS OF COMPLEX MATERIALS	L	T	P	C
Core/Elective/Supportive		ELECTIVE	3	0	0	3
Pre-requisite		Students should know about chemical analysis	Syllabus Version			R2021

Course Objectives:

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.

	Total Lecture hours	**60 hours**
Text Book(s)		
1	Text book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edn., 1982.	
2	Vogel's Text Book of Quantitative Chemical Analysis – A.I. Vogel, Pearson Education Ltd, VI Edition, 2001.	
3	Instrumental Methods of Analysis – Willard, Merit, Dean and Settle, CBS Publ. & Distributors, VI Edition, 1986.	
4.	Instrumental Analysis – Gary D. Christian & James, E. O'Reilly, Allyn & Bacon Inc, II Edition, 1986	
5.	Principles of Instrumental Analysis – Douglas A. Skoog, Saunders College Publ. III Edition, 1985.	
6	Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985.	
7	Fundamentals of Analytical Chemistry – D.A. Skoog and D.M. West, Holt Rinehart and Winston Publications, IV Edition, 1982.	
8	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	Analytical Chemistry – J.G. Dick, McGraw Hill Publishers, 1975.	
4	Chemistry of Engineering Materials – C.V. Agarwal, TARA Publicaions, II Edition, 1965.	
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]		
1.	https://youtu.be/KgUmNQD6m5Q-Alloy and their Properties	
2.	https://youtu.be/m-5EnGAMKF4-Determination of Copper in Brass	
3.	https://youtu.be/qu1v60L1Chk- Proximate Analysis of Fuel/Coal	
4.	https://youtu.be/_GqBl83Koig- Testing for Hydrogen, Oxygen, Carbon Dioxide, Ammonia	
	Course Designed By: Dr. Deepa P Nambiar and Dr. K. Ravichandran	

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

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

Course code	CHE C003	ANALYTICAL CHEMISTRY-PRACTICAL-I	L	T	P	C
Core/Elective/Supportive		Core	0	0	3	3
Pre-requisite		Students should know about analytical chemistry	Syllabus Version			R2021

Course Objectives:

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,		
	Total Lecture hours	**60 hours**

Text Book(s)	
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

Course code	**UOM1001**	**INTERNSHIP**	**L**	**T**	**P**	**C**
Core/Elective/Supportive		**Supportive**	**0**	**0**	**0**	**2**
Pre-requisite		Students should have an idea about analytical chemistry	**Syllabus Version**			**R2021**

Course Objectives:

The main objectives of this course are to:

- To train the student how to work safely in industries, research institutions, R&D labs, etc.,
- To understand the SOP for recording of data and analysis.
- To expose the student to new products and analysis

Expected Course Outcomes:

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

1.	To work in a lab safely and understand SOP	K1-K4
2.	To practice best lab practices and maintenance of instruments	K2-K4
3.	Submission of a detailed report and its oral presentation	K3-K5

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

	Internship	
Students can visit an Industry, R&D labs, Research institutions for a period of 15 days for on-site observation and training		
Course Designed By: 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	L	M	S	S	S	M	S	S
CO2	S	S	S	S	S	S	S	S	S	S
CO3	S	S	S	S	M	S	S	M	S	S
CO4	S	S	S	S	M	S	S	S	S	S
CO5	M	S	M	S	L	M	S	M	S	S

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

Course code	**CHE C601**	**PHYSICAL METHODS IN CHEMISTRY**	**L**	**T**	**P**	**C**
Core/Elective/Supportive		**Core**	**4**	**0**	**0**	**4**
Pre-requisite		Students should know about the fundamental aspects on spectroscopy and their importance in the characterization of chemical compounds. Basic knowledge on UV-Vis, IR, NMR and Mass spectroscopic techniques will be advantageous.	**Syllabus Version**			**R2021**

Course Objectives:

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.

:3 Unit	**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

Course code	CHE E003	ELECTRONICS, SIGNALS, CLASSICAL AND RADIOANALYTICAL METHODS OF ANALYSIS	L	T	P	C
Core/Elective/Supportive		Elective	3	0	0	3
Pre-requisite		Students should know about classical methods of analysis	Syllabus Version			R2021

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 and organic compounds samples	K2-K4
3.	To summaries the chemical reactions involved in analysis of materials using radio analytical techniques	
4.	To understand the upto date developments in computer programing languages and techniques	K2-K5
5.	Ability to choose the required programming language to write a program for their chemistry application.	K3-K4
6.	To device a protocol to analyze any ores, alloys and organic compounds that is provided 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

Analysis 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, Radioimmunoassasy. 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

Course code	CHE E602	BIOLOGICAL CHEMISTRY	L	T	P	C
Core/Elective/Supportive	Elective		3	0	0	3
Pre-requisite	Student able to understand the role of bio-organic compounds. Students should know about the fundamental aspects on biological system, mechanism, kinetics and analytical tools.		Syllabus Version			R2021

Course Objectives:

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

Course code	**CHE C004**	**ANALYSIS OF COMPLEX MATERIALS AND SEPARATION TECHNIQUES - PRACTICAL**	**L**	**T**	**P**	**C**
Core/Elective/Supportive		**Core**	**0**	**0**	**3**	**3**
Pre-requisite		Students should know about separation and chemical analysis	**Syllabus Version**			**R2021**

Course Objectives:

The main objectives of this course are to:

- To impart practical knowledge on the use of classical methods of analysis to complex materials
- To motivate the students to understand the basic principles of dissolution of complex materials and carry out quantitative analysis of substances important in day-to-day life
- To impart hands on training in chromatographic techniques.
- To separate and quantify samples using Ion exchange chromatography
- To analyse fuel samples
- To learn proper maintenance of record observations and data interpretation
- To conduct experiments in industry with real samples.

Expected Course Outcomes:

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

1.	Importance of analytical chemistry in the analysis of samples in day-to-day life	K1-K4
2.	To appreciate the modern problems and scientific controversies in analytical chemistry	K2-K4
3.	To design and perform experiments to separate the ions and estimate them qualitatively and quantitatively.	K3-K4

4.	To verify the nature of fuels and determine their properties as per standards	K2-K5
5.	To validate the theory of sampling, dissolution and separation of complex materials	K4-K6
6.	To understand the principle of ion exchange chromatography and quantify the ions with less than 1% error.	K5 & K6

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

Unit:1	**Analysis of Complex Materials Employing Titrimetric and Gravimetric Methods**	

1. Alloys – solder, cupro-nickel alloy, stainless steel, brass, aluminium alloy.
2. Carbonate and suphlide ores, cement.
3. Zinc dust, hydrogen peroxide, bleaching powder.
4. Pharmaceuticals – Asprin, Ascorbic acid, herbal medicine
5. Phosphate in cola beverages

Unit:2	**Chromatographic Techniques**	

Thin layer chromatography - Separation of cations and anions, dyes in ink.
Paper chromatography - Separation of cations.
Ion-exchange chromatography - Separation of Zn and Mg.
Separation of Cd and Zn.

Unit:3	**Fuel Analysis**	
	Melting point, Flash Point, Pour point	
	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. Vogel's Textbook of Quantitative Chemical Analysis Hardcover – 9 October 1989 by A.I. Vogel (Author)
2. Vogel's Qualitative Inorganic Analysis Paperback – 1 January 2012 by Svehla / Sivasankar (Author)

Reference Books

1. Vogel's Quantitative Chemical Analysis Paperback – 1 January 2009 by J. Mendham (Author)
2. Cooper and Gunn'S Dispensing for Pharmaceutical Students, 12/E Paperback – 1 January 2008

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

1. https://www.youtube.com/watch?v=Pq9z3CPSJ_E-Analysis of Asprin
2. https://www.youtube.com/watch?v=2K_C1SGIMU4-Analysis of Bleaching Powder
3. https://www.youtube.com/watch?v=23W5Z_redfs- Paper Chromatography
4. https://www.youtube.com/watch?v=qdmKGskCyh8-Thin Layer 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	L	M	S	M	S
CO2	S	M	M	S	L	S	S	S	M	S
CO3	S	S	S	S	M	M	S	S	M	M
CO4	S	S	S	S	S	M	M	S	S	S

CO5	S	S	S	S	M	S	S	S	S	L

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

Course code	**CHE C005**	**INSTRUMENTAL METHODS-PRACTICAL**	**L**	**T**	**P**	**C**
Core/Elective/Supportive		**Core**	**0**	**0**	**3**	**3**
Pre-requisite		Students should know about analytical instruments	**Syllabus Version**			**R2021**

Course Objectives:

The main objectives of this course are to:

- To impart practical knowledge on the use of instrumental methods of analysis
- To train using in conductivity and potentiometric titrations, pH measurements, CV for real time samples.
- To impart hands on training in spectrophotometric and emission analysis of complex materials
- To understand the separation using GC and HPLC techniques
- To conduct experiments in industry with real samples.

Expected Course Outcomes:

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

1.	Importance of analytical instruments in the analysis of samples in day-to-day life	K1-K4
2.	To appreciate the modern problems and scientific controversies in analytical chemistry and develop experimental skills required for analysis.	K2-K4
3.	To design and perform experiments to analyze complex materials and biological samples	K3-K4
4.	To estimate the ions present is samples using emission techniques	K2-K5
5.	To validate the theory of sampling, dissolution and estimation of complex materials and compounds.	K5 & K6

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

Spectrophotometry
1. Determination of Mn in steel.
2. Analysis of Permanganate – Dichromate mixture.
3. Determination of nitrite in water.
4. Determination of phosphate in water.
5. Photometric titration of copper and bismuth using EDTA.
6. Sulphate and phosphate determination
7. pKa of an indicator

Cyclic voltammetry
1. Estimation of metals, glucose, uric acid

Potentiometry:
1. Determination of cobalt using ferricyanide.
2. Complexometric titrations with EDTA.
3. Determination of chloride and iodide in a mixture.
4. Determination of chloride in tap water/ground water.

Conductometry:
1. Conductometric titrations.
2. Hardness of water.

Biamperometry:
1. Determination of Ferrous with ceric sulphate
2. Determination of thiosulphate.

Gas Chromatography:
1. Separation of hydrocarbons.

Flame Photometry:
1. Determination of sodium, potassium and calcium.
2. Determination of potassium in combined fertilizer.
3. Determination of calcium in wine.
4. Simultaneous determination of sodium and potassium in soil samples.
5. AAS - Determination of Cr, Pb, Ni

HPLC, Contact angle meter, Optical microscope

	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	Conductometric Analysis: Principles, Technique, Applications Hubert Thomas Stanley Britton Chapman & Hall, Limited, 1934
2	Flame photometry. John A Dean, New York, McGraw-Hill, McGraw-Hill series in advanced chemistry, 1960,

Reference Books

1	Understanding Voltammetry by Richard Guy Compton, Craig E Banks · 2007
2	Advanced Potentiometry Potentiometric Titrations and Their Systematic Errors By Erzsébet Néher-Neumann · 2009
3	Introduction to Voltammetric Analysis Theory and Practice By Francis George Thomas, Günter Henze · 2001

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

1.	https://www.youtube.com/watch?v=LpiU6NRa560-Analysis of Binary mixture
2.	https://www.youtube.com/watch?v=8CudRJjsrhU-Cyclic Voltammetry

3.	https://www.youtube.com/watch?v=H7sL5Ym3Z5Y-Conductometric Titrations.
4.	https://www.youtube.com/watch?v=7i6sGH5Me6g-Complexometric Titrations
Course Designed By: Dr. Deepa p Nambiar	

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

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

Course code	**CHE C006**	**OPTICAL AND SURFACE ANALYTICAL TECHNIQUES**	**L**	**T**	**P**	**C**
Core/Elective/Supportive		**Core**	**4**	**0**	**0**	**4**
Pre-requisite		Students should know about the analytical instrumentation	**Syllabus Version**			**R2021**

Course Objectives:

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 technologically advanced 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 contrast
SPM – 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, oxidation state 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

Course code	CHE C007	SEPARATION TECHNIQUES	L	T	P	C
Core/Elective/Supportive	Core		4	0	0	4
Pre-requisite	Students should know about the separation techniques		Syllabus Version			R2021

Course Objectives:

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

Expected Course Outcomes:

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 analysis of 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

Course code	**CHE E004**	**ELECTROANALYTICAL CHEMISTRY**	**L**	**T**	**P**	**C**
Core/Elective/Supportive		**Elective**	**3**	**0**	**0**	**3**
Pre-requisite		Basic knowledge of electrochemistry is essential	**Syllabus Version**			**R2021**

Course Objectives:

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

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 Electrokinetic applications**	**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 of Analytical 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 Edn Brooks/Cole publish; 7th edition, 2017
4.	E. Gileadi, E. Kirowa- Eisner and J. Penciner, 3. Interfacial Electrochemistry: An Experimental Approach, Addison-Wesley Publishing Company, Massachusetts,1975.
5.	P.T. Kissinger and W.R. Heineman, 8. Laboratory Techniques in Electroanalytical chemistry, Marcel Decker Inc., 1984

Reference Books

1	John O'M. Bockris, Amulya K. N. Reddy, "Modern Electrochemistry", Vol. I and II, Plenum Publishing, 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; 7th edition (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

Course code	**CHE E005**	**INTRODUCTION TO CHROMATOGRAPHY AND SURFACE TECHNIQUES**	**L**	**T**	**P**	**C**
Core/Elective/Supportive	**Elective**		**3**	**0**	**0**	**3**
Pre-requisite	Students should know about the		**Syllabus Version**			**R2021**

Course Objectives:

The main objectives of this course are to:

- To outline the principles of various chromatographic techniques along with the methodology used.
- To differentiate, isolate and characterize the various types of compounds present in liquids using HPLC
- To study the oxidation state of the surfaces
- 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 suitable chromatographic technique to separate samples	K1-K4
2.	Selection of procedures to separate compounds using chromatography	K2-K4
3.	To separate and estimate gaseous and liquid samples using instruments	K3-K5
4.	Compare and contrast the instrumentation used for GC and HPLC	K2-K5
5.	To obtain the structure of atoms and molecules as images using scanning probe techniques	K4-K5
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	**Chromatography**	**15 hours**

Principles of chromatography, planar (TLC/paper) chromatographic techniques - principle, materials, development, different modes of developing techniques, visualization, qualitative and quantitative analysis

Unit:2	GC & HPLC	15 hours
Gas chromatography – Principle, instrumentation – columns and detectors, applications. High Performance Liquid Chromatography – Theory, columns, detectors and applications		
Unit:3	**SPM & XPS**	**15 hours**
Scanning Probe Microscopy, XPS, Auger electron spectroscopy – Theory, Principle, instrumentation and general applications, EDS		

	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	Principles of Instrumental Analysis – Skoog and Leary, IV Edition, Saunders College Publishing, 1992.
2	Text Book of Quantitative Inorganic Analysis – A.I. Vogel, ELBS, III Edition, 1976, and IV Edition, 1985
3	Physical and Chemical Methods of Separation – E.W. Berg, McGraw Hill Publications, 1963
4.	Instrumental Methods of Analysis – Willard, Merit, Dean and Settle, CBS Publ. & Distributors, VI Edition, 1986.
Reference Books	
1.	Modern Analytical Chemistry – W.F. Pickering, Maroel Dec, 1971.
2.	Gas Analysis and Testing of Gaseous Materials – Alteri, Mmer. Gas Asso. 1965.
3.	Chromatography –Harry and Calvin, Van Nostrand Reinhold Company, II Edition, 1967
4.	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
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

UNIVERSITY OF MADRAS DEPARTMENT OF Analytical Chemistry	
Programme:	Ph.D., Analytical Chemistry
Programme Code:	CHE 001
Duration:	**3-5 years**

Programme Outcomes:	**PO 1** To understand the application of the analytical chemistry in today's changing technological world. **PO 2** To deliver an in-depth information to learners in the area of Analytical Chemistry and to empower them to work independently. **PO 3** To possess realistic and experimental knowledge across the principles of analytical chemistry. **PO 4** To learn fundamental tools in analytical chemistry, classical analysis, modern microscopy, thermal, radio analytical, optical and instrumentations tools and their applications to different disciplines of chemical analysis. **PO 5** To advances the acquaintance on the significance of spectroscopy, electrochemical, chromatography and surface analytical techniques. **PO 6** To demonstrate competence in solving industrial and scientific research problems through experiments by selection of the relevant international standard protocols. **PO 7** Professionally skilled towards employment in industries and higher studies in internationally renowned research institutions were they are competent to work as an individual and as a collaborative team member. **PO 8** Execute and implement the analytical chemistry concepts to critical innovative thinking in the laboratory and problem solving to meet current day challenges. **PO 9** To develop an appreciation for the problematic mission of adjudicating the accuracy and precision of data collected from the lab experiments and sharpened to them towards using appropriate computational statistical methods. **PO 10** To apply effectively the concepts of analytical chemistry towards interdisciplinary nature of chemistry, biology, medicine, material science, forensic science and other related fields to meet the ever-growing variety of chemical challenges.

Programme Specific Outcomes:	● 1 Trained to be a responsible analytical chemist and implement safe laboratory practices by handling glassware, equipment and chemical reagents appropriately following international standard operating procedures ● 2 Comprehensive analytical chemistry proficiency and research experience through methodically delivered courses and a mentored master project. ● 3 Competent in applying analytical chemistry to analyse complex materials to any substances using classical and modern separation, isolation and identification techniques. ● 4 Familiarity with spectroscopy, electrochemical, chromatography and surface analytical techniques along with the interpretation of spectra of unknown compounds ● 5 Highly skilled and knowledgeable to clear competitive exams for higher studies in premier research institutions and industrial sector.

List of Courses:

Course	Course Code	Title of the Course	Core/Elective/ Soft Skill	Credits
I	CHE P 001	Research and Publication Ethics		2
II	CHE P 002	Research Methodology	Core	4
III	CHE P 003	Instrumental Methods of Analysis	Core	6
III	CHE P 004	Analytical Techniques and Instrumentation-I	Core	6
III	CHE P 005	Analytical Techniques and Instrumentation-II	Core	6
IV	CHE P 006	A Course relating to Research Theme	Core	6

Method of Evaluation:

Sessional I	Sessional II	End Semester Examination	Total	Grade
20	20	60	100	*

* Marks with Grade: 90-100 (O) Outstanding; 80-89 (D+) Excellent;
75-79 (D) Distinction; 70-74 (A+) Very Good; 60-69 (A) Good; 50-59 (B) Average

Course code	CHE P 002	RESEARCH METHODOLOGY	L	T	P	C
Core/Elective/Supportive	CORE		5	1	0	6
Pre-requisite	Students should know what is research		Syllabus Version			R2021

Course Objectives:

The main objectives of this course are to:

- To familiarize scholars with basic concepts of research and the research process.
- Identify appropriate research topics, select and define appropriate research problem and parameters
- Paper publication in journals, prepare a project proposal, write a research report and thesis
- Organization of a chemistry laboratory
- Knowledge about sampling, errors, simple techniques and instruments for research

Expected Course Outcomes:

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

1.	To identify a suitable research area and carry out a literature survey	K1-K4
2.	To present and publish research work as journal papers, books, review articles and patents	K2-K4
3.	To organize and write a thesis	K3-K5
4.	To understand how to work in chemical lab following SOPs safely	K2-K5
5.	To summarize statistical treatment of data obtained from experiments	K4-K5
6.	To respond to sampling techniques and commonly used minor equipments	K5 & K6

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

Unit:1		**15 hours**

Research Problem - Aim, objectives, criteria for selecting a research problem. Definition of research problem. Research in fundamental and applied sciences. Research in industries. Problems and hypothesis in research, development and testing of hypothesis.

Survey of literature - Chemical nomenclature and literature, primary and secondary sources of literature including reviews, treatises and monographs. Literature searching – general references sources, Scopus, web of science, publons, Data base, internet, world wide web, chemical and analytical abstracts, science citation index, rating of journal. Responsibilities and functions of editors, referees. Scientific journals in India and abroad. Patents.

Unit:2		**15 hours**

Writing of thesis/paper – General formats, tables, figures, references, foot notes, appendices, reviewing and revising the papers, proof reading and final format. Presentation of scientific papers in seminars and symposia.

Unit:3		**15 hours**

Laboratory organization: Designing the laboratory, installation of equipments, stores and management, preparation of storage of reagents. Safety in laboratory and workshop. Organisation of demonstration and exhibition.

Management of Laboratory – Upgrading the conventional laboratory to microscale chemical laboratory, laminar and non-laminar flow laboratory, special instrumentation and facilities for microscale laboratory.

Automation in the Laboratory – Principles, automatic and semiautomatic instruments, autoanalyser, centrifugal analyser, flow injection analysis, smart instruments

Unit:4		**15 hours**

Statistics for analytical chemistry: Significant figures in arithmetic – addition, substraction, multiplication, division, logarithms and antilogarithms, significant figures and graphs. Errors – random and systematic, precision and accuracy, uncertainty and propagation of uncertainty, Gaussian distribution, Student's t, Q and F tests, simple and multiple linear regression.		
Unit:5		**15 hours**
Sampling: Theory of sampling, techniques, pitfalls, sampling in static and dynamic systems, sampling from polluted water and from eluates, sampling of air pollutants, aerosols, flyash. Transmission and storage of samples, techniques for handling air and moisture sensitive samples. Microanalysis: Principles and applications of zone refining, fractional distillation, molecular distillation, deep-freeze crystallisation and contamination control in analytical operations.		
	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	Quantitative Chemical Analysis, D.C. Harris, W.H. Freeman, New York, Fourth Edn. 1995
2	Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West and F.J. Holler, Saunders College Publishing. New York, Sixth Edn. 1992.
3	Analytical Chemistry: Principles. J.H. Kennedy, Saunders College Publishing, New York, Second Edn. 1990.
4.	Abstracting Scientific and Technical Literature, R.E. Maizell, J.F. Smith, T.E.R. Singer, Wiley – Interscience, New York, 1971.
5.	Techniques of Technical Report Writing, T.K.S. Iyengar, M.R. Rao and S.L.V. Chari, Allied Publishers, Madras, 1978.
6.	Research Paper Smart, L. Buffa, Random House, New York, 1997.
Reference Books	
1.	Statistics for Analytical Chemistry, J.C. Miller and J.N. Miller, Ellis Harwood, Chichester,1984.
2.	Statistics for Analytical Chemists, R.Caulcutt and R. Boddy, Chapmann and Hall, London, 1982.
3.	Microscale Manipulation in Chemistry, T.S. Ma and V. Herak, Wiley, 1976.
4.	Laboratory Organisation and Administration, K. Guy, Macmillan, London, 1963
5.	Treatise on Analytical Chemistry, I.M. Kolthoff and P.H. Elving, (Eds.) Part I & III.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://www.youtube.com/watch?v=jauhoR7w1YM-Sampling Techniques
2.	https://www.youtube.com/watch?v=mvMxhNtHB0M-Laboratory Automation
3.	https://www.youtube.com/watch?v=Vky9PDKx5KU-Scientific Paper
3.	https://www.youtube.com/watch?v=_uapR0qiN6s-Qualatitative Research
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	L	M	S	M	M	S
CO2	S	M	S	M	S	S	S	S	M	S
CO3	S	M	S	S	M	M	S	L	S	S
CO4	M	M	S	S	L	L	M	L	S	S
CO5	M	S	S	S	S	L	M	L	L	S

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

Course code	CHE P 003	INSTRUMENTAL METHODS OF ANALYSIS	L	T	P	C
Core/Elective/Supportive	CORE		5	1	0	6
Pre-requisite	Students should know about analytical techniques		Syllabus Version			R2021

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

Course code	CHE P 004	ANALYTICAL TECHNIQUES AND INSTRUMENTATION-I	L	T	P	C
Core/Elective/Supportive	CORE		3	0	0	3
Pre-requisite	Students should know about the fundamentals of instrumentation		Syllabus Version			R2021

Course Objectives:

The main objectives of this course are to:

- To outline functioning of electronic parts and organization of computer
- To familiarize with the functioning of electroanalytical techniques
- To carry out studies using spectral and laser based techniques
- To analyze trace quantities using atomic absorption and emission techniques
- To understand the need for hyphenated techniques

Expected Course Outcomes:

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

1.	To impart knowledge on digital electronics and computer programing	K1-K4
2.	Selection of procedures to analyze compounds using electroanalytical techniques	K2-K4
3.	To characterize and evaluate the properties of new materials developed using spectral and laser instruments.	K3-K5
4.	To identify and quantify the ions present in a given sample using absorption and emission techniques	K2-K5
5.	To obtain the structure of atoms and molecules using hyphenated techniques	K4-K5
6.	To understand the need and principle of hyphenated techniques in analyzing complex molecules	K5 & K6

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

Unit:1		**15 hours**

Electronics: Operational amplifier – properties and characteristics of opamps, circuits employing opamps, amplification and measurements of signals, application of opamps to voltage and current control and for mathematical operations.

Digital Electronics: analog and digital signals, binary numbers, basic digital circuit components, microprocessors and microcomputers, components of computers, computer programs and applications, computer networks. Cloud computing and Artificial Intelligence

Unit:2		**15 hours**

Electroanalytical Methods: Potentiometry – Potentiometric titrations and ion selective electrodes. Coulometry – Potentiostatic coulometry, coulometric titrations and mediators.Voltammetry – Polarography – DME, polarograms, currents in polarography, maxima, effect of dissolved oxygen and application to chemical analysis, amperometric titrations. Pulse polarography – Normal and differential pulse, square wave polarography, stripping analysis – cathodic and anodic stripping, potentiometric stripping, Linear sweep voltammetry, cyclic voltammetry, Types of electrodes and Chemically modified electrodes.

Unit:3		**15 hours**

Advanced Spectral Techniques: Principle and brief outline of instrumentation and analytical applications of the following techniques.

Application of laser sources in analytical chemistry. Photoacoustic spectroscopy, Photoacoustic infrared spectroscopy. Chemiluminescence. Near and far IR. Infrared emission spectroscopy.

Unit:4		**15 hours**

Atomic absorption and emission techniques – AAS, ICP, Fiber optics spectroscopy. Ion scattering spectroscopy. Secondary ion mass spectrometry.		
Unit:5		**15 hours**
Hyphenated techniques – HPLC-MS, HPLC-MS, HPLC/LC-IR. Hyphenated techniques – GC-MS, LC-MS, GC/LC-IR, LC-NMR, GC-OES		
	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	Quantitative Chemical Analysis, D.C. Harris, W.H. Freeman, New York, Fourth Edn. 1995.
2	Fundamentals of Analytical Chemistry, D.A. Skoog, D.M. West and F.J. Holler, Saunders College Publishing. New York, Sixth Edn. 1992.
3	Principles of Instrumental Analysis, D.A. Skoog and J.J. Leary, Saunders College Publishing, New York, Fourth Edn. 1992.
4.	Analytical Chemistry, G.D. Christian, Wiley, New York, Fourth Edn. 1986
Reference Books	
1.	Principles of Instrumental Analysis, D.A. Skoog, F.J. Holler and T.A. Nieman, Saunders College Publishing, New York, Fifth Edn. 1998
2.	Analytical Chemistry: Principles. J.H. Kennedy, Saunders College Publishing, New York, Second Edn. 1990.
3.	Principles of Radiochemistry, D.D. Sood, N. Ramamoothy and A.V.R. Reddy, Eds. IANCAS, Bombay, 1993.
4.	Substoichiometry in Radiochemical Analysis, J. Ruzicka and J. Stray, Pergamon Press, London, 1968
5.	Microscale Manipulation in Chemistry, T.S. Ma and V. Herak, Wiley, 1976.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://www.youtube.com/watch?v=KjIsEJcC3r8-Voltammetry, Potentiometry.
2.	https://www.youtube.com/watch?v=olgq2LU0nM0-GC-MS.
3.	https://www.youtube.com/watch?v=_35fKP5AfGk-LC MS
Course Designed By: Dr. Deepa P Nambiar	
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

Course code	CHE P005	ANALYTICAL TECHNIQUES AND INSTRUMENTATION-II	L	T	P	C
Core/Elective/Supportive	CORE		5	1	0	6
Pre-requisite	Students should know about analytical techniques		Syllabus Version			R2021

Course Objectives:

The main objectives of this course are to:

- To outline the principles of various chromatographic techniques along with the methodology used.
- To differentiate, isolate and characterize the various types of compounds present in gases and liquids using GC & HPLC
- To introduce the analysis of clinical and environmental samples
- To understand the principles of radiochemistry and its applications
- To develop and evaluate coatings and sensors with electrochemical instruments

Expected Course Outcomes:

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

1.	To identify the suitable chromatographic technique to separate samples	K1-K4
2.	Compare and contrast the instrumentation used for GC and HPLC	K2-K4
3.	To separate, identify and estimate the clinical and environmental samples	K3-K5
4.	To outline the radioanalytical applications in evaluating the compounds	K2-K5
5.	To study the electrochemical behavior of the samples using destructive and non destructive modes	K4-K5
6.	To determine and develop sensors, coatings and study corrosion behavior using electrochemical techniques	K5 & K6

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

Unit:1	Chromatography	15 hours

Principle, instrumentation, nature of stationary and mobile phases and method of detection and applications of the following techniques.

Unit:2	GC & HPLC	15 hours

Gas Chromatography. High Performance Liquid Chromatography. High Performance Thin Layer Chromatography. Ion Chromatography.

Unit:3	Clinical and Environmental analysis	15 hours

Principle and application of Kinetic method of analysis – kinetics, catalysis and enzyme catalysis Clinical analysis – immunoassay and trace element analysis Environmental analysis – Air (hydrogen sulphide, sulphur dioxide and oxides of nitrogen) and water (BOD, COD and trace elements like Cd, Cr, Pb, Se) analysis.

Unit:4	Radioanalytical Chemistry	15 hours

Nuclear chemistry and radiochemistry – Nuclear stability and structure, radioactivity and nuclear decay, detection and measurement of radiation, nuclear reactions, nuclear power reactors, application of radioisotopes, neutron activation analysis, isotopic dilution analysis, health and safety aspects.

Unit:5	Electrochemical Techniques	15 hours

Electrochemical workstation, Electrochemical Impedance Spectroscopy, Scanning electrochemical microscopy, applications for coatings, corrosion and sensors

	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	Treatise on Analytical Chemistry, I.M. Kolthoff and P.H. Elving, (Eds.) Part I & III.
2	Modern Polarographic Methods in Analytical Chemistry, A.M. Bond, Marcel Decker, New York, 1980
3	Radioactivity Applied to Chemistry, Arthur C.Wahl, Wiley, New York, 1951.
4.	Radiotracer Techniques and Applications, A. Evans and M. Muiamatsu, Marcel Decker, New York, 1977, Vol I & II.
5.	Electrochemical Methods, A. Bard and L.R. Faulkner, Wiley, New York, 1980.
Reference Books	
1.	Advances in Electroanalytical Methods – Series. Ed. A. Bard.
2.	Physical and Chemical Methods of Separation, B.W. Berg, McGraw-Hill, 1963.
3.	Chemical Methods of Separation, J.A. Dean, Von Nostrand, 1969.
4.	Separation and Purification Methods, E.S. Perry, Marcel Dekker, New York, 1975.
Related Online Contents [MOOC, SWAYAM, NPTEL, Websites etc.]	
1.	https://www.youtube.com/watch?v=KjIsEJcC3r8-Voltammetry, Potentiometry.
2.	https://www.youtube.com/watch?v=olgq2LU0nM0-GC-MS.
3.	https://www.youtube.com/watch?v=_35fKP5AfGk-LC MS
3.	https://youtu.be/PH1DR0c-jqw
Course Designed By: Dr. T.M. Sridhar	
Mapping with Programme Outcomes*	

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