M.Sc. Applied Chemistry

Semester - II

Course Code	**PT02CACH51**	Title of the Course	**Inorganic Chemistry – II**
Total Credits of the Course	4	Hours per Week	4

Course Objectives	➢ The objective of this course is to introduce the students to Quantum Chemistry uses high-level mathematics as a tool to understand atomic and molecular structure and properties, as well as chemical reactivity. ➢ To review the basic concepts of magnetochemistry and various types of magnetism. ➢ To develop an understanding of bioinorganic chemistry. ➢ To develop the concept related to Corrosion.

Course Content		
Unit	**Description**	**Weightage**
1.	**Wave mechanics** Operator algebra, Free particle; particle in a box; quantization; symmetry of the wave functions; use of the box model; cubical box; Particle on a sphere; normalization of the wave functions; rotation of a diatomic molecule, One dimensional harmonic oscillator, time independent perturbation theory for non-degenerate case, the variation theorem	25%
2.	**Magnetochemistry** Magnetic susceptibility; sources of paramagnetism; diamagnetic susceptibility; Pascal constants and constitutive corrections; antiferromagnetism; types of antiferromagnetism; Ferromagnetism; ferrimagnetism;, quenching of orbital magnetic moment by crystal field; Spin paring: spin paring in octahedral complexes; spin paring in non-octahedral complexes, Term symbols, magnetic properties of the compounds of lanthanides and actinides	25%
3.	**Bioinorganic Chemistry** Introduction to Bio-Inorganic chemistry, Iron-Sulphur proteins, Cytochromes of the electron transport chain, Cytochrome P-450 enzymes, Coenzyme B12, Blue copper proteins Metals in medicine: Antibiotic and related compounds, Metal deficiency and diseases, chelation therapy for metal ion detoxification, Metal ions in clinical diagnosis	25%

4.	**Corrosion** Introduction, Dry or chemical corrosion, wet or` electrochemical Corrosion, mechanism, pilling Bed worth rule, Types of corrosion-galvanic corrosion, concentration cell corrosion, Differential aeration corrosion, soil corrosion, Pitting corrosion, Intergranular corrosion, Microbial corrosion, Stress corrosion, Waterline corrosion, Erosion corrosion, Factors influencing corrosion, Corrosion Control: Proper designing, using pure metal, using metal alloys, cathodic protection, modifying the environment, use of Inhibitors.	25%

Teaching-Learning Methodology	➢ We make extensive use of chalk and board. ➢ ICT tools such as multimedia projector, smart board, etc. are also used for better explanation of scientific concepts. ➢ Detail lecture notes and other reference materials are also provided to the students as and when required from departmental library resources.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to
➢ Understand the concept of quantum chemistry. ➢ Understand the various types of magnetism. ➢ Explain the importance of bioinorganic chemistry. ➢ Understand the concept of corrosion.

References

Reference Books

- Introductory Quantum Chemistry, A. K. Chandra, Tata McGraw-Hill Publishing Company Ltd. 4th ed. (2004).
- Quantum Chemistry, R. K. Prasad, New Age International Publishers, 4th ed. (2010).
- Quantum Chemistry, N. Levine, Pearson India Pvt. Ltd., 7th ed. (2016).
- Quantum Chemistry Through Problem and Solutions, R. K. Prasad, New Age International Publishers, 1st ed. (2006).
- Introduction to Magnetochemistry, Alan Earshaw, Academic Press, Academic press London and new york 1st ed. (2013).
- Elements of Magneto chemistry, Dutta and Symal, East-West Press Pvt. Ltd. 2nd ed. (2004).
- Bio-inorganic Chemistry an Introduction, J. A. Cowan, Wiley-VCH, 2nd ed. (1997).
- Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, F. J. Holler, Saunders College Publishing, 9th ed. (2013).
- Metal ions in Biochemistry, P. K. Bhattacharya, Alpha Science International Ed. 1st Ed. (2005).

Books for further Reading

- Organotransition Metal Chemistry, John F. Hartwing, University Science Books, Sausalito, 1st ed. (2009).
- An Introduction to Quantum Chemistry, M. Satake, Y. Mido, H. Yasuhisa, S. Taguchi, M. S. Sethi, S. A. Iqbal, Discovery Publishing House, 2nd print (2006).
- Elements of Bioinorganic Chemistry, G. N. Mukerjee, Arabinda Das, U. N. Dhur & Sons Pvt. Ltd. 4th ed. (1993).

On-line resources to be used if available as reference material

- On-line Resources
- www.nptel.ac.in
- www.swayam.gov.in
- www.epgp.inflibnet.ac.in (e-PG pathshala)
- www.ndl.iitkgp.ac.in (National Digital Library)

M.Sc. Applied Chemistry

Semester - II

Course Code	**PT02CACH52**	Title of the Course	**Organic Chemistry – II**
Total Credits of the Course	4	Hours per Week	4

Course Objectives	➢ To introduce the concepts of aromaticity and aromatic substitution reaction. ➢ To learn the various name reactions of organic chemistry. ➢ To explain the role of chemical reagents in the oxidation, reduction, and transformation of various organic functional groups. ➢ To familiarize the concept of photochemistry.

Course Content		
Unit	**Description**	**Weightage**
1.	**Aromaticity and aromatic substitution reactions** Concept of aromaticity, Annulenes, aromaticity in charged rings, homoaromaticity, fused ring systems, heterocyclic rings. Introduction to aromatic/electrophilic substitution reactions, reaction mechanism of Friedel- Crafts alkylation and acylation reactions, Types of alkylation and acylating agents, nitration, sulfonation, and halogenation of aromatic compounds. Reactivity of substrates, Orientation of electrophilic substitution reactions in various aromatic substrates. Nucleophilic aromatic substitution reactions.	25%
2.	**Organic Name Reactions and their applications** Robinson ring annulation, Wittig reaction and its modifications; Peterson olefination, Shapiro reaction, Bamford Steven's reaction, Julia olefination, Stork Enamine reaction, Suzuki coupling, Sonogashira coupling, Vilsmeier-Haack reaction, Darzen condensation.	25%
3.	**Reagents in Organic Synthesis** **Oxidation Reagents:** CrO_3, MnO_2, SeO_2, $Pb(OAc)_4$, HIO_4, DMSO, HgO, $K_3Fe(CN)_6$, DDQ, Peracid. **Reduction Reagents:** $Al(O\text{-}tert\ Bu)_3$, $Al(Oi\ Pr)_3$, Na/NH_3, Zn/HCl, N_2H_4/OH^- , $NaBH_4$, $LiAlH_4$, TBTH. **Miscellaneous Reagents:** LDA, Wilkinson catalyst, alkyl lithium, Grignard reagent, Gilman reagent, PTC, NBS, DCC.	25%

4.	**Organic Photochemical reactions** Energy transfer, sensitization and quenching. Singlet and triplet states and their reactivity. Photochemistry of carbonyl compounds, alkenes, dienes and aromatic compounds. Singlet oxygen generation and reactions. Norrish reactions of acyclic ketones. Patterno-Buchi, Barton, photo-Fries and Di-ph methane rearrangement reactions. Applications of photoreactions and their applications for industrial synthesis.	25%

Teaching-Learning Methodology	➢ We make extensive use of chalk and board. ➢ ICT tools such as multimedia projector, smart board, etc. are also used for better explanation of scientific concepts. ➢ Detail lecture notes and other reference materials are also provided to the students as and when required from departmental library resources.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to

- Explain the aromaticity and aromatic substitution reaction.
- Get oneself familiarize with useful chemical transformations with various types of name reactions.
- Understand the chemistry involved in oxidation-reduction reactions by employing numerous reagents to appreciate chemo-selectivity of the reagents
- Suggest use of miscellaneous reagents in organic synthesis including Wilkinson catalyst, Grignard reagent and Gilman reagent, PTC, DCC, NBS etc.
- Recognize the role of photochemistry.

References

Reference Books

- Advanced Organic Chemistry, Part-A: Structure and Mechanisms, F. A. Carey and R. J. Sundberg, Kluwer Academic/ Plenum Publishers 5th ed. (2008).
- Advanced Organic Chemistry: Reaction Mechanism and Structure, Jerrry March, John Wiley, 4th ed. (2006).
- A Guidebook to Mechanism in Organic Chemistry, Peter Sykes, Pearson Pub. 6th ed. (2006).
- Organic Synthesis, M. B. Smith, Academic Press, 4th ed. (2016).
- Organic Chemistry-Clayden, Greeves, Warren and Wothevs, Oxford Univ. Press, 2nd ed. (2014).
- Organic Reactions, Stereochemistry and Mechanism: P.S. Kalsi, New Age Publication.
- Organic Reaction Mechanism: V. K. Ahluwalia and R. K. Parashar, Narosa publication.

Books for further reading

- Organic Chemistry Natural Products Vol. 1 & 2, O. P. Agrawal, Krishna Prakashan Media Pvt. Ltd. 41st ed. (2015).
- Principles of Organic Synthesis, R. O. C. Norman, A. Coxon, Blackie Academic & Pro Publisher, 3rd ed. (1993).
- Organic Reaction Mechanism, R. K. Bansal, New Age International Pvt. Ltd., 4th ed. (2010).
- Organic Photochemistry Principle and Application, J. Kagan, Academic Press, latest ed. (2012).

On-line resources to be used if available as reference material

- On-line Resources
- www.nptel.ac.in
- www.swayam.gov.in
- www.epgp.inflibnet.ac.in (e-PG pathshala)
- www.ndl.iitkgp.ac.in (National Digital Library)

M.Sc. Applied Chemistry
Semester - II

Course Code	**PT02CACH53**	Title of the Course	**Physical Chemistry - II**
Total Credits of the Course	4	Hours per Week	4

Course Objectives	➢ To introduce the concepts of Chemical Kinetics and reaction mechanism. ➢ The course contents aim at developing knowledge of solid state chemistry and nuclear chemistry. ➢ To explain the Concepts of molecular symmetry.

Course Content		
Unit	**Description**	**Weightage**
1.	**Chemical Kinetics and Reaction Mechanism** Basics of chemical kinetics: rate of reaction, factors influencing the rate of reaction, rate laws, rate law, consecutive reactions, chain reaction, parallel reactions, ionic reaction and salt effect, opposing reactions, reactions in flow system, enzyme catalyzed reactions, kinetics of fast reactions. Arrhenius equation, concept of activation energy, thermodynamic formulation of transition state theory.	25%
2.	**Solid State Chemistry** Structural principle in solid state chemistry, types of solids based on bonding, nature of packing, conductivity. Preparation of solids, Solid state reactions, Perfect and imperfect crystals, types of defects, intrinsic and extrinsic defects, point defects, Band structure of metals, insulators and semiconductors, X-ray diffraction for structure determination of solids, Bragg methods, Powder methods, Miller indices, Neutron diffraction, Symmetry in solids, types of symmetry in cubic crystal system.	25%
3.	**Nuclear Chemistry** Radioactive decay, nuclear reactions, Q value, cross sections, types of reactions, chemical effects of nuclear transformation, equilibrium, Nuclear fission and nuclear fusion. The separation of stable isotopes, the separation of unstable isotopes, Nuclear fuels and reactors, processing nuclear materials.	25%
4.	**Symmetry and Group theory** Concepts of molecular symmetry: symmetry elements, symmetry operations, definitions and theorems in group theory, Molecular point	25%

	groups: Identification and classification, notation of points groups, matrix representation of symmetry operations, types of matrices, matrix notation for symmetry elements: E, Cn, *i*, s, Sn. Matrix representation of point groups: product and square rule, inverse rule, Construction of character tables: rules, reducible and irreducible representations.	

Teaching-Learning Methodology	➢ We make extensive use of chalk and board. ➢ ICT tools such as multimedia projector, smart board, etc. are also used for better explanation of scientific concepts. ➢ Detail lecture notes and other reference materials are also provided to the students as and when required from departmental library resources.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to

- Learn kinetic and mechanistic aspects of complex reactions, opposing reactions, consecutive reactions, parallel reactions, chain reactions, ionic reactions and salt effect, enzyme catalyzed reactions, fast reactions.
- Explain the concept of solid state chemistry and nuclear chemistry.
- Discover group theory based mathematical methods by which aspects of a molecules symmetry can be determined and understood.
- Apply group theory and symmetry for predicting the molecular vibrations of Symmetrical molecules, selection rules for electronic transitions, infrared spectra and Raman spectra.

References

Reference Books

- Elements of Physical Chemistry, Peter Atkins, Julio De Paula, David Smith, Oxford University Press, 7th ed. (2017).
- Physical Chemistry, Ira N. Levine, Tata McGraw Hill Publishing House, 6th ed. (2011).
- Kinetics and Mechanism, A. A. Frost, R. G. Pearson, John Wiley & Sons, 2nd ed. (1958).
- Principles of the Solid State, H. V. Kheer, New Age International Publisher, 2nd ed. (2017).
- Chemical Kinetics, K. J. Laidler, Mc-Graw hill Publisher, Pearson Publication, 3rd ed. (1997).
- Solid State Chemistry, D. K. Chakrabarthy New Age International, 2nd ed. (2006).
- Solid State Chemistry and Its Applications, Anthony R. West, John Willey & Sons, 2nd ed. (2014).
- Elements of X-ray Diffraction, B. D. Cullity Addision – Wesley Publ. Co., 2nd ed. (1978).
- Essentials of Nuclear Chemistry, H. J. Arnikar, Wiley Eastern Limited, 4th ed. (2011).
- Elements of Nuclear Chemistry, R. Gopalan, Vikas Publishing House Pvt. Ltd. 1st ed. (1999).
- Group Theory and Its Chemical Applications, P. K. Bhattacharya, Himalaya Publishing House, 1st ed. (2010).
- Group Theory in Chemistry, M. S. Gopinathan, V. Ramakrishnan, Vishal Publishing Co. 2nd Reprint ed. (2013).
- Symmetry and Spectroscopy of Molecules, K. Veera Reddy, New Age International Publishers, 2nd ed. (2009).
- Symmetry and Group Theory for Chemists, N. N. Das, Asian Books Private Limited. 1st ed.

Books for further Reading

- Crystal – Structural Analysis, M. J. Buerger John Wiley and Sons, 3rd ed. (1962).
- Elements of Physical Chemistry, Peter Atkins, Julio De Paula, David Smith, Oxford University Press, 7th ed. (2017).
- Nuclear Chemistry, Bernard G. Harvey, Prentice - Hall, Inc., Englewood Cliffs, 1st ed. (1965).

- Principal of Physical Chemistry, B. R. Puri, L. R. Sharma and M. S. Pathania, V. P. D. Publisher, 47th ed. (2017).

On-line resources to be used if available as reference material

- On-line Resources
- www.nptel.ac.in
- www.swayam.gov.in
- www.epgp.inflibnet.ac.in (e-PG pathshala)
- www.ndl.iitkgp.ac.in (National Digital Library)

M.Sc. Applied Chemistry

Semester - II

Course Code	**PT02CACH54**	Title of the Course	**Practical**
Total Credits of the Course	4	Hours per Week	16

Course Objectives	➢ Describe how to design experiments, execute experiments, and investigate and infer the observations yielded. ➢ The students are trained to handle the experimental set up including standardization. ➢ Synthesis and quantitative analysis of organic and inorganic compounds. ➢ Quantification of metal ions using different titrations. ➢ Identification and separation of radicals present in inorganic mixture.

Course Content		
Unit	**Description**	**Weightage**
	Inorganic Chemistry **Ores analysis (7 hrs)** **1. Analysis of Hematite** 1) Acid insoluble residue 2) Iron as Fe_2O_3 3) Iron by redox method (volumetrically) **2. Determine the amount of Ca(II), Mg(II), Fe(III) and Carbonate in the given sample of Calcite ore.** **3. To analyze the given sample of Pyrolusite** 1) Acid insoluble residue 2) Iron as Iron oxide 3) Mn by using EDTA 4) MnO2 oxalic acid method/Iodometric method **4. To determine the amount of Al and Fe in the given sample of Bauxite ore** 1) Al as Al_2O_3 2) Fe as Fe_2O_3	100%

	5. Analysis of Industrial waste Determination of Calcium fluoride, Calcium and Carbonate from Industrial waste **6. Analysis of Cement: (White/Black Cement)** Determination of SiO_2, Fe^{+3}, Al^{+3}, Ca^{+2}, Mg^{+2} in a given sample. **Alloys analysis** 1. Analysis of German silver 2. Analysis of BRONZE 3. Analysis of Brass 4. Analysis of Steel 5. Miscellaneous **Organic Chemistry** **Single step preparations** 1. Preparation of Cinnamic acid by Perkin's reaction 2. Synthesis of 7-hydroxy 4-methyl coumarin 3. Synthesis of chalcone 4. Synthesis of phenyl salicylate 5. Synthesis of fluorescein from reaction of resorcinol and phthalic anhydride **Multi step preparations** 1. Synthesis of flavone 2. Preparation of Sulpha drug (p-Aminobenzene sulphanilamide) 3. Preparation of dyes	

Teaching-Learning Methodology	➢ Experimental and instrumental analysis demonstration at laboratory. ➢ Learner perform the same under the observation of supervisor.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal practical Examination (As per CBCS R.6.8.3)	30%
2.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to

- Determine the percentage of metal ion using complexometric titration, replacement titration and back titration.
- Perform different types of chemical reactions and synthesized various organic compounds.
- Monitor reaction progress by TLC

References

Reference Books

- Modern Analytical Chemistry, D. Harvey, The McGraw-Hill Pub. 1st ed.
- Instrumental Methods of Analysis, G.W. Ewing, McGraw Hill Ltd. 4th ed.
- Physical Methods in Inorganic Chemistry, R. S. Drago, John-Wiley Pub. 1st ed. (2012)
- A Textbook of Practical Organic Chemistry, A. I. Vogel, Longman. Pearson education, 5th ed. (2003).
- Practical Organic Chemistry, F. G. Mann and B. C. Saunders, Longman. Pearson education, 4th ed. (2009).

On-line resources to be used if available as reference material

- On-line Resources: From time to time there are many Online resources, including web sites, databases, e-books, bibliographies and platforms that offer educational videos, lectures on a range of topics can be suggested or displayed to the students.
- Major Web Sites used for Laboratory Activities like the Interactive Lab Primer; the Laboratory Safety Institute (LSI); Virtual Chemistry

M.Sc. Applied Chemistry

Semester - II

Course Code	**PT02CACH55**	Title of the Course	**Practical**
Total Credits of the Course	4	Hours per Week	16

Course Objectives	➢ Describe how to design experiments, execute experiments, and investigate and infer the observations yielded. ➢ The students are trained to handle the experimental set up including standardization. ➢ To describe the various aspects of physical and analytical chemistry.

Course Content		
Unit	**Description**	**Weightage**
	Physical and Analytical Chemistry ➢ To verify Beer-Lambert's law for potassium permanganate solution and hence to determine the molar extinction coefficient and unknown concentration of given sample spectrophotometrically. ➢ To determine the solubility of calcium oxalate in presence of KCl. (Ionic strength effect). ➢ Analysis of Pharmaceutical tablets. ➢ To estimate the amount of D-glucose in given solution colorimetrically. ➢ To determine the acid value of given oil. ➢ To determine zero shear viscosity (ηo) of a polymer solution at different temperatures. ➢ To titrate pH metrically a dibasic acid solution against alkali and calculate the first and second neutralization of the acid. ➢ To determine the decomposition kinetics of a polymer by TGA using iso-conversional method. ➢ To determine the relative strength of HCl and H_2SO_4 by studying the hydrolysis of methyl acetate. ➢ Determination of CMC of given surfactant by drop weight methods. ➢ To determine the percentage purity of glucose by iodimetry.	100%

	➢ Determination of acid value of polyester resin. ➢ To determine the epoxy equivalent weight of given epoxy resin. ➢ To determine chemical oxygen demand (COD) in a given water sample. ➢ Extraction of caffeine from dry tea leaves and its quantitative determination. ➢ To determine the pKa Value of an indicator by spectrophotometric method.	

Teaching-Learning Methodology	➢ Experimental and instrumental analysis demonstration at laboratory. ➢ Learner perform the same under the observation of supervisor.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Practical Examination (As per CBCS R.6.8.3)	30%
2.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to

- ➢ To study the Critical micelle concentrations (CMC) and surface active parameters of surfactant by surface tension method
- ➢ Student gained during theory teaching to the practical aspects such as monitoring rate of saponification, rate of muta-rotation of sugar, quantitative determination using spectrophotometry and refractometer. The students are trained to handle the experimental set up including standardization.
- ➢ Students learn how to use various instruments.

References

Reference Books

- Experiments in Physical Chemistry, J. M. Wilson, R. J. Newcombe, A. R. Denaro, R. M. W. Rickett, Pergamon Press, Oxford 2nd Revised and enlarged ed. (2013).
- Findlay's Practical Physical Chemistry, B. P. Levitt, Longman Group Limited, 9th Edition.
- A Laboratory Manual of Experiments in Physical Chemistry, D. Brennan, C. F. H. Tipper, McGraw-Hill Publishing Company Ltd., 1st ed. (1967).
- Experimental Physical Chemistry, R. C. Das, B. Behera, Tata McGraw-Hill Publishing Company Ltd., 1st ed. (1983).

Books for further readings

- Advanced Physico-Chemical Experiments: A Textbook of Practical Physical Chemistry and Calculations. J. Rose, Sir Isaac Pitman & Sons Ltd., 1st ed. (1964).
- Vogel's "Textbook of Quantitative chemical analysis" by G. H. Jeffery, J. Basserr Edition.5th ed. (1989).
- Encyclopaedia of Industrial Chemical Analysis, Vol. 14, p. 601, Wiley India, (2007).

On-line resources to be used if available as reference material

- On-line Resources: From time to time there are many Online resources, including web sites, databases, e-books, bibliographies and platforms that offer educational videos, lectures on a range of topics can be suggested or displayed to the students.
- Major Web Sites used for Laboratory Activities like the Interactive Lab Primer; the Laboratory Safety Institute (LSI); Virtual Chemistry

M.Sc. Applied Chemistry

Semester - II

Course Code	**PT02EACH51**	Title of the Course	**Instrumental Methods of Analysis**
Total Credits of the Course	4	Hours per Week	4

Course Objectives	➢ This course gives an introduction to instrumental methods of analysis in the field of chemistry. ➢ To Highlight the importance of various separation methods, electroanalytical methods, spectroanalytical methods and thermal methods of analysis.

Course Content		
Unit	**Description**	**Weightage**
1.	**Separation Methods** Principle, classifications of chromatographic methods, adsorption and partition chromatography, nature of partition forces, chromatographic behaviour of solutes, Column efficiency and resolution, Gas chromatography: detector, optimization of experimental conditions. Ion exchange chromatography, Thin layer chromatography (TLC), Gas chromatography (GC), High-performance Liquid chromatography (HPLC). Preparation of column, solvent systems and detection methods.	25%
2.	**Electroanalytical Methods** **Polarography and Voltammetry:** Introduction, Instrumentation, Ilkovic equation and its verification, Determination of half wave potential, application, Electrode system, advantages and disadvantages, components of limiting currents, polarography – polarography maxima, half-wave potential, Determination of relationship between half wave potential & diffusion coefficient, Factors governing diffusion current, calibration curve method. Voltammetric methods and its applications. **Amperometry:** Basic principles, instrumentation, nature of titration curves and applications.	25%
3.	**Spectroanalytical Methods** **Atomic Absorption and Emission:** Theoretical principles and instrumentation in absorption, flame photometry, Analytical application, ICP-AES (Inductively coupled plasma atomic emission spectroscopy). **ESR and Mossbauer**: Principles, Instrumentation and	25%

	Analytical applications of both the techniques.	
4.	**Thermal Methods of Analysis** **Thermogravimetry (TGA)**: Definition, types of TGA, instrumentation, information from TGA curve, factor affecting TGA curves (instrumental as well as characteristics of sample factors); Application of thermos gravimetry, Calculation of percent decomposition and composition of compounds, limitation and advantages of TGA. Derivative thermos gravimetry (DTG) and its advantages. **Differential Thermal Analysis (DTA)**: Definition, Theoretical basis of DTA, Instrumentation for DTA apparatus, Factors affecting the DTA curve, Application of DTA, Advantages and disadvantages of DTA. **Differential Scanning Calorimetry (DSC):** General definition, Nanochemistry basics, distinction between molecules, nanoparticles and bulk materials. Physico-chemical considerations of nanomaterials, Sizedependent properties.	25%

Teaching-Learning Methodology	➢ We make extensive use of chalk and board. ➢ ICT tools such as multimedia projector, smart board, etc. are also used for better explanation of scientific concepts. ➢ Detail lecture notes and other reference materials are also provided to the students as and when required from departmental library resources.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to
➢ Understand the analytical chemistry importance in different fields of chemistry ➢ learners have an idea about various separation and spectroanalytical methods of analysis. ➢ Explain various electroanalytical and thermal methods of analysis.

References

Reference Books

- Instrumental Methods of Analysis, Willard, Merrit, Dean and Settle, CBS Publishers & Distributors 7th ed. (2004).
- Fundamentals of Analytical Chemistry, D. A. Skoog, D. M. West, Thomson Brooks/Cole 9th ed. (2013).
- Atomic and Molecular Spectroscopy, Mool Chand Gupta, New Age International Publishers, Latest ed. (2001).
- Physical Chemistry: A Molecular Approach, Donald A. McQuarrie, John D. Simon, Viva Books, Viva Student Edition, Revised ed. (2011)
- Fundamentals of Molecular Spectroscopy, C. N. Banwell, E. M. McCash, Tata
- McGraw Hill publishing, 4th ed. (2017).
- Electrochemical Methods, A. J. Bard, L. R. Faulkner, Wiley- India edition, 2nd ed. (2001).

Books for further reading

- Introduction to Spectroscopy, Donald L. Pavia, Gary M. Lampman, George S. Kriz, Thomson Brooks/Cole publisher, 5th ed. (2009).
- Physical Chemistry, Ira N. Levine, Tata-McGraw Hill Edition, 4th ed. (2011).
- Molecular Spectroscopy, J. D. Graybeal, McGraw Hill Revised and Subsequent ed. (1993).
- Modern Spectroscopy, J. M. Hollas, John Wiley & Sons, (2003).
- High Resolution Spectroscopy, J. M. Hollas, Butterworths Heinemann Ltd. (1982).
- Instrumental method of Chemical Analysis, B. K. Sharma, Krishna Prakashan Media Pvt. Ltd., (2014).
- Instrumental Methods of Chemical Analysis, V. K. Ahluwalia, ANE Books (2015)

On-line resources to be used if available as reference material

- On-line Resources
- www.nptel.ac.in
- www.swayam.gov.in
- www.epgp.inflibnet.ac.in (e-PG pathshala)
- www.ndl.iitkgp.ac.in (National Digital Library)

M.Sc. Applied Chemistry

Semester - II

Course Code	**PT02EACH52**	Title of the Course	**Advanced Characterization Techniques**
Total Credits of the Course	4	Hours per Week	4

Course Objectives	➢ To introduce the advanced characterization techniques. ➢ To give the highlights of impedance spectroscopy and rheology. ➢ To impart the knowledge about the Optical Rotatory Dispersion and Circular Dichromism.

Course Content		
Unit	**Description**	**Weightage**
1.	**Impedance Spectroscopy** Fundamental of Electrochemical Impedance Spectroscopy – Concept of complex impedance, Complex dielectric, modulus and impedance data representations, Electrochemical Experiment: Charge and material transport, Fundamental ambiguity of impedance spectroscopy analysis, Graphical representation of impedance spectroscopy data – Nyquist and Bode representation of complex impedance data for ideal electrical circuits, Dielectric data representation, Applications.	25%
2.	**Rheology** Introduction, Subject and goals, Continuum mechanics as a foundation rheology, Viscoelasticity: liquids, solids, gels, Rheometry experimental methods, analysis and modelling of rheomechanical responses in static and dynamic modes, Applications of rheology in Polymers, Food and processing industries, paint, high energy materials etc. as case studies.	25%
3.	**Optical Rotatory Dispersion and Circular Dichromism** Introduction, Circular Birefringence, Circular Dichromism, Cotton effect, Optical Rotatory Dispersion, Comparison of ORD and CD curves, Axial Haloketone rule, The octant rule, Instrumentation for ORD and CD measurements, Applications.	25%
4.	**Microwave Spectroscopy** Introduction, Differences between Microwave spectroscopy and IR	25%

	Spectroscopy, Theory of Microwave Spectroscopy, Diatomic molecules as a Rigid rotator, Selection Rules for Rotational Spectra, Instrument for Microwave spectroscopy, Applications.	

Teaching-Learning Methodology	➢ We make extensive use of chalk and board. ➢ ICT tools such as multimedia projector, smart board, etc. are also used for better explanation of scientific concepts. ➢ Detail lecture notes and other reference materials are also provided to the students as and when required from departmental library resources.

Evaluation Pattern

Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written Examination (As per CBCS R.6.8.3)	15%
2.	Internal Continuous Assessment in the form of Practical, Viva-voce, Quizzes, Seminars, Assignments, Attendance (As per CBCS R.6.8.3)	15%
3.	University Examination	70%

Course Outcomes: Having completed this course, the learner will be able to

- Understand the fundamental concepts of Impedance Spectroscopy and Rheology.
- Learners know the concept of Optical Rotatory Dispersion and Circular Dichromism.
- Learners get ideas about Microwave Spectroscopy.

References

Reference Books

- Impedance Spectroscopy Applications to Electrochemical and Dielectric Phenomena, Vadim F. Lvovich, John Wiley & Sons, 1st ed. (2012).
- Electrochemical Impedance Spectroscopy, Mark E. Orazem, Bernard Tribollet, John Wiley & Sons. Physical Chemistry of Polymers, A. Tager, Mir Publishers, 2nd ed. (1978).
- Rheology: Concepts, methods and Applications. Alexander Ya. Malkin, Avraam I. Isayev, Chem Tec Publishing, 3rd ed. (2017).
- Understanding Viscoelasticity, Phan-Thien, Nhan, Springer Publication, 3rd ed.

(2017).

- Principles of Instrumental Analysis, D. A. Skoog, E. James Holler, S. R. Crouch, Thomson Brooks, 7th ed. (2017).
- Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, Jr., J. A. Dean, F. A. Settlw Jr., CBS Publishers and Distributors, 7th ed. (2004).
- Fundamentals of Analytical Chemistry, Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, Brooks/Cole Cengage Learning, 9th ed. (2014).

Books for further reading

- Introduction to Polymer Rheology, Montogomery T. Shaw, Wiley Publication, 1st ed. (2012).
- Instrumental Methods of Chemical Analysis, Gurdeep R. Chatwal, Sham K. Anand, Himalaya Publishing House, 5th ed. (2014).
- Instrumental Methods of Chemical Analysis, B. K. Sharma, Goel Publishing House, 24th ed. (2011).
- Instrumental Methods of Chemical Analysis, V. K. Ahluwalia, ANE Books Pvt. Ltd. 1st ed. (2015).

On-line resources to be used if available as reference material

- On-line Resources
- www.nptel.ac.in
- www.swayam.gov.in
- www.epgp.inflibnet.ac.in (e-PG pathshala)
- www.ndl.iitkgp.ac.in (National Digital Library)