Master of Science, Chemistry
M. Sc. Chemistry, Semester – III

Course Code	PS03ECHE51	Title of the Course	Separation methods
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To understand the principle of separation methods and their instrumentation and applications. 2. To enable operation of various instruments for separation of varieties of materials 3. To impart applications and troubleshooting of

Course Content		
Unit	Description	Weightage* (%)
1.	**Adsorption & Partition Chromatography**: History, Classification, Principles, Experimental, Factors affecting Column efficiency, Column Chromatography, Thin layer Chromatography, Liquidliquid Chromatography, Reverse phase Chromatography, Paper Chromatography applications.	25%
2.	**Solvent Extraction**: Principles, Mechanism of Extraction, Factors favoring solvent extraction, Quantitative treatment of Solvent Extraction, Equilibrium techniques of extraction, Advantages, Applications. **Supercritical Fluid Chromatography and Extraction:** Principle, Mechanism, Instrumentation of SFC and SFE, Applications.	25%
3.	**Gas Chromatography :** Principle, Theory and Instrumentation, Solid/Liquid Stationary phases, Column types, Detectors, Zone-broadening, Van-Deemter equation, factors affecting on Column efficiency, Plate theory, Rate theory, Applications. **High Performance Liquid Chromatography (HPLC):** Principle, Instrumentation, Applications. **Chiral Chromatography:** Stationary phases, mobile phase and Column types, Applications	25%
4.	**Ion Exchange Chromatography**: Ion Exchangers, Ion-exchange mechanism, Applications. **Size Exclusion Chromatography (GPC)**: Principle, Separation mechanism, Methods of Calibration, Applications. **Electrophoresis:** Principle, Reverse Osmosis, Electro dialysis, Zone Electrophoresis, Curtain Electrophoresis, Capillary Electrophoresis, Applications.	25%

Teaching-Learning Methodology	Information and Communication Technology (ICT) enable teaching with digital library, online course materials repositories etc. As well as counterpart conventional teaching methodology are also use to effective teaching

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical 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	
1.	This course offers ability to understand the principle of separation methods and their instrumentation and applications. This course also includes the trouble shooting and industrial problem solving for separation of various types samples. At the end of the course, students will be able to:
2.	Understand the mechanism of extraction, factors favouring solvent extraction.
3.	Perform the column chromatography, thin layer chromatography (TIC), high performance thin layer chromatography (HPTLC) and paper chromatography.
4.	Explain the theory and instrumentation of gas chromatography and its applications.
5.	Understand the principle, mechanism, instrumentation of SFC and SFE.
6.	Explain the key parameter of ion-exchanger such as swelling, selectivity and capacity.
7.	Understand the size exclusion chromatography (GPC) and electrophoresis.

Suggested References:	
Sr. No.	References

1.	Principles of Instrumental Analysis, 6th Edition 2006, by Douglas A. Skoog, F. James Holler, Timothy A. Nieman. ♉
2.	Instrumental Methods of Analysis, 6th Edition, by Willard, Merritt, Dean, Settle, CBS Publishers and Distributors.
3	Contemporary Chemical Analysis, by J. F. Rubinson and K. A. Rubinson, Princtice-Hall International Inc. 1998.
4	Introduction to Instrumental Analysis, by Robert D. Braun, McGraw-Hill Book company, New Delhi.
5	Instrumental Methods of Chemical Analysis, 24th Edition 2005, by B. K. Sarma, Goel Publishing House, Meerut.
6	Thinlayer Chromatrography, A Laboratory Handbook, 1st Edition (2005), by Egon Stahl, Springer (India) Pvt. Ltd. New Delhi

On-line resources to be used if available as reference material
On-line Resources
https://edu.rsc.org/experiments/leaf-chromatography/389.article
https://home.asdlib.org/

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Master of Science, Chemistry
M.Sc. Chemistry, Semester III

Course Code	PS03ECHE60	Title of the Course	Occupational Practices
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	1. To enrich their knowledge of the need for the protection of intellectual properties. 2. To impart knowledge about patent, IPR, copyright, and trademark. 3. To impart knowledge about principles and parameters of analytical method validation. 4. To make able to handle and control measures for hazardous chemicals and environmental pollution control. 5. To understand the importance of hygiene and safety in chemical industries.

Course Content		
Unit	Description	Weightage* (%)
1.	**Intellectual Property Rights:** Introduction to intellectual properties; Need for protection of intellectual properties; Industrial property: patents, trademark, industrial design, and geographical indications; Copyright and neighboring rights; IPR legislations in India, World IP organizations and treaties; Indian patent act; Patentability; Patent applications; Patent registration and filing; Patent cooperation treaty.	25
2.	**Validation of analytical methods and processes:** General principles of analytical method validation, parameters for method validation: specificity, selectivity, precision, accuracy, linearity and calibration curve, Range, Limit of detection and quantification, Robustness. Introduction to process validation; Regulatory basis for process validation; Pharmaceutical process validation; FDA guidelines; cGMP and GLP: cGMP guidelines viz. ICH/WHO/USFDA/EDQM/ Schedule M/NDA/AMDA.	25
3.	**Hazards:** Classification of Hazardous chemicals, transportation of Hazardous chemicals, Storage, Handling, and control measures for hazardous	25

	chemicals. Hazards and controls in Unit process and Unit Operations. Hazards – fire, mechanical, electrical, chemical, and pharmaceutical, Monitoring & prevention systems, industrial effluent testing &treatment. Control of environmental pollution.	
4.	**Concept of Industrial Safety:** Accidents investigation and Analysis, Statutory provisions, Types of chemical hazards and control, control techniques, process flow chart and its importance for a safety inspection, interpretation, use, and training of MSDS, UN, HAZCHEM. **Safety in the chemical industry:** General introduction, type of chemical hazards, Safety and risk phrases, Storage hazards and control, Prevention of overflow-pressure-temperature and process flow, Types of guards and valves for the vessel, its inlet, and outlet, need of remote and auto control valves, Process hazards and controls.	25

Teaching-Learning Methodology	To meet the effective teaching and the learning requirements, teaching-learning methodology will be a blend of lectures / PPT presentation/seminar/tutorials/assignments, etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical 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	
1.	Understand the need for the protection of intellectual properties.
2.	Understands patent, IPR, copyright, and trademark.
3.	Understand principles and parameters of analytical method validation.

4.	Handle and control measures for hazardous chemicals and environmental pollution control.
5.	Understand hygiene and safety in chemical industries.

Suggested References:

Sr. No.	References
1.	Intellectual Property Rights under WTO: Tasks Before India, Author: T. Rammappa – New Delhi, Wheeler Publishing, 2000.
2.	Intellectual Property Rights: Text & Cases; Author: Dr. S. Balasubhramanian, Dr. R. Radha krishnan, Publisher: Excel Books N Delhi, ISBN: 8174466096, ISBN-13: 9788174466099.
3.	How to Practice GMPs, Author: P.P. Sharma, Vandana Publications, Agra
4.	Pharmaceutical Process Validation, Author: Ira R. Berry and Robert Nash, Publisher: Marcel Decker Inc. (2^{nd} edition).
5.	Accident prevention manual for industrial operations, National safety council, Chicago, 10^{th} edition.
6.	Safety and Accident prevention in chemical operation, 2^{nd} edition, Howard H.
7.	Handbook of occupational safety and Health by S. Lawrence.
8.	MSDS – your guide to chemical safety
9.	Engineering design for control of workplace hazards, A. Richard
10.	Safety managers Handbook, J. J. Keller and Associates Inc, USA.
11.	Supervising safety for hazardous Processes, Dr. K. U. Mistry, Safety Health and Environment Association, 1^{st} edition.
12.	Fundamental of Industrial safety and health by Dr. K. U. Mistry

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

On-line Resources: https://swayam.gov.in/

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Master of Science, Chemistry
M. Sc. Chemistry, Semester – III

Course Code	PS03ECHE52	Title of the Course	Analytical techniques in Materials characterization
Total Credits of the Course	04	Hours per Week	04

Course Objectives:	1. To understand the principle of techniques for the characterisation of various materials such as pharmaceuticals, paints and pigments, inorganic materials etc. 2. To empower student for characterisations of various materials by selecting proper techniques

Course Content		
Unit	Description	Weightage* (%)
1.	**Mossbauer Spectroscopy:** Principle, Mossbauer nuclides, Spectral parameters required for evaluating Mossbauer spectra, Instrumentation, lamb mossbauer factor, Applications, Structure determination, nature of chemical bond, biological applications.	25%
2.	**Circular Dichromium (CD)in analysis of materials** Introduction, Instrumentation, experimental aspects, CD spectral features and interpretation, relation of CD spectral information to other spectroscopic techniques, Applications	25%
3.	**Analysis and testing of polymers:** • Chemical analysis of polymers: X-ray diffraction analysis, thermal analysis, TGA, DTA. • Physical testing of polymers: Mechanical properties, Fatigue testing, impact testing, tear resistance, hardness, abrasion resistance. • Thermal properties: Softening temperature, flammability. • Optical properties: transmittance, color, gloss, haze and transparency. • Electrical properties: dielectric constant and loss factor, resistively, dielectric strength, electronic properties. Chemical properties: resistance to solvents, vapor permeability, weathering.	25%
4.	**Analysis of Paints and Pigment** • Introduction, test on the total coating, water content, separation of pigment binder, thinner of solvent type coating and thinner of latex paints • Identification of the binder, Identification of polymer resins and oils, Identification of plasticizer, Analysis of the vehicle, Identification and Analysis of pigments,	25%

	• Identification of inorganic pigments, Analysis of white and tinted pigments 9 outline of general procedure, HCL insoluble, Titanium dioxide, total lead, acid soluble Al and Fe, acid soluble calcium, total zinc, antimony oxide, total sulfate, total carbonate) analysis of colored pigments, Black pigments, other pigments, identification and analysis of thinners.	

Teaching-Learning Methodology	Information and Communication Technology (ICT) enable teaching with digital library, online course materials repositories etc. As well as counterpart conventional teaching methodology are also use to effective teaching

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical 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	
1.	At the end of the course, students will be able to: Understand the spectral parameters required for evaluating Mossbauer spectra..
2.	Explain the instrumentation and experimental aspects of Circular Dichromium (CD) in analysis of materials.
3.	Perform the physical testing of polymers like mechanical properties, fatigue testing, impact testing, tear resistance, hardness and abrasion resistance.
4.	Understand the thermal properties, optical properties, electrical properties, electronic properties and chemical properties of polymers. Analyze and identify paints and pigment

Suggested References:	
Sr. No.	References
1.	Instrumental Methods of Chemical Analysis, 24th Edition 2005, by B. K. Sarma, Goel Publishing House,Meerut.
2.	Spectroscopy by H. Kaur, 5th Edition, Pragati Prakashan, Meerut, 2009.
3	Analytical Biochemistry, D, J. Homes and H. Peck, Longman (1983)
4	Bioanalytical Chemistry, S. R. Mikkelesen and E. Corton, John Wiley and sons 2004
5	Analysis of food and beverages, George Charalanbous, Accademic press 1978.
6	Encyclopaedia of industrial chemical analysis, snell et al Inter science

On-line resources to be used if available as reference material
On-line Resources
https://home.asdlib.org/

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Master of Science, Chemistry
M.Sc. Chemistry, Semester (III)

Course Code	PS03ECHE53	Title of the Course	Applications of Inorganic Chemistry in Industry
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	1. The students explain the importance of inorganic chemistry in pigments, electrochemistry, corrosion and waste water treatment. 2. The students out line the manufacturing processes of inorganic pigments. 3. The students predict the uses of pigments in foods, plants and animals. 4. The students explain the advancement in the electrochemical industry and applications of surface modified electrodes. 5. The students explain the principles and application of corrosion inhibitors. 6. The students explain the collection, processing, advanced treatment and reuse of waste water.

Course Content		
Unit	Description	Weightage* (%)
1.	Pigments Introduction; Pigments in foods–naturally occurring plant- and animal- pigments; Synthetic food pigments such as Sunset yellow, Allura red, etc.; pigments in plants – raw materials for paints; Physical properties of the pigments in paints; Brief descriptions of the manufacturing process and use of commonly used pigments such as White lead, Zinc oxide, Titanium dioxide, etc.	25%
2.	Electrochemical Applications Introduction; brief discussion on classical electrodeposition of metals; Advancement in the electrochemical industry–modification of electrode surface, brief discussion with respect to preparations and properties of surface modified electrodes such as nafion modified electrodes, pvp modified electrodes, etc.; Applications of surface modified electrodes such as Electrocatalysis, ion selective electrodes, etc.	25%
3.	Corrosion Inhibitors Introduction, Types of corrosion Principles of corrosion inhibitors, corrosion as an electrochemical process, Practical aspects of corrosion inhibition, Anion inhibitor properties in neutral electrolytes, some application of corrosion inhibitors (cooling water circulation-once through and open systems, engine radiation & cooling systems,	25%

	central heating system, refrigeration plants and high chloride systems, water for steam raising, corrosion inhibitors for paint coating)	
4.	Waste and Waste Water Technology Water processing, Operation of waterworks, Wastewater flows and characteristics, Wastewater collection systems, Wastewater processing, Operation of wastewater systems, Advanced wastewater treatment, Water reuse	25%

Teaching-Learning Methodology	Class room teaching, seminars, quizzes, and assignments

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical 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	
1.	Explain the importance of inorganic chemistry in pigments, electrochemistry, corrosion and waste water treatment.
2.	Explain the descriptions of the manufacturing processes of inorganic pigments
3.	Predict the uses of pigments in foods, plants and animals.
4.	Acquire the knowledge of advancement in the electrochemical industry and applications of surface modified electrodes.
5.	Explain the principles and application of corrosion inhibitors.
6.	Explain the collection, processing, advanced treatment and reuse of waste water.

Suggested References:

Sr. No.	References
1.	Handbook of Industrial Chemistry, Vol.1 by K.H. Davis, F.S.Berner, CBS Publishers, Bangalore.
2.	Comprehensive Coordination Chemistry, Chapter 57, 58.
3.	Insight into Speciality Inorganic Chemicals, Chapter 15, by David Thompson, The Royal Society of Chemistry, 1995.
4.	New Trends in Green Chemistry, 2nd Edition by V.K. Ahluwalia and M. Kidwai, Anamaya Publishers, 2007.
5.	Water and Wastewater Technology, 4th edition by Mark J. Hammer and Mark J. Hammer Jr., Eastern Economy Edition.
6.	Wastewater engineering by Calf and Eddy.
7.	Wastewater treatment for pollution control by Arceivala.
8.	Manual on sewage & sewage treatment, Ministry of Works, Delhi.
9.	Principles of water quality control by T.H.Y. Tebbut.

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)

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Master of Science, Chemistry
M.Sc. Chemistry, Semester (III)

Course Code	PS03ECHE54	Title of the Course	Selected Topics in Advanced Inorganic Chemistry-I
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	1. The students explain fundamentals of heterogeneous catalysis, catalytic materials, and industrial heterogeneous catalytic processes. 2. The students apply heterogeneous catalysis for green chemistry. 3. The students predict the applications of inorganic materials in catalysis, biological systems and environmental studies. 4. The students explain important properties of nanomaterials and aerogels. 5. The students understand the fundamentals of photocatalysis and photocatalytic materials and processes.

Course Content		
Unit	Description	Weightage* (%)
1.	Heterogeneous Catalysis: Fundamentals and Applications Introduction, Definition of catalysis, Types of catalysis, Basics of heterogeneous catalysis, advantages of heterogeneous catalysis, supports for heterogeneous catalysis, Catalytic process, Aspects of heterogeneous catalysis in green chemistry, Applications of heterogeneous catalysis	25%
2.	**Photocatalysis** Homogeneous photocatalysis, Hetrogeneous photocatalysis, Semiconductors, Photocatalytic materials, Plasmonic photocatalysts, Mechanism of phtocatalysis, Photocatalytic degradation for removal of pollutants, Photocatalytic organic transformations, CO_2 reduction, Photocatalytic breakdown of water	25%
3.	Polyoxometalate Chemistry from Topology via Self-Assembly to Applications Introduction to Polyoxometalate Chemistry, Synthetic Methodologies, POM-Based Supramolecular Structures, Applications of POM in Catalysis, Biological systems and environmental studies	25%
4.	Types of nanomaterials, General preparative methods for various nanomaterials, Some important properties of nanomaterials: optical properties of metal and semiconductor nanoparticles, magnetic properties, Some special nanomaterials: Carbon nanotubes: Types, synthesis using various methods, Porous silicon: Preparation and	25%

	mechanism of porous silicon formation, Factors affecting porous structure, properties of porous silicon; Aerogels: Types of aerogels, Properties and applications of aerogels, Applications of nanomaterials in electronics, energy, automobiles, sports and toys, textile, cosmetics, medicine, space and defense. Environmental effects of nanotechnology	

Teaching-Learning Methodology	Classroom teaching, assignments, quizzes, and seminars

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical 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	
1.	Explain fundamentals of heterogeneous catalysis, catalytic materials, and industrial heterogeneous catalytic processes.
2.	Evaluate and analyze photocatalytic reactions including hydrogen generation reactions
3.	Assessheterogeneous catalysis for green chemistry.
4.	Predict the applications of inorganic materials in catalysis, biological systems and environmental studies.

Suggested References:	
Sr. No.	References
1.	Sulabha K. Kulkarni, Nanotechnology-Principles and Practices, Capital Publishing Co., 2007.
2.	Polyoxometalate Chemistry from Topology via Self-Assembly to Applications by Michael T. Pope and Achim Müller, Kluwer Academic Publishers, New York.

3.	Advances in Inorganic Chemistry by Rudi van Eldik, Lee Cronin-Polyoxometalate Chemistry, 2017, Zoe Kruze.
4.	Modern Heterogeneous Catalysis by Rutger A. van Santen, Wiley-VCH.
5.	Heterogeneous Catalysis: Fundamentals and Applications by Julian R.H. Ross, Elsevier.
6.	Handbook of Green Chemistry, Green Catalysis, Vol. 2 by Paul T. Anastas, Wiley-VCH.
7.	Polyometalate Molecular Science, NATO Science Series, Vol. 98.
8.	Nanoparticle Technology for Drug Delivery, Ram B. Gupta and Uday B. Kompella, Taylor & Francis.
9.	Introduction to heterogeneous catalysis by Per Stoltze.
10.	Nanotechnology by S. Shanmugam, MJP Publisher.
13.	Porous materials by Duncan W. Bruce, Dermot O'Hare, Richard I. Walton, Wiley-VCH.
14.	Kaneko M. & Okura, I. (2003). Photo catalysis: Science and Technology. Springer
15.	D. M. Roundhill, Photochemistry and Photophysics of Metal Complexes, Plenum Press, New York and London (1994).
16.	G. J. Ferraudi, Elements of Inorganic Photochemistry, John Wiley & Sons (1988).

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)

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Master of Science, Chemistry
M.Sc. Chemistry, Semester (III)

Course Code	PS03ECHE55	Title of the Course	Mechanical and Electrical Properties of Polymers
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	1. For structures formed by polymers in the solid state, students study their characteristics and what measurement methods should be used to examine them. 2. Students, further, to study how the thermal, electrical, and optical properties shown by polymers in the solid state relate to their solid structure.

Course Content		
Unit	Description	Weightage* (%)
1.	Mechanical properties of polymer; introduction, general considerations, objectives, different types of mechanical behavior, elastic solids and polymer, state of stress and strain, generalized Hook's law. Behavior of polymers in rubber like state; finite strain elasticity, generalized definition of strain and stress, strain-stress relationship, use of strain energy function, experimental studies of finite elastic behaviors in rubbers.	25
2.	Statistical molecular theories of the rubber like state, thermodynamic considerations, statistical considerations. Linear viscoelastic behavior; viscoelastic behavior, mathematical treatment of linear viscoelastic behavior, dynamical measurements, the complex modulus and complex compliance, the relationship between the complex modulii and the stress relaxation modulus, the relaxation strength	25
3.	The glassy state and the glass transaction, Experimental studies of the linear viscoelastic behaviors of polymers: general introduction, time-temperature equivalence and superposition, transition state theories, WLF equation. Relaxation transition and their relationship to molecular structure: relaxation transitions in amorphous polymers, Dynamic mechanical testing.	25
4.	Electrical properties of polymer: volume resistively dielectric break down, dialectical constant, dielectric loss dissipation factor, electrostatic charging, dielectric behaviors of polar and non polar polymers in an alternating filled varying frequency and temperature, relaxation time and temperature dependence, conductivity and temperature dependence, factor affecting dielectric behavior polymers. Conducting polymers: chronology, synthesis,	25

	characterization, doping, mechanism of conduction, Electrochemical Impedance Spectroscopy (EIS).	

Teaching-Learning Methodology	The institutional course consists of classroom lessons and video projection of the lessons is also used in classroom. The students are also able to obtain directly the above material from the University Digital Library Service.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical 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	
1.	Understanding the mechanical behavior, elastic solids, state of strain and stress of the polymers with experimental theory.
2.	Understand the thermodynamic and statistical considerations, visco-elastic behavior.
3.	Learn about dynamic mechanical analysis(DMA) for the polymers.
4.	Understanding the electrical properties of polymer, conducting polymers and Electrochemical Impedance Spectroscopy (EIS).

Suggested References:	
Sr. No.	References
1.	Polymer science and material science H.B. Vol. I & II by Jenkins, A.D. North Holland publishing co., Amsterdam London.
2.	Mechanical properties of solid polymers, I.M. WardWiley-lnterscience, john-Wiley and sons Ltd. New York

3.	Mechanical properties of polymers, L.E. Nielson Reinhold publishing co., Chapman and hall Ltd. London
4.	Electrical properties of polymers, A.R. Blythe Cambridge University press, Cambridge
5.	"Electrical properties" in encyclopedia of polymer science and technology, John Wiley and sons. Inc. New York
6.	Physical chemistry of polymers, A. Tager Mir publishers, Moscow.
7.	Impedance Spectroscopy, Vadim F.Lvovich, John Wiley & Sons Inc.2012.

On-line resources to be used if available as reference material
On-line Resources
https://www.youtube.com/watch?v=_pHtXBLpB5o

Master of Science, Chemistry
M.Sc. Chemistry, Semester (III)

Course Code	PS03ECHE56	Title of the Course	Selected Topics in Polymers-I
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	1. To provide knowledge according to need of hour. 2. To provide knowledge on different kinds of rubbers and their properties. 3. To make the students capable of selecting and designing the suitable rubber for specific applications

Course Content		
Unit	Description	Weightage* (%)
1.	**Natural Polymers:** Polysaccharides and Lignin, Reaction of Cellulose, Glycogen, Proteins, Nucleic acids **Water soluble polymers**: Importance of water-soluble polymers, Classification of water-soluble polymers, Functions and Properties of water-soluble polymers, Starch, Manufacturing process of corn starch, Structure, Composition and Properties of Starch, Degradation processes of Starch, Starch derivatives, Cellulose and its properties, Methyl Cellulose, Carboxymethyl Cellulose, Polyethylene oxide, Polyvinyl alcohol, Polyvinyl pyrrolidone, Polyacrylic acid	25
2.	**Fiber Forming Polymers**: Introduction, Fibers (Semisynthetic Fibers, Synthetic Fibers, Structure and Properties of Fibers, Applications), Rayon or artificial silk, Nitrocellulose rayon, Cuprammonium rayon and properties of cuprammonium rayon, Viscose rayon and properties of viscous rayon, Kapron Fiber, Terylene or Dacron Fiber, Orlon Fiber, Saran Fiber, Fabric Defects, Fiber Spinning Processes	25
3.	**Rubber General Purpose**: History and Importance of Rubber, Polymer Repeating groups of rubber, Natural Rubber and Balta, Types of Natural Rubber, Raw Materials, Production of Rubber, Latex and its compositions, Concentration and Stabilization methods of Latex, Taping of Rubber Latex, Refining of Crude Rubber, Technically Classified Rubber, Various forms of Natural Rubber, Vulcanization of Natural Rubber, Non-sulphur vulcanization, Peroxide vulcanization, Factors affecting the process of vulcanization, Vulcanization Techniques and Properties, Reclaimed Rubber **Compounding Materials and Uses**: Compounding Materials, Peroxide Crosslinking of Elastomers, Reinforcing Fillers - Carbon Black, Reinforcing Fillers – Silica, Mineral Fillers for Rubber	25
4.	**Non-Diene Elastomers**: Polyisobutylene, Polysiloxanes, Fluoroelastomers, Chlorinated rubber, Rubber Hydrochloride, Cyclized Rubber, Oxidized Rubber, Ebonite	25

	Rubber Special Purpose: Styrene Butadiene Rubber, Polybutadiene Rubber, Polyisoprene Rubber, Ethylene Propylene Rubber, Butyl Rubber, NitrileRubber, Neoprene Rubber. Fluoroelastomers, Thiokol Rubber, and Thermoplastic Elastomers	

Teaching-Learning Methodology	The institutional course consists of classroom lessons and video projection of the lessons is also used in classroom. The students are also able to obtain directly the above material from the University Digital Library Service.

Evaluation Pattern

Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical 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

1.	Study the proteins, nucleic acids, polysaccharides and understand the importance of natural polymers and biopolymers properties and applications.
2.	Understand structure and properties of natural rubber and other synthetic elastomers.
3.	Understand manufacturing processes involved in various synthetic and natural rubber.
4.	Understand vulcanization reaction and vulcanizing agents for different synthetic elastomers.
5.	Production of rubber components and their quality controls.

Suggested References:

Sr. No.	References
1.	Polymer Chemistry an Introduction (3rd Indian Edition), Malcolm P. Stevens, Oxford University Press
2.	Elastomer and Rubber Compounding Materials, I. Franta, Elsevier Publication

3.	Polymer Science and Technology, J. Fried, Prentice-Hall of India Private Limited
4.	Rubber Technology, Maurice Morton, Van Nostrand Reinhold Publication, New York
5.	Handbook of Textile Fiber Structure, Fundamentals and Manufactured Polymer Fibers, S. J. Eichhorn, J. W. S. Hearle, M. Jaffie and T. Kikutani, Elsevier

On-line resources to be used if available as reference material
https://www.youtube.com/watch?v=q8ZF16XfIsc
https://www.youtube.com/watch?v=YGa1Adkndgs

Master of Science, Chemistry
M.Sc. Chemistry, Semester (III)

Course Code	**PS03ECHE57**	Title of the Course	Advanced Characterization Techniques
Total Credits of the Course	**04**	Hours per Week	**04**

Course Objectives:	The students will be taught the basics to advanced level concepts of thermal methods of analysis which dealt in details along with few practical examples. A detail of various separation methods along with their principles will be provided. The advanced characterization technique like rheology and impedance spectroscopy also be provided.

Course Content

Unit	Description	Weightage* (%)
I	**Thermal 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 thermogravimetry, Calculation of percent decomposition and composition of compounds, limitation and advantages of TGA. Derivative thermogravimetry (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. Thermo Mechanical Analysis (TMA), Dynamic Mechanical Analysis (DMA) : Instrumentation and Applications.	25
II	**Separation Techniques :** Chromatography : Introduction, Different types of chromatography methods, Introduction, Principles, Applications of Gas Chromotography, High Performance Liquid Chromatography, Gel Chromatography, Ion-Exchange Chromatography, Electro Chromatography.	25
III	**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
IV	**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,	25

	Dielectric data representation, Applications.	

Teaching-Learning Methodology	Chalk and board method along with ICT tools Model demonstration as per the demand of the topic

Evaluation Pattern		
Sr. No.	**Details of the Evaluation**	**Weightage**
1.	Internal Written / Practical 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	
1.	To understand instrumentation and applications, advantages and disadvantages of thermogravimetry (TGA), derivative thermogravimetry (DTG), differential thermal analysis (DTA),differential scanning calorimetry(DSC) and thermos-mechanical analysis (TMA).
2.	The separation techniques based on chromatography help the students in determining the purity of laboratory synthesized compounds, natural products and active pharmaceutical ingredients.
3.	To appropriate rheometry experimental methods, analysis and modelling of rheomechanical responses in static and dynamic mode and applications of rheology in industry.
4.	The students will learn the electrode dynamic surface phenomena at interfaces and applications based on it to study semiconductors and conductors.

Suggested References:

Sr. No.	**References**
1.	Principles of Instrumental Analysis, D. A. Skoog, E. James Holler and S. R. Crouch, Thomson Brooks, 2nd Edition.
2.	Instrumental Methods of Analysis, H. H. Willard, L. L. Merritt, Jr., J. A. Dean, F. A. Settlw Jr., CBS Publishers and Distributors, New Delhi, 7th Edition

3.	Fundamentals of Analytical Chemistry, Douglas A. Skoog, Donald M. West, F. James Holler, Stanley R. Crouch, Brooks/Cole Cengage Learning. 8th Edition.
4.	Introduction to Instrumental Analysis, Pharma Med. Press., Hyderabad, Indian Reprint.
5.	Instrumental Methods of Chemical Analysis, B. K. Sharma, Goel Publishing House, 28th Edition.
6.	Physical Chemistry of Polymers, A. Tager, Mir Publishers, Moscow.
7.	Rheology : Concepts, methods and Applications. Alexander Ya. Malkin and Avraam I. Isayev, Chem Tec Publishing, 3rd Edition. 2006.
8.	Introduction to Polymer Rheology, Montogomery T. Shaw, Wiley Publication, 2012.
9.	Understanding Viscoelasticity, Phan-Thien, Nhan, 2017. Springer Publication.
10.	Impedance Spectroscopy : Applications to Electrochemical and Dielectric Phenomena, Vadim F. Lvovich, John Wiley & Sons
11.	Electrochemical Impedance Spectroscopy, Mark E. Orazem, Bernard Tribollet, John Wiley & Sons.

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)

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Master of Science, Chemistry
M.Sc. Chemistry, Semester (III)

Course Code	**PS03ECHE58**	Title of the Course	Selected Topics in Physical Chemistry - II
Total Credits of the Course	**04**	Hours per Week	**04**

Course Objectives:	This course is aims to introduce the concept of biophysical chemistry which covers proteins, nucleic acids, RNA, DNA etc. Bioenergetics and Thermodynamics of biological processes will be discussed. Various renewable energy sources for sustainable energy are also covered in it. Fundamental of computation or theoretical chemistry will be introduced to students.

Course Content

Unit	Description	Weightage* (%)
I	**Biophysical Chemistry – I :** *Introduction :* The cell and its constituents, proteins, nucleic acids, RNA and DNA, enzymes etc. *Bioenergetics and Thermodynamics:* Molecular interpretation of Energy and Enthalpy, Non-covalent reactions, hydrophobic interactions, Protein and Nucleic Acids. Biochemical Applications of Thermodynamics, Thermodynamics of Metabolism, Role of ATP in biological Systems (hydrolysis of ATP). Biological Reactions, Double Stranded Formation in Nucleic Acids, Ionic Effect on Protein–Nucleic Acid Interactions.	25
II	**Biophysical Chemistry – II :** *Kinetics:* Basic Concepts, Enzyme kinetics, catalytic antibodies and RNA enzymes- Ribozymes, Michaelis Menten Kinetics, Competition and Inhibition, Monod-Whyman Changeux Mechanism. Photochemistry and Photobiology, Photosynthesis. *Physical Equilibria:* Bilayers and Membranes, Biological Membranes, Membrane Equilibrium, Transport through cell membrane, Active and Passive Transport, Osmosis and Diffusion.	25
III	**Energy Systems :** Alternative energy needs and option, Fossile fuels : petroleum, natural gas and coal – origin, processing production of value added products – available current conversion technologies. Electrochemical power sources ; theoretical background, types of cells, Fuel cells – classification – chemistry of fuel cells and biochemical fuel cells. Solar Energy conversion devices – photovoltaic cells, Design and mechanism of solar cells, Silicone solar cells and alternatives, thin film solar cells and third generation solar cells, Thermodynamics limit of light concentrators and light conversion	25
IV	**Computational Chemistry :** Introduction to UNIX and WINDOWS, softwares for chemical structure preparation, Computation & modelling – definition of terms; need of approximate methods in quantum mechanics; Computable quantities –	25

	structure, Potential energy surfaces and chemical properties; Classification of computational methods, Molecular Dynamics (MD) and Monte Carlo method, *Ab intio* Methods ; Hartree-Fock method for atoms, SCF treatment of polyatomic molecules, DFT method etc.	

Teaching-Learning Methodology	Chalk and board method along with ICT tools Model demonstration as per the demand of the topic

Evaluation Pattern		
Sr. No.	**Details of the Evaluation**	**Weightage**
1.	Internal Written / Practical 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	
1.	The student will learn basic and advanced thermodynamic principles of the structure of biological macromolecules along with their kinetic and equilibrium studies.
2.	Energy systems based on renewable energy sources as an alternative of fossil based fuel is covered and discussed about available energy conversion technologies.
3.	Students are expected to learn different types of molecular simulations and electronic structure calculations using various methods.
4.	Understand bulk chemical processes at a molecular level and also develop concept of potential energy surfaces and understand their implications on reaction mechanism

Suggested References:	
Sr. No.	**References**
1.	Physical Chemistry : Principles and Applications in Biological Sciences, I. Tinoco Jr., K. Sauer, J. C. Wang, J. D. Puglisi, Pearson Publications, 4th Ed., 2002.
2.	Biophysical Chemistry by C. R.Cantor and P.R. Schimmel, WH Freeman & Company, New York, 2004.

3.	Biophysical Chemistry By A. Upadhyay, K Upadhyay and N. Nath, Himalaya Publishing House, 2005.
4.	Biophysical Chemistry By Gurtu and Gurtu, Pragati Edition, 2007.
5.	Solar cell Materials – Developing Technologies, Ed. Gavin J. Conibeer, Arthur Willoughby, John Wiley & Sons.
6.	Fuel Cells, Vladimir S. Bagotsky, John Wiley & Sons.
7.	Computational Chemistry: A Practical Guide for Applying Techniques to Real-World Problems. David C. Young, John Willey & Sons, 2001
8.	Essentials of computational Chemistry: Theories and models, C. J. Cramer, John Wiley & Sons.2002

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)

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Master of Science, Chemistry
M.Sc. Chemistry, Semester III

Course Code	PS03ECHE59	Title of the Course	Selected Topics in Organic Chemistry
Total Credits of the Course	4	Hours per Week	4

Course Objectives:	1.To understand and familiarize color and constitution relationship in dyes and pigments. 2. To impart knowledge to design and synthesis of dyes and pigment. 3. To understand the effect of the structural modifications on stability and color of dyes and pigments. 4. To impart fundamental knowledge of various non-textiles dyes. 5. To understand the basics of fluorescent brightening agents. 6. To impart the basics of various pericyclic reactions. 7. To familiarize with various theories of pericyclic reactions to access the feasibility of various pericyclic reactions. 8. To impart the knowledge to predict stereochemical outcome of various pericyclic reactions.

Course Content		
Unit	Description	Weightage* (%)
1.	**Dyes:** Brief introduction to fundamentals of dyes; Classification of dyes based on structure and applications; Non textile dyes-Leather, food, hair, ink, photographic, indicator, NIR, Indigo dyes.	25
2.	**Pigments:** Organic and Inorganic pigments-Introduction, classification, characteristics and applications. Organic pigments- Synthesis and evaluation. FBA-Characteristics, classification, synthesis and applications. Colour photography, LCD.	25
3.	**Pericyclic Reactions-I:** General introduction, Theories of pericyclic reactions: FMO, Woodward-Hoffmann rules, Huckel-Mobius rules. Electrocyclic reactions: Ring opening and closing reactions of 4n and4n+2 system; cation (Nazarov reaction) and anion type molecules;small ring opening. Sigmatropic reactions: [1, n]; [2, 3] $-SeO_2$, Somellet-Haouser, Wittig, Mislow Evan's rearrangements; [3, 3]- Cope, Claisen, Claisen-Cope,Aza-Cope; [5, 5].	25
4.	**Pericyclic Reactions-II:**	25

	Theories of pericyclic reactions: FMO, Woodward-Hoffmann rules, Huckel-Mobius rules. Cycloadditions: [2+2] thermal and photochemical; [4+2]-Diels-Alder reactions, diene and dinophile nature; Inter, intra and heterocycloaddition reaction with region and stereoselectivity. [3+2]-dipolar cycloaddition, introduction of different dipoles, their reactions dipolarophiles (inter, intra). Cycloadditions reactions of more than six π electrons. Group transfer reactions: Ene reactions, diimide (N_2H_2), synβ-elimination.	

Teaching-Learning Methodology	To meet the effective teaching and the learning requirements, teaching-learning methodology will be blend of lectures/ PPT presentation / seminar/ tutorials / assignments etc.

Evaluation Pattern		
Sr. No.	Details of the Evaluation	Weightage
1.	Internal Written / Practical 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	
1.	Understand color and constitution relationship in dyes and pigments.
2.	Able to classify dyes and pigments based on their use and structure.
3.	Able to know the structural modification which can change absorption wavelength and intensity of dyes and pigments.
4.	Have insight of factor which affects the stability of dyes and pigments.
5.	Able to design and synthesize various dyes and pigments.
6.	Fundamental knowledge of various non-textiles dyes.
7.	Understand the basics of fluorescent brightening agents.

8.	Understand basics of various pericyclic reactions.
9.	Able to identify feasibility of various pericyclic reactions using various theories for the same.
10.	Able to predict stereochemical outcome of various pericyclic reactions.
11.	Able to solve problems related various pericyclic reactions.

Suggested References:

Sr. No.	References
1.	Colour Chemistry : Synthesis, Properties and applications of Organic dyes and pigments, A. T. Peters, H. S. Freeman
2.	The Chemistry of Synthetic dyes and pigments, by H. A. Lubs, Reinhold Publication (1955)
3.	The Chemistry of Synthetic dyes, Volume I to IX, Edited by K. Venkataraman, Academic Press (1971)
4.	The production and applications of fluorescent Brighteing Agents, Milos Zahradnik, John Wiley & Sons. 1982
5.	Synthetic dyes, Gurdeep R. Chatwal, 4^{th} revised and enlarged edition, HimalayaPublishing House
6.	Handbook of synthetic dyes and pigments, Vol. – 2 (Intermediates), 2^{nd} edition, K. M.Shah, Multi-tech publishing co. Mumbai
7.	Handbook of synthetic dyes and pigments, Vol. – 3 (Pigments), 2^{nd} edition, K. M. Shah, Multi-tech publishing co. Mumbai
8.	Aspects of organic photochemistry, William M. Horspool, Academic Press
9.	Frontier orbitals and organic chemical reactions, Ian Fleming
10.	Molecular Orbitals and Organic Chemical Reactions, Student Edition, Ian Fleming, (2010), Wiley
11.	Pericyclic reactions, Ian Fleming, oxford
12.	Advance organic chemistry: part A & B, Carey and Sundberg
13.	Photochemistry and pericyclic reactions, Jagdamba Singh, Jaya Singh

14.	Modern methods of organic synthesis, 4th edition, W. Carruthers, Iain Coldham, Cambridge university press
15.	Organic chemistry, 2nd edition, J. Clayden, N. Greeves, S. Warren, Oxford university press
16.	Organic chemistry, 7th edition, R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, Pearson
17.	Pericyclic reactions: a mechanistic and problem solving approach, Sunil Kumar, Vinod Kumar, S P Singh, Elsevier
18.	Essentials of Pericyclic and Photochemical Reactions, Biswanath Dinda, Springer

On-line resources to be used if available as reference material:
On-line Resources: https://swayam.gov.in/

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