For 2-Year PG Programme
(Scheme B-1)
With Major Practicum Component

CHEMISTRY-CORE (THEORY) SYLLABUS
M.Sc. III Semester

Part A- Introduction				
Program: 2-Year PG		**Class-M.Sc.**	**Semester-III**	**Session: 2025-26**
Subject–Chemistry				
1	**Course Code**	**CC-32 (T)**		
2	**Course Title**	**Advanced Analytical Chemistry**		
3	**Course Type**	**CORE Course**		
4	**Pre-requisite**	**To study this course, students must have Chemistry as one of the subjects in B.Sc. Degree Course**		
5	**Course Learning Outcomes (CLO)**	**Upon successful completion of this Course, learners will be able to:** ➢ Categorize analytical methods into classical and instrumental categories and demonstrate safe laboratory practices. ➢ Perform gravimetric and volumetric techniques with accuracy and precision, and evaluate data using appropriate statistical tools. ➢ Explain the principles, instrumentation, and applications of atomic absorption spectroscopy, flame photometry, ICP-AES, and ICP-MS. ➢ Analyze and interpret results from X-ray structural analysis and thermal methods such as TGA, DTA, and DSC. ➢ Understand and apply hyphenated techniques (GC-MS and LC-MS), including interface technologies and sensitivity considerations. ➢ Interpret complex analytical data and select appropriate techniques for elemental and molecular analysis. ➢ Demonstrate competency in the use of advanced analytical instrumentation relevant to research, industry, pharmaceuticals, and environmental sciences.		
6	**Credit Value**	**Theory–06**		
7	**Total Marks**	**Maximum Marks: Total 100** **University Exam (UE)-60,** **CCE-40**	**Minimum Passing Marks: 40**	

Part B-Content of the Course		
Total No. of Lectures-Tutorials-Practical (hours per week): 06 **L-T-P: 90-0-0 (Total Hours)**		
Unit	**Topic**	**No. of Lectures**
1	**Indian Knowledge System and its relationship with Analytical Methods:** Knowledge of ancient indian analytical chemistry, functions of ancient tools such as, dhol (grinding drum), swadeni, patan, Kukkutapatha (crucible lid), Vahini (distillation apparatus), Puta (furnance), Bharani (measuring vessel), nirvapayantra (cooling vessel) and khalvayantra (mortar and pestle), etc. Classification of analytical methods-classical and instrumental. Types of instrumental analysis. Sample preparations-dissolution and decompositions, Gravimetric techniques, Volumetric techniques, and safety in the analytical Laboratory. **Evaluation and reliability of analytical data:** Accuracy, precision, classification of errors, mean deviation and standard deviation, Least square methods, regression coefficient, F-test, t-test and Chi-test. ***Keywords***: Instrumental Analysis, Sample Preparation, Gravimetric and Volumetric Techniques, Analytical Accuracy and Precision, Statistical Data Evaluation ***Activities:*** 1. Problem Solving: i. Practice sets on mean, standard deviation, accuracy, precision, and error classification. ii. Solve statistical problems using F-test, t-test, and Chi-square test. iii. Calculations for gravimetric and volumetric analyses. iv. Exercises on least squares method and regression analysis in analytical data evaluation. 2. Poster Making Topics: i. Ancient Indian Analytical Tools and Their Scientific Significance ii. Types of Analytical Methods: Classical vs Instrumental iii. Statistical Tools in Analytical Chemistry iv. Safety Protocols in Analytical Laboratories 3. Seminars: i. Evolution of Analytical Chemistry: From Rasashastra to Modern Techniques ii. Comparison of Classical and Instrumental Analytical Methods iii. Role of Statistics in Ensuring Data Accuracy in Chemistry.	15

2	**Spectro-Chemical Methods of Chemical Analysis-I** **Atomic absorption spectroscopy (AAS):** Principle, instrumentation, production of atoms and ions, hollow cathode lamp, burners, detectors, sensitivity and detection limits in AAS, advantages and disadvantages of AAS, chemical and spectral interferences, applications of AAS. **Spectro-Chemical Methods of Chemical Analysis-II** **Flamephotometry:** Principle of flame photometry, theory, instrumentation, combustion flames, detectors, and analysis of Na, K, Ca, Mg, and Li. **Inductively coupled plasma Emission spectroscopy and Inductively coupled plasma Mass spectrometry (ICP-AES, ICP-MS):** Principle of AES, instrumentation, plasma, AES detectors, quadrupole mass spectrometers, difference between the two detectors, applications. ***Keywords***: Atomic Absorption Spectroscopy (AAS), Flame Photometry, ICP-AES and ICP-MS, Plasma Source and Atomization, Mass and Emission Spectrometry, Elemental Analysis Applications ***Activities:*** 1. Problem Solving: i. Calculation of concentration using Beer–Lambert Law. ii. Detection limits and sensitivity analysis in AAS. iii. Calculation of emission intensity *vs* concentration for Na^+, K^+, Ca^{2+}, etc. iv. Detection limits and sensitivity comparison between Flame Photometry and ICP-MS. v. Problems based on calibration curves in emission spectroscopy. 2. Poster Making Topics: i. Working and Instrumentation of Atomic Absorption Spectroscopy and Flame Photometer. ii. Working Principle and Instrumentation of Comparison between Flame Photometry, ICP-AES and ICP-MS. iii. Applications of AAS in Environmental and Clinical Chemistry iv. Applications of ICP Techniques in Trace Metal Analysis. v. Combustion Flames and Atomization Techniques in Spectroscopy. 3. Seminars/ Presentations: i. Comparison of AAS with other Atomic Spectroscopic Methods (ICP-AES, Flame Photometry) ii. Role of AAS in Trace Element Detection in Food and Water iii. Application-based presentation on AAS in forensic, pharmaceutical, or environmental analysis. iv. Modern Applications of ICP-MS in Environmental Monitoring. v. Use of Flame Photometry in Clinical and Agricultural Chemistry.	20

3	**X-ray Diffraction:** Bragg condition, Miller indices, X-Ray emission, Moseley Law, Duane Hunt Law, Laue Method and Debye Scherrer method of X-ray structural analysis of crystals, Crystal density, Structure of simple lattices and X-ray intensities, structure factor and its relation to intensity and electron density, phase problem. Description of the procedure for an X-ray structure analysis, absolute configuration of molecules. ***Keywords***: X-ray diffraction, Duane Hunt Law, Debye Scherrer Equation, X-ray structure analysis ***Activities:*** 1. Problem Solving: i. Bragg's Law calculations: determination of d-spacing, wavelength, and angle. ii. Miller indices and interplanar distance in cubic lattices. iii. Crystal density using unit cell parameters. iv. Calculations related to structure factor and intensity. 2. Poster Making: i. Bragg's Law and Crystal Structure Determination. ii. X-ray Diffraction Techniques: Laue vs. Debye-Scherrer. iii. Historical Milestones in XRD: Bragg, Moseley, and Beyond. 3. Seminars / Presentations: i. Laue and Debye-Scherrer Methods: Applications in Modern Crystallography. ii. Miller Indices and Their Role in Crystal Planes Identification. iii. Comparison of X-ray Emission and Diffraction Methods. iv. Applications of XRD in Drug Design, Materials Science and Nanotechnology.	20
4	**Differential and Thermal methods of analysis:** Principles and instrumentation of TG and DTA. Complementary nature of TG and DTA. Differential scanning calorimeter (DSC). Applications of thermal methods in analytical chemistry. ***Keywords***: Thermogravimetric Analysis (TGA), Differential Thermal Analysis (DTA) and DSC, Thermal Methods in Analytical Chemistry ***Activities:*** 1. Problem Solving: i. Calculation of mass loss and enthalpy change from TG/DSC curves.	15

	ii. Analysis TG and DTA plots for decomposition steps and thermal transitions. 2. Poster Making: i. TG vs DTA vs DSC: Working Principles and Applications. ii. Thermal Methods in Material and Pharmaceutical Analysis. 3. Seminars /Presentations: i. Complementary Nature of TGA and DTA in Material Analysis. ii. Instrumentation and Interpretation of TG/DTA/DSC Curves. iii. Structure Factor, Intensity, and Crystal Symmetry in XRD. iv. Comparative Case Study: TG-DTA Analysis of Organic vs Inorganic Materials.	
5	**Hyphenated Techniques:** Introduction of hyphenated techniques and their sensitivity levels. Gas Chromatography-Mass Spectrometry (GC-MS) Technique: Introduction, Instrumentation, interface and applications Liquid Chromatography- Mass Spectrometry (LC-MS) technique: Introduction, instrumentation, interface (ESI, APCI, APPI), Time-of-flight analyzer, Quadrupole analyzer and applications. ***Keywords***: Hyphenated Analytical Techniques, GC-MS (Gas Chromatography–Mass Spectrometry), LC-MS (Liquid Chromatography –Mass Spectrometry), Ionization Interfaces (ESI, APCI, APPI), Analytical Sensitivity and Applications **Activities:** 1. Problem Solving Activities: i. Interpretation of GC-MS/LC-MS spectra to identify unknown compounds. ii. Compare sensitivity and selectivity of GC-MS vs. LC-MS. 2. Poster Making: i. Hyphenated Techniques. ii. GC-MS vs LC-MS: Principles, Interfaces, and Applications. 3. Seminars/ Presentations: i. Hyphenated Techniques in Pharmaceutical Analysis. ii. Instrumentation and Applications of GC-MS. iii. LC-MS Interface Technologies: ESI, APCI and APPI. iv. Role of TOF and Quadrupole in Advanced Molecular Analysis. v. Working Principle and Block Diagram of GC-MS and LC-MS. *vi.* Hyphenated Techniques for Trace Analysis in Forensics and Food Safety.	20

Part C-Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:

Books

1. Sharma, P.V., Rasashastra, Bhaishajya Kalpana, Chaukhambha Bharati Academy, Varanasi.
2. Christian, G.D. Analytical Chemistry, John Wiley.
3. Skoog, D.A., West, D.M., Holler, F.J. Fundamentals of Analytical Chemistry, W.B. Saunders.
4. Willard, H.A., Merritt, L.L., Dean, J.A., Instrumental Methods of Analysis.Van Nostrand, New York.
5. Skoog, D.A., West, D.M. Principles of Instrumental Analysis, Holt Rinehart and Winston, New York.
6. Robinson, K.A. Chemical Analysis, Harper Collins Publishers, NewYork.
7. Mendham, J., Denney, R.C., Barnes, J.D., Thomas, M.J.K., Vogel's Textbook of Quantitative Chemical Analysis, Pearson Education.
8. Settle, F.A., Handbook of Instrumental Techniques for Analytical Chemistry, Prentice Hall.

Suggested equivalent online courses and Web sources:

- https://archive.nptel.ac.in/course.html
- https://ugcmoocs.inflibnet.ac.in/index.php/courses/moocs
- https://swayam.gov.in/explorer

Part D- Assessment and Evaluation

Maximum Marks: 100
Internal Assessment (CCE):40
External Assessment (UE): 60

Internal Assessment		
	Continuous and Cumulative Evaluation (CCE) Methods will be based on the following defined components:	**Marks**
a.	**Class Tests**	
b.	**Presentation/Assignment/Quiz/Group Discussion**	
c.	**Appropriate weightage of attendance in the Class**	
	Total	**40**
External Assessment		
	Theory Paper as per University Examination	
	Total	**60**
Grand Total		**100**

For 2-Year PG Programme
(Scheme B-1)
With Major Practicum Component

CHEMISTRY-CORE (PRACTICUM) SYLLABUS
M.Sc. III Semester

Program: 2-Year PG		Class-M.Sc.	Semester-III	Session: 2025-26
Subject– Chemistry				
1	Course Code	PC-31		
2	Course Title	Advanced Spectroscopic Techniques and Applications		
3	Course Type	PRACTICUM Course		
4	Course Learning Outcomes (CLO)	Upon successful completion of this Course, learners will be able to: ➢ Analyze the electronic spectra of transition metal coordination complexes using Tanabe-Sugano diagrams. ➢ Interpret X-ray photoelectron spectroscopy (XPS) data to determine core binding energies and relate them to chemical environments. ➢ Determine the pKa of acid-base indicators using colorimetric techniques. ➢ Analyze nuclear magnetic resonance (NMR) spectra to interpret structural features and calculate coupling constants. ➢ Integrate theoretical spectroscopic principles with experimental data for the qualitative and quantitative analysis of complex molecules.		
5	Credit Value	Practical–04		
6	Total Marks	Maximum Marks: Total 100 University Exam (UE)-60, CCE-40		Minimum Passing Marks: 40

Total No. of Lectures- Tutorials-Practical (08 hours per week):
L-T-P: 0-0-120 (Total Hours)

A. Assignments/Practice/ Survey/Fieldwork	**No. of Hours: 120**
B. List of Experiments to be performed in laboratory	
1. Electronic spectral analysis of transitional metal-based coordination complex *e.g.*, (i). Potassium trioxalato chromate (II) complex and (ii). Nickel (II) Dimethyl Glyoximate (DMG) complex using Tanabe-Sugano diagram.	

2. Interpretation of XPS spectra, calculate the core binding energies, assign the peaks and explain the variation in core Binding Energies.
3. Determination of pKa of an indicator (*e.g.*, methyl red) by colorimetric method.
4. Spectral Interpretation/ Calculations using IR technique.
5. Spectral Interpretation/ Calculations using NMR technique.
6. Spectral Interpretation/ Calculations using Mass spectrometry technique.
7. Spectral Interpretation/ Calculations using UV-Visible/ Electronic techniques.
8. Structure elucidation of unknown compounds using UV-Visible, IR, NMR, Mass spectral data.

Part C: Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:
Books

1. Gauglitz, Günter; Moore, Dr. David S. Handbook of Spectroscopy: Second, Enlarged Edition, Wiley-VCH.
2. Pavia, Donald L.; Lampman, Gary M.; Kriz, George S. Introduction to Spectroscopy, Cengage Learning.
3. Inamdar, Nazma N. Solving Spectroscopy Problems: A Basic Approach, N.S. Publications.
4. Feinstein, Karen. Guide to Spectroscopic Identification of Organic Compounds, White Science Publishing.
5. Bandyopadhyay, A.K. Nanomaterials, New Age International Publishers.

Suggested equivalent online courses and Web Sources:
(All URLs accessed in April 2025)

- https://archive.nptel.ac.in/course.html
- https://ugcmoocs.inflibnet.ac.in/index.php/courses/moocs
- https://swayam.gov.in/explorer

Part D: Assessment and Evaluation

Maximum Marks: 100
Internal Assessment (CCE): 40
External Assessment (UE): 60

Internal Assessment

	Continuous and Cumulative Evaluation (CCE) Methods will be based on following defined components:	Marks
a.	Class/ Laboratory Practical Tests	
b.	Seminar/ Demonstration/ Viva voce/ Lab Record etc.	
c.	Appropriate weightage of attendance in the Class	
	Total	40
	External Assessment	
	Practicum Paper as per University Examination	
	Total	60
	Grand Total	100

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CHEMISTRY-CORE (PRACTICUM) SYLLABUS
M.Sc. III Semester

Part A – Introduction				
Program: 2-Year PG		**Class-M.Sc.**	**Semester-III**	**Session: 2025-26**
Subject– Chemistry				
1	**Course Code**	**PC-32**		
2	**Course Title**	**Advanced Analytical Chemistry**		
3	**Course Type**	**PRACTICUM Course**		
4	**Course Learning Outcomes (CLO)**	**Upon successful completion of this Course, learners will be able to:** ➢ Estimate functional groups such as amino, nitro, hydroxyl, and carboxylic in organic compounds using classical analytical methods. ➢ Determine the strength and concentration of biologically important molecules including glycine, glucose, and phosphate. ➢ Identify plant pigments and calculate retention factor (Rf) values using paper and thin-layer chromatography techniques. ➢ Perform the chromatographic separation of amino acid mixtures and interpret the results. ➢ Conduct spectroscopic estimations of amino acids, proteins, carbohydrates, aspirin, and caffeine with accuracy and precision. ➢ Determine reaction kinetics, such as the rate constant for sugar inversion, using polarimetry. ➢ Calculate the equivalent and molecular weight of organic acid samples using direct titration methods. ➢ Apply a range of analytical chemistry techniques to evaluate the composition and properties of chemical and biological samples.		
5	**Credit Value**	**Practical–04**		
6	**Total Marks**	**Maximum Marks: Total 100** **University Exam (UE)-60, CCE-40**		**Minimum Passing Marks: 40**
Part B- Content of the course				
Total No. of Lectures- Tutorials-Practical (08 hours per week): **L-T-P: 0-0-120 (Total Hours)**				
A. Assignments/Practice/ Survey/Fieldwork				**No. of Hours: 120**
B. List of Experiments to be performed in laboratory				

1. Estimation of Amino, Nitro, Hydroxyl, and Carboxylic groups.
2. Estimation of the strength of Glycine.
3. Estimation of Glucose.
4. Identification of pigments in the plant leaves and calculation of retention factor (Rf) values by paper/TLC chromatography.
5. Separation of amino acids mixture by paper chromatography.
6. Spectroscopic estimation of Amino acids, Proteins, Carbohydrates, Aspirin, and Caffeine.
7. Determination of rate constant for inversion of sugar using Polarimeter.
8. Determination of equivalent weight and molecular weight of an organic acid sample by the direct titration method.
9. Determination of Phosphate concentration in a soft drink.
10. Calculation of mass loss and enthalpy change from TG/DSC curves.
11. Theoretical Analysis of TGA, DTA, and DSC plots for decomposition steps and thermal transitions.
12. Spectral interpretation of d-spacing, wavelength, and angle using Bragg's Law.

Part C: Learning Resources

Text Books, Reference Books, Other Resources

Suggested Readings:

Books

1. Vogel, A.I. Vogel's Textbook of Quantitative Chemical Analysis, Pearson Education.
2. Skoog, D.A., West, D.M., Holler, F.J. Fundamentals of Analytical Chemistry, Cengage Learning.
3. Willard, H.H., Merritt, L.L., Dean, J.A., Settle, F.A. Instrumental Methods of Analysis, CBS Publishers & Distributors.
4. Chatwal, G.R., Anand, S.K. Instrumental Methods of Chemical Analysis, Himalaya Publishing House.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry, New Age International Publishers.
6. Vogel, A.I. Laboratory Manual of Organic Chemistry, Longman Group Ltd.
7. Plummer, D.T. An Introduction to Practical Biochemistry, McGraw-Hill.

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	Total	**40**
	External Assessment	
	Practicum Paper as per University Examination	
	Total	**60**
	Grand Total	100