Department of Chemistry

National Institute of Technology Agartala

Curricula and Syllabi
for

MSc Course in Chemistry

July-2021

First Semester

S.N.	Course Name	Code	Marks	Teaching hrs/week			Credit
				L	T	P	
1	Inorganic Chemistry-I	PCY01B01	100	3	1	0	4
2	Organic Chemistry-I	PCY01B02	100	3	1	0	4
3	Physical Chemistry-I	PCY01B03	100	3	1	0	4
4	Analytical and Environmental Chemistry	PCY01B05	100	3	1	0	4
5	Organic Chemistry Laboratory	PCY01P02	100	0	0	6	4
Total			**500**	**12**	**4**	**6**	**20**
Total contact hrs per week = 22				**Total credit = 20**			

Second Semester

S.N.	Course Name	Code	Marks	Teaching hrs/week			Credit
				L	T	P	
1	Inorganic Chemistry-II	PCY02B05	100	3	1	0	4
2	Organic Chemistry-II	PCY02B06	100	3	1	0	4
3	Physical Chemistry-II	PCY02B07	100	3	1	0	4
4	Biochemistry	PCY02B08	100	3	1	0	4
5	Physical Chemistry Laboratory	PCY02P03	100	0	0	6	4
Total			**500**	**12**	**4**	**6**	**20**
Total contact hrs per week = 22				**Total credit = 20**			

Third Semester

S.N.	Course Name	Code	Marks	Teaching hrs/week			Credit
				L	T	P	
1	Inorganic Chemistry-III	PCY03B09	100	3	1	0	4
2	Organic Chemistry-III	PCY03B10	100	3	1	0	4
3	Physical Chemistry-III	PCY03B11	100	3	1	0	4
4	Instrumental Method of Analysis of Chemical Compounds	PCY03B12	100	3	1	0	4
5	Inorganic Chemistry Laboratory	PCY03P04	100	0	0	6	4
Total			**500**	**12**	**4**	**6**	**20**
Total contact hrs per week = 22				**Total credit = 20**			

Fourth Semester

Students may opt for Option-I or Option-II from below

Option-I

S.N.	*Course Name*	*Marks*	*Teaching hrs/week*			*Credit*
			L	*T*	*P*	
1	Elective-I	100	3	1	0	4
2	Dissertation	200	0	0	15	8
3	Project Seminar	100	0	0	0	5
4	Comprehensive Viva	100	0	0	0	3
Total		**500**	**3**	**1**	**15**	**20**
Total contact hrs per week = 19			**Total credit = 20**			

*Elective courses

(To choose ANY ONE course)

S.N.	*Course Name*	*Code*
1	Inorganic Photochemistry and Supramolecular Chemistry	PCY04E08
2	Organic Named Reactions, Synthesis, Structure and Reactivity	PCY04E10
3	Molecular Spectroscopy–Theory and Instrumentation	PCY04E12
4	Chemistry of Nanomaterials	PCY04E13

Option-II

S.N.	*Course Name*	*Marks*	*Teaching hrs/week*			*Credit*
			L	*T*	*P*	
1	Industrial Project	300	0	0	40	12
2	Project Seminar	100	0	0	0	5
3	Comprehensive Viva	100	0	0	0	3
Total		**500**			**40**	**20**
Total credit = 20						

Summary of Marks and Credit: Sem-I to Sem-IV

S.N.	*Name of Semester*	*Marks*	*Credit*
1	First Semester	500	20
2	Second Semester	500	20
3	Third Semester	500	20
4	Fourth Semester	500	20
Total		**2000**	**80**

First Semester

Course: *Inorganic Chemistry-I* **Code: PCY01B01**
L-T-P: 3-1-0 **Credit: 4**

Program Outcomes (POs):
Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO-5	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-6	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEOs (Program Educational Objectives):

PEO-1	Obtain the important knowledge on Coordination Chemistry with modern experimental along with theoretical skills.
PEO-2	Ability to analyse the problems in the context of practical relevance to the industrial applications.
PEO-3	Improving their professional progress along with scientific knowledge through continuing which will be helpful for higher studies.

PSOs (Program Specific Objectives):
Students will be able to

PSO-1	Understand the fundamental principles and theories that interpret the physico-chemical properties of coordination compounds.
PSO-2	Impart complete knowledge of mechanisms of reactions taking place in transition metal complexes.
PSO-3	To pursue higher education along with R&D accomplishments.

Course Objective

(i) Elucidate the bonding in coordination compounds in term of Crystal Field Theory and Molecular Orbital Theory
(ii) To provide the knowledge about the magnetic properties of transition metal complexes and their significance
(iii) To provide the concepts in mechanism of substitution reactions and redox reactions of inorganic complexes and concise description about acidic and basic hydrolysis with geometry of intermediate formed during reaction of octahedral complexes.
(iv) To study inorganic reaction mechanisms presented in the literature to solve chemical problems.

Course Content

1) Coordination Compounds: structure, bonding, spectral and magnetic properties (24 L):

Structure and Bonding: Application crystal field theory in thermodynamic properties, variation of ionic radii, lattice energy and hydration energy of coordination compound. spectral properties, spectrochemical series, nephelauxtic series. Stereochemistry of complexes, Structural distortion and lowering of symmetry, electronic, steric and Jahn-Teller effects on energy levels, absolute configuration of complexes. experimental evidence for metal-ligand orbital overlap; ligand field theory, molecular orbital theory as applied to metal complexes, brief introduction to Angular Overlap Model.

Electronic Spectra: Spectroscopic ground states, correlation diagrams, Orgel diagram for transition metal complexes (d^1-d^9) states, Tanabe-Sugano diagram for transition metal complexes (d^1-d^9) states. electronic spectra of octahedral and tetrahedral complexes and calculation of ligand-field parameters. Charge transfer spectra, spectroscopic methods of assignment of absolute configuration in optically active metal chelates, stereochemical information of optically active metal chelates.

Magnetic Property: Diamagnetism, paramagnetism, ferromagnetism and antiferromagnetism, Pascasl's corrections, Anomalous magnetic moments, orbital contribution, magnetic exchange coupling, spin crossover and spinel.

2) Reaction mechanism of transition metal complexes (21 L):

Substitution Reactions: Energy profile of a reaction, reactivity of metal complex, inert and labile complexes, Nature of substitution reactions; prediction of reactivity of octahedral, tetrahedral and square-planar complexes in terms of crystal field activation energy and structure preference energy; rates of reactions; Acid hydrolysis and factors affecting acid hydrolysis, base hydrolysis, Conjugate base mechanism, Direct and Indirect evidences in favour of conjugation mechanism.

Electron Transfer Reactions: Mechanism and rate laws; various types of electron transfer reaction (Inner sphere, outer sphere, and one electron transfer) mechanism. Cross reaction and Marcus-Husch theory, correlation between thermal and optical electron transfer reactions; identification of intervalence transfer bands in solution and Anation reaction.

Rearrangement Reactions: Racemisation,Twist mechanism, Ray-Dutt and Bailer mechanism.

Course Outcome

CO-1	Better understanding the theory of bonding behind coordination compounds.
CO-2	Student will learn application of inorganic reaction mechanisms in the areas of industrial synthesis, preparation and biological catalytic processes.
CO-3	Students will familiar with the comprehensive subject areas of coordination Chemistry and it will help them with their project/ research purpose
CO-4	Students will be capable to explore innovation in research in both chemistry and allied fields of science and technology.

Reference Books: -

1. F. Basalo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Edn (1967), Wiley Eastern Ltd., New Delhi
2. D. F. Shriver and P. W. Atkins, Inorganic Chemistry, 3rd Edn. (1999), ELBS, London.
3. F. A. Cotton and G. Wilkinson, Advanced Inorganic Chemistry, 6th Edn. (1999), John Wiley & Sons, New York.
4. Martin L. Tobe and John Burgess, Inorganic Reaction Mechanisms, Ist Edn. (1999) Longmans.
5. J.E. Huheey, E.A. Keiter and R.L. Keiter, Inorganic Chemistry, 4th Edn. (1993), Addison-Wesley Pub. Co., New York.
6. F.A. Cotton and G. Wilkinson Advanced Inorganic Chemistry, 6th Edn. (1999), John Wiley & Sons, New York.
7. R. S. Drago, Physical Methods in Inorganic Chemistry, International Edn. (1971), Affiliated East-West Press, New Delhi
8. A.K.Das and M.Das Fundamental Concepts of Inorganic Chemistry: Volume 5, 1st Edn (2014), CBS Publishers and distributors.
9. G. L.Geoffrey and M. S. Wrighton, Organometallic Photochemistry, (1979), Academic Press.
10. K. K. Rohatagi-Mukherjee, Fundamentals of Photochemistry, (1978) Wiley Eastern.
11. M. S. Wrighton, Inorganic and Organometallic Photochemistry, ACS Pub.,1978.
12. V. Balzani and V. Carasiti, Photochemistry of Co-ordination compounds, Academic Press, 1970.

Mapping with the POs/ PEOs: Matrix formation for attainments

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	**3**	**2**	**1**	**2**	**2**	**2**	**3**	**-**	**3**
CO-2	**3**	**2**	**2**	**2**	**2**	**-**	**3**	**-**	**3**
CO-3	**3**	**-**	**2**	**2**	**2**	**2**	**2**	**2**	**-**
CO-4	**3**	**3**	**2**	**2**	**3**	**-**	**2**	**-**	**3**

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2	PSO-3
CO-1	**4**	**2**	**3**
CO-2	**4**	**-**	**2**
CO-3	**3-**	**4**	**3**
CO-4	**3**	**-**	**2**

Course: *Organic Chemistry-I* **Code: PCY01B02**
L-T-P: 3-1-0 **Credit: 4**

Program Outcomes (POs):
Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO-5	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-6	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEOs (Program Educational Objectives):

PEO-1	To focus on the reactive intermediates for designing the organic reactions applicable to the fields of medicinal, drug delivery and nanotechnology.
PEO-2	Understanding the spatial distribution of the molecules helpful for structural-properties relationships of organic materials in the context of practical relevance of life.
PEO-3	To analyze the professional needs in applied chemical industry technology through the knowledge of day-to-day organic polymers.

PSOs (Program Specific Objectives):

PSO-1	To apply the knowledge of reagents and reactions for the development of new drug candidates, drug delivery concepts and nano-molecular devices.
PSO-2	To apply successfully the modern polymers in the high-tech organic materials as a part of this course.

Course Objective

1. To introduce the knowledge of reagents and reactive intermediates require to carry out wide range of organic reactions.
2. To introduce the fundamentals of stereochemistry to understand the spatial distribution of organic molecules during the conversion of some reactant to a product via reactive intermediates.
3. The students will learn about different types of polymers used in day to day life and understand their functions as well as see how they are related to things they come across in everyday life.

Course Content

(1) Reagents and methods (10 L)

Classification of organic reaction-Oxidation reactions: Different oxidation processes. Reduction: Different reduction processes. Nucleophilic, electrophilic, dissolving metal reductions, catalytic reduction- homo- and heterogeneous catalysts. Fucntionalization of alkenes-hydroboration, epoxidation and aziridanation.

(2) Stereochemistry (20 L)

Molecular symmetry and chirality; stereoisomerism, Atropisomerism, classifications, configurational nomenclature, configuration and conformation. Projection formula: Fischer sawhorse, Newman and Flying wedge, threo and erythro. Relative and absolute configuration; determination of relative configuration: (i) chemical correlation not affecting the chiral atom, (ii) chemical correlation affecting bonds to the chiral atom in a 'known way' (iii) correlation by asymmetric synthesis: Horeaus rule, Prelog's rule, Cram's rule (Felkin modification), and sharpless rule, (iv) Physical methods: NMR, Mass, IR, dipole moment, ORD, CD, Effect of conformation on reactivity in acyclic compounds and cyclohexane derivatives, stereochemistry of polycyclic compounds, allylic straqin (A^{1-2}, A^{1-3}). Enantio- and diastereo-selective synthesis.

(3) Natural products chemistry (15 L)

Classification, occurrence, isolation and biosynthesis of terpenes, alkoliods, steroids and flavonoids. Structure elucidation of the following: Santonin, abetic acids, morphine, papavarine, cholesterol, bile acid, apigenin, quercetin.

Course Outcome

CO-1	Students will acquire the knowledge of methods of intermediates generation in organic chemistry and their importance for the generalization of numerous reactions.
CO-2	Students will be able to understand the role of stereochemistry during designing the organic reactions.
CO-3	Students will be able to understand the importance of plastics and polymers applicable in our everyday life.

Reference Books:

1. Smith, Michael B., March, Jerry. March's Advanced Organic Chemistry: Reactions, Mechanisms, and Structure, Sixth Edition. ISBN 13: 978-0-471-72091-1. ISBN 10: 0-471-72091-7.
2. Organic Chemistry. Sixth edition (Morrison, Robert Thornton; Boyd, Robert Neilson). Mel Mosher. J. Chem. Educ., 1992, 69 (11), p A305.
3. E.J. Eliel, Stereochemistry of carbon compounds, McGraw Hill.
4. I. L Finar, Organic chemistry vol.2: Stereochemistry and the Chemistry of Natural Products, 5^{TH} Edition, Pearson, 2011.

Mapping with the POs/ PEOs: Matrix formation for attainments

S- Strong, M-Moderate and W-Weak

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	**M**	**M**	**S**	**S**	**S**	**S**	**S**		
CO-2	**M**	**M**	**S**	**S**	**S**	**S**		**M**	
CO-3	**M**	**M**	**S**	**S**	**S**	**S**	**S**		

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2
CO-1	**4**	**2**
CO-2	**4**	**-**
CO-3	**3**	**4**

Course: *Physical Chemistry-I* **Code: PCY01B03**
L-T-P: 3-1-0 **Credit: 4**

Program Outcomes (POs):
Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO-5	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-6	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEOs (Program Educational Objectives):

PEO-1	Acquire the fundamental principles of chemistry with modern experimental and theoretical skills.
PEO-2	Ability to analyse the problems in the context of practical relevance to the society while maintaining environmental safety and economic factors.
PEO-3	Enhancing their professional growth along with scientific knowledge through continuing education.

PSOs (Program Specific Objectives):
Students will be able to

PSO-1	Acquire knowledge for determination of solution conductnace, reaction rate and colloidal properties, adsorption, etc.
PSO-2	Successfully apply the principles which have been learned as a part of this course in problems in chemistry and allied discipline.
PSO-3	Evaluate the energy scenario along with environment related issues in our society.

Course Objective

1. To introduce the concept of electrochemistry and thermodynamics of electrolytes in solution.
2. To set off the fundamentals of electrolytic double layer and associated phenomena.
3. Studying this subject the students will learn about the basic aspects of both experimental and theoretical reaction dynamics, chemical reactions, and applications
4. Have accurate idea of adsorption, classifications; interfacial phenomenon and its significance and also able to understand the mechanism of different adsorption isotherms;
5. Describe the preparation, properties and purification of colloids; classify emulsions and describe their preparation and properties.

6. Students could develop their skills to correlate theoretical and experimental aspects covered in this subject.

Course Content

(1) Electrochemistry and Thermodynamics of Electrolytic Solution (15 L):

Nernst equation; redox-system; electrochemical cells; ion-ion interaction, Kohlrausch's law of independent migration of ions; ionic mobilities; hydration of ions; ionic atmosphere; ionic strength; ionic equilibria; Debye-Huckel theory of dilute ionic solution; limiting law and Debye-Huckel-Onsagar equation; conductometric and potentiometric titrations; free energy and activity; electrode-electrolyte interfaces; electrical double layer at interface-Helmholtz, Gouy-Chapman and Stern models; Butler-Volmer equation-derivation and applications, Tafel plot.

(2) Reaction Dynamics (10 L):

Molecular basis of chemical reaction, potential energy surfaces and reaction dynamics; kinetics of different complex reactions; theories of reaction rates-Arrhenius, collision and TS theory; general features of reactions of different orders and molecularity, unimolecular, diffusion controlled, photochemical reactions and enzyme kinetics; dynamics of electron transfer and proton transfer processes; influence of solvents, dielectric constant and ionic strength on reaction rates, primary and secondary salt effects, kinetic isotope effect.

(3) Colloids and Surface Chemistry (20 L):

Colloids: classification (lyophilic and lyophobic), characteristics, preparation, purification, and kinetics: Brownian motion and translation diffusion, osmotic pressure; rotary Brownian motion; light scattering and Tyndall effect; liquid-gas and liquid-liquid interfaces; surface and interfacial tensions; adsorption and orientation at interfaces; Langmuir adsorption isotherm; BET equation for multimolecular adsorption; association colloids-micelle formation, spreading; surface films and Langmuir-Blodgett films; solid gas interface; capillary condensation; contact angles and wetting; adsorption from solution charged interfaces: electrical double layer and electro-kinetic phenomena; colloid stability; lyophobic sols; van der Waals forces between colloidal particles; rheology: introduction, viscosity, non-Newtonian flow; viscoelasticity; emulsions and foams: oil-in-water and water-in-oil emulsion.

Course Outcome

CO-1	Students will have a clear idea of electrolyte solutions and solution conductivity. Learn about the thermodynamics of electrochemistry, the structure of the electrode/electrolyte interface and electrode processes.
CO-2	The students will be able to- • identify thermodynamics property of any system to apply it for various systems • acquire the knowledge of phase equilibria for various systems • get knowledge about various electrochemical phenomena
CO-3	Students will have the basic concepts on both experimental and theoretical reaction dynamics; potential energy surface.
CO-4	After studying these topic students will acquire knowledge of surface phenomena, adsorption.
CO-5	Students will have the basic concepts including adsorption, colloids, emulsions.
CO-6	Comprehend idea about the synthesis and applications of surfactants and micelles.

Reference Books:

1. Modern Electrochemistry, Vol. I and Vol. II, J.O.M. Bockris and A. K. N. Reddy, Plenum.
2. An Introduction to Electrochemistry, Samuel Glasstone, 2016, EWP.
3. Chemical Kinetics, K. J. Laidler, McGraw Hill.
4. Foundation of Chemical Kinetics S. W. Benson MGH, 1982.
5. Micelles, Theoretical and Applied Aspects, Y. Moroi, Plenum.
6. Colloid and Interface Science, Pallab Ghosh, PHI Learning Pvt. Ltd., 2009.

Mapping with the POs/ PEOs: Matrix formation for attainments

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	**3**	**2**	**1**	**1**	**1**	**2**	**2**	**-**	**-**
CO-2	**2**	**2**	**2**	**2**	**2**	**2**	**2**	**-**	**-**
CO-3	**2**	**1**	**2**	**2**	**3**	**2**	**2**	**-**	**-**
CO-4	**2**	**2**	**3**	**2**	**3**	**3**	**-**	**-**	**3**
CO-5	**1**	**2**	**2**	**2**	**3**	**3**	**-**	**2**	**-**
CO-6	**3**	**3**	**3**	**-**	**2**	**3**	**-**	**2**	**-**

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2	PSO-3
CO-1	**-**	**4**	**-**
CO-2	**-**	**-**	**3**
CO-3	**4**	**-**	**-**
CO-4	**-**	**-**	**2**
CO-5	**2**	**-**	**-**
CO-6	**-**	**-**	**-**

Course: *Analytical and Environmental Chemistry* **Code: PCY01B04**
L-T-P: 3-1-0 **Credit: 4**

Program Outcomes (POs):
Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO-5	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-6	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEOs (Program Educational Objectives):

PEO-1	Acquire the fundamental principles of Chemistry with modern experimental and theoretical skills.
PEO-2	Ability to analyse the problems in the context of practical relevance to the society while maintaining environmental safety and economic factors.
PEO-3	Enhancing the professional growth along with scientific knowledge through continuing education.

PSOs (Program Specific Objectives):
Students will be able to

PSO-1	Learn basic principles of chromatography, TGA, DTA, polarography etc and be familiar with practical aspect of each technique
PSO-2	Gain knowledge about the foremost Environmental problems and analysis of pollutant
PSO-3	Evaluate the environment related issues in our society.

Course Objective

(i) To relate the conceptual understanding of the basic principles and application of some separation methods in Chemistry
(ii) To understand about the phases of thermal degradation outlines of materials using various types of thermal systems like TGA, DTA, DSC, etc. and basic conception about different theoretical concept and their applications
(iii) Comprehensive knowledge and broad understanding of environment.
(iv) Diagnose diverse kinds of toxicity in the environment and their control.

Course Content

(1) Analytical Chemistry (15 L):

(i) Chromatography: general principles, methods and applications of column (adsorption and partition), paper chromatography, paper electrophoresis, thin layer chromatography, gas chromatography (GC), high performance liquid chromatography (HPLC), supercritical fluid chromatography, size-exclusion chromatography, ion exchange chromatography and chiral chromatography.

(ii) Thermal methods: Theory, methodology and applications of thermogravimetric analysis (TGA), Differential Thermal Analysis (DTA), and Differential scanning calorimetry (DSC). Principles, techniques and applications of thermometric titration methods.

(iii) Polarography: Origin of polargraphy, Current-voltage relationship, Theory of polarographic waves Instrumentation, Ilkovic equation, Qualitative and quantitative applications.

(2) Environmental Chemistry (30 L):

(i) Chemistry of the Environment: Environmental terminology and nomenclatures, Environmental segments, The natural cycles of environment (Hydrological, Oxygen, Nitrogen). Ecological balance and planning of Industrial complexes. Reactions in living systems. Bioreactors. Biochemical process in industries.

(ii) Chemical Toxicology: Toxic chemicals in the environments, Impact of toxic chemicals on enzymes. Biochemical effects of arsenic, cadmium, lead, mercury, carbon monoxide, nitrogen oxides, sulphur oxides.

(iii) Air Pollution: Particulates, Aerosols, SOx, NOx, COx, hydrocarbon and halogens Photochemical smog, sulphurous smog, Suspended Particulate Matter (SPM) sampler, Chemistry of ozone layer and Air-quality standards.

(iv) Water Pollution: Water-quality parameters and standards: physical and chemical parameters, Dissolved oxygen, BOD, COD, Total organic carbon, Total nitrogen, Total sulfur, Total phosphorus, Chlorine, Pesticides and heavy metals as water pollutants.

(v) Soil pollution: Inorganic and organic components in soil, acid-base and ion-exchange reactions in soil, micro and macro nutrients, nitrogen pathways and NPK in soil and some important pollutants in soil.

(vi) Social issues and Environment Law: Solid waste management, disaster management, Environment protection act, Wildlife protection act, Forest conservation act, Environmental issues in legislation.

Course Outcome

CO-1	Understand the basic principles associated with chromatography and discuss how these are applied to the various specific applications of chromatography
CO-2	Resolve the problems established on numerous thermal concepts, design experiments with accurate data handling and analysis, and analyze several thermodynamic parameters.
CO-3	Diagnose different types of toxicity in the environment and their control.
CO-4	Able to recognize the Greenhouse effect, water and air pollution, etc. and to make conscious society about environmental pollution.

Reference Books:

1. G. D. Christian, Analytical Chemistry, 5th Edition (1994), John Wiley & Sons, New York.
2. D.A. Skoog, Principles of Instrumental Analysis, 5th Edition (1998), Saunders College Publishing, Philadelphia, London.
3. G.W. Ewing, Instrumental Methods of Chemical Analysis, 5th Edition (1978), McGraw Hill Books Co., New York.
4. J.H. Kennedy, Analytical Chemistry: Principles, 2nd Edition (1990), Saunders Holt, London.
5. R.L. Pecsok, L. D. Shields, T. Cairns and L.C. Mc William, Modern Methods of Chemical Analysis, 2nd Edition (1976), John Wiley, New York.
6. F.W. Fifield and W.P.J. Hairens, Environmental Analytical Chemistry, 2nd Edition (2000), Black Well Science Ltd.
7. A.K. Das and M.Das Environmental Chemistry with green Chemistry 1st Edition (2015), Books and allied(P) Ltd.
8. S.K. Banerji, Environmental Chemistry, 1st Edition (1993), Prentice-Hall of India, New Delhi.
9. S.M. Khopkar, Environmental Pollution Analysis, 1st Edition (1993), Wiley Estern Ltd., New Delhi
10. A.K. De, Environmental Chemistry, 4th Edition (2000), New Age International Private Ltd.,New Delhi.

Mapping with the POs/ PEOs: Matrix formation for attainments

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	**3**	**2**	**2**	**-**	**-**	**2**	**2**	**2**	**-**
CO-2	**2**	**2**		**3**	**2**	**2**	**2**	**-**	**2**
CO-3	**2**	**-**	**2**	**-**	**-**	**-**	**2**	**-**	**2**
CO-4	**2**	**-**	**2**	**-**	**3**	**2**	**2**	**2**	**3**

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2	PSO-3
CO-1	**3**	**4**	**2**
CO-2	**3**	**2**	**3**
CO-3	**4**	**2**	**2**
CO-4	**4**	**2**	**2**

Course: *Organic Chemistry Laboratory* **Code: PCY01P02**
L-T-P: 0-0-6 **Credit: 4**

Program Outcomes (POs):
Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO-4	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO-5	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-6	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEOs (Program Educational Objectives):

PEO-1	Acquire the fundamental knowledge for handling organic practical experiments.
PEO-2	To train the students with modern practical skill for understanding the organic chemistry.
PEO-3	Enhancing their professional growth along with scientific knowledge through practical skill and to innovate for further research.

PSOs (Program Specific Objectives):

PSO-1	Enhance their practical knowledge for carrying out organic experiments which are relevant and important to modern chemistry.
PSO-2	To acquire the fundamental practical skills for the understanding of organic chemistry.
PSO-3	Students can acquire the knowledge of organic chemistry through organic experiments keeping the environmental safety of hazards chemicals and to familiarize with the practical skills for conducting experiments relevant to the commercial important compounds.

Course Objective

(1) To familiarize with the practical knowledge of organic Chemistry
(2) To develop practical skill for the identification of organic compounds, preparation of organic compounds which are useful to our daily life.
(3) To train the students, the art for the estimation of organic common organic compounds.
(4) Students will also learn techniques for the separation of organic compounds using TLC and column chromatography techniques.

Course Content

1. Systematic qualitative analysis of an organic compound and identification of the compound by preparing their suitable derivatives.
   a. Detection of the following functional groups in an unknown organic compound by systematic chemical test : $–NH_2$ - $CONH_2$, –OH, –CHO , >C=O , –COOH
   b. Preparation, purification and melting point determination of a crystalline derivative of the given compound.

2. Organic Preparation:-

i) *p*-Bromoaniline from *p*-bromoacetanilide.
ii) Phenyl benzoate from Phenol.
iii) β-Naphthyl benzoate from β-naphthol.
iv) Preparation of Benzanilide from aniline.
v) Benzoic acid from benzamide
vi)Benzilic acid from benzoin
vii)Benzil from benzoin
viii) Methyl orange from sulphanilic acid
ix) Picric acid from phenol

3. Estimation of aniline, quantitative estimation of glucose from Fehling's solution.
4. Chromatographic methods of analysis:

Separation techniques by TLC and column chromatography:

a. Separation of aminoacides (dl-alanine, Tryptophan, Phenylalanine, leucine, Serine, Cystine, Aspartic acid etc.) by TLC.
b. Column chromatography separation of leaf pigments from spinach leaves.
c. Separation and identification of mixture of benzoin and benzil by column chromatography
d. Separation of mixture of dyes (fluorescein and methylene blue) by TLC
e. Separation of mixture of dyes (fluorescein and methylene blue) by column chromatography.

Course Outcome

CO-1	To determine functional group and identify an unknown organic compound preparing suitable derivatives.
CO-2	To prepare various important organic compounds through their practical skill and acquire the understanding for the mechanism of the reaction
CO-3	To perform the estimation of some important common organic compounds which are relevant and important to daily use.
CO-4	To acquire the fundamental knowledge for the separation of mixture of organic compounds by TLC and Column chromatography and apply the principles of chromatography for the separation of organic compound mixtures.

Reference Books:

1. *An Advanced Course in Practical Chemistry*, A. K. Nad, B. Mahapatra, A. Ghoshal, New Central Book Agency Pvt. Ltd., Kolkata, 2016.
2. *Vogel's Textbook of Practical Organic Chemistry* 5th Edition, 2005, Pearson.
3. F.G. Mann, *Practical Organic Chemistry* 4th Edition, Pearson.
4. *Techniques and Experiments for Organic Chemistry*, by Addison Ault, University Science book, 6th edition.

Mapping with the POs/ PEOs: Matrix formation for attainments

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	**1**	**2**	**1**	**2**	**3**	**2**	**2**	**2**	**2**
CO-2	**2**	**3**	**2**	**2**	**3**	**2**	**2**	**-**	**3**
CO-3	**2**	**2**	**2**	**2**	**3**	**3**	**2**	**2**	**2**
CO-4	**2**	**3**	**3**	**2**	**3**	**3**	**2**	**-**	**3**

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2	PSO-3
CO-1	**2**	**3**	**2**
CO-2	**-**	**2**	**3**
CO-3	**3**	**2**	**-**
CO-4	**3**	**3**	**3**

Second Semester

Course: *Inorganic Chemistry-II* **Code: PCY02B05**
L-T-P: 3-1-0 **Credit: 4**

Program Outcomes (POs):
Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO-5	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-6	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEOs (Program Educational Objectives):

PEO-1	Obtain the fundamental principles of chemistry with modern experimental and theoretical skills.
PEO-2	Ability to analyse the problems such as construction of artificial leaf, used of metal ion in drug in the context of practical relevance to the socio-economical and environmentally being system.
PEO-3	Improving their professional progress along with scientific knowledge continuing through which will be helpful for higher studies.

PSOs (Program Specific Objectives):
Students will be able to

PSO-1	To acquire knowledge about the basic properties of organometallic compounds, their uses as catalyst in various industrial applications.
PSO-2	Successfully apply the principles of chemistry of coordination complexes to understand functions of biological systems
PSO-3	To pursue higher education along with R&D accomplishments.

Course Objective

(i) To deliver the basic understanding of organometallic chemistry along with mentioning the structures, bonding, reactivity and use of organometallic compounds.
(ii) To provide the role of several organometallic catalysts and their mechanism and their potential application in Industry.
(iii) To bring the role of metal complexes to empathetic functions of biological systems like recognize the active site structure along with functions of some metal ion containing metalloproteins and enzymes
(iv) To providing a thorough knowledge of bioinorganic chemistry as the current areas of research interest.

Course Content

(1) Organometallic Chemistry (24 L):

Metal Carbonyls and related compounds: Classification; 18 electron rule, 16-electron rule, π-complexes, heptacity, isolobal and isoelectronic relationship; Preparation, structure, and properties: bonding in metal carbonyl, nitrosyl, phosphine, alkyl, complexes; vibrational spectra, non-transition organometallics.

Reactions of transition metal complexes: Reaction of organometallic compounds by oxidative addition, reductive elimination, insertion, hydrogenation, carbonylation, hydroformylation and polymerization.

Complexes of unsaturated molecules: Preparation, bonding and structure of alkene, alkyne, allyl, dienyl, trienyl and aryl complexes; Fischer and Schrock carbene and carbyne complexes, fluxionally and dynamic equillibria, metallocenes.

Applications in catalysis: Hydrogenation, Zeigler-Natta polymerization, hydrocarbonylation, hydroformylation of olefins using cobalt or rhodium catalysts (Oxo process). Fischer-Tropsch synthesis and Wacker Process catalyst.

(2) Bio-inorganic Chemistry (21 L):

Role of metal ions in biological processes: General introduction about essential and trace metal ions and their role in biological systems and Na^+/K^+ pump.

Metalloproteins and metalloenzymes: Biochemistry of iron and copper: Dioxygen binding, transport and storage through Hemoglobin, Myoglobin, Hemerythrin, and Hemocyanin; Blue copper proteins: Type 1, Type 2, and Type 3 copper centers in O2 activating proteins; Metal-sulfide proteins: Ferredoxin and Nitrogenase; Nitrate and nitrite reduction (NO_3- and NO_2-reductase Metalloporphyrins and respiration-Cytochromes; Metals at the center of photosynthesis: Magnesium and Manganese; Metalloenzymes: Carbonic anhydrase, carboxypeptidases, alcohol dehydrogenase and vitamin B12; Ion transport across membrane; Urease, hydrogenase, Anti-oxidative functions, Synthetic models of iron-sulfur proteins; molybdo-enzymes–molybdenum cofactors (molybdenum-pterin complexes); Ferritin, transferritin and hemosiderin; DNA probe and chemotherapeutic agents.

Course Outcome

CO-1	Students will understand the important and elementary features of organometallic chemistry.
CO-2	Students will acquire the knowledge about the interdisciplinary character of organometallic chemistry and the industrial prospect of organometallic chemistry
CO-3	Students will learn principles of chemistry of coordination complexes to understand functions of biological systems.
CO-4	Students will aware with the broad subject areas of organometallic compound and bio-inorganic it will help them with their project as well as research purpose

Reference Books:

1. D. F. Shriver and P. W. Atkins, *Inorganic Chemistry*, 5th Edn. (1999), ELBS, London.
2. F. A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry*, 6th Edn. (1999), John Wiley & Sons, New York.
3. J. E. Huheey, E. A. Keiter and R. L. Keiter, *Inorganic Chemistry*, 4th Edn. (1993), Addison-Wesley Pub. Co., New York.
4. R. H. Crabtree, The organometallic chemistry of the transition metals, 5th Edn. (2012), Wiley.
5. B. D. Gupta and Anil J. Elias, Basic organometalli chemistry: concepts, syntheses, and applications of transition metals, 1st Edn. (2010) Crc Press.
6. A. K. Das and M. Das *Fundamental Concepts of Inorganic Chemistry: Volume 6*, 1st Edn (2014), CBS Publishers and distributors.
7. I. Bertini, H. B. Grey, S. J. Lippard and J. S. Valentine, *Bioinorganic Chemistry*, Viva Books Pvt. Ltd., New Delhi (1998)
8. S. J. Lippard and J. M. Berg, *Principles of Bioinorganic Chemistry*, University Science Books, (1994).
9. A. K. Das, *Bioinorganic Chemistry* Books & Allied, Kolkata, (2007).
10. W. Kaim and B. Schwederski, *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life, An Introduction and Guide*, Wiley, New York (1995)

Mapping with the POs/ PEOs: Matrix formation for attainments

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	**3**	**2**	**2**	**1**	**2**	**2**	**3**	**-**	**3**
CO-2	**2**	**2**	**2**	**-**	**3**	**-**	**3**	**-**	**3**
CO-3	**3**	**-**	**-**	**2**	**-**	**3**	**2**	**-**	**-**
CO-4	**2**	**3**	**2**	**-**	**3**	**3**	**2**	**-**	**3**

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2	PSO-3
CO-1	**4**	**2**	**3**
CO-2	**4**	**-**	**2**
CO-3	**3**	**4**	**3**
CO-4	**3**	**-**	**2**

Course: *Organic Chemistry-II* **Code: PCY02B06**
L-T-P: 3-1-0 **Credit: 4**

Program Outcomes (POs):
Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO-5	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-6	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEOs (Program Educational Objectives)

PEO-1	To focus on reaction design and methodology development in the fields of medicinal technology, molecular nanotechnology and energy related sciences.
PEO-2	Understanding the structure, properties, and reactions of organic materials in the context of practical relevance all earthly life.
PEO-3	Analyzing the professional needs in applied chemical industry technology through the knowledge of day-to-day organic molecules.

PSOs (Program Specific Objectives)

PSO-1	To apply the knowledge of new advanced chemicals, reagents, catalysts in the development of new drug candidates, drug delivery concepts and nano-molecular devices.
PSO-2	Successfully apply many modern, high-tech organic materials as a part of this course.

Course Objective

1. To introduce the knowledge of Heterocyclic compunds which have a wide range of application as pharmaceuticals, agrochemicals and as veterinary products. Students will learn and find applications as sentizers, developers, antioxidants, as corrosion inhibitors, as copolymers, dyestuff , etc.
2. To introduce the fundamentals of any chemical substance produced during the conversion of some reactant to a product via reactive intermediates.
3. The students will learn how important enzymes are by functioning as a catalyst in most all biological processes. In learning about the functions of enzymes, they will also see how they are related to things they come across in everyday life.

Course Content

(1) Heterocyclic Chemistry (15 L):

Nomenclature and classification of heterocyclic compounds. Synthesis, physical and chemical properties of pyrimidines, purines, oxazoles, iso-oxazoles, thiazoles and iso-thiazoles, pyrazoles, imidazoles and cumarines.

(2) Chemistry of reactive intermediate (10 L):

Classical and non classical carbocations and carbanions; radicals, radical cations, radical anions, carbenes, arenes and nitrenes, benzynes. General methods of generation, detection, stability, reactivity and structure of intermediate.

(3) Enzyme Chemistry (20 L):

Chemical and biological catalysts. Enzymes- nomenclature and classification, structure and theories of enzyme specificity. Michaelis Menten equation, Effects of pH and temperature on enzymatic activity, Types of enzyme inhibition, Factors influencing catalytic efficiency of enzymes. Different types of enzyme catalyzed reactions. Enzyme mechanisms of chymotripsin, ribonuclease, lysozyme and carboxypeptidase-A. Co-enzyme chemistry. Enzyme models: Host-guest chemistry, Molecular Interactions in Molecular Recognition, molecular asymmetry and prochirality, crown ether, cryptates, cyclodextrins and calixarin.

Course Outcome

CO-1	To predict the structure and properties of natural products in the pharmaceutical and related sciences with a background in the field of organic molecules.
CO-2	Students will be able to identify the role of enzymes in the everyday life.
CO-3	Students will acquire the knowledge of methods of intermediates generation in organic chemistry and their importance for the generalization of numerous reactions.

Reference Books:

1. Smith, Michael B., March, Jerry. March's Advanced Organic Chemistry*: Reactions, Mechanisms, and Structure*, Sixth Edition. ISBN 13: 978-0-471-72091-1. ISBN 10: 0-471 72091-7.
2. Carey F. A. and Sundberg R. J., *Advanced Organic Chemistry*, Parts A & B , Plenum, U.S., 2004.
3. March J, *Advanced Organic Chemistry*, John Wiley , 1992.
4. Colin Suckling, *Enzyme Chemistry: Impact and Applications*, Springer; 2nd ed. 1990. Softcover reprint of the original 2nd ed. 1990 edition (11 November 2011).

Mapping with the POs/ PEOs: Matrix formation for attainments

S- Strong, M-Moderate and W-Weak

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	**S**	**M**	**M**	**M**	**M**	**M**	**M**	**-**	**-**
CO-2	**-**	**M**	**-**	**M**	**-**	**M**	**S**	**-**	**-**
CO-3	**M**	**-**	**S**	**-**	**S**	**S**	**S**	**-**	**-**

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2
CO-1	**4**	**2**
CO-2	**4**	**-**
CO-3	**3**	**4**

Course: *Physical Chemistry-II* **Code: PCY02B07**
L-T-P: 3-1-0 **Credit: 4**

Program Outcomes (POs):
Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO-5	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-6	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEOs (Program Educational Objectives):.

PEO-1	Acquire the fundamental principles of Quantum Chemistry, Photo-Chemistry and Equilibrium Thermodynamics with modern experimental and theoretical skills.
PEO-2	Ability to analyse the problems in the context of practical relevance to the society.
PEO-3	Enhancing their professional growth along with scientific knowledge through continuing education.

PSOs (Program Specific Objectives):
Students will be able to

PSO-1	Apply their knowledge to develop theoretical insight of engine, behaviour of tiny particle and photo-physical properties of molecules.
PSO-2	Successfully apply the principles of quantum mechanics, photochemistry and equilibrium thermodynamics for various engineering materials which have been learned as a part of this course.
PSO-3	Evaluate the energy scenario along with environment related issues in our society.

Course Objective

1. Connect the historical development of quantum mechanics with previous knowledge and learn the basic properties of quantum world.
2. Understand and explain the differences between classical and quantum mechanics
3. Solve Schrodinger equation for simple potentials.
4. Describe and explain photochemical and photophysical processes and mechanisms with suitable theoretical models, and apply established experimental methods for the investigation of these processes.
5. Describe the interaction of excited states with their surroundings and analyse photoinduced electron transfer and excitation energy transfer with quantitative models.

6. Familiarity with basic concepts in solution thermodynamics, and an ability to relate the characteristics and relative energies of different liquid and solid solutions to the phase diagram of the system.

Course Content

1) Quantum Chemistry (10 L):

Fundamentals of quantum mechanics: basic postulates, operators; time-independent and time-dependent Schrödinger equation; exactly solvable systems; particle in a box of various dimensions and tunnelling; harmonic oscillator; rigid rotator; hydrogen atom-wave functions including shapes of atomic orbitals; orbital and spin angular momenta; Pauli exclusion principle, Zeeman effect, spin-orbit coupling.

2) Photochemistry (15 L):

Interaction of electromagnetic radiation with matter; Jablönski diagram; absorption spectroscopy: Lambert-Beers law; fluorescence and phosphorescence: Stokes shift, mirror-image rule, lifetimes and quantum yields; fluorescence polarization and anisotropy; solvent relaxation; excited state acidity and basicity; fluorescence quenching: mechanism & dynamics; specific and non-specific interactions between fluorophor and solvent; excimer and exciplex; biochemical applications of environment sensitive fluorescent probes (photosynthesis, etc.).

3) Group Theory and Spectroscopy (20 L):

Symmetry and group theory: Properties of group, subgroup and class, symmetry elements and operations, point groups, matrix representation of groups, operators and basis functions, similarity transformation, reducible and irreducible representations, Great orthogonality theorem and its consequences, character table, Projection operators and its applications. Hybridization schemes for σ-orbital, hybridization schemes for π-bonding for AB_n type molecules. Molecular rotational and vibrational spectroscopy: Rotations and vibrations of diatomic and polyatomic molecules, internal coordinates, normal modes and their symmetry, selection rules for fundamental vibrational transition.

Course Outcome

CO-1	Student will acquire the knowledge about the theoretical chemistry is important because it uses math and physics to predict events.
CO-2	Students will obtain a proper idea about group theory which is the study of symmetry.
CO-3	Student will easily dealing with an object that appears symmetric, group theory can help with the analysis which stays invariant under some transformations.
CO-4	Students will have proper idea why and how the formation of laser light is only possible through photochemistry which contain monochromatic rays with coherent radiations and only for this property, LASER light is used for cutting hard material like metal, diamond etc, also there is some application of LASER light in medical field.
CO-5	After studying this course they will able to find out how and why Fluorescence spectroscopy become an excellent diagnostic as well as excellent research tool in medical microbiology field, in food analysis, forensic science.
CO-6	Medical diagnosis, medical science etc with high sensitivity and specificity.

Reference Books:

1. D.A. McQuarrie, Quantum Chemistry, OUP (1983).
2. P.W. Atkins et al Molecular Quantum Mechanics, OUP, 1998.
3. R. K. Prasad, Quantum Chemistry, New Age International, New Delhi, 19974.
4. Fundamentals of Molecular Spectroscopy, C.N. Banwell, E.M. McCash, 4th Edn., McGraw-Hill.
5. Chemical Applications of Group Theory, F.A.Cotton, 3ed, Wiley.
6. Group Theory and Quantum Mechanics, M. Tinkham, McGraw Hill, 1964.
7. A. S. Kunju, G. Krishnan, Group Theory and its Applications in Chemistry, PHI Learning Pvt. Ltd., 2008.
8. P. W. Atkins – Physical Chemistry, 7th Edn. Oxford (2000).
9. I. N. Levine, Physical Chemistry, 5th Edn., McGraw Hill, New Delhi, 1995.
10. Physical Chemistry, G.W. Castellan, 3rd Edn. Addison Wesley.

Mapping with the POs/ PEOs: Matrix formation for attainments

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	3	2	-	-	-	-	2	-	-
CO-2	-	2	-	3	2	-	2	-	-
CO-3	-	-	-	-	-	2	2	-	-
CO-4	-	-	-	3	2	-	-	-	3
CO-5	-	2	2	-	-	-	-	2	-
CO-6	-	-	-	3	3	3	-	2	-

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2	PSO-3
CO-1	-	4	-
CO-2	-	-	3
CO-3	4	-	-
CO-4	-	-	2
CO-5	2	-	-
CO-6	-	-	-

Course: *Biochemistry* **Code: PCY02B08**
L-T-P: 3-1-0 **Credit: 4**

Program Outcomes (POs):
Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO-5	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-6	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEOs (Program Educational Objectives):

PEO-1	To embody a fundamental approach to the chemistry of life and convey the strongly unifying contribution of biochemistry and molecular biology to other scientific disciplines.
PEO-2	To provide a significant input in clinical care and provide significant opportunities for research and development at both clinical and laboratory level, whether a student is scientifically or medically qualified.
PEO-3	To enrich the students about the chemical processes within and relating to living organisms.

PSOs (Program Specific Objectives):

PSO-1	To teach how scientific reasoning can be applied to clinical decision making, and provides a framework for solving clinical problems that require molecular insights.
PSO-2	To provide valuable knowledge with respect to the complex molecular relationship which allows to sustain life.

Course Objective

1. To allow the understanding of processes involved in cell aging and death.
2. To confer the knowledge on the process of energy transformation in living beings and signaling mechanisms, as well as providing necessary knowledge to be able to understand scientific and technological research.
3. To provide a good platform with solid knowledge in biochemistry for scientific and technological advances and its importance in pharmaceutical development

Course Content

(1) Amino acids and peptides (10 L)

Amino acids: Introduction, isoelectric point, ninhydrin reaction. Peptides: peptide linkage, synthesis of peptides using N-protection and C-protection, solid phase peptide synthesis, determination of peptide sequence using Dansyl chloride, Edman's reagent, Sanger's reagent and carboxypeptidase. Primary, secondary, tertiary and quaternary structure of proteins.

(2) Nucleic acids (10 L)

Purine and pyrimidine bases of nucleic acids, base pairing via H-bonding. Structure of RNA and DNA, nucleoside and nucleotide, double helix model of DNA and forces responsible for holding it. Chemical and enzymatic hydrolysis of nucleic acids. Chemical synthesis of mono and trinucleoside. Denaturation and renaturation of DNA strands, cellular RNAs and their functions.

(3) Lipids: (10 L)

Classification of lipids, fatty acids- essential fatty acids, structure, properties and function of triacyl-glycerols, phosphoglycerides,sphingolipids,cholesterol, prostaglandins. Lipoproteins-composition and function, role in atherosclerosis. Properties of lipid aggregates – micelles, bilayers, liposomes and their possible biological functions. Biological membrane. Fluid mosaic model of membrane structure.

(4) Carbohydrates (20 L)

Conformation of monosaccharides, structure and functions of important monosaccharides like glycosides, deoxy sugars, myoinositol amino sugars. N-acetylmuramic acid, sialic acid, disaccharides and polysaccharides. Structural polysaccharides–cellulose and chitin.Storage polysaccharides - starch and glycogen. Acetonation reaction of D-glucose, Structure and biological functions of glucosaminoglycans or mucopolysaccharides. Carbohydrates of glycoproteins and glycolipids. Role of sugars in biological recognition. Blood group substances. Ascorbic acid.

Course Outcome

CO-1	Students will be able to know the fact of being acquainted and understanding each of the events which allow proper functioning of life and will understand the fact that any alteration of these processes result in the different disorders which afflict living things.
CO-2	Understanding of disease and tissue and how biomedical sciences lead to therapeutic advances under different circumstances in any clinical discipline.
CO-3	Students will dive into drug development and screening and learn about the various ways for drug screening such as top-down and bottom-up methods.

Reference Books:

1. *Lehninger Principles of Biochemistry*, by Albert L. Lehninger, David L. Nelson, Michael M. Cox. Fourth Edition, 1119 pages.
2. *Biochemistry*, by Jeremy M. Berg, John L. Tymoczko, Lubert Stryer.
3. *Essentials of Chemical Biology*, A. Miller and J. Tanner, Wiley and Sons, 2008.

Mapping with the POs/ PEOs: Matrix formation for attainments

S- Strong, M-Moderate and W-Weak

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	**S**	**M**	**-**	**M**	**M**	**M**	**M**	**-**	**-**
CO-2	**-**	**M**	**-**	**-**	**-**	**S**	**M**	**-**	**-**
CO-3	**-**	**-**	**M**	**M**	**M**	**S**	**M**	**-**	**-**

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2
CO-1	**4**	**2**
CO-2	**4**	**-**
CO-3	**3**	**4**

Course: *Physical Chemistry Laboratory* **Code: PCY02P03**
L-T-P: 0-0-6 **Credit: 4**

Program Outcomes (POs):
Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO-5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO-6	Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PEOs (Program Educational Objectives):

PEO-1	Adapt to work with new experiments, assimilate updated information, and be able to solve complex problems based on practical physical chemistry.
PEO-2	Learn the fundamental applications of physical chemistry through experimental techniques using modern state-of-the-art equipment.

PSOs (Program Specific Objectives):
Students will be able to

PSO-1	Prepare themselves for their higher studies by learning good laboratory practices using the modern methods and techniques, while simultaneously develop professional skills to be able to work in chemical and other industries requiring knowledge/experience of practical physical chemistry.
PSO-2	Successfully apply their practical experience to analytically determine/estimate amount of substances in water, their physical properties, among others.

Course Objective

1. Students will learn the ethics and acquire training required for physical chemistry laboratory.
2. The practicals have been designed such that the students develop knack for learning physical chemistry in their theory courses. In addition, the concepts that they learn in theory could be augmented due to their laboratory experiments, data collection, and calculation.
3. To introduce the students to the modern experiments that not just help to enhance their knowledge on the laws of physical chemistry but seek to solve problems at international, national and regional level based on practical physical chemistry.
4. Eventually, the course should be able to make students think rationally in their encounter with problems requiring knowledge of physical chemistry laboratory experience and training.

Course Content

PART A: Experimental

1) Determination of rate constant of alkaline hydrolysis of ethyl acetate, and determination of activation parameters, effect of ionic strength.
2) Determination of partition coefficient of benzoic acid between water and benzene.
3) Kinetics of acid hydrolysis of an ester.
4) Determination of the order of saponification for the reaction of ethyl acetate with sodium hydroxide, conductometrically.
5) Solvent effect and salt effect on the kinetics of alkaline hydrolysis of crystal violet.
6) Determination of standard electrode potential of AgCl-Ag electrode and evaluation of mean activity coefficient of HCl.
7) Determination of specific rotation of cane sugar and determination of composition of a sugar solution of unknown strength.
8) Solvent and micellar effect on the fluorescence of 1-naphthol and determination of CMC of a surfactant.
9) Potentiometric titration of ferrous ammonium sulphate using $KMnO_4/K_2Cr_2O_7$ as standard and determination of the redox potential of Fe^{3+}/Fe^{2+} system on the hydrogen scale.
10) Kinetics of reaction $I^- + S_2O_8^{2-}$ by colorimetric method.
11) Adsorption of acetic acid on charcoal and validity of Frendlich's adsorption isotherm.
12) Conductometric titration of triple mixture KCl, NH_4Cl, HCl by NaOH and $AgNO_3$.
13) Preparation of Ag, Cu nanoparticles and characterization using UV-Vis spectrophotometer.
14) Determination of the formula of cuproammonium ion using UV-Vis spectrophotometer.
15) Verification of Beer-Lambert's law and determination of pKa of an indicator, spectrophotometrically in homogeneous and heterogeneous media.

PART B: Computational

1) Modelling of interactions involving macrobodies like planar surfaces, macrospheres, etc.
2) Structure optimization and conformational analysis using *ab initio* molecular orbital theory.
3) Thermochemistry in different QM model chemistries.
4) Tautomeric preferences and solvent effects.
5) Stereoselectivity in Diels-Alder reactions.
6) Flexible models and calculation of force constants.
7) Structural and dielectric properties of a polar medium: Continuum models versus molecular models.
8) Calculation of structure, energy and free energy through simulations using molecular models.
9) Molecular docking of biomolecules.
10) Potential energy surfaces and optimization methods using Gaussian.

Course Outcome

CO-1	By the end of the course, the student should have acquired hands-on training on physical chemistry practicals which would go on to help them in their academic and research career.
CO-2	They have acquired basic knowledge and mastered the art of handling modern equipments and developing computational skills for advanced practicals and research.
CO-3	They should be able to apply their knowledge in other disciplines and for solving complex problems facing mankind in daily life.

Reference Books:

1. Experiments in Physical Chemistry J.C. Ghosh, Bharati Bhavan 1974,New Delhi
2. Advanced experimental chemistry (Physical) J.N.Gurtu, & NR Kapoor, S.C. Company 1980
3. Laboratory Manual in Physical Chemistry WJ Popiel, ELBS 1970
4. Advanced Practical in Physical Chemstry JB Yadav, Pragati Prakasan Meerut
5. Practical Physical Chemistry, A. M. James and F. E. Prichard, Longman.
6. D. P. Shoemaker, C. W. Garland & J. W. Nibler. Experiments in Physical Chemistry (5^{th} edn.), McGraw Hill (1989).
7. A.R. Leach, *Molecular Modelling : Principles and Applications*, Longman (1996).
8. T. Schlick, *Molecular Modelling and Simulation*, Springer (2006).
9. P.W. Atkins, *Molecular Quantum Mechanics*, Oxford (1997).
10. J. Israelachvili, *Intermolecular and surface Forces*, Academic (1991).
11. C.L. Brooks III, M.Karplus, B.M. Pettitt, *Proteins: A theoretical Perspective of Dynamics, Structure and Thermodynamics*, John Wiley (1988).

Mapping with the POs/ PEOs: Matrix formation for attainments

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	**2**	**2**	**3**	**2**	**3**	**2**	**2**	**-**	**-**
CO-2	**-**	**2**	**3**	**3**	**3**	**2**	**2**	**-**	**-**
CO-3	**-**	**-**	**-**	**3**	**3**	**3**	**2**	**-**	**-**

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2
CO-1	**-**	**4**
CO-2	**-**	**-**
CO-3	**4**	**-**

Third Semester

Course: *Inorganic Chemistry-III* **Code: PCY03B09**
L-T-P: 3-1-0 **Credit: 4**

Program Outcomes (POs):
Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO-5	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-6	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEOs (Program Educational Objectives):

PEO-1	Obtain the elementary idea about essentials and application of existing chemical and scientific theories.
PEO-2	Understand the essential role of Inorganic Chemistry in our society.
PEO-3	Ability to explore innovative filed of research in both chemistry and allied fields of science and technology.

PSOs (Program Specific Objectives):
Students will be able to

PSO-1	Ability to understand elementary knowledge and fundamentals application of Inorganic Chemistry to understand properties of late transition elements and cluster compounds.
PSO-2	Impart the background knowledge on solid state chemistry and inorganic cluster for various applications
PSO-3	Prospects to excel in academics, research or Industry.

Course Objective

(i) The course provides chemistry of main group elements and f-block elements and the separation method of lanthanides and actinides.
(ii) Explain about preparation, properties and structure of Heteropoly and Isopoly acids
(iii) Predict the structural stability of several metal clusters by polyhedral skeletal electron pair theory and applications of Metallaboranes/Metallacarboranes as catalysts for different type of chemical reactions.
(iv) Understand the solid state chemistry, crystal structures of various ionic compound, defects and explain the electronic properties and band theory of insulator, conductors and semiconductors.

Course Content

1) Chemistry of transition elements (10 L):

Comparative study of *d*- and *f*-block Elements: A general treatment of the d-block elements; A general treatment of the Chemistry of lanthanides, positioning the periodic table; electronic configuration, lanthanide contraction, extraction; oxidation states, spectral and magnetic properties.

Electronic structure, ionic radii, oxidation state, spectra and paramagnetic properties of actinides elements, actinide hypothesis, a brief chemistry of uranium and thorium, isolation of neptunium, plutonium and americium and their aqueous chemistry**.**

2) Cage and Cluster Compounds and Inorganic Polymer (20L):

Boranes and Metal Clusters: Types and IUPAC nomenclature; Wade's polyhedral skeleton electron pair theory (PSEPT); W. N. Lipscomb's styx rules and semi-topological structures of boranes. Equivalent and resonance structures; Wade's v*s* Lipscomb's methods of studying higher boranes; heteroboranes, metallaboranes, metallacarboranes, applications of PSEPT over heteroboranes; Metal-metal bonds. Concept of quadrupolar bond and its comparison with a C-C bond; Types of metal clusters and multiplicity of M-M bonds. Simple and condensed metal carbonyl clusters. Applications of PSEPT and Wade's-Mingo's and Lauhr's rule over metal carbonyl clusters. Metal halide and metal chalcogenide clusters: Bloomington schuffle in dinuclear tungsten clusters

Inorganic Polymers: Classification, Types of Inorganic Polymerization, Comparison with organic polymers, Boron-oxygen and boron-nitrogen polymers, silicones, coordination polymers, sulphur-nitrogen, sulphur-nitrogen-fluorine compounds, phosphorous-nitrogen.

3) Solid state chemistry (15 L):

Introduction to single crystal, unit cell, Bravais lattice, crystal system and symmetry, crystal planes, Miller indices, reciprocal lattice, Lau-equation, Brag's law, scattering of X-ray and X-ray diffraction, fourier series, electron density and structure factor. Various X-ray diffraction method. determination of space group, methods of solving the phase problem, patterson and direct methods for determination of crystal structure.Voids, radiostic, structures of AX, AX2, AX3 types and their derived species, sphalite, wurzite, fluorite, perovskite, ilmentite, rutile, silicate and layered structure; Refinement of simple band theory- k-space and Brillouin Zones, band structure of metals, insulators and semiconductors, intrinsic and extrinsic semiconductors, doped semiconductors, p-n junctions; superconductors, Meissner effects, basic concepts of BCH theory.

Course Outcome

CO-1	Understand the fundamental principles and theories that interpreted the physicochemical properties of late transition element.
CO-2	Industrial use and medicinal significance of these late transition compounds
CO-3	Comprehend the chemistry of clusture compounds and apply PSEPT for structural aspect of carboranes, metallo boranes, hetero boranes, etc.
CO-4	Understanding of electronic properties & band theory of insulator, conductors and semiconductors.

Reference Books:

1. A. R. West, Solid State Chemistry and its Applications(1984), John Wiley and Sons Singapore.
2. L.V. Azaroff, Introduction to Solids(1977)Tata McGraw-Hill, New Delhi
3. L. Smart and E Moore, Solid State Chemistry(1992)Chapman & Hall, Madras
4. H. V. Keer Principles of Solid State(1993), , Wiley Eastern
5. N. N. Greenwood and A. Earnshaw, *Chemistry of the Elements*, 2nd Edn. (1997), Butterworth Heinemann, London
6. J. E. Huheey, E. A. Keiter and R. L. Keiter, *Inorganic Chemistry*, 4th Edn. (1993), Addison-Wesley Pub. Co., New York.
7. F. A. Cotton and G. Wilkinson *Advanced Inorganic Chemistry*, 6th Edn. (1999), John Wiley & Sons, New York.

Mapping with the POs/ PEOs: Matrix formation for attainments

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	**3**	**2**	**-**	**-**	**2**	**-**	**2**	**2**	**-**
CO-2	**3**	**2**	**-**	**2**	**-**	**3**	**2**	**-**	**-**
CO-3	**3**	**-**	**2**	**-**	**3**	**2**	**2**	**2**	**-**
CO-4	**2**	**-**	**-**	**2**	**3**	**3**	**2**	**-**	**3**

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2	PSO-3
CO-1	**3**	**4**	**3**
CO-2	**3**	**3**	**3**
CO-3	**3**	**-**	**4**
CO-4	**3**	**3**	**2**

Course: *Organic Chemistry-III* **Code: PCY03B10**
L-T-P: 3-1-0 **Credit: 4**

Program Outcomes (POs):
Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO-5	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO-6	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PEOs (Program Educational Objectives):

PEO-1	To provide research domain building a bridge between fundamental studies of organic photochemical reactions and their industrial application.
PEO-2	To bridge the gap between classic laboratory chemistry and large-scale reactions.
PEO-3	To addresses practical technological issues and challenges, giving the examples of applications of industrial organic chemistry in real life

PSOs (Program Specific Objectives):

PSO-1	The aim of the is to make students familiar with the concepts and applications in two important topics in advanced organic chemistry, namely concerted organic reactions and organic photochemistry.
PSO-2	To provide knowledge of general application of photochemistry and the use of photochemical processes to impart function to photoactive molecules as sensors, switches and other devices.
PSO-3	To impart the knowledge of industrially used materials for their applications as engineering materials.

Course Objective

1. To provide the knowledge of photochemical systems that use sunlight to drive important chemical reactions or to generate electricity for the development of sustainable sources of energy.
2. Industrial Organic Chemistry examines all major industrial manufacturing technologies and reaction types with a focus on organic chemistry in general and petroleum refining in particular.
3. To provide a good platform with solid knowledge in pericyclic reactions for scientific and technological advances.

Course Content

(1) Pericyclic Reaction (15 L):

Molecular orbital symmetry. Frontier orbitals of ethylene, 1, 3- butadiene, 1,3,5- hexatriene and allyl system. Classification of pericyclic reactions. Correlation diagram, FMO and PMO approach. Elecctrocyclic reaction – conrotatory and disrotatory motions, 4n, 4n+2 and allyl systems. Cycloaddition – antarafacial and suprafacial additions, 4n and 4n+2 systems, 2+2 addition of ketenes, 1,3 –dipolar cycloadditions and chelotropic reactions. Sigmatropic rearrangements - suprafcial and antarafacial shifts of H, sigmatropic shifts involving carbon moieties, 2,3-, 3,3- and 5,5- sigmatropic rearrangements. Claisen, Cope and aza-Cope rearrangements, Ene reaction, Group transfer reaction, Fluxional tautomerism, regioselectivity, periselectivity.

(2) Organic Photochemistry (10 L):

Photo-chemical energy, Jablonski-diagram, photo-sensitisation and quenching, Quantum yields, Norrish type-I, type-II processes, Paterno-Buchi reaction, photochemistry of unsaturated compounds and carbonyl compounds. Photochemistry of organic compounds: Isomerization, addition and substitution. Di- pi methane rearrangement, Photo Fries rearrangement.

(3) Industrial Organic Chemistry (10 L):

Basic products of industrial synthesis, chemicals from natural gases, petrochemicals and coal, chemicals of industrial importance: olefins, acetylenes, halo-compounds, alcohols, aromatics, amides, polyamides. Organic reactions of industrial importance (hydrogenation, dehydroformylation and polymerization) fermentation technology for the production of alcohols.

(4) Paints, Pigments and Food Chemicals (10 L):

Introduction, classification and applications of organic pigments. Paints- classification, constituents and applications. Food chemicals: Types of food additives, risks and benefits, function and applications of food flavours. Brief introduction of pheromones- Introduction, classification and structure.

Course Outcome

CO-1	Students will understand the utility of pericyclic and photochemical reactions and can apply them routinely for efficient synthesis of complex organic molecules.
CO-2	The student will be able to meet the demand of engineering materials in the industries
CO-3	The students will understand the impact of the professional engineering materials and develop the knowledge for sustainable development of the society.

Reference Books:

1. *Pericyclic Reactions*, Ian Fleming, John Wiley, 1976.
2. *Introduction to Organic Photochemistry*, J. D. Coyle.
3. *Industrial Organic Chemistry*, Prof. Dr. Klaus Weissermel, Prof. Dr. Hans-Jürgen Arpe, 4th Edn., WILEY-VCH Verlag GmbH & Co. KgaA, 2003.

Mapping with the POs/ PEOs: Matrix formation for attainments

S- Strong, M-Moderate and W-Weak

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	**M**	**M**	**S**	**S**	**W**	**M**	**S**	**-**	**-**
CO-2	**M**	**M**	**S**	**M**	**S**	**S**	**-**	**M**	**-**
CO-3	**M**	**M**	**S**	**S**	**S**	**S**	**-**	**-**	**S**

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2	PSO-3
CO-1	**4**	**2**	**3**
CO-2	**4**	**-**	**2**
CO-3	**3**	**4**	**3**

Course: *Physical Chemistry-III* **Code: PCY03B11**
L-T-P: 3-1-0 **Credit: 4**

Program Outcomes (POs):
Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO -4	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO-5	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-6	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEOs (Program Educational Objectives):

PEO-1	Acquire the fundamental principles of Chemistry with modern experimental and theoretical skills.
PEO-2	Ability to analyse the problems in the context of practical relevance to the society while maintaining environmental safety and economic factors.
PEO-3	Enhancing their professional growth along with scientific knowledge through continuing education.

PSOs (Program Specific Objectives):
Students will be able to

PSO-1	Apply their knowledge to develop theoretical insight Statistical mechanics, behaviour of tiny particle and photo-physical properties of molecules.
PSO-2	Successfully apply the principles of Statistical mechanics, catalysis for various engineering materials which have been learned as a part of this course.
PSO-3	Evaluate the energy scenario along with environment related issues in our society.

Course Objective

1. Statistical mechanics provides a framework for relating the microscopic properties of individual atoms and molecules to the macroscopic bulk properties of materials that can be observed in everyday life, thereby explaining thermodynamics as a result of the classical and quantum mechanical descriptions of statistics.
2. The students will revise how important are catalysts? As most of the fundamental and applied research is done by industrial companies and university research laboratories to find out how catalysts work and to improve their effectiveness. Not only that most of the chemical reactions that occur in the human body and in other living things provided by enzymes, a biocatalyst only.

3. To introduce the knowledge of Polymers which are widely used advanced materials, which are found almost in every material used in our daily life. Polymers make up many of the materials in living organisms, including, for example, proteins, cellulose and nucleic acids.

Course Content

1) Statistical Thermodynamics (20 L):

Probability and entropy; ensembles; Boltzmann statistics; molecular and molar partition functions; translational, rotational, vibrational, and electronic partition functions; reference state of zero energy; equilibrium constant and partition function; partition function and thermodynamic parameters, Sackur-Tetrode equation; equations of state for ideal gas; equipartition theorem; specific heat capacity of solids (Einstein's model); ideal lattice gas (Langmuir adsorption isotherm); theory of absolute reaction rates; distribution laws : Fermi-Dirac and Bose-Einstein statistics. Numerical problems.

2) Catalysis-Principles and Application (15 L):

Basic principles of catalysis; homogeneous and heterogeneous catalysis; adsorption: surface area, pore size and acid strength measurements, enthalpy and entropy; selection, preparation and evaluation of catalysts: test reactions, promoters, carriers and stabilizers; mechanism of reactions: hydrogenation and dehydrogenation, dehydration of alcohols, olefin hydrogenation, decomposition of N_2O, oxidation of CO, ketonization of carboxylic acids, cracking of hydrocarbons. Applications: petrochemical industry-reforming and refining, value added chemicals, environmental protection, auto exhaust catalysts, novel catalytic materials; fuel cell; photocatalysis; photocleavage of water and phase transfer catalysis.

3) Macromolecules (10 L):

Introductory concept, definition and classification of polymers; resin, rubber, plastics; characterization: number average, molecular weight average and viscosity average molecular weight; concept of segment and segment length; thermodynamics of dilute polymer solutions; molecular weight determination; structure of polymers in solution; kinetics of polymerization; mechanistic aspect: addition, ionic, coordination, condensation polymerization; crystal structure of polymers; effect of different parameters on T_m and T_g.

Course Outcome

CO-1	Students will be able to identify the basic equations connecting the translational, rotational, vibrational and electronic properties of isolated (i.e. gas-phase) molecules to their thermodynamics.
CO-2	They have acquired the knowledge of most basic descriptions of the vibrations of ions, atoms or molecules within crystals as well as the most elementary models for describing cooperative behaviour and phase transitions in gas-surface and liquid-liquid systems.
CO-3	Students will gain the information: Applications of Polymers; polymer testing and consultancy for plastics, additives with applications including aerospace, electronics, packaging and medical devices.
CO-4	Knowledge of contemporary environmental issues and assess the effects of pollution.
CO-5	Students have the clear idea how catalysts speed up the rate of reaction, which saves money because the plant doesn't have to operate for as long to produce the same amount of product? How catalysts allow the reaction to work at a much lower temperature? Cracking, isomerisation and hydrocarbon synthesis.
CO-6	Comprehend idea about the synthesis and applications of polymer science.

Reference Books:

1. T. L. Hill, Statistical Thermodynamics, Addision Wesley 1960.
2. D.A. McQuarrie, Statistical Thermodynamics, Viva Books Pvt Ltd 2003.
3. M. C. Gupta, Statistical Thermodynamics, WEL 1995.
4. Modern Molecular Photochemistry, Nicholas J. Turro, University Science Books, 1991.
5. Introduction to Polymer Science, V.R. Gowarikar, N.V. Vishwanathan and J. Sridhar, Wiley Eastern.
6. Physical Chemistry, P.W. Atkins,7thEdn. 2000, Oxford University Press.

Mapping with the POs/ PEOs: Matrix formation for attainments

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	**3**	**2**	**-**	**-**	**-**	**1**	**2**	**-**	**-**
CO-2	**-**	**2**	**2**	**-**	**2**	**3**	**3**	**-**	**-**
CO-3	**-**	**-**	**-**	**3**	**-**	**-**	**2**	**-**	**-**
CO-4	**-**	**-**	**-**	**-**	**3**	**3**	**-**	**-**	**3**
CO-5	**-**	**2**	**3**	**3**	**-**	**1**	**-**	**2**	**-**
CO-6	**2**	**-**	**-**	**3**	**3**	**3**	**-**	**2**	**-**

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2	PSO-3
CO-1	**-**	**4**	**-**
CO-2	**-**	**-**	**3**
CO-3	**4**	**-**	**-**
CO-4	**-**	**-**	**2**
CO-5	**3**	**-**	**-**
CO-6	**-**	**-**	**-**

Course: *Instrumental Method of Analysis of Chemical Compounds*
Code: PCY03B12 L-T-P: 3-1-0 Credit: 4

Program Outcomes (POs):
Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO-5	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-6	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEOs (Program Educational Objectives):

PEO-1	Acquire the fundamental principles of spectroscopy with modern experimental and theoretical skills.
PEO-2	Ability to analyse the problems in the context of practical relevance to the society.
PEO-3	Enhancing their professional growth along with scientific knowledge through continuing education.

PSOs (Program Specific Objectives):
Students will be able to

PSO-1	This course provides an introduction to the knowledge of the spectroscopy methods about structure of the chemistry compounds, as well as experimental usage of chosen methods (ESR, UV- VIS, IR, NMR and MS).
PSO-2	Understanding of these concepts is fundamental in understanding how molecules interact with light.
PSO-3	Evaluate the energy scenario along with environment related issues in our society.

Course Objective
After the course, the student should be able to familiar with:
1. Spectroscopy is used in analytical chemistry because atoms and molecules have unique spectra. As a result, these spectra can be used to detect, identify and quantify information about the atoms and molecules.
2. UV/Vis spectroscopy is routinely used in analytical chemistry for the quantitative determination of different analytes, such as transition metal ions, highly conjugated organic compounds, and biological macromolecules.
3. IR spectroscopy measures the vibrations of atoms and based on this it is possible to determine the functional groups. It is used by chemists to determine functional groups in molecules.

4. Nuclear magnetic resonance spectroscopy is widely used to determine the structure of organic molecules in solution and study molecular physics, crystals as well as non-crystalline materials. NMR is also routinely used in advanced medical imaging techniques, such as in magnetic resonance imaging (MRI).
5. Mass spectrometry represents a powerful technique to determine the molecular weight of compounds by separating molecular ions on the basis of their mass and charge.

Course Content

1) ESR Spectroscopy (20 marks):
Basic principle of ESR spectroscopy, Hyperfine coupling, Spin polarization for atoms and transition metal ions, Spin-orbit coupling and significance of g-tensors, application to transition metal complexes, organic molecule including free radicals.

2) NMR Spectroscopy (45 marks):
^{1}H NMR Spectroscopy: Introduction, theory, instrumentation, long range spin-spin interaction, shielding and deshielding effects, interpretation of non-first order NMR; double resonance, Lanthanide shift reagent, INDOR, NOE, effect of solvents (aliphatic and aromatic), preliminary idea on ^{19}F, ^{31}P, ^{14}N, ^{15}N, ^{17}O. NMR of solids, NMR imaging. C^{13} NMR Spectroscopy: Introduction, theory, instrumentation, chemical shift, coupling constants, application in organic molecules, 2D NMR, multidimensional NMR- DEPT, COSY.

3) Mass Spectrometry (35 marks):
Generation of ions, fragmentations and detections; Mc Lafferty rearrangement.
EI, CI, FD, FAB etc; different fragmentation pattern in EI. GC-MS and HR-MS. Application of UV, IR, NMR and MS in structure elucidation.

Course Outcome

CO-1	After studying this course student will know basic information on EPR, UV-VIS, IR, NMR, MS etc. methods.
CO-2	Student will be able to select spectroscopy methods suitable for solving given scientific problem.
CO-3	Student will be able to analyze results of measurements using spectroscopy methods.
CO-4	Student have concern how Nuclear Magnetic Resonance (NMR) spectroscopy became as an analytical chemistry technique used in quality control and research for determining the content and purity of a sample as well as its molecular structure. Student can interpret a 2D spectrum.
CO-5	Explain why Mass spectrometry (MS) is a powerful analytical tool with many applications in pharmaceutical and biomedical field.
CO-6	Explain why like LC–MS, GC–MS and LC/MS/MS becomes sensitive detector for chromatographic techniques.

Reference Books:
1. Organic Spectroscopy by William Kemp.
2. Introduction to Spectroscopy by Donald L. Pavia.
3. Elementary Organic Spectroscopy by Y R Sharma.
4. Structure Determination Using Spectroscopic Methods by Hans J. Reich.
5. Problems in Organic Structure Determination: A Practical Approach to NMR Spectroscopy 1st Edn**.** by Roger G. Linington and Philip G. Williams**.**
6. Organic Structures from Spectra 4th Edn. by L D Field.

Mapping with the POs/ PEOs: Matrix formation for attainments

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	3	2	1	-	2	2	2	-	-
CO-2	-	2	2	3	2	2	2	-	-
CO-3	-	-	-	-	3	3	2	-	-
CO-4	-	-	-	3	3	-	-	-	3
CO-5	-	2	2	-	3	3	-	2	-
CO-6	-	-	2	-	3	3	-	2	-

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2	PSO-3
CO-1	-	3	-
CO-2	-	-	3
CO-3	4	-	-
CO-4	-	3	3
CO-5	2	-	-
CO-6	-	-	3

Course: *Inorganic Chemistry Laboratory* **Code: PCY03P04**
L-T-P: 0-0-6 **Credit: 4**

Program Outcomes (POs):
Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO-5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO-6	Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environ-ments.

PEOs (Program Educational Objectives):

PEO-1	Achievement of confidence in handling chemicals, glassware and instruments professionally in chemical industries and develop the modern techniques.
PEO-2	Successfully apply their practical experience to determine analytical estimation of materials applicable in our daily life.

PSOs (Program Specific Objectives):

PSO-1	Enable the students to learn various fundamental chemical concepts and processes.
PSO-2	Acquisition of skills to pursue and explore the field of much current interest and activity in future research.

Course Objective

1. To understand the basic concepts in systematic methods of qualitative chemical analysis of inorganic salt mixtures.
2. To have exposure to the underlying principle of the chosen analytical method for a particular assays.
3. To know the fundamentals and conditions to obtain a desirable metal complexes and their preliminary characterization.

Course Content

I. Semimicro qualitative analysis

Systematic analysis of inorganic salt mixtures containing six ions including one of the following rare elements: W, Mo, Au, Pt, Pd, Se, Te, V, Ti, Zr, U, Th and Ce and the interfering anion (/phosphate/borate/fluoride).

II. Analytical Techniques (involving volumetric-redox and complexometric, gravimatric, spectrophotometric and chromatographic methods) of investigation in two and three component mixtures.

1. Estimation of iron (II/III) and chromium (III) in a given binary mixture
2. Estimation of iron (II/III) and calcium (II) in a given binary mixture
3. Determination of calcium and magnesium in a given sample of water
4. Separation and determination of Cu(II) and Ni(II) by gravimetric method
5. Spectrophotometric determination of chromium and manganese in a given steel sample
6. Determination of composition of iron(II)-phenanthroline, Fe(III)- sulfo salicylic acid complex by Job's method
7. Spectrophotometric determination of copper-ethylenediammine complex by slope ratio method
8. Thin layer chromatographic separation of Ni, Mn, Co and Zn. Determination of their Rf values
9. Separation of cations by paper/column chromatography
10. Separation of anions by paper/column chromatography

III. Preparation of inorganic compounds:

Following the allied reactions and physical studies includes melting point, conductance measurements, UV-Visible spectroscopy Fluorescence spectroscopy, determination of yield percentage and CFSE value.

i) Hexamminecobalt(III) chloride

ii) Tris(ethylenediamine)cobalt(III) chloride

iii) Dichlorobis(ethylenediamine)nickel(II)

iv) Hexamminenickel(II) chloride

v)Tris(acetylacetonato)iron(III)

vi) Manganese(III)acetylacetonate

vii) Azidopentamminecobalt(III) chloride

Course Outcome

CO-1	Students will have hands-on experience on basic principles in separation and identification of components in inorganic salt mixture.
CO-2	Development of skills in analytical measurements aimed at obtaining qualitative and quantitative information about the composition and structure of various materials that have relevance to both fundamental understanding as well as applications towards improving the quality of life.
CO-3	Training in synthesis of complexes and basic instrumental methods of analysis for their preliminary characterization will pave the way to future research work.

Reference Books:

1. A.I. Vogel, Macro and Semicro qualitative Inorganic Analysis, Orient Longman, 1969.
2. J. Basset, R.C. Denney, G.H. Jeffery and J. Memdham, Vogel's Text Book of quantitative Inorganic Analysis, ELBS, 4th Edn., 1978.
3. H. H. Willard, L. L. Merrit and J.A. Dean, Instrumental methods of analysis, East-West Press, 4th Edn, 1974.
4. G.W. Parshall (Ed. In chief), Inorganic Synthesis, Vol 15, McGraw Hill, P. 48, 1974.
5. D. D. Sood, S. B. Mohaharand, A. V. R. Reddy, Experiments in Radiochemistry Theory and Practice, IANCAS Publications, 1994.
6. W.L. Jolly : Synthesis and characterization of inorganic compounds Prentice Hall Inc.
7. S. C. Das, Advanced Practical Chemistry for 3-Year Honours Course, 6th Edn., 2012

Mapping with the POs/ PEOs: Matrix formation for attainments

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6
CO-1	**2**	**2**	**1**	**-**	**3**	**2**
CO-2	**-**	**2**	**-**	**2**	**-**	**-**
CO-3	**3**	**-**	**2**	**2**	**2**	**2**

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2
CO-1	**4**	**-**
CO-2	**3**	**-**
CO-3	**-**	**4**

Fourth Semester

Course: *Inorganic Photochemistry and Supramolecular Chemistry*
Code: PCY04E08

Program Outcomes (POs):

Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO-5	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO-6	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PEOs (Program Educational Objectives):

PEO-1	Get the fundamental awareness about basics and application of existing chemical and scientific theories.
PEO-2	Understand the vital role of Inorganic Chemistry in our society.
PEO-3	Capability to discover innovative filed of research in both chemistry and allied fields of science and technology.

PSOs (Program Specific Objectives):

Students will be able to

PSO-1	Learn about different of inorganic photochemical reaction and with real life.
PSO-2	Learn the about the application of photo chemically active inorganic complexes to construct solar light driven energy harvesting system.
PSO-3	To pursue higher education along with industrial accomplishments.

Course Objective

(i) To impart knowledge of about the different of inorganic photochemical systems and their applications.

(ii) To impart through knowledge of light driven water splitting using inorganic coordination complexes and to use inorganic reaction mechanisms presented in the literature to solve chemical problems.

(iii) To convey information of vaarious types of supramolecules, structures and their applications as organic-inorganic materials, sensors, and devices.

(iv) To focused on understanding the Chemistry of noncovalent bonding.

Course Content

Inorganic Photochemistry (20 L):

Prompt and delayed reactions, d-d and charge-transfer reactions, transitions in metal-metal bonded systems. Photoreactions of complexes of Cr(III) and Co(III), photo-aquation, photo-substitution and photo-racemization. Photochemistry of $Ru(bpy)_3^{2+}$ and its application as photocatalyst for photo-splitting of water, photooxidation of 2-propanol and photo-reduction of carbon dioxide, cyanide bridged triruthenium(II) bipy complexes as antenna. Photochemistry of diisocyanide bridged diimers of Rh(I). Applications of quenching and sensitization techniques in the identification of reactive state in coordination complexes. Photochemistry of Transition Metal Carbonyls and Europium complexes. Inorganic photochemistry in biological processes and their model studies; application of photochemical reactions of coordination compounds-synthesis and catalysis.

Supramolecular Chemistry (25 L):

Concepts and development, Nature of binding interactions in supramolecular structures: ion-ion, ion-dipole, dipole-dipole, H-bonding, cation-π, anion-π, π-π and vander waal interactions, Supramolecular Chemistry in Life, Ionophores, Porphyrin and other tetrapyrrollic macrocycles, Coenzymes, Neurotransmitters, DNA and biochemical self-assembly. Host–guest Chemistry**:** Synthesis and structures of crown ethers, Lariat ethers, Podands, Cryptands, Spherands, Calixarene, Cyclodextrins, Cyclophanes, Cryptophanes, Carcerands and hemicarcerands, Host-guest interactions, Preorganisation and complimentarity, Lock and key analogy, Binding of cationic, Anionic, Ion pair and neutral guest molecules.

Self-assembly: Self assembly by H-bonding, Catenanes, Rotaxanes, Dendrimers and Supramolecular gels; Relevance of supramolecular chemistry to mimic biological system.

Molecular Devices: Machine, electronic devices, wires, rectifiers, switches and logic gates; Examples of recent developments in supramolecular chemistry from current literature.

Course Outcome

CO-1	Student will learn application of inorganic reaction mechanisms in the areas of industrial synthesis, preparation and biological catalytic processes.
CO-2	Students can develop cost effective portable molecular system for water spiting to generate H_2 as a source of sustainable energy by using the concept of inorganic photochemistry.
CO-3	Acquire the knowledge of specific synthesis of structure and reaction of supramolecules, and nature of bindings involved in biological systems
CO-4	Structure of supramolecules of various types in solid state and applications of supramolecules to construct molecular devices

Reference Books:

1. Jean-Marie Lehn, *Supramolecular Chemistry*, VCH, Weinheim (1995).
2. Beer, P.D., Gale, P. A., and Smith, D. K., *Supramolecular Chemistry*, Oxford University Press (1999).
3. Steed, J. W., and Atwood, J. L., *Supramolecular Chemistry*, Wiley (2000).
4. F. A. Cotton and G. Wilkinson, *Advanced Inorganic Chemistry*, 6th Edn. (1999), John Wiley & Sons, New York.
5. A. K. Das and M.Das *Fundamental Concepts of Inorganic Chemistry: Volume 5*, 1st Edn (2014), CBS Publishers and Distributors.
6. K. K. Rohatagi-Mukherjee, *Fundamentals of Photochemistry*, (1978) Wiley Eastern.
7. M. S. Wrighton, *Inorganic and Organometallic Photochemistry*, ACS Pub.,1978.

Mapping with the POs/ PEOs: Matrix formation for attainments

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	**3**	**2**	**2**	**-**	**-**	**-**	**2**	**2**	**3**
CO-2	**-**	**2**	**-**	**2**	**3**	**3**	**2**	**2**	**-**
CO-3	**2**	**-**	**2**	**2**	**-**	**-**	**2**	**-**	**2**
CO-4	**3**	**-**	**-**	**-**	**3**	**2**	**-**	**-**	**3**

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

Table 2

CO	PSO-1	PSO-2	PSO-3
CO-1	**3**	**4**	**2**
CO-2	**3**	**-**	**3**
CO-3	**4**	**-**	**-**
CO-4	**4**	**2**	**2**

Course: *Organic Named Reactions, Synthesis, Structure and Reactivity*
Code: PCY04E10

Program Outcomes (POs):

Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO -5	Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO-6	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PEOs (Program Educational Objectives):

PEO-1	To provide the knowledge of structure-activity relationships for designing the synthesis of organic molecules
PEO-2	To get the knowledge of planning, designing and execution of synthetic pathways for organic reactions.
PEO-3	To impart the knowledge of Name Reactions and Re-arrangements for practical applications in industries.

PSOs (Program Specific Objectives):

PSO-1	The aim of is to make students familiar with the concepts of planning, designing and execution of synthetic pathways for organic reactions.
PSO-2	The students will be able to apply the name reactions in industrial level synthesis.
PSO-3	To impart the knowledge of industrially used materials for their applications as engineering materials.

Course Objective

1. To provide the knowledge of planning, designing and execution of synthetic pathways for organic reactions.

2. Industrial Organic Chemistry examines all major industrial manufacturing technologies and reaction types with a focus on organic chemistry in general. tructure-activity relationships for designing the synthesis of organic molecules

3. To provide a good platform for scientific and technological research towards synthetic organic chemistry.

Course Content

(1) Quantitative relationship between structure and reactivity (10 L):

Structure and reactivity, types of mechanisms, types of reactions, thermodynamics and kinetic requirements, Linear free energy relations: Hammett equation; equilibrium and rates in organic reactions. The separation of polar, steric and resonance effects: Taft equation.

(2) Design of organic synthesis (15 L)

Planning a synthetic pathway; molecular characteristics: Retrosynthesis, Disconnection approach, synthons, linear and convergent synthesis, Umploung of reactivity and protecting groups.

(3) Name Reactions and Re-arrangements (20 L)

Name reaction in organic synthesis: Pinacol-pinacolone rearrangement, Favorski rearrangement, Fries rearrangement, Knoevenagel reaction, Mannich reaction, Michael reaction, Oppeananer oxidation, Wolf Kishner reaction, Wagner- Meerwein rearrangement, Benzil-Benzilic Acid rearrangement, Beckmann Rearrangement, Diels-alder reaction, Claisen rearrangement, Wittig rearrangement, Mc Murry reaction, Mitsunovo reaction ,Julia olifination Shapiro reaction, Swern oxidation, Baylis-Hilman reaction, Baeyer Villager reaction, Dienone-phenol rearrangement, Neber rearrangement and Stephen rearrangement. Phosphorous ylides and sulphur ylides.

Course Outcome

CO-1	Students will understand the utility of structure-activity relationships for designing the synthesis of organic molecules and can apply them routinely for efficient synthesis of complex organic molecules.
CO-2	The student will be able to meet the demand of present organic materials in the industries
CO-3	The students will understand the nature of organic synthesis and will be able to apply in drug and chemical industries.

Reference Books:

1. March J, Advanced Organic Chemistry, John Wiley, 1992.
2. Thomas Laue, Andreas Plagens Named Organic Reactions, 2nd Edition, John Wiley, 2005.
3. P.S Kalsi, Organic synthesis through disconnection approach, 2nd Edition, Medtech, 2017.

Mapping with the POs/ PEOs: Matrix formation for attainments

S- Strong, M-Moderate and W-Weak

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	**M**	**S**	**S**	**M**	**S**	**S**	**S**	**-**	**-**
CO-2	**S**	**M**	**M**	**S**	**S**	**S**	**-**	**S**	**S**
CO-3	**S**	**M**	**M**	**M**	**S**	**S**	**-**	**-**	**S**

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2	PSO-3
CO-1	**4**	**2**	**3**
CO-2	**4**	**-**	**2**
CO-3	**3**	**4**	**3**

Course: *Molecular Spectroscopy-Theory and Instrumentation*
Code: PCY04E12

Program Outcomes (POs):

Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO-5	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-6	Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PEOs (Program Educational Objectives):

PEO-1	Acquire the fundamental principles of molecular spectroscopy with modern experimental and theoretical skills.
PEO-2	Ability to analyse the problems in the context of practical relevance to the society.
PEO-3	Enhancing their professional growth along with scientific knowledge through continuing education.

PSOs (Program Specific Objectives):

Students will be able to

PSO-1	Molecular Spectroscopy course provides an introduction to the knowledge of the spectroscopy methods about structure of the chemistry compounds, as well as experimental usage of chosen methods (IR, NMR, and UV- VIS).
PSO-2	Understanding of these concepts is fundamental in understanding how molecules interact with light.
PSO-3	Evaluate the energy scenario along with environment related issues in our society.

Course Objective

1. Understand quantum chemical principles
2. Student will know the basic physical chemistry law that govern molecular spectroscopy
3. The course provides an introduction to molecular spectroscopy.
4. Some of the fundamental concepts used in understanding molecular spectroscopy will be discussed in detail.
5. Understanding of these concepts is fundamental in understanding how molecules interact with light.
6. Finally the course provides specific study of the application of molecular spectroscopy to different areas of science.

Course Content

(1) Atomic and Molecular Spectroscopy (25 L):

Vector model of atom; Stern-Gerlach experiment; atomic term symbol; many electron system and antisymmetry principle; atomic spectra; pure rotational and vibrational spectra of diatomic and polyatomic molecules; vibrational-rotational coupling; Raman spectroscopy of molecules; electronic spectra of molecules; selection rules for vibrational, electronic and Raman spectra; introduction to resonance spectroscopy: NMR, ESR, hyperfine interaction, photoelectron spectroscopy, Auger spectroscopy, Mössbauer spectroscopy.

(2) Spectroscopy and Instrumentation (20 L):

Fundamentals of 2D- and FT-NMR; Auger spectroscopy; analytical techniques based on Auger spectroscopy; X-ray photoelectron spectroscopy; UV-photoelectron spectroscopy; SEM; TEM; surface enhanced Raman spectroscopy; single molecule spectroscopy; 3-photon echo spectroscopy; fluorescence spectroscopy; lasers: fundamentals, Q-switched and mode-locked; ultra fast lasers to determine excited state lifetime and dynamics.

Course Outcome

CO-1	Student will know basic information on molecular methods (IR, Raman, UV-VIS, NMR, EPR).
CO-2	Student will be able to select molecular spectroscopy methods suitable for solving given scientific problem.
CO-3	Student will be able to analyze results of measurements using molecular spectroscopy methods.
CO-4	Student shows interest in the phenomenon of the interaction of light with matter in terms of the relationship with the molecular structure
CO-5	Explain why atomic spectra consist of lines whereas molecular spectra at room temperature are broad and continuous.
CO-6	Explain the difference between a 3- and 4-level laser and why it is not possible to have a 2-level laser.

Reference Books:

1. *Fundamentals of Molecular Spectroscopy*, C.N. Banwell, E.M. McCash, 4th Edn., McGraw-Hill.
2. *Modern Spectroscopy*, J. Michael Hollas, 4th Edn., Wiley.
3. *Introduction to Spectroscopy*, D. L. Pavia, G. M. Lampman, George S. Kriz, Cengage Learning India Pvt. Ltd.
4. *Introduction to Molecular Spectroscopy*, G. M. Barrow, McGraw Hill.
5. *Molecular Spectroscopy*, I. N. Levine, Wiley.
6. *Molecular Spectra and Molecular Structure I,II,III*, G. Herzberg.

Mapping with the POs/ PEOs: Matrix formation for attainments

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	**3**	**2**	**2**	**-**	**2**	**-**	**2**	**-**	**-**
CO-2	**-**	**2**	**2**	**3**	**-**	**3**	**2**	**-**	**-**
CO-3	**-**	**-**	**-**	**-**	**3**	**-**	**2**	**-**	**-**
CO-4	**2**	**-**	**-**	**3**	**-**	**3**	**-**	**-**	**3**
CO-5	**-**	**2**	**2**	**-**	**-**	**-**	**-**	**2**	**-**
CO-6	**2**	**-**	**2**	**-**	**3**	**3**	**-**	**2**	**-**

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2	PSO-3
CO-1	**-**	**4**	**-**
CO-2	**-**	**-**	**3**
CO-3	**4**	**-**	**-**
CO-4	**-**	**-**	**2**
CO-5	**2**	**-**	**-**
CO-6	**-**	**-**	**-**

Course: *Chemistry of Nanomaterials*
Code: PCY04E13

Program Outcomes (POs):

Programs must validate that their students achieve the following outcomes

PO-1	Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
PO-2	Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3	Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4	Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO-5	Understand the impact of the professional and engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-6	Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PEOs (Program Educational Objectives):

PEO-1	Obtain the fundamental principles of chemistry with modern experimental and theoretical skills.
PEO-2	Ability to analyse the problems in the context of practical relevance to the society while maintaining environmental safety and economic factors.
PEO-3	Enhancing their professional growth along with scientific knowledge through continuing education.

PSOs (Program Specific Objectives):

Students will be able to

PSO-1	Familiar with all the different types of newly discovered carbon structures, known as fullerenes, nanotubes and graphene.
PSO-2	Understanding the importance of basic chemistry behind the properties of materials at the nanometre range.
PSO-3	Enhancing their professional growth along with the knowledge through continuing education the fundamental principles nanoscience and nanotechnology

Course Objective

1. Basic approaches to synthesize inorganic colloidal nanoparticles and their self-assembly in solution and surfaces

2. Acquire knowledge about theproperties chemical reactions of fullerenes, especially C_{60}, and idea about how carbon nano tubes is synthesized by different method and their properties.

3.To deliver a broad knowledge of synthetic methodologies for the synthesis of graphene oxide and basic concepts about properties of graphene and oxidised product graphene oxide.

4. To advance usage of chemistry for modern technology and to introduce students to inter- and multi-disciplinary science and engineering.

Course Content

Introduction to Nanomaterials (15 L):

Scientific revolution; atomic structures-molecular and atomic size; Bohr radius; emergence of nanomaterials; synthesis of zero, one, two, three dimensional nanostructured materials; size effects on properties; surface plasmon resonance, quantum confinement; synthesis and fabrication: top-down and bottom-up; solution based synthesis, vapour-phase synthesis, sol-gel method, lithography method, synthesis using frameworks, supports and substrates.

Chemistry of Carbon Nanomaterials (20 L):

(i) Fullerenes: discovery of fullerenes, synthesis of fullerenes, structural feature of fullerenes, properties of fullerenes, chemical reactivity of fullerenes, Osmylation reaction, addition reaction, substitution reaction, photo chemical reaction polymerisation reaction, classification of fullerenes: exohedral and endohedral fullerenes, application of fullerenes.

(ii) Carbon nanotubes: synthesis of carbon nanotubes by arc discharge method, laser ablation method and chemical vapour disposition method**,** role of transition metal catalyst in the growth of CNTs Vapour-liquid-solid (VLS) growth and solution-liquid-solid (SLS) growth of the carbon nano tubes and its application in various field.

(iii) Graphene and graphene oxide: discovery of graphene, preparation of graphene oxide by Hummer's Method, formation mechanism of graphene oxide, top-down approach of synthesis of graphene oxide, bottom-up approach to synthesis of graphene oxide, comparison among graphene, graphene oxide and reduced graphene oxide, properties of graphene and graphene oxide, reaction of graphene oxide with acid and base, reduction reaction, non-covalent chemistry of graphene oxide, Raman spectra and optical properties of graphene oxide, photoluminescence property of graphene oxide, graphene oxide, quantum dots.

Application of Nanomaterials (10 L):

Waste water treatment by using nanoparticles, catalytic oxidation of CO to CO_2 at lower temperature by nanoparticles, nano composite materials for photochemical water splitting, for solar cell and lithium-ion batteries, drug delivery; bio-conjugation; sensing.

Course Outcome

CO-1	Student will learn about various techniques to synthesis of scalable nano domain materials and usage of chemistry for modern technology.
CO-2	Students will learn about the importance of nano carbon materials like CNTs, graphene etc in modern science
CO-3	Students should be able to recognise application of fullerenes, CNTs, graphene in energy harvesting system
CO-4	Student can be able to join a research group in nanoscience nanotechnology as a student researcher having prior knowledge in chemistry of nanomaterials.

Reference Books:

1. C. N. R. Rao, A. Müller and A. K. Cheetham, Nanomaterials Chemistry: Recent Developments and New Directions, John Wiley & Sons, 2007.
2. A. M. Dimiev and S. Eigler, Graphene Oxide: Fundamentals and Applications, John Wiley & Sons, 2016.
3. A. K. Das, An Introduction to Nanomaterials and Nanoscience, CBS Publishers & Distributors Pvt. Ltd., 2017.
4. T. Pradeep, Nano: The Essentials, Tata McGraw-Hill Education, 2007.

Mapping with the POs/ PEOs: Matrix formation for attainments

1: Slight (Low) 2: Moderate (Medium) 3: Substantial (High) and for No Correlation "-"

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PEO-1	PEO-2	PEO-3
CO-1	**M**	**M**	**-**	**M**	**M**	**-**	**M**	**M**	**-**
CO-2	**M**	**M**	**M**	**M**	**-**	**M**	**M**	**-**	**M**
CO-3	**-**	**S**	**S**	**S**	**M**	**M**	**M**	**S**	**-**
CO-4	**M**	**M**	**S**	**M**	**S**	**M**	**-**	**-**	**S**

To establish the correlation between COs & PSOs

2: Slight (Low) 3: Moderate (Medium) 4: Substantial (High) and for No Correlation "-"

CO	PSO-1	PSO-2	PSO-3
CO-1	**3**	**4**	**-**
CO-2	**3**	**2**	**3**
CO-3	**4**	**-**	**2**
CO-4	**4**	**3**	**2**