MARUDHAR KESARI JAIN COLLEGE FOR WOMEN (AUTONOMOUS)

Vaniyambadi – 635 751

PG Department of Chemistry

for

Postgraduate Programme

Master of Science in Chemistry

From the Academic Year 2024-25

CONTENT

LEARNING OUTCOMES BASED CURRICULUM FRAMEWORK FOR POSTGRADUATE EDUCATION

1. Preamble

Chemistry plays a pivotal role in all aspects of physical & biological sciences, engineering, agriculture, medicine, and allied health disciplines. The knowledge of chemistry is essential for student to make the sustainable development and face the upcoming societal change. To impart the basic knowledge of science to young women community, the Department of Chemistry started B.Sc. Programme in the year 2017 followed by M.Sc. Chemistry Programme at 2020. The department offers Chemistry program with the aim of producing chemists with high professional competence, in carrying out both basic and applied chemistry research. The department has well equipped with the latest instruments required to carry out practical experiments in the laboratories and separate library with all needed books.

The faculty members have contributed research towards publication of several research papers in national and international conferences and peer reviewed journals. The research has been carried out in frontier areas of chemistry such as environmental chemistry, electrochemistry, nano materials, coordination chemistry, synthetic organic chemistry, photochemistry, polymer chemistry, and green chemistry. As extension activities, our faculty members and students visit remote villages and various industries in training them to develop entrepreneurial skills and competencies.

In the forthcoming academic year, B.Sc. & M.Sc. Chemistry syllabus provides an integrated and unified approach towards chemical sciences covering all branches of chemistry and following Choice Based Credit System with Outcome Based Education. The curriculum is rigorous in accord to international standards and covers theory and practical courses with full emphasis to construct intellectual assets. In the final semester, the PG students are encouraged to carry out research project in reputed research institutions to enhance their exposure level and placement abilities.

2. PROGRAMME OUTCOMES (PO)

Programme	**M.Sc., Chemistry**
Programme Code	**PS07**
Duration	**2 years [PG]**
Programme Outcomes	**PO1: Disciplinary Knowledge:** Acquire knowledge in chemistry and apply the knowledge in their day-to-day life for betterment of self and society. **PO2: Cognitive and Problem-Solving Skills:** Develop critical, analytical thinking and problem-solving skills. **PO3: Societal and Environmental Impact:** Address and develop solutions for societal and environmental needs at local, regional, and national levels. **PO4: Research-Related Skills**: Develop research skills in defining problems, formulating and testing hypotheses, analyzing, interpreting, and drawing conclusions from data. **PO5: Employability and Entrepreneurship:** Enhance employability and entrepreneurship among students, along with ethical and communication skills. **PO6: Self-Directed Learning**: Work independently and engage in lifelong learning and continuous professional development. **PO7: Moral and Ethical Awareness/Reasoning**: Understand the importance of ethical behavior in professional contexts and be able to recognize and address ethical dilemmas. **PO8: Lifelong Learning and Adaptability:** Be prepared for lifelong learning and professional development, including the ability to adapt to changes in technology, business practices, and economic conditions.

3. PROGRAMME SPECIFIC OUTCOMES (PSO)

Programme Specific Outcomes:	**PSO1: Placement:** Apply principles of organic, inorganic, and physical chemistry to design and synthesize novel compounds, contributing to advancements in pharmaceuticals, materials science, and sustainable industries. **PSO2: Research and Development:** Develop expertise in Nano Science and Green Chemistry to design and implement sustainable, pollution-free technologies with high accuracy, fostering innovation in environmental protection, industrial applications, and entrepreneurship. **PSO3: Contribution to the Society:** Integrate practical expertise in compound analysis to ensure precision in quality control, research, and innovation, contributing to industrial growth and societal well-being.

4. Eligibility for Admission:

Candidate for admission to the first year of M.Sc., Chemistry shall be required to have passed the UG with Chemistry.

5. Methods of Evaluation and Assessments

Methods of Evaluation		
Internal Evaluation		25 Marks
External Evaluation	End Semester Examination	75 Marks
	Total	**100 Marks**
Methods of Assessment		
Recall (K1)	Simple definitions, MCQ, Recall steps, Concept definitions	
Understand / Comprehend (K2)	MCQ, True/False, Short essays, Concept explanations, short summary or overview	
Application (K3)	Suggest idea/concept with examples, suggest formulae, solve problems, Observe, Explain	
Analyze (K4)	Problem-solving questions, finish a procedure in many steps, Differentiate Between various ideas, Map knowledge	
Evaluate (K5)	Longer essay/Evaluation essay, Critique or justify with pros and cons	
Create (K6)	Check knowledge in specific or offbeat situations, Discussion, Debating or Presentations	

6. Skeleton & Syllabus

Semester - I						
Code	Course Title	Hours Distribution				C
		L	T	P	S	
24PCHC11	CC – 1 Organic Reaction Mechanism-I	3	1	2	0	5
24PCHC12	CC – 2 Structure and Bonding in Inorganic Compounds	3	1	2	0	3
24PCHC13P	CC - 3 Organic Chemistry Practical	0	0	4	0	3
24PCHE11	EC - 1 Nanomaterials and Nanotechnology	3	1	1	0	3
24PCHE12	EC – 2 Molecular Spectroscopy	3	1	1	0	3
24PCHA11	AECC – 1 Chemistry in Consumer Products	1	1	0	0	2
24PCHR11	VE - 1 Human Rights	1	1	0	0	2
					30	**21**

Semester - II						
Code	Course Title	Hours Distribution				C
		L	T	P	S	
24PCHC21	CC – 4 Organic Reactions Mechanism-II	3	1	2	0	4
24PCHC22	CC – 5 Physical Chemistry – I	3	1	2	0	4
24PCHC23P	CC - 6 Inorganic Chemistry Practical	0	0	4	0	3
24PCHC24	CC – 7 Bio-Inorganic Chemistry	2	1	1	0	3
24PCHE21 24PCHE22	EC – 3 Medicinal Chemistry EC – 4 Green Chemistry	2	1	1	0	3
24PCHE23 24PCHE24	EC – 5 Industrial Chemistry EC – 6 Materials Science	2	1	1	0	3
24PCHS21	SEC - 1 (NME) Cosmetic Chemistry	1	1	0	0	2
					30	**22**

L-Lecture T-Tutorial P-Practical S-Seminar C-Credit

Students must complete at least one online course (MOOC) from platforms like SWAYAM, NPTEL, or Naan Mudhalvan within the fifth semester. Additionally, engaging in a specified Self-learning Course is mandatory to qualify for the degree, and successful participation will be acknowledged with an extra credit of 2*.

1ST YEAR: FIRST SEMESTER

Course Code	Course Name	Category	L	T	P	S	Credits	Hours	Marks		
									CIA	External	Total
24PCHC11	Core Course 1 - Organic Reaction Mechanism – I	Core	3	1	2	0	5	6	25	75	100

Learning Objectives	
LO1	To understand the feasibility and the mechanism of various organic reactions.
LO2	To comprehend the techniques in the determination of reaction mechanisms.
LO3	To understand the concept of stereochemistry involved in organic compounds.
LO4	To correlate and appreciate the differences involved in the various types of organic reaction mechanisms.
LO5	To design feasible synthetic routes for the preparation of organic compounds.

Unit	Content	Hours
1	**Methods of Determination of Reaction Mechanism:** Reaction intermediates. The transition state, Reaction coordinate diagrams, Thermodynamic and kinetic requirements of reactions: Hammond postulate. Methods of determining mechanism: non-kinetic methods – product analysis, determination of intermediates - isolation, detection, and trapping. Effect of structure on reactivity: Hammett and Taft equations.	18
2	**Aromatic and Aliphatic Electrophilic Substitution:** Aromaticity: Aromaticity in benzenoid, non-benzenoid, heterocyclic compounds and annulenes. Reactions involving nitrogen electrophiles: nitration, nitrosation and diazonium coupling; Sulphur electrophiles: sulphonation;	18

	Halogen electrophiles: chlorination and bromination; Carbon electrophiles: Friedel-Crafts alkylation, acylation and arylation reactions. Aliphatic electrophilic substitution Mechanisms: SE_2 and SE_i, SE_1 - Mechanism and evidences.	
3	**Aromatic and Aliphatic Nucleophilic Substitution:** Aromatic nucleophilic substitution: Mechanisms - SNAr, SNi and Benzyne mechanisms - Evidences. Reactivity of nucleophile, Effect of structure, leaving group and attacking nucleophile. Reactions: Oxygen and Sulphur - nucleophiles, Bucherer and Rosenmund reactions, Von Richter, Sommelet-Hauser and Smiles rearrangements. SN_1 and SN_2 mechanisms and evidences. Aliphatic nucleophilic substitutions at an allylic carbon, aliphatic trigonal carbon and vinyl carbon.	18
4	**Stereochemistry-I:** Racemic modifications: Racemization by thermal, anion, cation, reversible formation, epimerization, mutarotation. D, L system, Cram's and Prelog's rules: R, S notations, proR, proS, absolute and relative configurations. Chiral shift reagents and chiral solvating reagents. Criteria for optical purity: Resolution of racemic modifications, asymmetric transformations and asymmetric synthesis. Stereoselective and stereospecific synthesis.	18
5	**Stereochemistry-II:** Conformation and reactivity of acyclic systems, intramolecular rearrangements, neighbouring group participation, chemical consequence of conformational equilibrium - Curtin-Hammett Principle. Stability of five and six-membered rings: mono-, di- and poly substituted cyclohexanes, conformation and reactivity in cyclohexane systems. Fused and bridged rings: bicyclic, poly cyclic systems, decalins and Brett's rule. Optical rotation and ORD curves, Cotton effect.	18

CO	Course Outcomes
CO1	To recall the basic principles of organic chemistry.
CO2	To understand the formation and detection of reaction intermediates of organic reactions.
CO3	To predict the reaction mechanism of organic reactions and stereochemistry of organic compounds.
CO4	To apply the principles of kinetic and non-kinetic methods to determine the mechanism of reactions.
CO5	To design and synthesize new organic compounds by correlating the stereochemistry of organic compounds.

Textbooks:	
1	March J. and Smith M. "Advanced Organic Chemistry", John-Wiley and Sons. 5th ed., 2001.
2	Gould E. S. "Mechanism and Structure in Organic Chemistry", Holt, Rinehart and Winston Inc., 5th ed., 1959.
3	Kalsi P. S. "Stereochemistry of Carbon Compounds", NewAge International Publishers, 8th ed., 2015.
4	Bruice P. Y. "Organic Chemistry", Prentice Hall, 7th ed., 2013.
5	Clayden J, Greeves N. and Warren S. "Organic Compounds", Oxford University Press, 2nd ed., 2014.
Reference Books:	
1	Carey F. A. and Sundberg R. J. "Advanced Organic Chemistry Part-A and B", Kluwer Academic / Plenum Publishers, 5th ed., 2007.
2	Morris D. G. "Stereochemistry", RSC Tutorial Chemistry Text 1, 2001.
3	Isaacs N. S. "Physical Organic Chemistry", ELBS, Longman, UK, 1987.
4	Eliel E. L. "Stereochemistry of Carbon Compounds", Tata-McGrawHill, 2000.
5	Finar I. L. "Organic chemistry", Vol-1 & 2, 6th ed., Pearson Education Asia, 2004.
Web resources:	
1	https://www.masterorganicchemistry.com/reaction-guide/
2	https://www.khanacademy.org/science/organic-chemistry/aromatic-compounds/reactions-benzene/v/electrophilic-aromatic-substitution
3	https://m.youtube.com/watch?v=Efh5GkVbhEc
4	https://chem.libretexts.org/Courses/Sacramento_City_College/SCC%3A_Chem_420_-_Organic_Chemistry_I/Text/06%3A_Stereochemistry_at_Tetrahedral_Centers/6.01%3A_Chirality
5	https://www.masterorganicchemistry.com/

Mapping with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	3	3	3	3	3	3
CO2	2	3	3	3	3	2	3	3	3	3	3
CO3	3	3	2	3	3	3	3	2	3	3	3
CO4	2	3	3	3	3	2	3	3	3	3	3
CO5	2	3	2	3	3	2	3	2	3	3	3
Total	12	15	13	15	14	12	15	13	15	15	15
Average	**2.4**	**3.0**	**2.6**	**3.0**	**2.8**	**2.4**	**3.0**	**2.6**	**3.0**	**3.0**	**3.0**

3 – Strong, 2- Medium, 1- Low

1ST YEAR: FIRST SEMESTER

Course Code	Course Name	Category	L	T	P	S	Credits	Hours	Marks		
									CIA	External	Total
24PCHC12	**Core Course 2 - Structure and Bonding in Inorganic Compounds**	**Core**	**3**	**1**	**2**	**0**	**3**	**6**	**25**	**75**	**100**

Learning Objectives	
LO1	To understand the Structural properties of main group compounds and clusters.
LO2	To gain fundamental knowledge on structural aspects of ionic crystals.
LO3	To familiarize various diffraction and microscopic techniques.
LO4	To understand the effect of point defects and line defects in ionic crystals.
LO5	To evaluate the structural aspects of solids.

Unit	Content	Hours
1	**Molecular Geometry:** Structure of main group compounds and clusters: VB theory – Effect of lone pair and electronegativity of atoms (Bent's rule) on the geometry of the molecules; Structure of silicates - applications of Pauling's rule of electrovalence - isomorphous replacements in silicates – ortho, meta and pyro silicates – one dimensional, two dimensional and three-dimensional silicates.	18
2	**Boron Compounds and Clusters:** Chemistry of boron – Preparation, properties and structure of boranes, higher boranes - types of boranes closo, nido, arachno. (B_2H_6, B_4H_{10}, B_5H_{11}, B_6H_{10}, $B_{10}H_{14}$) linear and cyclic borazines ($B_3N_3H_6$), boron nitrides $(BN)_x$ and borates ions — STYX numbers, Wade's rules. Metal clusters: Chemistry of low molecularity metal clusters only – Structure of Re_2C_{l8}; multiple metal – metal bonds.	18

3	**Solid State Chemistry:** Structural features of the crystal systems: Rock salt, Zinc blende & Wurtzite, fluorite and anti-fluorite, rutile and anatase, cadmium iodide and nickel arsenide; Spinels - normal and inverse types and perovskite structures.	18
4	**Techniques in Solid State Chemistry:** X-ray diffraction technique: Bragg's law, Powder diffraction method – Principle and Instrumentation; Electron microscopy – difference between optical and electron microscopy, theory, principle, instrumentation, sampling methods and applications of SEM and TEM.	18
5	**Band Theory and Defects in Solids:** Band theory – features and its application of conductors, insulators and semiconductors, Intrinsic and extrinsic semiconductors; Defects in crystals – point defects (Schottky, Frenkel, metal excess and metal deficient) and their effect on the electrical and optical property, laser and phosphors; Linear defects and its effects due to dislocations.	18

CO	Course Outcomes
CO1	Predict the geometry of main group compounds and clusters.
CO2	Explain about the packing of ions in crystals and apply the radius ratio rule to predictthe coordination number of cations.
CO3	Understand the various types of ionic crystal systems and analyze their structural features.
CO4	Explain the crystal growth methods.
CO5	To understand the principles of diffraction techniques and microscopic techniques.

Textbooks:	
1	West A. R, "Solid state Chemistry and its Applications", 2nd ed., (Students Edition), John Wiley & Sons Ltd., 2014.
2	Bhagi A. K. and Chatwal G. R, "A Textbook of Inorganic Polymers", Himalaya Publishing House, 2001.
3	Smart L. and Moore E, "Solid State Chemistry – An Introduction", 4th ed., CRC Press, 2012.
4	Purcell K. F. and Kotz J. C, "Inorganic Chemistry", W.B. Saunders Company, Philadelphia, 1977.
5	Huheey J. E, Keiter E. A. and Keiter R. L, "Inorganic Chemistry",4th ed., Harper and Row, NewYork, 1983.
Reference Books:	
1	Douglas D. E, McDaniel D. H. and Alexander J. J, "Concepts and Models in Inorganic Chemistry", 3rd ed., John Wiley, 1994.
2	Tilley R. J. D, "Understanding Solids - The Science of Materials", 2nd ed., Wiley Publication, 2013.
3	Rao C. N. R. and Gopalakrishnan J, "New Directions in Solid StateChemistry", 2nd ed., Cambridge University Press, 1986.
4	Moeller T, "Inorganic Chemistry: A Modern Introduction", John Wiley & Sons Ltd., New York, 1982.
5	Shriver D. F, Atkins P. W. and Langford C. H, "InorganicChemistry", 3rd ed., Oxford University Press, London, 2001.
Web resources:	
1	https://webbook.nist.gov/chemistry/
2	https://ocw.mit.edu/courses/3-091sc-introduction-to-solid-state-chemistry-fall-2010/
3	https://nptel.ac.in/courses/104104101
4	https://foundry.lbl.gov/about/facilities/the-national-center-for-electron-microscopy-ncem/
5	https://ocw.mit.edu/courses/3-185-transport-phenomena-in-materials-engineering-fall-2003/

Mapping with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	3	3	3	3	3	3
CO2	2	3	3	3	3	2	3	3	3	3	3
CO3	3	3	2	3	3	3	3	2	3	3	3
CO4	2	3	3	3	3	2	3	3	3	3	3
CO5	2	3	2	3	3	2	3	2	3	3	3
Total	12	15	13	15	14	12	15	13	15	15	15
Average	**2.4**	**3.0**	**2.6**	**3.0**	**2.8**	**2.4**	**3.0**	**2.6**	**3.0**	**3.0**	**3.0**

3 – Strong, 2- Medium, 1- Low

1ST YEAR: FIRST SEMESTER

Course Code	Course Name	Category	L	T	P	S	Credits	Hours	Marks		
									CIA	External	Total
24PCHC13P	**Core Course 3 - Organic Chemistry Practical**	**Core**	**0**	**0**	**4**	**0**	**3**	**4**	**25**	**75**	**100**

Learning Objectives	
LO1	To understand the concept of separation, qualitative analysis and preparation of organic compounds.
LO2	To develop analytical skill in the handling of chemical reagents for separation of binary and ternary organic mixtures.
LO3	To analyze the separated organic components systematically and derivative them suitably.
LO4	To construct suitable experimental setup for the organic preparations involving two stages.
LO5	To experiment different purification and drying techniques for the compound processing.

Unit	Content	Hours
1	**Separation and analysis:** a) Two component mixtures. Ternary component (Demo)	12
2	**Estimations:** a) Estimation of Phenol (Bromination) b) Estimation of Aniline (Bromination)	12
3	**Estimations:** a) Estimation of Glucose (Redox) b) Estimation of Glycine (Acidimetry) c) Estimation of Amino group (Acetylation)	12

4	**Preparation of Organic Compounds (Single stage):** a) Methyl-m-nitro benzoate from ethyl benzoate (nitration) b) Benzo phenone oxime from benzophenone (addition) c) o-Chlorobenzoic acid from anthranilic acid (Sand mayer reaction) d) p-Benzoquinone from hydroquinone (oxidation) e) Phenylazo-2-naphthol from aniline (diazotization)	12
5	**Preparation of Organic Compounds (Two stages):** a) p-Bromoacetanilide from aniline b) p-Nitroaniline from acetanilide c) Acetyl salicyclic acid from methyl salicylate d) Benzilic acid from benzoin e) m-Nitrobenzoic acid from methyl benzoate	12

SCHEME OF VALUATION

24PCHC13P - ORGANIC CHEMISTRY PRACTICAL

Internal assessment	: 25 Marks
External assessment	: 75 Marks
Total	: 100 Marks
Max. Marks	: 75 Marks
Estimation	: 30 Marks
Preparation of Organic Compounds	: 30 Marks
Record	: 10 Marks
Viva voce	: 5 Marks

CO	Course Outcomes
CO1	To recall the basic principles of organic separation, qualitative analysis and preparation.
CO2	To explain the method of separation and analysis of separated organic mixtures andconvert them as derivatives by suitable preparation method.
CO3	To determine the characteristics of separation of organic compounds by various chemical reactions.
CO4	To develop strategies to separate, analyze and prepare organic compounds.
CO5	To formulate a method of separation, analysis of organic mixtures and design suitable procedure for organic preparations.

Textbooks:	
1	Mohan, "Organic Analytical Chemistry: Theory and Practice", Narosa, 2003.
2	Ahluwalia V. K, Bhagat ., and Agarwal R, "Laboratory Techniques in Organic Chemistry", I. K. International, 2005.
3	Gnanaprakasam N. S. and Ramamurthy G, "Organic Chemistry Lab Manual", S. V. Printers, 1987.
4	Vogel A. I, Tatchell A. R, Furniss B. S, Hannaford A. J. and Smith P. W. G, "Vogel's Textbook of Practical Organic Chemistry", 5th ed., Prentice Hall, 1989.
5	Jonathan Clayden, Nick Greeves and Stuart Warren, "Organic Practical: Techniques and Transformations", Oxford University Press, 2014.
Reference Books:	
1	Tatchell A. R, Furniss B. S, Hannaford A. J, Smith P. W. G. and Tatchell A. R, "Vogel's Textbook of Practical Organic Chemistry", Pearson Education Ltd., 2009.
2	Hayden-McNeil, "Organic Chemistry Laboratory Notebook", Hayden-McNeil Publishing, 2010.
3	John C. Gilbert and Stephen F. Martin, "Experimental Organic Chemistry: A Miniscale & Microscale Approach", Cengage Learning, 2015.
4	Jerry R. Mohrig, David Alberg, Gretchen Hofmeister, and Paul F. Schatz, "Techniques in Organic Chemistry", W. H. Freeman, 2010.
5	James W. Zubrick, "Organic Chemistry: A Laboratory Manual", Wiley, 2001.
Web resources:	
1	https://www.ncbi.nlm.nih.gov/books/NBK547700/
2	https://webbook.nist.gov/chemistry/
3	https://www.nist.gov/publications/certification-standard-reference-materialr-917d-d-glucose-dextrose
4	https://chem.libretexts.org/Courses/Sonoma_State_University/SSU_Chem_335B/Material_for_Exam_3/Chapter_18%3A_Electrophilic_Aromatic_Substitution/18.4_Nitration_and_Sulfonation
5	https://www.masterorganicchemistry.com/

Mapping with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	3	3	3	3	3	3
CO2	2	3	3	3	3	2	3	3	3	3	3
CO3	3	3	2	3	3	3	3	2	3	3	3
CO4	2	3	3	3	3	2	3	3	3	3	3
CO5	2	3	2	3	3	2	3	2	3	3	3
Total	12	15	13	15	14	12	15	13	15	15	15
Average	**2.4**	**3.0**	**2.6**	**3.0**	**2.8**	**2.4**	**3.0**	**2.6**	**3.0**	**3.0**	**3.0**

3 – Strong, 2- Medium, 1- Low

1ST YEAR: FIRST SEMESTER

Course Code	Course Name	Category	L	T	P	S	Credits	Hours	Marks		
									CIA	External	Total
24PCHE11	**Elective Course 1 - Nanomaterials and Nanotechnology**	**Elective**	**3**	**1**	**1**	**0**	**3**	**5**	**25**	**75**	**100**

Learning Objectives	
LO1	To learn about the synthesis and chemical process of nanoscience.
LO2	To understand the various types of nano materials and their properties.
LO3	To analyse the various application of nanotechnology in remediation of pollution.
LO4	To apply principles and characterization of nanoscience by XRD, SEM, EDAX, TEM.
LO5	To understand the applications of synthetically important nano materials.

Unit	Content	Hours
1	**Synthesis of Nanomaterials by Chemical Processes:** Introduction to nanomaterials and nanotechnologies. Chemical precipitation and co-precipitation, polyol – borohydride reduction methods – Sol-Gel synthesis; Microemulsions synthesis – Hydrothermal – Solvothermal synthesis methods – Microwave assisted synthesis – Sonochemical assisted synthesis – Core-Shell nanostructure – Quantum dot (QDs) synthesis.	15
2	**Structural Properties of Nanomaterials:** Bonding and structure of the nano materials, predicting the type of bonding in a substance crystal structure. Metallic nano particles, surfaces of materials, nanoparticle Size. Techniques to study the following properties of nanomaterials - Thermal, mechanical and electrical properties.	15
3	**Nanotechnology - Environmental and Health Effects:** Environmental pollutants in air, water, soil, hazardous and toxic wastes – application of nanotechnology in remediation of pollution	15

	– The challenge to occupational health and hygiene – toxicity of nanoparticles – effects of inhaled nanosized particles – skin exposure to nanoparticles – impact of CNTs on respiratory systems – hazards and risks of exposure to nanoparticles – monitoring nanoparticles in workplace and sensors.	
4	**Nanostructured Materials Characterization Techniques:** X-ray diffraction (XRD) – SEM – EDAX – TEM – Elemental mapping – FTIR – UV Visible spectrophotometer – Laser Raman Spectroscopy – Thermo gravimetric Analysis (TGA), Differential Scanning Calorimeter (DSC) – Differential Thermal Analyzer (DTA) – X-ray Photoelectron Spectroscopy (XPS).	15
5	**Nanocomposite Materials and Nanolubricants** **Nanocomposites** - Types of nanocomposites - Organic and Inorganic hybrid nanocomposites -Polymer matrix composites, metal matrix composites, ceramic matrix composites; Applications of composites in drug delivery, automobiles and aerospace industries. **Nanolubricants** - Classification, properties and mechanism of different types of nanolubricants.	15

CO	Course Outcomes
CO1	To explain methods of fabricating nanostructures.
CO2	To relate the unique properties of nanomaterials to reduce dimensionality of the material.
CO3	To understand the health and safety related to nanomaterials.
CO4	To familiar with analytical techniques used to characterize nanomaterials, such as SEM, TEM, XRD), and spectroscopic methods (UV-Vis, FTIR, Raman).
CO5	To discuss applications of nanocomposites and nanolubricants

Textbooks:	
1	Sanjay Mathur and Mrityunjay Singh, "Nanostructured Materials and Nanotechnology", 2nd ed., Willey, 2008.
2	Carl C. Koch, "Nanostructured Materials", Noyes Publications, New York, 2002.
3	Nazri G. A. and Pistoia G, "Science and Technology", Kulwer Acdemic Publishers, Dordrecht, Netherlands, 2004.
4	Brown P. and Stevens K, "Nanofibers and Nanotechnology in Textiles", Woodhead publication London, 2006.
5	Altmann J. and Routledge, "Military Nanotechnology: Potential Applications and Preventive Arms Control", Taylor and Francis Group, 2006.
Reference Books:	
1	Chattopadhyay K, "An Introduction to Nanoscience and Nanotechnology", Prentice Hall Learning Pvt. Ltd, 2009.
2	Shi D, Aktas B, Pust L. and Mikailov F, "Nanostructured Magnetic Materials and their Applications", Springer, 2002.
3	Victor E. Borisenko, "A Handbook on Nanoscience and Nanotechnology", Wiley VCH, 2008.
4	Pradeep T, "A Textbook of Nanoscience and Nanotechnology", McGraw Hill Education, 2017.
5	Hari Singh Nalwa, "Encyclopedia of Nanoscience and Nanotechnology", American Scientific Publishers, 2004.
Web resources:	
1	https://www.nano.gov/
2	https://ocw.mit.edu/courses/3-091sc-introduction-to-solid-state-chemistry-fall-2010/
3	https://pubmed.ncbi.nlm.nih.gov/
4	https://www.thermofisher.com/us/en/home/materials-science/learning-center/scanning-electron-microscopy.html
5	https://www.asminternational.org/asm-handbook-volume-21-composites/results/-/journal_content/56/06781G/PUBLICATION/

Mapping with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	3	3	3	3	3	3
CO2	2	3	3	3	3	2	3	3	3	3	3
CO3	3	3	2	3	3	3	3	2	3	3	3
CO4	2	3	3	3	3	2	3	3	3	3	3
CO5	2	3	2	3	3	2	3	2	3	3	3
Total	12	15	13	15	14	12	15	13	15	15	15
Average	**2.4**	**3.0**	**2.6**	**3.0**	**2.8**	**2.4**	**3.0**	**2.6**	**3.0**	**3.0**	**3.0**

3 – Strong, 2- Medium, 1- Low

1ST YEAR: FIRST SEMESTER

Course Code	Course Name	Category	L	T	P	S	Credits	Hours	Marks		
									CIA	External	Total
24PCHE12	**Elective Course – 2 Molecular Spectroscopy**	**Elective**	**3**	**1**	**1**	**0**	**3**	**5**	**25**	**75**	**100**

Learning Objectives	
LO1	To understand the influence of rotation and vibrations on the spectra of the polyatomic molecules.
LO2	Understand the principles of vibrational spectroscopy.
LO3	To highlight the significance of Franck-Condon principle to interpret the selection rule, intensity and types of electronic transitions.
LO4	Gain knowledge of the NMR, fine structure of ESR absorption, Hyperfine structure, double resonance in ESR and techniques of ESR spectroscopy.
LO5	To carry out the structural elucidation of molecules using different spectral techniques.

Unit	Content	Hours
1	**Rotational and Raman Spectroscopy:** Rotational spectra of diatomic and polyatomic molecules. Intensities of rotational spectral lines, effect of isotopic substitution. Non-rigid rotators. Classical theory of the Raman effect, polarizability as a tensor, polarizability ellipsoids, quantum theory of the Raman effect, Stokes and anti-Stokes lines. Vibrational Raman spectra, Raman activity of vibrations, rule of mutual exclusion.	15
2	**Vibrational Spectroscopy:** Vibrations of molecules, harmonic and anharmonic oscillators - vibrational energy expression, energy level diagram. Diatomic vibrating rotor, vibrational-rotational spectra of diatomic molecules, P, R branches, breakdown of the Born-Oppenheimer approximation. Vibrations of polyatomic molecules – symmetry properties, overtone and combination frequencies.	15

3	**Electronic Spectroscopy:** Electronic spectroscopy of diatomic molecules, Frank-Condon principle, dissociation and pre-dissociation spectra. $\pi \rightarrow \pi^*$, $n \rightarrow \pi^*$ transitions and their selection rules. Photoelectron Spectroscopy: Basic principles, photoelectron spectra of simple molecules. Lasers: Laser action, population inversion properties of laser radiation, examples of simple laser systems.	15
4	**NMR and ESR Spectroscopy:** Spin-spin interactions: Homonuclear coupling interactions - AX, AX_2, AB types. ^{13}C NMR and structural correlations, Satellites. ESR spectroscopy Characteristic features of ESR spectra, line shapes and line widths; The g value and the hyperfine coupling parameter. Interpretation of ESR spectra and structure elucidation of organic radicals using ESR spectroscopy; Spin orbit coupling.	15
5	**Mass Spectrometry, EPR and Mossbauer Spectroscopy:** Ionization techniques- Electron ionization (EI), chemical ionization (CI), fragmentation processes of organic molecules, deduction of structure through mass spectral fragmentation. EPR spectra of anisotropic systems - anisotropy in g value, causes of anisotropy, anisotropy in hyperfine coupling, hyperfine splitting caused by quadrupole nuclei. **Practice:** Structural elucidation of simple organic molecules by UV-Visible, FT-IR, NMR, and Mass spectral data.	15

CO	Course Outcomes
CO1	To understand the importance of rotational and Raman spectroscopy.
CO2	To apply the vibrational spectroscopic techniques to diatomic and polyatomic molecules.
CO3	To evaluate different electronic spectra of simple molecules using electronic spectroscopy.
CO4	To perform the most commonly used NMR and ESR spectroscopy to interpret the chemical compounds and their characteristics.
CO5	To develop the knowledge on principle, instrumentation and structural elucidation of simple molecules using Mass, EPR and Mossbauer Spectroscopy.

Textbooks:	
1	Banwell C. N. and McCash E. M, "Fundamentals of Molecular Spectroscopy", 4th Ed., Tata McGraw Hill, New Delhi, 2000.
2	Silverstein R. M. and Webster F. X, "Spectroscopic Identification of Organic Compounds", 6th ed., John Wiley & Sons, New York, 2003.
3	Kemp W, "Applications of Spectroscopy", English Language Book Society, 1987.
4	Williams D. H. and Fleming I, "Spectroscopic Methods in Organic Chemistry", 4th ed., Tata McGraw-Hill Publishing Company, New Delhi, 1988.
5	Straughan B. P. and Walker S, "Spectroscopy", Vol.3, Halstead Press, Sydney, 1978.
Reference Books:	
1	Barrow G. M, "Introduction to Molecular Spectroscopy", McGraw Hill, NewYork, 1964.
2	Sharma Y. R, "Elementary Organic Spectroscopy–Principles and Chemical Applications, S.Chand, New Delhi, 1992.
3	Rahman A, "Nuclear Magnetic Resonance-Basic Principles", Springer-Verlag, New York, 1986.
4	Nakamoto K, "Infrared and Raman Spectra of Inorganic and Coordination Compounds - PartB", 5th ed., John Wiley & Sons Inc., New York, 1997.
5	Weil J. A, Bolton J. R. and Wertz J. E, "Electron Paramagnetic Resonance", Wiley Interscience, 1994.
Web resources:	
1	https://www.nist.gov/spectroscopy
2	https://cccbdb.nist.gov/
3	https://webbook.nist.gov/chemistry/
4	https://nationalmaglab.org/user-facilities/nmr-mri-s/
5	https://acsanalytical.org/

Mapping with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	3	3	3	3	3	3
CO2	2	3	3	3	3	2	3	3	3	3	3
CO3	3	3	2	3	3	3	3	2	3	3	3
CO4	2	3	3	3	3	2	3	3	3	3	3
CO5	2	3	2	3	3	2	3	2	3	3	3
Total	12	15	13	15	14	12	15	13	15	15	15
Average	**2.4**	**3.0**	**2.6**	**3.0**	**2.8**	**2.4**	**3.0**	**2.6**	**3.0**	**3.0**	**3.0**

3 – Strong, 2- Medium, 1- Low

1ST YEAR: FIRST SEMESTER

Course Code	Course Name	Category	L	T	P	S	Credits	Hours	Marks		
									CIA	External	Total
24PCHA11	**Ability Enhancement Compulsory Course 1 - Chemistry in Consumer Products**	**AEC**	**1**	**1**	**0**	**0**	**2**	**2**	**25**	**75**	**100**

Learning Objectives	
LO1	To learn step-by-step process of various types of soap manufacturing.
LO2	To explore the formulation and development of detergent products.
LO3	To gain knowledge of common raw materials used in cosmetics, including oils, waxes, colors, preservatives and fragrances.
LO4	To understand the cosmetic formulation principles, including the selection of active ingredients, excipients, and additives to achieve desired skincare effects.
LO5	To identify common toxic chemical ingredients found in skincare and toiletries products.

Unit	Content	Hours
1	**Soaps:** Types of Soaps, manufacture of soaps, formulation of toilet soaps – different ingredients used - soft soaps, shaving soaps, herbal soaps and antibacterial soaps.	6
2	**Detergents:** Types of detergents - anionic detergents and cationic detergents – manufactures and applications; detergent performance; Green detergents - sustainable alternatives.	6
3	**Cosmetics:** Cosmetics - Introduction about raw materials in cosmetics - (oil, waxes, color, preservative and fragrance). Shampoo - different kinds shampoo – anti-dandruff, anti-lice, herbal and baby shampoo, hair dye – manufacture of conditioners (raw materials and uses only).	6
4	**Skin Care Products:** Preparation of cosmetics - skin and hair - skin lighteners, sun screen lotions - skin toners anti wrinkling creams. Lip care - lip gloss – lipsticks - lip liners, moisturizers - crack creams, Sun cream and UV rays protecting cream.	6
5	**Toxicity:** Toxic chemical ingredients – skincare products – toiletries products – carcinogens; preservatives - parabens, formaldehyde-releasing agents, fragrances - phthalates, surfactants - sodium lauryl sulfate, and colorants - coal tar dyes.	6

CO	Course Outcomes
CO1	To learn about various soap making techniques.
CO2	To understand the structure-property relationships of surfactants in detergents.
CO3	To apply the knowledge to develop cosmetic products with desired properties.
CO4	To understand the cosmetic formulation principles, including the selection of active ingredients, excipients, and additives to achieve desired skincare effects for both skin and hair products.
CO5	To explore the adverse health effects associated with harmful chemicals found in skincare and toiletries products.

Textbooks:	
1	David A. Katz and Richard A. Lawton, "Chemistry of Household Products", Thomson Learning, 2001.
2	Richard J. Farn, "Chemistry and Technology of Surfactants", Blackwell Publishing, 2006.
3	NIIR Board, "Modern Technology of Cosmetics", Asia Pacific Business Press Inc., New Delhi, 2004.
4	Ernest W. Flick, "Cosmetic and Toiletry Formulations", Noyes Publications, 2001.
5	D. F. Williams and W. H. Schmitt, "Chemistry and Technology of Cosmetics and Toiletries", Blackie Academic & Professional, 1992.
Reference Books:	
1	André O. Barel, Marc Paye, and Howard I. Maibach, "Handbook of Cosmetic Science and Technology", CRC Press, 2001.
2	Charles S. Sell, "Chemistry of Fragrances: From Perfumer to Consumer", Royal Society of Chemistry, 2006.
3	Michael Showell, "Handbook of Detergents, Part F: Production", CRC Press, 2009.
4	Romanowski P. and Schueller R, "Beginning Cosmetic Chemistry: Practical Knowledge for the Cosmetic Industry", Allured Books, 3rd ed., 2009.
5	John Toedt, Darrell Koza, and Kathleen Van Cleef-Toedt, "Chemical Composition of Everyday Products", Greenwood, 2005.
Web resources:	
1	https://www.gutenberg.org/
2	https://openlibrary.org/
3	https://www.cleaninginstitute.org/
4	https://www.aad.org/
5	https://www.ewg.org/

Mapping with Programme Outcomes and Programme Specific Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO1	3	3	3	3	2	3	3	3	3	3	3
CO2	2	3	3	3	3	2	3	3	3	3	3
CO3	3	3	2	3	3	3	3	2	3	3	3
CO4	2	3	3	3	3	2	3	3	3	3	3
CO5	2	3	2	3	3	2	3	2	3	3	3
Total	12	15	13	15	14	12	15	13	15	15	15
Average	**2.4**	**3.0**	**2.6**	**3.0**	**2.8**	**2.4**	**3.0**	**2.6**	**3.0**	**3.0**	**3.0**

3 – Strong, 2- Medium, 1- Low

1ST YEAR: SECOND SEMESTER

Course Code	Course Name	Category	L	T	P	S	Credits	Hours	Marks		
									CIA	External	Total
24PCHC21	Organic Reaction Mechanism - II	Core	3	1	2	0	4	6	25	75	100

Learning Objectives	
LO1	To understand the concept of aromaticity in benzenoid, non-benzenoid, heterocyclic and annulene compounds.
LO2	To understand the mechanism involved in various types of organic reactions with evidences.
LO3	To understand the applications of synthetically important reagents.
LO4	To correlate the reactivity between aliphatic and aromatic compounds.
LO5	To design synthetic routes for synthetically used organic reactions.

Unit	Content	Hours
1	**Elimination and Free Radical Reactions:** Mechanisms: E_2, E_1, and E_1cB mechanisms. Syn- and anti-eliminations. Orientation of the double bond: Hoffmann and Saytzeff rules. Reactivity: Effect of substrate, attacking bases, leaving group and medium. Long lived and short-lived radicals – Production of radicals by thermal and photochemical reactions, Detection and stability of radicals, characteristics of free radical reactions - Reactions of radicals: Polymerization, addition, halogenations, aromatic substitutions, rearrangements. Reactivity: Reactivity on aliphatic, aromatic substrates, reactivity in the attacking radical, effect of solvent.	**18**
2	**Oxidation and Reduction Reactions:** Mechanism of oxidation reactions: Dehydrogenation by quinones, selenium dioxides, ferricyanide, permanganate, osmium tetroxide, oxidation of saturated hydrocarbons, alcohols, halides and amines. Reactions involving cleavage of C-C bonds - oxidative decarboxylation, allylic oxidation, oxidation by chromium trioxide-pyridine, DMSO-Oxalyl chloride (Swern oxidation) and Corey-Kim oxidation, dimethyl sulphoxide- dicyclohexyl carbodiimide (DMSO-DCCD). Mechanism of reduction reactions: Wolff-Kishner, Clemmenson, Rosenmund, McFadyen-Steven's reduction, Hydroboration with cyclic systems, MPV and Bouveault- Blanc reduction.	**18**

3	**Rearrangements:** Rearrangements to electron deficient carbon: Pinacol - pinacolone and semi-pinacolone rearrangements - applications and stereochemistry, Wagner-Meerwein, Demjanov, Dienone-phenol, Baker-Venkataraman, Benzilic acid and Wolff rearrangements. Rearrangements to electron deficient nitrogen: Hofmann, Curtius, Schmidt, Lossen, Beckmann rearrangements. Rearrangements to electron deficient oxygen: Baeyer-Villiger oxidation and Dakin rearrangements. Rearrangements to electron rich atom: Favorskii, Stevens, [1,2]-Wittig and [2,3]-Wittig rearrangements. Fries and Photo Fries rearrangement. Intramolecular rearrangements – Claisen, Cope, Oxy-Cope, Benzidine rearrangements.	**18**
4	**Addition to Carbon Multiple Bonds:** Mechanisms: (a) Addition to carbon-carbon multiple bonds- Addition reactions involving electrophiles, nucleophiles, free radicals, Orientation and reactivity, hydrogenation of double and triple bonds, Michael reaction, addition of oxygen and Nitrogen; (b) Addition to carbon-hetero atom multiple bonds: Mannich reaction, acids, esters, nitrites, Wittig reaction, Prins reaction. Addition of Grignard reagents, organozinc and organolithium reagents to carbonyl and unsaturated carbonyl compounds. Mechanism of condensation reactions involving enolates – Stobbe reactions. Hydrolysis of esters and amides, ammonolysis of esters.	**18**
5	**Reagents and Modern Synthetic Reactions:** Lithium diisopropylamine (LDA), Sodium cyanoborohydride ($NaBH_3CN$), *meta*-Chloroperbenzoic acid (m-CPBA), Dimethyl aminiopyridine (DMAP), Triethylamine (TEA), Diazobicyclo[5.4.0]undec-7-ene (DBU), Diisopropylazodicarboxylate (DIAD), Diethylazodicarboxylate (DEAD), *N*-bromosuccinimide (NBS), Trifluoroacetic acid (TFA), Tetramethyl piperiridin-1-oxyl (TEMPO), Phenyltrimethylammonium tribromide (PTAB). Diazomethane and Zn-Cu, Diethyl maleate (DEM), $TiCl_3$, $NaIO_4$, Pyridinium chlorochromate (PCC), Pyridinium dichromate (PDC), Meisenheimer complex**.** Heck reaction, Negishi reaction, Baylis-Hillman reaction.	**18**

CO	Course Outcomes
CO1	To recall the basic principles of aromaticity of organic and heterocyclic compounds.
CO2	To understand the mechanism of various types of organic reactions.
CO3	To predict the suitable reagents for the conversion of selective organic compounds.
CO4	To correlate the principles of substitution, elimination, and addition reactions.
CO5	To design new routes to synthesis organic compounds.

Textbooks:	
1.	J. March and M. Smith, "*Advanced Organic Chemistry"*, 5th ed., John-Wiley and Sons. 2001.
2.	E. S. Gould, "*Mechanism and Structure in Organic Chemistry",* 1st ed., Holt, Rinehart and Winston Inc., 1959.
3.	P. S. Kalsi, "*Stereochemistry of carbon compounds"*, 8th ed., New Age International Publishers, 2015.
4.	P. Y. Bruice, "*Organic Chemistry"*, 7th ed., Prentice Hall, 2013.
5.	R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, "*Organic Chemistry"*, 7th ed., Pearson Education, 2010.
Reference Books:	
1.	S. H. Pine, "*Organic Chemistry"*, 5th ed, McGraw Hill International Edition, 1987.
2.	L. F. Fieser and M. Fieser, "*Organic Chemistry"*, 4th ed., Asia Publishing House, Bombay, 2000.
3.	O. P. Agarwal, "*Organic Chemistry: Reactions & Reagents*", 53rd ed., Krishna Prakashan Media (P) Ltd., 2015.
4.	T. L. Gilchrist, "*Heterocyclic Chemistry"*, 2nd ed., Longman Press, 1989.
5.	J. A. Joule and K. Mills, "*Heterocyclic Chemistry"*, 4th ed., John-Wiley, 2010.
Web resources:	
1.	https://sites.google.com/site/chemistryebookscollection02/home/organic-chemistry/organic
2.	https://www.organic-chemistry.org/
3.	https://www.masterorganicchemistry.com/
4.	https://onlinecourses.nptel.ac.in/
5.	https://www.masterorganicchemistry.com/

Mapping with Programme Outcomes and Programme Specific Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO 1	3	3	3	3	2	3	3	3	3	3	3
CO 2	2	3	3	3	3	2	3	3	2	3	3
CO 3	3	3	2	3	3	3	3	2	3	3	2
CO 4	3	2	3	3	3	2	3	3	2	3	3
CO 5	2	3	2	3	3	3	3	2	3	3	3
Total	13	14	13	15	14	12	15	13	13	15	14
Average	**2.6**	**2.8**	**2.6**	**3.0**	**2.8**	**2.6**	**3.0**	**2.6**	**2.6**	**3.0**	**2.8**

3 – Strong, 2 – Medium, 1 - Low

1ST YEAR: SECOND SEMESTER

Course Code	Course Name	Category	L	T	P	S	Credits	Hours	Marks		
									CIA	External	Total
24PCHC22	**Physical Chemistry - I**	**Core**	**3**	**1**	**2**	**0**	**4**	**6**	**25**	**75**	**100**

Learning Objectives	
LO1	To recall the fundamentals of thermodynamics and the composition of partial molar quantities.
LO2	To understand the classical and statistical approach of the functions.
LO3	To compare the significance of Maxwell-Boltzman, Fermi-Dirac and Bose-Einstein.
LO4	To correlate the theories of reaction rates for the evaluation of thermodynamic parameters.
LO5	To study the mechanism and kinetics of reactions.

Unit	Content	Hours
1	**Classical Thermodynamics:** Partial molar properties - Chemical potential, Gibb's- Duhem equation-binary and ternary systems. Determination of partial molar quantities. Thermodynamics of real gases - Fugacity- determination of fugacity by graphical and equation of state methods. Thermodynamics of ideal and non-ideal binary mixtures, Duhem - Margulus equation applications of ideal and non-ideal mixtures. Activity and activity coefficients-standard states.	**18**
2	**Statistical thermodynamics:** Concepts of thermodynamic and mathematical probabilities. Assemblies, ensembles, canonical particles. Maxwell - Boltzmann, Fermi Dirac & Bose-Einstein Statistics-comparison and applications. Partition functions - evaluation of translational, vibrational and rotational partition functions for monoatomic ideal gases. Statistical approach to Thermodynamic properties: pressure, internal energy, entropy, enthalpy, Gibb's function, Helmholtz function, residual entropy, equilibrium constants and equipartition principle.	**18**
3	**Irreversible Thermodynamics:** Theories of conservation of mass and energy, entropy production in open systems by heat, matter and current flow, force and flux concepts. Onsager theory-validity and verification-Onsager reciprocal relationships. Electro kinetic and thermomechanical effects-Applications of irreversible thermodynamics to biological systems.	**18**

4	**Kinetics of Reactions:** Theories of reactions, collision theory of reaction rates, Effect of temperature on reaction rates, Unimolecular reactions-Lindeman reactions, Transition state theory--applications of ARRT to reactions between atoms and molecules - primary salt effect and secondary salt effect, homogeneous catalysis- acid- base catalysis-mechanism of acid base catalyzed reactions- Bronsted catalysis law, enzyme catalysis-Michelis-Menton catalysis.	**18**
5	**Kinetics of complex and fast reactions:** Kinetics of complex reactions, reversible reactions, consecutive reactions, parallel reactions, chain reactions. Chain reactions-chain length, kinetics of $H_2 – Cl_2$ & $H_2 – Br_2$ reactions (Thermal and Photochemical reactions). Study of fast reactions-relaxation methods- temperature and pressure jump methods electric and magnetic field jump methods - stopped flow flash photolysis methods and pulse radiolysis.	**18**

CO	Course Outcomes
CO1	To explain the classical and statistical concepts of thermodynamics.
CO2	To compare and correlate the thermodynamic concepts to study the kinetics of chemical reactions.
CO3	To discuss the various thermodynamic and kinetic determination.
CO4	To evaluate the thermodynamic methods for real gases ad mixtures.
CO5	To compare and correlate the thermodynamic concepts to study the kinetics of chemical reactions.

Textbooks:

1.	J. Rajaram and J. C. Kuriacose, "*Thermodynamics for Students of Chemistry*", 2nd ed., S.L.N.Chand and Co., Jalandhar, 1986.
2.	I. M. Klotz and R. M. Rosenberg, "*Chemical thermodynamics*", 6th ed., W.A. BenjaminPublishers, California, 1972.
3.	M. C. Gupta, "*Statistical Thermodynamics*", 1st ed., New Age International Pvt. Ltd., New Delhi, 1995.
4.	K. J. Laidler, "*Chemical Kinetics*", 3rd ed., Pearson, Reprint - 2013.
5.	J. Rajaram and J. C. Kuriokose, "*Kinetics and Mechanisms of chemical transformation*", 1st ed., Macmillan India Ltd, Reprint - 2011.

Reference Books:

1.	D. A. Mcqurrie And J. D. Simon, "*Physical Chemistry - A Molecular Approach*", 2nd ed., Viva Books Pvt. Ltd., New Delhi, 1999.
2.	R. P. Rastogi and R. R. Misra, "*Classical Thermodynamics*", 3rd ed., Vikas Publishing, Pvt. Ltd., New Delhi, 1990.
3.	S. H. Maron and J. B. Lando, "*Fundamentals of Physical Chemistry*", 5th ed., Macmillan Publishers, New York, 1974
4.	L. B. Ytsiimiriski, "*Kinetic Methods of Analysis*", 2nd ed., Pergamom Press, 1996.
5.	Gurdeep Raj, "*Phase rule*", 1st ed., Goel Publishing House, 2011.

Web resources:

1.	https://nptel.ac.in/courses/104/103/104103112/
2.	https://nptel.ac.in/courses/112103016
3.	https://onlinecourses.nptel.ac.in/noc24_ch34/preview
4.	https://www.youtube.com/watch?v=zVEKh_mCGqw
5.	https://nptel.ac.in/courses/112103016

Mapping with Programme Outcomes and Programme Specific Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO 1	3	3	3	3	2	3	3	3	3	3	3
CO 2	2	3	3	3	3	2	3	3	3	2	3
CO 3	3	3	2	3	3	3	3	2	3	2	3
CO 4	2	3	3	3	3	2	3	3	2	3	3
CO 5	2	3	2	3	3	2	3	2	3	3	3
Total	12	15	13	15	14	12	15	13	14	13	15
Average	**2.4**	**3.0**	**2.6**	**3.0**	**2.8**	**2.4**	**3.0**	**2.6**	**2.8**	**2.6**	**3.0**

3 – Strong, 2 – Medium, 1 - Low

1ST YEAR: SECOND SEMESTER

Course Code	Course Name	Category	L	T	P	S	Credits	Hours	Marks		
									CIA	External	Total
24PCHC23P	**Inorganic Chemistry Practical**	**Core**	**0**	**0**	**4**	**0**	**3**	**4**	**25**	**75**	**100**

Learning Objectives	
LO1	To understand and enhance the visual observation as an analytical tool for the quantitative estimation of ions.
LO2	To recall the principle and theory in preparing standard solutions.
LO3	To train the students for improving their skill in estimating the amount of ion accurately present in the solution.
LO4	To estimate metal ions, present in the given solution accurately without using instruments.
LO5	To determine the amount of ions, present in a binary mixture accurately.

Unit	**Content**	**Hours**
1, 2 & 3	**Analysis of Mixture of Cations:** Analysis of a mixture of four cations containing two common cations and two rare cations. Cations to be tested. Group-I : W and Pb Group-II : Mo, Cu, Bi and Cd Group-III : Ce, Zr, V, Cr, Fe and Ti Group-IV : Zn, Ni, Co and Mn Group-V : Ca, Ba and Sr Group-VI : Li and Mg	36
4 & 5	**Quantitative Analysis of the following Mixtures (by Volumetric/Gravimetric method)** 1. Estimation of Zinc and Magnesium in a mixture 2. Estimation of Copper and Nickel in a mixture 3. Determination of Nickel in the presence of Iron 4. Determination of Magnesium in the presence of Iron	24

SCHEME OF VALUATION

24PCHC23P - INORGANIC CHEMISTRY PRACTICAL

Internal assessment	: 25 Marks
External assessment	: 75 Marks
Total	: 100 Marks
Max. Marks	: 75 Marks
Analysis of Mixture of Cations	: 40 Marks
Estimation	: 20 Marks
Record	: 10 Marks
Viva voce	: 5 Marks

CO	Course Outcomes
CO1	To identify the anions and cations present in a mixture of salts.
CO2	To apply the principles of semi micro qualitative analysis to categorize acid radicals and basic radicals.
CO3	To acquire the qualitative analytical skills by selecting suitable confirmatory tests and spot tests.
CO4	To choose the appropriate chemical reagents for the detection of anions and cations.
CO5	To synthesize coordination compounds in good quality.

Textbooks:	
1	A. JeyaRajendran, " *Microanalytical Techniques in Chemistry: Inorganic Qualitative Analysis*", 1st ed., United Global Publishers, 2021.
2	V. V. Ramanujam, "*Inorganic Semimicro Qualitative Analysis",* 3rd ed., The National Publishing Company, Chennai, 1974.
3	G. Svehla, "*Vogel's Text book of Inorganic Qualitative Analysis",* 4th ed., ELBS, London.
4	G. H. Jeffery, J. Bassett, J. Mendham, and R. C. Denney, "*Vogel's Textbook of Quantitative Inorganic Analysis*", 6th ed., Wiley, 2002.
5	Gary D. Christian, "*Analytical Chemistry: Principles and Techniques*", 9th ed., Wiley, 2021.

Reference Books:	
1	G. Pass, and H. Sutcliffe, "*Practical Inorganic Chemistry",* 1st ed., Chapman Hall, 1965.
2	W. G. Palmer, "*Experimental Inorganic Chemistry",* 1st ed., Cambridge University Press, 1954.
3	A. I. Vogel, "*Qualitative Inorganic Analysis*", 3rd ed., Longmans, 1961.
4	F. A. Cotton and G. Wilkinson, "A*dvanced Inorganic Chemistry*", 6th ed., Wiley-Interscience, 1988.
5	Gary L. Miessler and Donald A. Tarr, "*Inorganic Chemistry*", 5th ed., Pearson Prentice Hall, 2010.

Web resources:	
1	https://www.masterorganicchemistry.com/
2	https://nptel.ac.in/
3	https://ocw.mit.edu/
4	https://www.google.com/url?sa=E&source=gmail&q=https://www.jstor.org/
5	https://www.google.com/url?sa=E&source=gmail&q=https://www.sciencedirect.com/

Mapping with Programme Outcomes and Programme Specific Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO 1	3	3	3	3	2	3	3	3	3	3	3
CO 2	2	3	3	3	3	2	3	3	3	3	2
CO 3	3	3	2	2	3	3	3	2	2	3	3
CO 4	3	3	3	2	3	2	3	3	3	3	3
CO 5	3	3	2	3	3	2	3	2	2	3	3
Total	14	15	13	13	14	12	15	13	13	15	14
Average	**2.8**	**3.0**	**2.6**	**2.6**	**2.8**	**2.4**	**3.0**	**2.6**	**2.6**	**3.0**	**2.8**

3 – Strong, 2 – Medium, 1 - Low

1ST YEAR: SECOND SEMESTER

Course Code	Course Name	Category	L	T	P	S	Credits	Hours	Marks		
									CIA	External	Total
24PCHC24	**Bio-Inorganic Chemistry**	**Core**	**2**	**1**	**1**	**0**	**3**	**4**	**25**	**75**	**100**

Learning Objectives	
LO1	To understand the role of essential trace elements in biological systems.
LO2	To understand the structure, function, and properties of oxygen carriers and other transport proteins.
LO3	To study the process of nitrogen fixation and photosynthesis.
LO4	To assess the toxicity and therapeutic applications of metals in medicine.
LO5	To apply the properties, kinetics, and factors affecting enzyme activity.

Unit	Content	Hours
1	**Essential Trace Elements:** Selective transport and storage of metal ions: Ferritin, Transferrin and sidorphores; Sodium and potassium transport, Calcium signaling proteins. Metalloenzymes: Zinc enzymes–carboxypeptidase and carbonic anhydrase. Iron enzymes–catalase, peroxidase. Copper enzymes – superoxide dismutase, Plastocyanin, Ceruloplasmin, Tyrosinase. Coenzymes - Vitamin-B_{12} coenzymes.	**12**
2	**Transport Proteins:** Oxygen carriers -Hemoglobin and myoglobin - Structure and oxygenation Bohr Effect. Binding of CO, NO, CN– to Myoglobin and Hemoglobin. Biological redox system: Cytochromes-Classification, Cytochrome P-450. Non-heme oxygen carriers-Hemerythrin and hemocyanin. Iron-sulphur proteins- Rubredoxin and Ferredoxin- Structure and classification.	**12**
3	**Nitrogen Fixation:** Introduction, types of nitrogen fixing microorganisms. Nitrogenase enzyme - Metal clusters in nitrogenase redox property - Dinitrogen complexes - transition metal complexes of dinitrogen - nitrogen fixation via nitride formation and reduction of dinitrogen to ammonia. Photosynthesis: photosystem-I and photosystemII-chlorophylls structure and function.	**12**
4	**Metals in Medicine:** Metal Toxicity of Hg, Cd, Zn, Pb, As, Sb. Therapeutic compounds: Vanadium-based diabetes drugs; Platinum-Containing anticancer agents. Chelation therapy: Cancer treatment. Diagnostic agents: Technetium imaging agents, Gadolinium MRI imaging agents. Temperature and critical magnetic field.	**12**
5	**Enzymes:** Introduction and properties -nomenclature and classification. Enzyme kinetics, free energy of activation and the effects of catalysis. Michelis - Menton equation - Effect of pH, temperature on enzyme reactions. Factors contributing to the efficiency of enzyme.	**12**

CO	Course Outcomes
CO1	To explain the role of essential trace elements in biological systems, including their transport, storage, and function in metalloenzymes.
CO2	To describe the structure, function, and properties of oxygen carriers and other transport proteins involved in redox reactions.
CO3	To understand the process of nitrogen fixation and photosynthesis, including the role of nitrogenase enzymes and photosystems.
CO4	To evaluate the toxicity and therapeutic applications of metals in medicine, such as chelation therapy and diagnostic agents.
CO5	To explain the properties, kinetics, and factors affecting enzyme activity, as well as the Michaelis-Menten equation.
Textbooks:	
1	I. Bertini, A. Sigel, and H. Sigel, "*Metal Ions in Biological Systems: Volume 42: Transport and Storage of Metal Ions: Ferritins, Transferrins, and Siderophores"*, 1st ed., Springer, 2004.
2	R. E. Dickerson and I. Geis, "*Emoglobin: Structure, Function, and Evolution*, 1st ed., Benjamin/Cummings Publishing Company, 1983.
3	B. K. Burgess and D. J. Lowe, "*Nitrogenase: A Molybdenum-Iron Enzyme"*, 1st ed., Wiley-VCH, 1996.
4	C. F. Meares, "*Metal Ions in Biological Systems: Volume 28: Chemistry and Biological Applications of Vanadium"*, 1st ed., Springer, 1990.
5	A. Fersht, "*Structure and Mechanism in Protein Science: A Guide to Enzyme Catalysis and Protein Engineering"*, 3rd ed., W. H. Freeman, 2003.
Reference Books:	
1	J. J. R. Fraústo da Silva and R. J. P. Williams, "*The Biological Chemistry of Elements: The Inorganic Chemistry of Life"*, 2nd ed., Oxford University Press, 2009.
2	L. Stryer, "*Biochemistry"*, 5th ed., W. H. Freeman, 2002.
3	R. H. Burris, "*Nitrogen Fixation: Principles and Practice"*, 1st ed., Chapman & Hall, 1990.
4	E. A. Liberles, "*Medicinal Inorganic Chemistry: A Bioinorganic Approach"*, 2nd ed., John Wiley & Sons, 2009.
5	D. E. Koshland Jr., "*Enzyme Catalysis"*, 1st ed., W. H. Freeman, 1970.
Web resources:	
1	https://www.google.com/url?sa=E&source=gmail&q=https://pubchem.ncbi.nlm.nih.gov/
2	https://www.google.com/url?sa=E&source=gmail&q=https://www.rcsb.org/
3	https://www.britannica.com/summary/nitrogen-fixation
4	https://www.google.com/url?sa=E&source=gmail&q=https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3584006/
5	https://www.google.com/url?sa=E&source=gmail&q=https://www.enzyme.com/

Mapping with Programme Outcomes and Programme Specific Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO 1	3	3	3	3	2	3	3	3	2	3	3
CO 2	2	3	3	3	3	2	3	3	3	2	3
CO 3	3	3	2	3	3	3	3	2	3	2	3
CO 4	2	3	3	3	3	2	3	3	2	3	3
CO 5	2	3	2	3	3	2	3	2	3	3	3
Total	12	15	13	15	14	12	15	13	13	13	15
Average	**2.4**	**3.0**	**2.6**	**3.0**	**2.8**	**2.4**	**3.0**	**2.6**	**2.6**	**2.6**	**3.0**

3 – Strong, 2 – Medium, 1 - Low

1ST YEAR: SECOND SEMESTER

Course Code	Course name	Category	L	T	P	S	Credits	Hours	Marks		
									CIA	External	Total
24PCHE21	Medicinal Chemistry	Elective 3	2	1	1	0	3	4	25	75	100

Learning objectives	
LO1	To study the chemistry behind the development of pharmaceutical materials.
LO2	To gain knowledge on mechanism and action of drugs.
LO3	To understand the need of antibiotics and usage of drugs.
LO4	To apply knowledge of CNS pharmacology to the treatment of various disorders.
LO5	To identify and apply the action of various antibiotics.

Unit	Content	Hours
1	**Introduction to receptors:** Introduction, targets, Agonist, antagonist, partial agonist. Receptors, Receptor types, Theories of Drug receptor interaction, Drug synergism, Drug resistance, physicochemical factors influencing drug action.	12
2	**Antibiotics:** Introduction, Targets of antibiotics action, classification of antibiotics, enzyme-based mechanism of action, SAR of penicillins and tetracyclins, clinical application of penicillins, cephalosporin. Current trends in antibiotic therapy.	12
3	**Antihypertensive agents and diuretics:** Classification of cardiovascular agents, introduction to hypertension, etiology, types, classification of antihypertensive agents, classification and mechanism of action of diuretics, Furosemide, Hydrochlorothiazide, Amiloride.	12
4	**Central Nervous System (CNS) Drugs:** Introduction to the CNS, CNS Disorders - Anxiety, depression, schizophrenia, Parkinson's disease, Alzheimer's disease, epilepsy. Classes of CNS Drugs - Antidepressants, Antipsychotics, Anxiolytics, Anticonvulsants, Analgesics, Stimulants. Mechanisms of action, Drug metabolism and Pharmacokinetics, Therapeutic applications, various adverse effects.	12
5	**Analgesics, Antipyretics and Anti-inflammatory Drugs:** Introduction, mechanism of inflammation, classification and mechanism of action - Paracetamol, Ibuprofen, Diclofenac, Naproxen, Indomethacin, Phenylbutazone and Meperidine. Medicinal chemistry of antidiabetic agents - Introduction, types of diabetics, drugs used for the treatment, chemical classification, mechanism of action, treatment of diabetic mellitus. Chemistry of insulin and sulfonyl urea.	12

CO	Course Outcomes
CO1	To predict a drugs properties based on its structure.
CO2	To describe the factors that affect its absorption, distribution, metabolism, and excretion, and hence the considerations to be made in drug design.
CO3	To explain the relationship between drug's chemical structure and its therapeutic properties.
CO4	To critically evaluate the mechanisms of action, therapeutic applications, and potential adverse effects of various CNS drugs.
CO5	To identify different targets for the development of new drugs for the treatment of infectious and GIT.
Textbooks:	
1	Jayashree Ghosh, "*A text book of Pharmaceutical Chemistry*", 1st ed., S. Chand and Co. Ltd, 1999.
2	Wilson, Charles Owens: Beale, John Marlowe; Block, John H, Lipincott William, "*Wilson's Comprehensive Textbook of Ophthalmology*", 12th ed., Lippincott Williams & Wilkins, 2011.
3	Graham L. Patrick, "*An Introduction to Medicinal Chemistry*", 5th ed., Oxford University Press, 2013.
4	O. LeRoy, "*Natural and synthetic organic medicinal compounds*", 1st ed., Ealemi, 1976.
5	S. Ashutosh Kar, "*Medicinal Chemistry*", 1st ed., Wiley Eastern Ltd, New Delhi, 1993.
Reference Books:	
1	Lipincott Williams, "*Foye's Principles of Medicinal Chemistry*", 7th ed., 2012.
2	Donald J. Abraham, David P. Rotella, Alfred Burger, *"Burger's Medicinal Chemistry, Drug Discovery and Development"*, 6th ed., Academic press, 2010.
3	John M. Beale Jr and John M. Block, "*Wilson and Gisvold's Textbook of Organic Medicinal and Pharmaceutical Chemistry*", 12th ed., Wolters Kluwer, 2011.
4	P. Parimoo, "*A Textbook of Medical Chemistry*", 1st ed., CBS Publishers, New Delhi, 1995.
5	S. Ramakrishnan, K. G. Prasannan and R. Rajan, "T*extbook of Medical Biochemistry*", 3rd ed., Orient Longman. Hyderabad, 1993.
Web resources:	
1	https://www.ncbi.nlm.nih.gov/books/NBK482447/
2	https://reference.medscape.com/drugs/antimicrobials
3	https://www.classcentral.com/course/swayam-medicinal-chemistry-
4	https://www.webmd.com/drugs/2/drug-15964-3/analgesic-oral/aspirin-oral/details
5	https://hopkinsdiabetesinfo.org/type-2-meds/

Mapping with Programme Outcomes and Programme Specific Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO 1	3	2	3	3	2	3	3	3	3	3	3
CO 2	3	3	3	3	3	2	2	3	3	3	3
CO 3	3	2	2	3	3	3	2	2	3	3	3
CO 4	3	2	3	3	2	2	3	3	3	3	3
CO 5	3	3	2	3	3	2	3	2	3	3	3
Total	15	12	13	15	13	12	13	13	13	12	13
Average	**3.0**	**2.4**	**2.6**	**3.0**	**2.6**	**2.4**	**2.6**	**2.6**	**2.6**	**2.4**	**2.6**

3 – Strong, 2 – Medium, 1 - Low

1ST YEAR: SECOND SEMESTER

Course Code	Course Name	Category	L	T	P	S	Credits	Hours	Marks		
									CIA	External	Total
24PCHE22	**Green Chemistry**	**Elective 4**	**2**	**1**	**1**	**0**	**3**	**4**	**25**	**75**	**100**

Learning objectives	
LO1	To discuss the principles of green chemistry.
LO2	To propose green solutions for chemical energy storage and conversion.
LO3	To understand soil properties and microbial roles in soil processes.
LO4	Propose solutions for pollution prevention in Industrial chemical and fuel production, Automotive industry and Shipping industries.
LO5	Propose green solutions for industrial production of Surfactants, Organic and Inorganic chemicals.

Unit	Content	Hours
1	**Introduction to Green Chemistry:** Introduction - Need, Goals and Limitations Green Chemistry - Chemical accidents, terminologies, International green chemistry organizations - Twelve principles of Green Chemistry with examples.	12
2	**Green Synthesis and Reagents:** Choice of starting materials - reagents, catalysts and solvents - Green chemistry in everyday life - Designing green synthesis - Green reagents - Green solvents - Criteria, general methods of preparation, effect on organic reaction - Supercritical carbon dioxide - Green synthesis.	12
3	**Soil Chemistry:** Soil - Classification, properties, soil texture, soil water, soil temperature, soil minerals, buffering of soil, soil fertility and soil formation - Types of soil enzymes - Dehydrogenases, phosphatases, ureases - Role of enzymes in soil processes - Nutrient cycling, organic matter decomposition.	12
4	**Phase Transfer Catalysis and Green Synthesis:** Phase transfer catalysis in green synthesis - Oxidation using hydrogen peroxide, crown ethers, esterification, saponification, anhydride formation, elimination reaction and displacement reaction.	12
5	**Green Synthesis Using Advanced Techniques:** Microwave induced green synthesis - Principle, Instrumentation and applications - Sonochemistry – Instrumentation - Cavitation theory - Combined microwave and sonochemical synthesis - Environmental and economic benefits of green synthesis.	12

CO	Course Outcomes
CO1	To recall the basic chemical techniques used in conventional industrial preparations and in green innovations.
CO2	To understand the various techniques used in chemical industries and in laboratory.
CO3	To gain knowledge of soil chemistry for agricultural and environmental management.
CO4	To apply the principles of PTC, microwave and ultrasonic assisted organic synthesis.
CO5	To design and synthesize new organic compounds by green methods.
Textbooks:	
1	V. K. Ahluwalia and M. R. Kidwai, "*New Trends in Green Chemistry*", 1st ed., Anamalaya Publishers, 2005.
2	W. L. McCabe, J. C. Smith and P. Harriott, "*Unit Operations of Chemical Engineering*", 7th ed., McGraw-Hill, New Delhi, 2005.
3	J. M. Swan and D. St. C. Black, "*Organometallics in Organic Synthesis*", 1st ed., Chapman Hall, 1974.
4	V. K. Ahluwalia and R. Aggarwal, "*Organic Synthesis: Special Techniques*", 1st ed., Narosa Publishing House, New Delhi, 2001.
5	A. K. De, "*Environmental Chemistry*", 1st ed., New Age Publications, 2017.
Reference Books:	
1	P. T. Anastas and J. K. Warner, "*Oxford Green Chemistry -Theory and Practical"*, 1st ed., University Press, 1998.
2	A. S. Matlack, "*Introduction to Green Chemistry*", 1st ed., Marcel Dekker, 2001.
3	M. C. Cann and M. E. Connely, "*Real-World Cases in Green Chemistry*", 1st ed., American Chemical Society, Washington, 2000.
4	M. A. Ryan and M . Tinnesand, "*Introduction to Green Chemistry*", 1st ed., American Chemical Society Washington, 2002.
5	Chandrakanta Bandyopadhyay, "*An Insight into Green Chemistry*", 1st ed., Books and Allied (P) Ltd, 2019.
Web resources:	
1	https://www.acs.org/greenchemistry.html
2	https://www.rsc.org/journals-books-databases/about-journals/green-chemistry/
3	https://www.acs.org/greenchemistry.html
4	https://www.nsf.gov/div/index.jsp?div=CHE
5	https://chemistry.berkeley.edu/topics/green-chemistry

Mapping with Programme Outcomes and Programme Specific Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO 1	3	3	3	2	2	3	3	3	3	3	3
CO 2	2	3	3	3	2	2	2	3	3	3	3
CO 3	3	2	2	3	3	3	3	3	3	3	2
CO 4	2	3	2	3	2	2	2	3	3	3	3
CO 5	2	2	2	3	3	2	3	3	3	3	3
Total	12	13	12	14	12	12	13	15	15	15	14
Average	**2.4**	**2.6**	**2.4**	**3.0**	**2.4**	**2.4**	**2.6**	**3.0**	**3.0**	**3.0**	**2.8**

3 – Strong, 2 – Medium, 1 - Low

1ST YEAR: SECOND SEMESTER

Course Code	Course Name	Category	L	T	P	S	Credits	Hours	Marks		
									CIA	External	Total
24PCHE23	**Industrial Chemistry**	**Elective 5**	**2**	**1**	**1**	**0**	**3**	**4**	**25**	**75**	**100**

Learning Objectives	
LO1	To recall basic statistical concepts, control chart types, and quality assurance principles.
LO2	To explain the concept of relative volatility in distillation.
LO3	To calculate the material balance for a filtration process.
LO4	To break down the steps involved in extracting a metal from its ore.
LO5	To judge the effectiveness of different personal protective equipment.

Unit	Content	Hours
1	**Statistical Quality Control Techniques**: Statistical treatment of data - Control charts. Quality Assurance: Elements of quality Assurance, Quality Management System: ISO 9001:2000 QMS and ISO 14000 Series of Standards. Six Sigma Approach to Quality: Applying Six Sigma to chemical Industries. Good Laboratory Practices: Principles of GLP, GMP in Chemical and Pharmaceutical Industries.	**12**
2	**Distillation Unit Process**: Types of distillation processes, concept of batch and continuous distillation, simple steam distillation - advantages, disadvantages and application. Evaporation and Drying - factors affecting the rate of evaporation and choice of evaporators, application of evaporation, equipment- climbing film evaporator, drying process, free moisture, bound moisture and equilibrium moisture content, purpose of drying, equipment- rotary dryer.	**12**
3	**Purification and Filtration**: Filter media and filter aids, characteristics of ideal filter aids, factors affecting the rate of filtration and choice of filter media, equipment - bag filters and candle filters. Material Balance - steady and unsteady state of flow processes, material balance equation, flow/block diagrams for various industrially important chemical engineering operations - distillation and crystallization.	**12**

4	**Metallurgical Operations:** Crushing and pulverization, concentration methods, gravity separation, magnetic concentration, froth flotation process, chemical methods - calcination and roasting, reduction using carbon and carbon monoxide, Alumino thermite reduction, auto reduction, refining methods - polling, parting and electrolyte refining. Metallurgical Extraction - Lead from galena, Aluminum from bauxite and Zinc from Zinc blende.	**12**
5	**Industrial Hygiene & Safety**: Personal protective equipments. Industrial hazards and Safety: Process hazards checklists, hazard surveys, safety program, Hazop safety reviews. Industrial pollution: Classification of hazardous chemicals, storage, transportation, handling, risk assessments, challenges/solutions. Eco-friendly effluents disposal: advanced waste water treatment, effluent quality standards and laws. Sensors: Concept of molecular sensors its properties and applications.	**12**

CO	Course Outcomes
CO1	Able to use statistical tools to analyze process data and identify quality issues.
CO2	To design and optimize distillation processes for various applications.
CO3	To select appropriate purification and filtration techniques for different materials.
CO4	To evaluate the feasibility of extracting metals from different ores.
CO5	To implement effective industrial hygiene and safety practices.
Textbooks:	
1	Douglas C. Montgomery, "*Statistical Quality Control: A Modern Introduction*, 9th ed., John Wiley & Sons, 2018.
2	J. D. Perry, "*Distillation: Principles and Applications"*, 5th ed., McGraw-Hill Education, 2015.
3	Warren L. McCabe, Julian C. Smith, and Peter Harriott, "*Unit Operations of Chemical Engineering"*, 8th ed., McGraw-Hill Education, 2016.
4	J. C. Agarwal, "*The Extractive Metallurgy of Copper"*, 3rd ed., Elsevier, 2013.
5	Kenneth R. Holness and David H. Slone, "*Industrial Hygiene: Principles and Practices"*, 3rd ed., John Wiley & Sons, 2015.
Reference Books:	
1	George E. P. Box, William G. Hunter, and J. Stuart Hunter, "*Statistical Methods for Engineers and Scientists"*, 3rd ed., John Wiley & Sons, 2005.
2	J. M. Coulson and J.F. Richardson, "*Separation Processes in Chemical Engineering"*, 3rd ed., Pergamon Press, 1991.
3	Robert H. Perry, Don W. Green, and James O. Maloney, "*Perry's Chemical Engineers' Handbook"*, 9th ed., McGraw-Hill Education, 2019.
4	A. K. Biswas and W.G. Davenport, "*Extractive Metallurgy: Principles and Practice"*, 4th ed., Elsevier, 2013.
5	Clayton W. Hoyle, Jr., and Kenneth R. Holness, "*Industrial Hygiene: A Comprehensive Textbook"*, 4th ed., John Wiley & Sons, 2013.
Web resources:	
1	https://www.projectmanager.com/blog/quality-assurance-and-testing
2	https://www.britannica.com/summary/distillation
3	https://www.britannica.com/dictionary/filtration
4	https://en.wikipedia.org/wiki/Metallurgy
5	https://www.osha.gov/

Mapping with Programme Outcomes and Programme Specific Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO 1	3	2	3	3	2	3	2	3	3	3	2
CO 2	3	3	3	2	3	2	2	3	3	3	3
CO 3	3	2	2	3	3	3	3	3	3	3	3
CO 4	3	3	3	3	3	2	2	3	2	3	3
CO 5	3	3	2	3	3	2	2	3	3	3	3
Total	15	13	13	14	14	12	11	15	14	15	14
Average	**3.0**	**2.6**	**2.6**	**2.8**	**2.8**	**2.4**	**2.2**	**3.0**	**3.0**	**3.0**	**3.0**

3 – Strong, 2 – Medium, 1 - Low

1ST YEAR: SECOND SEMESTER

Course Code	Course Name	Category	L	T	P	S	Credits	Hours	Marks		
									CIA	External	Total
24PCHE24	**Materials Science**	**Elective 6**	**2**	**1**	**1**	**0**	**3**	**4**	**25**	**75**	**100**

Learning Objectives	
LO1	To understand the crystal structure, growth methods and X-ray scattering.
LO2	To explain the optical, dielectric and diffusion properties of crystals.
LO3	To recognize the basis of semiconductors, superconductivity materials and magnets.
LO4	To study the synthesis, classification and applications of nanomaterials.
LO5	To learn about the importance of materials used for renewable energy conversion.

Unit	**Content**	**Hours**
1	**Crystallography:** Symmetry - unit cell and Miller indices - crystal systems - Bravais lattices - point groups and space groups - Xray diffraction-Laue equations-Bragg's law-reciprocal lattice and its application to geometrical crystallography. Crystal structure–powder and single crystal applications. Electron charge density maps, neutron diffraction-method and applications.	**12**
2	**Crystal Growth Methods:** Nucleation–equilibrium stability and metastable state. Single crystal –Low and high temperature, solution growth– Gel and sol-gel. Crystal growth methods- nucleation–equilibrium stability and metastable state. Melt growth - Bridgeman-Stockbarger, Czochralski methods. Flux technique, physical and chemical vapour transport. Lorentz and polarization factor - primary and secondary extinctions.	**12**
3	**Properties of Crystals:** Optical studies - Electromagnetic spectrum (qualitative) refractive index – reflectance – transparency, translucency and opacity. Types of luminescence – photo-, electro-, and injection luminescence, LEDs – organic, Inorganic and polymer LED materials - Applications. Dielectric studies- Polarisation - electronic, ionic, orientation, and space charge polarisation. Effect of temperature, dielectric constant, dielectric loss. Types of dielectric breakdown–intrinsic, thermal, discharge, electrochemical and defect breakdown.	**12**

4	**Special Materials:** Superconductivity: Meissner effect, Critical temperature and critical magnetic Field, Type I and II superconductors, BCS theory-Cooper pair, Applications. Soft and hard magnets – Domain theory Hysteresis Loop-Applications. Magneto and giant magnetoresistance. Ferro, ferri and antiferromagnetic materials applications, magnetic parameters for recording applications. Ferro-, Piezo-, and pyro electric materials – properties and applications. Shape memory Alloys-characteristics and applications, Non-linear optics Second Harmonic Generators.	**12**
5	**Materials for Renewable Energy Conversion:** Solar Cells: Organic, bilayer, bulk heterojunction, polymer, perovskite based. Solar energy conversion: lamellar solids and thin films, dye-sensitized photo voltaic cells, coordination compounds anchored onto semiconductor surfaces - Ru(II) and Os(II) polypyridyl complexes. Photochemical activation and splitting of water, CO_2 and N_2. Manganese based photo systems for water-splitting. Complexes of Rh, Ru, Pd and Pt - photochemical generation of hydrogen from alcohol.	**12**

CO	Course Outcomes
CO1	To understand and recall the synthesis and characteristics of crystal structures, semiconductors, magnets, nanomaterials and renewable energy materials.
CO2	To integrate and assess the structure of different materials and their properties.
CO3	To analyse and identify new materials for energy applications.
CO4	To explain the importance of crystal structures, piezoelectric and pyroelectric materials, nanomaterials, hard and soft magnets, superconductors, solar cells, electrodes, LED uses, structures and synthesis.
CO5	To design and develop new materials with improved property for energy applications.
Textbooks:	
1	S. Mohan and V. Arjunan, "*Principles of Materials Science"*, 2nd ed., MJP Publishers, 2016.
2	Arumugam, "*Materials Science*", 2nd ed., Anuradha Publications, 2007.
3	Giacavazzo et. al., "*Fundamentals of Crystallography*", 2nd ed., International Union of Crystallography, Oxford Science Publications, 2010.
4	Woolfson, "*An Introduction to Crystallography*", 3rd ed., Cambridge University Press, 2012.
5	James F. Shackelford and Madanapalli K. Muralidhara, "I*ntroduction to Materials Science for Engineers*", 6th ed., Pearson Press, 2007.
Reference Books:	
1	M. G. Arora, "*Solid State Chemistry*", 2nd., Anmol Publications, New Delhi, 2001.
2	Q. K. Puri and V. K. Babbar, "*Solid State Physics*", 5th ed., S Chand and Company Ltd, 2001.
3	C. Kittel, "*Solid State Physics*", 5th ed., John-Wiley and Sons, NY, 1966.
4	E. P. Meyers, "*Introductory Solid State Physics*", 1st ed., Viva Books Private Ltd., 1998.
5	A. R. West, "*Solid State Chemistry and Applications*", 2nd ed., John-Wiley and Sons, 1987.
Web resources:	
1	https://en.wikipedia.org/wiki/Crystal_structure
2	https://en.wikipedia.org/wiki/Czochralski_method
3	https://en.wikipedia.org/wiki/Dielectric
4	https://en.wikipedia.org/wiki/Superconductivity
5	https://en.wikipedia.org/wiki/Solar_cell

Mapping with Programme Outcomes and Programme Specific Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO 1	3	3	3	2	2	3	3	2	2	3	2
CO 2	2	2	3	3	3	3	3	3	3	3	3
CO 3	3	3	2	2	3	3	3	2	3	3	3
CO 4	3	3	3	2	3	3	2	3	3	3	2
CO 5	2	2	2	3	3	3	3	3	3	3	3
Total	13	13	13	12	14	15	14	13	14	15	13
Average	**2.6**	**2.6**	**2.6**	**2.4**	**2.8**	**3.0**	**2.8**	**2.6**	**2.4**	**3.0**	**2.6**

3 – Strong, 2 – Medium, 1 - Low

1ST YEAR: SECOND SEMESTER

Course Code	Course Name	Category	L	T	P	S	Credits	Hours	Marks		
									CIA	External	Total
24PCHS21	**Cosmetic Chemistry**	**SEC-1 (NME)**	**1**	**0**	**1**	**0**	**2**	**2**	**25**	**75**	**100**

Learning Objectives	
LO1	To understand formulations of various types of cosmetics.
LO2	To understand the makeup preparations and personal grooming.
LO3	To knowledge about regulatory bodies and rules governing personal care products.
LO4	To understand the importance and health benefits of essential oils in cosmetic industries.
LO5	To understand beauty treatments.

Unit	Content	Hours
1	**Skin Care:** Nutrition of the skin, skincare and cleansing of the skin; face powder – ingredients; creams and lotions – cleansing, moisturizing all purpose, shaving and sunscreen (formulation only); Gels – formulation and advantages. Lab Practice: Prepare a hand sanitizer.	**6**
2	**Hair Care and Dental Care:** Shampoos – types – powder, cream, liquid, gel – ingredients; conditioner – types – ingredients. Toothpastes – ingredients – mouthwash. Lab Practice: Formulate a basic Shampoos, prepare a basic toothpaste and mouthwash.	**6**
3	**Make Up:** Base – foundation – types – ingredients; lipstick, eyeliner, mascara, eye shadow, concealers, rouge. Lab Practice: Synthesize a basic lip balm.	**6**
4	**Perfumes:** Classification of perfumes - Natural – plant origin – parts of the plant used, chief constituents; synthetic – classification emphasizing characteristics – esters – alcohols – aldehydes – ketones. Lab Practice: Prepare a customized perfume of body spray.	**6**
5	**Beauty Treatments:** Facials - types – advantages – disadvantages; facemasks – types; bleach - types – advantages – disadvantages; shaping the eyebrows; hair coloring and dyeing; pedicure, manicure - advantages – disadvantages. Lab Practice: Prepare a clay-based face mask.	**6**

CO	Course Outcomes
CO1	Know about the composition of various cosmetic products.
CO2	Understand chemical aspects and applications of hair care and dental care and skincare products.
CO3	Understand chemical aspects and applications of perfumes and skincare products.
CO4	To understand the methods of beauty treatments their advantages and disadvantage.
CO5	Understand the hazards of cosmetic products.
Textbooks:	
1	Thankamma Jacob, "*Foods, Drugs and Cosmetics – A consumer guide*", Macmillan Publication, London, 1997.
2	Zoe Diana Draelos (Editor) and Lauren Thaman (Editor), "C*osmetic Formulation of Skin Care Products*", CRC Press, 2nd ed., 2006.
3	Meyer R and Rosen (Editor), "*Harry's Cosmeticology*", Chemical Publishing Company, 9th ed., 2019.
4	André O, Barel (Editor), Marc Paye (Editor), Howard I and Maibach (Editor), "*Handbook of Cosmetic Science and Technology*", CRC Press, 3rd ed., 2014.
5	Maison G and deNavarre, "*The Chemistry and Manufacture of Cosmetics*", Van Nostrand Reinhold, 2nd ed., 2009.
Reference Books:	
1	Wilkinson J. B. E. and Moore R. J, "*Harry's Cosmeticology*", 7th ed., Chemical Publishers, London, 1997.
2	George Howard, "*Principles and Practice of Perfumes and Cosmetics*", 1987.
3	Milady, "*Milady Standard Cosmetology*", Cengage Learning Publishers, 13th ed., 2016.
4	Hiroshi Iwata, "*Formulas, Ingredients and Production of Cosmetics: Technology of Skin- and Hair-Care Products in Japan*", Springer, 1st ed., 2016.
5	Zoe Diana Draelos, "*Cosmetic Dermatology: Products and Procedures*", Wiley-Blackwell Co., 2nd ed., 2016.
Web resources:	
1	https://www.paulaschoice.com/ingredient-dictionary
2	https://www.thespruce.com/about-us-4776800
3	https://www.makeupalley.com/categories/foundation-makeup
4	https://perfumesociety.org/
5	https://www.aad.org/public/everyday-care

Mapping with Programme Outcomes and Programme Specific Outcomes

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3
CO 1	3	3	3	3	3	3	3	2	2	3	3
CO 2	2	3	3	3	2	3	3	2	2	3	3
CO 3	3	3	3	2	3	3	3	2	3	2	3
CO 4	3	3	3	3	3	3	3	2	3	3	3
CO 5	3	2	3	3	3	3	3	2	3	2	3
Total	14	14	15	14	14	15	15	10	13	13	15
Average	**2.8**	**2.8**	**3.0**	**2.8**	**2.8**	**3.0**	**3.0**	**2.0**	**2.6**	**2.6**	**3.0**

3 – Strong, 2 – Medium, 1 - Low

Continuous Internal Assessment (CIA) Test

The following procedure will be followed for the award of internal marks:

CIA Exam I: Three hours duration for 75 marks (First 2 ½ Units)
CIA Exam II cum Model Exam: Three hours duration for 75 marks (Full Syllabus)

Internal Mark Distribution	Theory & Practical
CIA – I (75 Marks)	5
CIA – II (75 Marks)	5
Library Usage in Hours	5
Attendance	5
Assignment / Seminar / Observation	5
Internal Marks	**25**

Format to Entering in all Continue Internal Assessment (CIA) Tests and Internal Marks

Reg. No.	Name	CIA - 1	CIA - 2	Marks Conversion	Library Usages	Attendance	Assignment / Seminar / Observation	Total Marks	Remarks

Recommendations for Entering Library Usage:

Library usage for UG in hours	Marks to be awarded
Minimum 10 Hours	5

Attendance:

Attendance Earned	Category	Marks to be Awarded
91% and above	Highly Regular	5
75% but below 90%	Regular	4
65% but below 74%	Shortage	3
55% but below 64%	Detained	2
Below 54%	Redo	0

THEORY QUESTION PAPER PATTERN END SEMESTER EXAMINATIONS FOR UG & PG DEGREE PROGRAMMES - 3 HOURS DURATION

Part A	To answer All the 10 Short Questions (Two Questions from each UNIT)	10 X 2 = 20 Marks
Part B	To answer All the 5 questions (either or, type) (One Question from each UNIT)	5 X 5 = 25 Marks
Part C	To answer 3 questions (out of 5 questions) (One question from each UNIT)	3 X 10 = 30 Marks
TOTAL		**75 Marks**
(Equal Weightage should be given to each unit)		