Department of Chemistry, School of Basic Sciences, CSJM University, Kanpur

Minutes of Meeting of Board of Studies

An online meeting of Board of Studies of Chemistry Department, School of Basic Sciences, was held on 7th July' 2023 at 12:15 pm to modify the syllabus of M.Sc. Chemistry/ M.Sc. Industrial Chemistry, two year (Four Semester) programme. The following members (as approved by the Vice Chancellor, CSJM University) attended the meeting.

1. Prof. Deepak Srivastava, Department of Plastic Technology, HBTU- External Member

2. Dr. Debashis Adhikari, Associate Professor, Dept. of Chemical Sciences, IISER Mohali, Mohali-140306-External Member.

3. Prof. Sudhir Kumar Srivastava, Dean, Science faculty, Department of Chemistry, DAV College, Kanpur- Internal Member

4. Prof. Meet Kamal Dwivedi, Dept. of Chemistry Christ Church P.G. College, Kanpur-208001- Internal Member

5. Dr. B.P. Singh, Department of Chemistry, CSJM University, Kanpur- Internal Member

6. Dr. Rashmi Dubey, Department of Chemistry, CSJM University, Kanpur- Internal Member

7. Dr. Dhananjay Dey, Coordinator, Dept. of Chemistry, CSJM University, Kanpur- internal Member.

8. Prof. R. K. Dwivedi, Director, School of Basic Sciences, CSJM University, Kanpur- Convenor.

Special Invitees:

1) Dr. Ratna Shukla, Dept. of Chemistry, CSJM University, Kanpur.
2) Dr. P.S. Niranjan, Dept. of Chemistry, CSJM University, Kanpur.
3) Dr. Meraj Jafri, Dept. of Chemistry, CSJM University, Kanpur.

10.07.2023

The syllabus was discussed in detail. Following modifications have been done to our existing M.Sc. NEP implemented syllabus:

1. One unit related to the Indian Knowledge system is included in the Paper first –Inorganic Chemistry- I of the first semester as recommended by the BOS Members.

2. The following courses have been shifted from the second semester to the fourth semester:

Environmental Chemistry

3. The following course has been shifted from semester fourth to third: Advanced organic chemistry

4. Paper name of open elective for other department i.e. "Industrial Applications in Chemistry" has been changed as "Applications of Chemistry" and first unit has been replaced by Medicinal Chemistry.

5. Last semester courses classes can be in online mode and the courses can be taken through MOOC/NPTEL

6. In the last semester the Research Project credit has been increased from 8 to 16.

Students will be doing four-month internship/field work followed by the dissertation, presentation and viva

Department of Chemistry, School of Basic Sciences, CSJM University, Kanpur

Minutes of Meeting of Board of Studies

Prof. Deepak Srivastava,
Dept. of Plastic Technology
HBTU.

Dr. Debashis Adhikari
Associate Professor
Dept. of Chemical Sciences
IISER Mohali

Prof. Sudhir Kumar Srivastava
Dean, Science Faculty
DAV College

Prof. Meet Kamal
Dept. of Chemistry
Christ Church P.G. College

Dr. B.P. Singh
Dept. of Chemistry
CSJM University

Dr. Rashmi Dubey
Dept. of Chemistry
CSJM University.

Dr. Ratna Shukla
Dept. of Chemistry
CSJM University.

Dr. P.S. Niranjan
Dept. of Chemistry
CSJM University.

Dr. Meraj Jafri
Dept. of Chemistry
CSJM University.

Dr. Dhananjay Dey (Coordinator)
Dept of Chemistry
CSJM University.

Dr. R.K. Dwivedi (Convenor)
Director, School of Basic Science
CSJM University

Proposed Syllabus
for
M.Sc. Chemistry
(NEP)
CHOICE BASED CREDIT SYSTEM

Department of Chemistry

CSJM UNIVERSITY, CAMPUS

Kanpur

Syllabus of M.Sc. (Chemistry)

Department of Chemistry

School of Basic Sciences

CSJM University Campus, Kanpur

Semester wise – Distribution of Course

Total Marks- 2100, Total Credit- 98

1Credit = 1hour/week

L= Lecture, T= Tutorial, P= Practical

Total classes for each paper per semester = 50

	IST YEAR / IST SEM					
COURSE CODE	**TYPE**	**COURSE TITLE**	**MIN CREDITS**	**CIA**	**ESE**	**MAX. MARKS**
B02U0701T	CORE I	Inorganic Chemistry I	4	25	75	100
B02U0702T	CORE II	Organic Chemistry I	4	25	75	100
B02U0703T	CORE III	Physical Chemistry I	4	25	75	100
B02U0704T	CORE IV	Analytical Chemistry	4	25	75	100
B02U0705P	PRACTICAL	Inorganic chemistry Practical	4	25	75	100
	PROJECT	RESEARCH PROJECT				-
	TOTAL		20			500
IST YEAR / IIND SEM						
B02U0801T	CORE V	Inorganic Chemistry II	4	25	75	100
B02U0802T	CORE VI	Organic Chemistry II	4	25	75	100
B02U0803T	CORE VII	Physical Chemistry II	4	25	75	100
B02U0804T B02U0805T	ELECTIVES	Polymer Chemistry Liquid State	4	25	75	100
B02U0806P	PRACTICAL	Organic Chemistry Practical	4	25	75	100
B02U0807R	PROJECT	RESEARCH PROJECT	8	25	75	100
	MINOR ELECTIVE FROM OTHER FACULTY (IN IST YR- Ist/IInd SEM)*		4/5/6	25	75	100
	TOTAL		32			700
IIND YEAR / IIIRD SEM						
B02U0901T	CORE VIII	Applications of Spectroscopy	4	25	75	100
B02U0902T	CORE IX	Advance Principles of Physical Chemistry	4	25	75	100
B02U0903T B02U0904T	ANY TWO ELECTIVES TO BE CHOSEN	1. Inorganic Chemistry-III 2.Bio-organic Chemistry 3.Nano Chemistry	4	25	75	100
B02U0905T B02U0906T B02U0907T		4. Chemistry of Materials, Petrochemicals and Fertilizers 5. Advanced organic chemistry	4	25	75	100

B02U0908P	PRACTICAL	Physical Chemistry Practical	4	25	75	100
	PROJECT	RESEARCH PROJECT				-
	TOTAL		20			500
IIND YEAR / IVTH SEM						
B02U1001T	ANY TWO ELECTIVES TO BE CHOSEN	Environmental Chemistry	5	25	75	100
B02U1002T		Advanced Physical Chemistry	5	25	75	100
B02U1003T		Advanced Inorganic Chemistry				
B02U1004T		Applications of Chemistry in Industries				
B02U1005T		Green Chemistry				
B02U1006T		Photochemistry				
B02U1007T		Atomic and Molecular Spectroscopy				
B02U1008R	PROJECT	RESEARCH PROJECT	16	50	150	200
	TOTAL		26			400
GRAND TOTAL		**(I + II) Year**	98			**2100**

NOTE:

1. * A Minor Elective from other faculty shall be chosen In 1st Year (Either Ist / IInd Semester) as per availability.
2. Last semester of master's programme shall comprise of 4 to 6 months training/ Internship along with two theory papers (to be chosen by students amongst a basket of elective papers).
3. For the students of II year /IV semester the theory classes will be conducted in online / offline (hybrid) mode at the university or the credits may be earn via MOOC courses. Accordingly, a list of relevant courses offered in that session and the assign credits shall be intimated to the students by the MOOC nodal officer and course coordinators.
4. Research project can be done in form of Internship/Survey/Field work/Research project/ Industrial training, and a report/dissertation shall be submitted that shall be evaluated via seminar/presentation and viva voce.
5. The student straight away will be awarded 25 marks if he publishes a research paper on the topic of Research Project or Dissertation

Debarki Adhikari

Rahul

Rahul

10.07.2023

Semester I

Paper I: B02U0701T

Inorganic Chemistry-I *Credits:4*

Outcome: At the end of this course student is able to

CO1	Acquire the knowledge and have the ability to describe the bonding, MO theory, and molecular term symbols of inorganic molecules & ions.
CO2	Understand the metal-ligand bonding, crystal field theory, spectrochemical series, and Jhan teller effect.
CO3	Understand the fundamentals of electronic spectroscopy, Orgel and Tanabe-Sugano diagrams for transition metal complexes
CO4	To learn about the formation and stability of metal complexes and their determination
CO5	Understand the chemistry of inert & labile complexes and the substitution reaction of inorganic complexes. Mechanistic aspects of different types of reaction of metal complexes in solution.
CO6	Learn the ancient history of indian chemistry, use of chemistry in medicine and Metallurgy.

Course details:

Unit 1: Indian Knowledge System

The ancient history of Indian chemistry, Various treatises on Chemistry, the use of chemistry in medicines, Metallurgy, Use of chemistry for occult practices.

Unit 2: Chemical Bonding

Walsh diagram; Evidence of MO pictures from spectra and reactivity; Molecular term symbols (ground & excited state). $p\pi$ - $d\pi$ bonding , 3C-2e bonding, μ-bond, δ-bond.

Unit 3: Metal ligand bonding & electronic spectra

Crystal field theory, Splitting of d orbitals .Crystal field stabilization energies in weak field and strong field environments, spectrochemical series and Jahn-Teller effects on energy levels spin-orbit coupling, quenching of orbital contribution,. Spectroscopic ground states, correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1 –d^9 states), calculations of Dq, B and β parameters, charge transfer spectra

Unit 4: Metal Ligand Equilibrium

Equilibria Stability of mononuclear, polynuclear mixed ligand complexes in solution, Stepwise

and overall formation constants, trends in stepwise constants factors affecting the stability of metal complexes – chelate effect, determination of stability constants.

Unit 5: Reaction Mechanism

Inert and labile complexes-Explanation of lability on the basis of CFSE. Substitution reactions (dissociative, associative, Id, & Ia mechanisms) in square planar, tetrahedral and octahedral geometries with special reference to d^n ion complexes.

Books Recommended:

TEXT BOOKS

1. Ancient Indian Sciences – B. Seal.
2. Science in Ancient India (Science of the Past) – Melissa Stewert

REFERENCE BOOKS

3. D. F. Shriver, P. W. Atkins and C. H. Langford, *Inorganic Chemistry*, Oxford University Press, New York (1990.)
4. B. Douglas, D. McDaniel and J. Alexander, *Concepts and Models of Inorganic Chemistry*, 3rd Edn, John Wiley and Sons, Inc., New York (2001). .
5. J. E. Huheey, E. A. Keiter and R. L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th Edn, Harper Collins College Publishers, New York (1993).
6. T. P. Fehlner, J. –F. Halet and J. –Y. Saillard, *Molecular Clusters — A Bridge to Solid State Chemistry*, Cambridge University Press, Cambridge (2007).).
7. M. Driess and H. Noth (Eds.), *Molecular Clusters of the Main Group Elements*, Wiley-VCH, Weinheim (2004).
8. O. Kahn, *Molecular Magnetism*, VCH, New York (1993).
9. P. Braunstein, L. A. Oro and P. R. Raithby (Eds.), *Metal Clusters in Chemistry*, Wiley-VCH, Weinheim (1999).
10. M. H. Chisholm (Ed.), *Early Transition Metal Clusters with π-Donor Ligands*, VCH, New York (1995).
11. J. D. Lee, *Concise Inorganic Chemistry*, Chapman and Hall, London (1991).

Debashis Adhikari

Semester I

Paper II: B02U0702T
Organic Chemistry-I *Credits:4*

Outcome: At the end of this course student is able to:

CO1	Learn the concept of aromaticity & different types of reactive intermediates.
CO2	Learn modern synthetic methods for the preparation of heterocyclic compounds and their structural elucidation.
CO3	Learn the concept of thermal & photochemical reactions.
CO4	Learn the different types of organometallic compounds and their uses in organic synthesis
CO5	Learn the different types of rearrangement reactions in organic synthesis.

Course details:

Unit 1: Reactive intermediates & Aromaticity
General methods of generation, detection, stability, reactivity and structure of the intermediates, Classical and non-classical carbocations and carbanions; radicals, radical cations, radical anions, carbenes, arynes and nitrenes, Aromaticity: Concept of aromaticity, benzenoid and non-benzenoid aromatic compounds.

Unit 2: Pericyclic Reactions
Cycloaddition, Electrocyclic, Sigmatropic and Cheletropic reactions.

Unit 3: Heterocyclic synthesis
Introduction, synthesis and properties of Thiophene, Furan, Pyridine, Pyrrole, Quinoline and Indole.

Unit 4: Reagents in Organic synthesis
Grignard reagent, $NaBH_4$, $LiAlH_4$, Gilman's reagents, Lithium dimethyl cuprate, DDQ, oxidising agents: SeO_2.

Unit 5: Rearrangement and Reactions

Pinacol/Pinacolone Rearrangement, Wagner-Meerwein Rearrangement, Wolff Rearrangement, Hofmann Rearrangement, Curtius Reaction, Lossen Rearrangement, Schmidt Reaction, Beckmann Rearrangement, Favorskii Rearrangement and Claisen Rearrangements, Aldol Reaction, Perkin Reaction,Stobbe Reaction, Reimer-Tiemann Reactions.

Books Recommended:

REFERENCE BOOKS

1. Clayden, Greeves, Warren and Wothers, *Organic Chemistry*, Oxford University Press (2001).
2. M.B. Smith & Jerry March, *March's Advanced Organic Chemistry*, 5th Edition, John Wiley & Sons, New York (2001).
3. Peter Sykes, *A Guide book to Mechanism in Organic Chemistry*, 6th Edition, Orient Longman Ltd., New Delhi (1997).
4. S. M. Mukherjee and S.P Singh , *Reaction Mechanism in Organic Chemistry*, Ist Edition , Macmillan India Ltd., New Delhi (1990).
5. T.H. Lowry and K.S. Richardson, *Mechanism and Theory in Organic Chemistry*, 3rd Edition, Addison–Wesley Longman Inc. (IS Edition) (1998).
6. G.S. Zweifel and M.H. Nantz, *Modern Organic Synthesis*, Freeman and Company, New York (2007).
7. M.S. Singh, *Advanced Organic Chemistry: Reactions and Mechanism*, Pearson Education (Singapore) Pvt. Ltd. (2005).
8. S.M. Mukherjee and S.P. Singh, *Pericyclic Reactions*, Mac Millan India, New Delhi (1980).
9. Jagdamba Singh and LDS Yadav, Advanced Organic Chemistry/Organic synthesis, Pragati Prakashan (2011).
10. I. Fleming, *Pericyclic Reactions*, Oxford University Press, Oxford (1999).

Debashis Adhikari

Semester I

Paper III: B02U0703T
Physical Chemistry-I *Credits: 4*

At the end of this course student is able to:

CO1	Understand different laws of chemical kinetics, chemical thermodynamics, statistical thermodynamics, and electrochemistry.
CO2	Analyse the complex reaction kinetics, apply the concept of kinetics to experimental techniques for fast reaction, phase equilibria and phase rule of different systems, semiconductor and electrolyte interface etc.
CO3	Apply the concept of ensembles, partition function in the case of monoatomic and diatomic molecules
CO4	Identify the metal electrolyte interface and its application in different systems.
CO5	Apply the concept of Semiconductor/electrolyte Interface to different applications.

Course details:

Unit 1: Chemical Kinetics
Rate laws and temperature dependence, steady state approximation, kinetics of complex reactions, oscillatory reactions (Belousov- Zhabotinskii reaction), determination of reaction mechanism, collision and transition state theories of rate constant, Catalysis and enzyme kinetics, experimental techniques for fast reactions(stopped-flow, temperature-jump and flash photolysis).

Unit 2: Chemical thermodynamics
Thermodynamics properties: enthalpy, entropy, free energy, Partial molar properties in ideal mixture, chemical potentials, its determination and variation with temperature and pressure, Gibbs -Duhem equation. Fugacity and activity, variation with temperature and pressure, variation of Fugacity of a gas mixture, Duhem- Margules equation and its application. Le-Chatelier's principle, Phase equilibria and phase rule, thermodynamics of ideal and non-ideal gases and solutions.

Unit 3: Statistical Thermodynamics
Introduction: concept of ensembles, Thermodynamic probability, Boltzmann distribution law, Boltzmann Planck equation and its significance, Fermi-Dirac and Bose -Einstein distribution ,Translational, Rotational , Vibrational and Electronics partition function, its application in the case of monoatomic and diatomic molecules.

Unit 4: Electrochemistry

Electrochemistry of solutions, Deby- Huckel – Onsager treatment and its extension , Metal / Electrolyte interface: OHP and IHP, potential profile across double layer region, potential difference across electrified interface; structure of the double layer: Helmholtz-

Perrin, Gouy-Chapman, and Stern models.

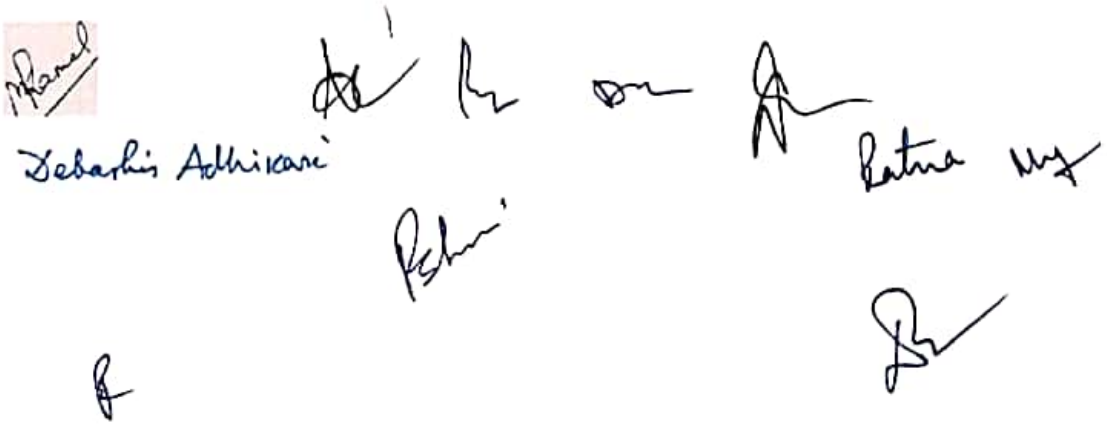
Unit 5: Semiconductors(SC)/ Electrolyte Interface

Semiconductor (SC)/electrolyte interface: Creation of space charge region, capacity of space-charge, Mott-Schottky plots for n-type and p-type semiconductors, determination of flat-band potential and donor/acceptor densities, application of SC/electrolyte interface in solar cells.

Books Recommended:

REFERENCE BOOKS

1. J.O. M. Bockris and A.K.N. Reddy, *Modern Electrochemistry*, Vol.2A & B, 2nd Ed. Plenum Press, New York (1998).
2. E. Fermi, *Thermodynamics*, Dover Publications , New York (1956). . E. Fermi, *Thermodynamics*, Dover Publications , New York (1956).
3. K. J. Laidler, *Chemical Kinetics*, 3rd Ed. Harper & Row, New York (1987).
4. P. W. Atkins and J. D. Paula, *Physical Chemistry*, 8th Ed., Oxford University Press, New York (2006).
5. Ira N. Levine, *Physical Chemistry*, 5thEd., Tata Mc Graw Hill Pub. Co. Ltd. ,New Delhi (2001).
6. P.W. Atkins, *Comprehensive Physical Chemistry*, Oxford University Press, New York (2006).



Semester I

Paper IV: B02U0704T
Analytical Chemistry *Credits:4*

Outcome: After successfully completing this course students will be able to

CO1	Purification, separation, and identification of compounds need special techniques.
CO2	Knowledge of solvent extraction
CO3	Basics and application of electron microscopies like SEM and TEM
CO4	Separation of mixtures using different chromatographic Techniques

Course details:

Unit 1: Basics of Filtration Processes:

Introduction to unit processes and unit operations, Screening, Mixing, Coagulation and Flocculation, Sedimentation: Type of settling, Filtration for wastewater treatment. Types of filters -rapid sand filter, slow sand filter, high rate filter, pressure filter. Gravitational settling, Centrifugal impaction, Inertial impaction, Diffusion, Electrostatic precipitation,

Unit 2: Electron Microscopy:

Introduction, Principle and Instrumentation of Scanning Electron Microscope(SEM) and Transmission Electron Microscope (TEM).

Unit 3: Separation Techniques:

Solvent extraction (liquid-liquid extraction), general principles, relationship between extraction and distribution coefficient, distribution ratio, multiple extractions, extraction of metal organic complexes and ion association complexes.

Unit 4: Chromatographic Techniques:

Classification, basic principles and theory of chromatography, Paper and thin-layer chromatography: various techniques of development, visualization and evaluation of chromatograms, Ion-exchange chromatography: ion exchange process, synthesis and structure of ion-exchange resin, resolution, retention parameters, ion-exchange capacity.

Unit 5: Thermal Analysis:

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.

Books Recommended:

TEXT BOOKS

1. Bassette and co-workers, *Vogel's Textbook of Quantitative Chemical Analysis, Longman Group UK (1989).*

REFRENCE BOOKS

2. C.N Banwell , *Fundamentals of Molecular Spectroscopy,4th Ed.,* McGraw Hill Education (2017).
3. M.H. Willard, L.L. Merrit, , J.A. Dean, F.A. Settle, *Instrumental Methods of Analysis,* 7th Ed. , CBS Publishers & Distributors (2004).
4. F.W. Fifield, D. Kaley , *Principles and Practice of Analytical Chemistry, 4th Ed., Blackie Academic and Professional (1995).*

Semester 1

Paper V: B02U0705P

Inorganic Chemistry Practical

Credits:4

Outcome: After successfully completing this course students will be able to

CO1	Ability to separate and identify different cations and anion from a mixture of inorganic salts.
CO2	Understanding the principles of separation and analysis of different ions and their applications in real fields.
CO3	Learn the techniques of chromatographic separation of mixture of cations and anions.
CO4	Understanding the principles of Iodometric titration and gravimetric analysis of different ions and their applications in real fields.
CO5	Ability to prepare different types of transition metal complexes.

Course details:

1. Qualitative analysis of inorganic mixture salts containing six-radicals including rare element salts and interfering radicals.
   a) Qualitative analysis of acid radicals
   b) Qualitative analysis of basic radicals
   c) Qualitative analysis of interfering radicals.
2. Quantitative analysis
   a) Estimation of chloride ion in water sample.
   b) Estimation of copper in a solution of cupric salts.
   c) Estimation of nickel by gravimetric analysis
3. Determination of total hardness of water.
4. Preparation of inorganic and coordination compounds and their characterization
   a) hexaaminenickel(II)chloride
   b) tetraamminecopper(II)sulphate monohydrate.
   c) Trans-K[$Cr(C_2O_4)_2(H2O)_2$]
   d) Tris(thiourea) copper(I) complex
   e) Co(Salen) complex

Books Recommended:

TEXT BOOK

1) A. I. Vogel, *A Text Book of Quantitative Inorganic Analysis*, 3rd Ed., Longmans (1961).

REFERENCE BOOKS

2. M. Kolthoff, P. J. Elving and E. B. Sandell , *Treatise on Analytical Chemistry*, Pt-I, II, III, The Interscience Encyclopedia, Inc., New York (1959).

Semester II

Paper VI: B02U0801T
Inorganic Chemistry-II

Credits: 4

Outcome: After successfully completing this course students will be able to

CO1	Understand the structure and bonding in boranes, styx rule, wades rule .
CO2	Understand the chemistry of d-block elements and their spectral and magnetic properties
CO3	Understand the chemistry of lanthanides and actinides elements.
CO4	Learn the chemistry of metal clustures, skeletal electron count, isolobal analogy, capping rule.

Course details:

Unit 1: Chemistry of s and p block elements
Classification, synthesis, reaction, structure and bonding in Boranes, Nitrogens and Phosphorous compounds, Lipscomb's topological concept, styx rule, Wade's rules. Alkali metal complexes with macrocyclic ligands, Aqueous and complex chemistry of beryllium and aluminium.

Unit 2: Chemistry of d block elements
Synthesis, structure, reactions properties and bonding of 4d and 5d elements. molybdenum blue, tungsten blue, ruthenium blue, platinum blue, tungsten bronze, ruthenium red.

Unit 3: Chemistry of f Block Elements
Chemistry of Lanthanide: electronic configurations – oxidation states – Lanthanide contraction –its consequences – magnetic and spectral properties – occurrence, extraction and separation techniques , Use of lanthanides and their compounds.

Chemistry of Actinides: Synthesis of Trans uranium - electronic configurations – oxidation states position in the periodic table – actinide contraction – comparsion of magnetic and spectral properties of actinides with those of lanthanides

Unit 4 : Organometallic Chemistry
Historical development, classification, nomenclature, valence electron count, oxidation number and formal ligand charge. 18-electron rule, concept of hapticity; synthesis, structure and bonding of homo and heteroleptic metal-carbonyls, nitrosyls, alkyls, alkenes, allyl, alkynes, and arenes.

Unit 5: Metal Clusters
Cages and metal clusters, Metal carbonyl clusters: skeletal electron counting, Wade-Mingos-

Louher rule, Application of isolobal and isoelectronic relationships, capping rules, carbide, nitride, chalcogenide and halide containing clusters Cr, Re, Nb, Ta, Mo and W clusters, Cluster compounds in catalysis.

Books Recommended:

Reference books

1. F. Basaloand R.G. Pearson, *Mechanism of Inorganic Reactions*, 2nd Ed., Wiley Eastern Ltd., New Delhi (1967).
2. D.F. Shriver and P.W. Atkins, *Inorganic Chemistry*, 3rd Ed., ELBS, London (1999).
3. F.A. Cotton and G.Wilkinson, *Advanced Inorganic Chemistry*, 6th Ed., John Wiley & Sons, New York (1999).
4. Keith F. Purcell and John C. Kotz ,*Inorganic Chemistry*, W.B. Sauders Com., Hong Kong (1987).
5. Martin L. Tobe and John Burgess, *Inorganic Reaction Mechanisms*, 1st Ed. Longmans (1999).

Semester II

Paper VII: B02U0802T
Organic Chemistry-II

Credits:4

Outcome: After successfully completing this course students will be able to

CO1	Learn the basic concept of Stereochemistry & its applications.
CO2	Learn the mechanism of addition reactions
CO3	Learn the mechanism of different types of substitution reactions.
CO4	Learn the basic photochemistry & different types of photochemical reactions

Course details:

Unit 1: Stereochemistry

Molecular symmetry and chirality, stereoisomerism: definitions, classifications, configuration and conformation (R-S), Conformational analysis of n-Butane, cyclohexane and decalenes, optical activity in bi-phenyl, allenes and spiranes

Unit 2: Addition to carbon-carbon multiple bonds

Addition to carbon-carbon multiple bonds: Addition reactions involving electrophiles, nucleophiles and free radicals, cyclic mechanisms. Orientation and reactivity, Hydrogenation, Hydroboration, Oxymercuration, Sulfenylation, Seleneylation, 1, 3- dipolar species addition, Hydoxylation: Prevost & Woodward hydroxylation, Using $KMnO_4$ and OsO_4, Epoxidation, Sharpless asymmetric epoxidation, Michael reaction, Prins reaction, Addition to cyclopropane ring, Addition to conjugated system.

Unit 3 : Aliphatic ,Electrophilic and nucleophilic substitution reaction

Nucleophilic (SN^1 & SN^2) substitution reaction, Electrophilic substitution reaction. Elimination reaction, Regioselectivity

Unit 4: Photochemistry of Carbonyl Compounds

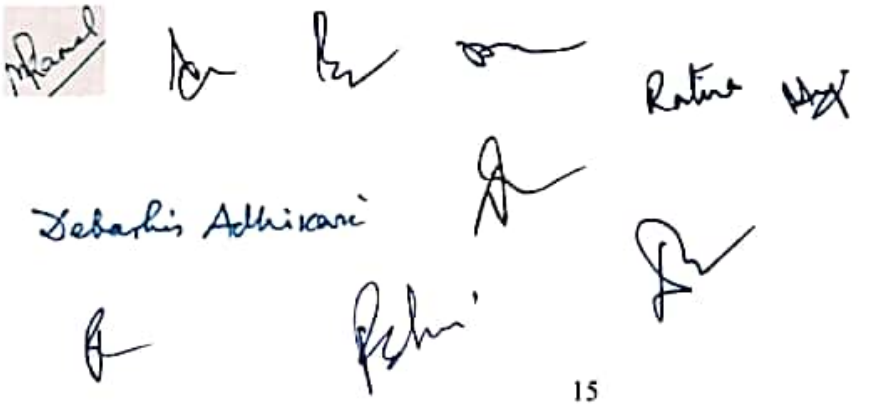
Photo reduction of Ketone, Norrish Type I and II, photochemistry of α,β unsaturated ketones and cyclic ketones, Barton reaction and Hoffmann Loeffer Fretage reaction. Paterno Buchi

reaction, olefin, Cis – Trans isomerism, dimerisation, Photochemistry of aromatic compounds: Rearrangement, isomerisation and addition to olefin. Photochemistry of Butadiene and Di-π-methane rearrangement, Photofries rearrangement.

Books Recommended:

Reference Books:

1. Clayden, Greeves, Warren and Wothers, *Organic Chemistry*, Oxford University Press (2001).
2. M.B. Smith & Jerry March, *March's Advanced Organic Chemistry*, 5th Ed., John Wiley & Sons, New York (2001).
3. Peter Sykes, *A Guide Book to Mechanism In organic Chemistry*, 6th Ed., Orient Longman Ltd., New Delhi (1997).
4. G. S. Zweifel and M. H. Nantz, *Modern Organic Synthesis*, Freeman and Company, New York (2007).
5. S.M. Mukherjee and S.P. Singh , *Reaction Mechanism in Organic Chemistry*, 1st Ed., Macmillan India Ltd., New Delhi (1990).
6. T.H. Lowry and K.S. Richardson, *Mechanism and Theory in Organic Chemistry*, 3rd Ed., Addison–Wesley Longman Inc. (1998).
7. S. M. Mukherjee and S.P Singh , *Reaction Mechanism in Organic Chemistry*, 1st Edition , Macmillan India Ltd., New Delhi (1990).
8. Jagdamba Singh and LDS Yadav, Advanced Organic Chemistry/Organic synthesis, Pragati Prakashan (2011).



Semester II

Paper VIII: B02U0803T
Physical Chemistry-II *Credits: 4*

Outcome: After successfully completing this course students will be able to

CO1	Understand the postulate of quantum mechanics, theorem of operators
CO2	Analyse the different oscillators, equations and its solution, applications to H- like atoms.
CO3	Apply the concept of quantum mechanics, perturbation to He- like atom, LCAO-Mo theory and its application
CO4	Identify the symmetry elements and operation conjugacy relations and classes, character table and uses.
CO5	Apply the concept colloids and surface chemistry to different surface areas, comparison of surface reactions and reaction rates.

Course details:

Unit 1: Introduction to quantum mechanics
Postulates of quantum mechanics, Angular momentum and linear operator, Hermitian operators, properties of operators, Theorems of operators

Unit 2: Exactly soluble system
Linear harmonic oscillators, Harmonic vibration, Hermite differential equation and its solution through recursion relation polynomial, H- like atoms, Laguerre and associated polynomial, Legendre Polynomial equation and their solution

Unit 3: Approximate method, Huckel M. O. Theory and Chemical bonding
Variation method, secular equation, Slater determinant, Perturbation method, First order perturbation, Application to He-like atom, Symmetric and antisymmetric wave functions. Huckel theory of conjugate systems, bond order and charge density, its calculation, Application of ethylene, butadiene, allyl and benzene, LCAO- MO theory, application of LCAO-MO theory to H_2^+ ion and H_2 molecule.

Unit 4 : Symmetry and Group Theory
Symmetry elements and symmetry operation, definitions of group, subgroup, relation between orders of a finite group and its subgroup. Conjugacy relation and classes. Point symmetry group, Schonflies symbols, representations of groups of matrices, Character of a representation, The great orthogonality theorem (without proof) and its importance, Character tables and their use.

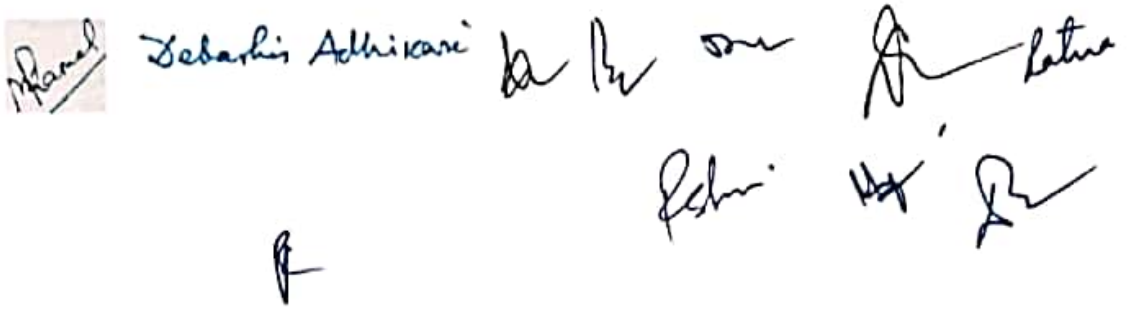
Unit 5: Colloids and Surfaces Chemistry
Stability and properties of colloids, Isotherms and surface areas, Bimolecular surface reactions: catalytic activity at surfaces, transition state theory of surface reactions, rates of chemisorption and desorption, unimolecular and bimolecular surface reactions, comparison

of homogeneous and heterogeneous reaction rates, surface heterogeneity.

Books Recommended:

Reference Book:

1. Ira N. Lavine, *Quantum Chemistry*, Pearson Education India (2016).
2. R .K. Prasad , *Quantum Chemistry*, 4th Edition, New Age International Publishers, New Delhi (2010)
3. A.K. Chandra, *Introduction to Quantum Chemistry*, 4th Ed., Tata McGraw Hill (2017).
4. John S. rose, *A Course on Group Theory*, Dover Publications Inc. (2003)
5. J.C. Berg, *Introduction Interfaces and Colloids*, World Scientific Publishing Co. (2009).



Semester II

Paper IX: Elective 01

Elective Papers

Semester II

Elective201:B02U0804T

Polymer Chemistry

Course outcomes (CO) : After completion of this course the students will be able to:

CO1	The basics and different kind of polymers with their properties.
CO2	The concept of molecular weight and distribution
CO3	Difference between crystalline melting temperature and glass transition temperature with variation in properties of polymers
CO4	The effect of factors such as polymer structure, molecular weight, branching and diluents on crystallinity, mechanical properties.
CO5	Techniques of polymer processing

Course details:

Unit I

Basic Concepts, Kinetics and Rheology

Polymers and their classification, nomenclature, Types of Polymerization: condensation, addition (free radical, cationic and anionic), copolymerization, Kinetics, Polydispersity and Molecular weight distribution, practical significance and measurement of molecular weight

Unit II

Thermodynamics and Transition properties of polymer

Glass transition temperature in polymers (T_g), Melt transition (T_m), factors influencing glass transition temperature, relationship between T_g and T_m. Process of Polymer dissolution, The Flory –Higgins Theory of polymer dissolution

Unit III

Polymer Processing

Plastics, Elastomers and Fibres, Processing techniques: calendaring, casting, moulding, thermoforming, foaming, reinforcing and fiber spinning, film and laminates. Manufacturing of Thermocol.

Unit IV

Commercially Important Polymers and Applications

Commercially important Thermosetting and Thermoplastic polymers, Resins: Phenol-Formaldehyde resins, Urea- Formaldehyde resins, Epoxy resins, Melamine- Formaldehyde resins. Biomedical polymers, electrically conducting polymers, smart polymers

Recommended Text Books:

Reference Book:

1. Fried JR, Polymer Science and Technology, Prentice-Hall of India,(2000)

2. Billmeyer F.W., Textbook of Polymer Science, Wiley-Interscience: New York (1984)

3. DeGennes, P.G. Scaling Concepts in Polymer Physics, Cornell University Press (1979)

4. Young R.J. & Lovell, P.A., Introduction to Polymers 2nd Ed., Champan & Hall (1991)

Semester II

Elective202:B02U0805T

Liquid State *Credits:4*

Course outcomes (CO) : After completion of this course the students will be able to:

CO1	Define liquid state, supercool liquid, ionic liquids and liquid crystals
CO2	Understand the properties of liquids , theories of liquids, model approach etc.
CO3	To apply concept in distribution function and related equation..
CO4	Understand and analyse the glass transition in supercool and ionic liquids.
CO5	Understand and investigates concept of the structure of liquid forming compounds , properties and application

Course details:

Unit 1: General Properties of Liquids
Liquid as dense gases, as disordered solids, some thermodynamics relations, internal pressure and its significance in liquids , Different types of intermolecular forces in liquids, different potential functions for liquid Classical partition function for liquid, Correspondence principles, Configuration integral, Configuration Properties

Unit 2: Theory of Liquid
Theory of liquid , Partition function method or model approach, Single cell model, Communal energy and entropy, LTD model, significant structure model

Unit 3: Distribution Function and Related equation
Radial distribution function method, Equation of state in terms of RDF, Molecular distribution function, Pair distribution function, Relationship between Pair distribution and pair potential function, Cluster expansion

Unit 4: Supercool and Ionic Liquids
Theories of transport properties, Non Arrhenius behaviour of transport properties, Cohen – Turnbull free volume model, Configurational Entropy model, Glass transition in supercooled liquids.

Unit 5: Liquid Crystal
Introduction, classification, structure of liquid crystal forming compounds, chemical properties, applications.

Books Recommended:
Reference Books:
1. P.A Egilstaff, *An Introduction to liquid state*, Acdemic Press (1994).
2. A.F.M Barton, *The Dynamic Liquid state*, Longman (1974).
3. T.L. Hill, *An introduction to statistical thermodynamics*, Addison Wiley (1960).
4. H. Eyring and M. S. John, *Significant liquid Structures*, ACS Publications (1961).

Semester II

Paper X : B02U0806P

Organic Chemistry Practical *Credits: 4*

Outcome: After successfully completing this course students will be able to

CO1	Ability to separate and identify different functional group from a mixture of organic compound.
CO2	Understanding the principles of separation and analysis of different functional group.
CO3	Learn the techniques of chromatographic separation of mixture.
CO4	Ability to prepare different types of organic compounds.
CO5	Ability for the extraction of natural product from plants

Course details:

Unit 1: Qualitative Analysis

Qualitative Analysis Identification of unknown organic compounds, separation, purification and identification of compounds of binary mixture (both are solids, one liquid & one solid) using TLC & column chromatography, Chemical tests. IR spectra to be used for functional group identification.

Unit 2: Preparation of Organic Compound

1. Synthesis of Dibenzal acetone from benzaldehyde (Aldol condensation).
2. Synthesis of p-nitroacetanilide from acetanilide
3. Synthesis of anthranilic acid from phthalic anhydride.
4. Synthesis of p-aminoazo benzene from aniline.
5. Synthesis of p–bromoaniline.
6. Synthesis of ethyl n-butylacetoacetate by acetoacetic ester condensation.
7. Cannizaro reactions: 4-chlorobenzaldehyde as substrate.

Unit 3: Extraction:

1. Isolation of caffeine from tea leaves.
2. Isolation of lycopene from tomato.

3. Extraction and identification of DNA from green peas and onions.

Books Recommended:

Text Books:

1. A.R. Tatchell, *Vogel's Textbook of Practical Organic Chemistry*, 5th Ed., John Willey (1996).

Reference Books:

1. H. Middleton , *Systematic Qualitative Organic Analysis*, Adward Arnold (1939).

2. H. Clark, *Handbook of Organic Analysis*, Adward Arnold (1946)

Semester II

Paper XI : B02U0807R
Research Project ***Credit: 8***

Research project/ Industrial training and seminar

project report should be submitted and evaluated on the basis of seminar and project report.

Course outcomes (CO) : After completion of this course the students will be able to:

CO1	To provide comprehensive learning platform to students where they can enhance their employ ability skills and become job ready along with real corporate exposure.
CO2	To enhance students' knowledge in one particular technology.
CO3	To provide learners hands on practice within a real job situation
CO4	Ability to communicate efficiently.

Course details: As per Ordinance.

Paper XII: Minor Elective from other faculty

Debarshi Adhikari

Semester III

Paper XIII: B02U0901T

Applications of Spectroscopy *Credits: 4*

Outcome: After successfully completing this course students will be able to

CO1	Understand the fundamentals of rotational & vibrational spectroscopy.
CO2	Learn the principles, instrumentation & applications of electronic spectroscopy.
CO3	Learn the principles, instrumentation & applications of NMR spectroscopy.
CO4	Learn the principles, instrumentation & applications of ESR spectroscopy.
CO5	Learn the principles, instrumentation & applications of MASS spectrometry.

Course details:

Unit 1: Rotational and rotation-vibrational spectroscopy
Introduction, Principles, Instrumentation and Application of IR, FT-IR instrumentation, Raman spectroscopy: Raman Effect, rotational and rotation- vibrational Raman transitions, nuclear spin effects, polarization of Raman lines.

Unit 2: Electronic spectroscopy
Introduction, Principles, Instrumentation and Application of UV- Visible, Franck-Condon factor, solvent effects.

Unit 3: Nuclear Magnetic Resonance Spectroscopy
Introduction, Principles, Instrumentation and Application of NMR spectroscopy

Unit 4: Electron Spin Resonance Spectroscopy

Introduction, Principle, Technique, Instrumentation and Applications of ESR.

Unit 5: Mass Spectrometry

Introduction, Principles, Instrumentation and Application of Mass Spectroscopy

Books Recommended:
Reference Books:

1. J. M. Hollas, *Modern Spectroscopy*, 4th Ed., John Wiley & Sons Ltd., Chichester (2004).
2. G. M. Barrow, *Introduction to Molecular Spectroscopy*, McGraw-Hill (1962).
3. C. N. Banwell and E.M. Mc Cash, *Fundamentals of Molecular Spectroscopy*, 4th edition,

Tata McGraw Hill, New Delhi (1994).
4. A. Carrington and A. D. Mc Lachlan, *Introduction to Magnetic Resonance* , Chapman and Hall, London (1979).

5. J. M. Hollas, *Modern Spectroscopy*, 4th Ed., John Wiley & Sons (2004).

6. R. S. Drago, *Physical Methods in Chemistry*, W.B. Saunders Co., U.K. (1977)

7. R.M. Silverstein, G.C. Bassler & T.C. Morrill, *Spectroscopic Identification of Organic Compound*, John Wiley& Sons (1981).

8. E. A. O. Ebsworth, *Structural Methods in Inorganic Chemistry*, Blackwell Scientific Publications (1991).

9. W. Kemp, *Organic Spectroscopy*, 3rd Ed., W. H. Freeman & Co. (1991).

Debashis Adhikari

Semester-III

Paper XIV: B02U0902T
Advance Principles of Physical Chemistry *Credits:4*

At the end of this course student is able to:

CO1	Understand the postulate of electrochemistry, polarizable and non-polarizable interfaces, and electroanalytical techniques.
CO2	Analyse the different electro-catalytic process, batteries, electrochemical cells and electrochemical process (relevance to energy conversion).
CO3	Apply the concept of chemical kinetics to different reaction (between ions), solvent effect, effect of pressure on reaction rates in solution, collision between the molecules.
CO4	Identify the crystal structure, application of Bragg's law, defects in solids.
CO5	Apply the concept thermodynamics (equilibrium and non-equilibrium thermodynamics) to different system, entropy generated during heat transfer, thermoelectric effect.

Course details:

Unit 1: Advanced Electrochemistry
Introduction to electrochemistry: Nernst equation, electrode kinetics, dynamic electrochemistry, Butler-Volmer equation under near equilibrium and non-equilibrium conditions, exchange current density, Tafel plot, polarizable and non-polarizable interfaces. Overpotentials. Potentiostatic and galvanostatic electrochemical methods including chronoamperometry, coulometry, cyclic voltammetry and impedance spectroscopy.

Unit 2: Electrocatalysis
Definitions, Electrocatalytic potential, effect of electric field on electrocatalysis, Nanostructured and surface modified electrodes. Introduction to batteries, fuel cells and electrochemical solar cells. Electrochemical processes of particular relevance to energy conversion

Unit 3: Reactions in Solutions
Reaction between ions, effect of solvent (single & double sphere models), interpretation of frequency factor and entropy of activation, influence of ionic strength, salt effect, reactions involving dipoles, influence of pressure on reaction rates in solution, Molecular collisions

Unit: 4 Solid State

Crystals structures, Bragg's law and applications, Band structures of solids, defects in solids Perfect and imperfect crystals, intrinsic and extrinsic defects, point defects, line and plane defects, vacancies- Schottky defects and Frenkel defects, semiconductors: intrinsic and extrinsic (p-type and n- type), superconductors.

Unit 5: Non-equilibrium Thermodynamics

Difference between equilibrium and non-equilibrium thermodynamics, Criteria of non-equilibrium thermodynamics; Assumptions of non-equilibrium thermodynamics, uncompensated heat and its relation to other thermodynamic functions, Fluxes and forces relation between these two quantities, Entropy production in heat transfer, mass transfer in flow of current, in mixing of gases, and in chemical reaction; The Phenomenological equations: The linear laws, The Onsagar relation, microscopic reversibility and Onsager reciprocity. Coupled reaction. Thermoelectric effects: Seebeck, Peltier and Thompson effect.

Books Recommended:

Text Books:

1.C. Kalidas & M.V. Sangaranarayanan, *Non Equilibrium Thermodynamics: Principles and application*, Macmillan India Limited (2002).

2. J. Rajaram andJ.C. Kuriacose, *Kinetics and Mechanism of Chemical Transformation*, I[st] Ed. , MacMillan India Ltd., New Delhi (1993).

Reference Books:

1. J. O. M Bockris & A. K. N. Reddy, *Modern Electrochemistry: Vol II* , Plenum Rosetta (2012).

2. A. J. Bard, L. R. Faulkner, *Electrochemical Methods: Fundamentals and Applications, 2nd Ed.* John Wiley and Sons (2001).

3. Piero Zanello, *Inorganic Electrochemistry: Theory, Practice and Applications, 2nd Ed.*, Royal Society of Chemistry (2019).

4. S. R. de Groot and P. Mazur, *Non Equilibrium Thermodynamics* , Dover Publications Inc., New York (1984).

5. I. Prigogine, *Introduction to Thermodynamics of Irreversible Processes ,3rd Ed., John Wiley and sons (1968).*

6. *Reaction Kinetics*(1998), M. J. Pilling and A.P.W, Seakins, Oxford Science Publication, New York

7.K.J. Laidler, *Chemical Kinetics*, 3rd Ed., Harper & Row Publishers, New York (1967).

8.. B. G. Cox, *Modern Liquid Phase Kinetics*, Oxford University Press, Oxford (1994).

9.. R. D. Levine and R. B.Bernstein, *Molecular Reaction Dynamics and Chemical Reactivity*, Oxford University Press, Oxford (1987).

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Semester III

Paper XV: Elective 01
Paper XVI: Elective 02

Elective Papers

Semester III

Elective 301: B02U0903T
Inorganic Chemistry-III *Credit:4*

Outcome: After successfully completing this course students will be able to

CO1	Understand the role of metal ions in biological systems.
CO2	Learn the chemistry of different types of dioxygen transport & storage protein.
CO3	Understand the redox reaction mechanism, outer sphere & inner sphere reaction of inorganic complexes
CO4	Understand the catalytic reaction, mechanism and industrial applications of transition metal complexes, Wilkinson catalyst, Grubb's catalyst.

Course details:

Unit 1: Elements of Life
Roles of metal ions, Role of metal ions in medicine, Metal dependent diseases: Wilson's disease, Alzheimer disease, Metal complexes as drugs & mechanism: drugs. Toxic effects of metal ions, detoxification by chelation therapy.

Unit 3: Metal Ion Transport and Storage Proteins & Enzymes
Ferritin, transferrin, celluloplasmin, iron-sulphur protein (ferredoxin, rubredoxin), riske protein, Transport across biological membrane: Na+ - K+ - ATPase, ionophores. Oxygen transport & storage: haemoglobin(oxy-deoxy form), myoglobin, O_2 binding, partial pressure & Bohr effect, heamocyanin, hemerythrin, copper protein, model synthetic complex of Fe, Co, Cu. Hydrolytic enzymes: carbonic anhydrase, carboxypeptidase, urease. Protective metalloenzymes such as cytochromes, cytochrome P-450, superoxide dismutase, catecholase, peroxidase, nitorgenase , catalase, xanthine oxidase, Cobalamins including vitamin and coenzyme B12.

Unit 3: Redox-Reaction Mechanism
Redox reactions: Classifications, kinetics and mechanism, outer-sphere reaction, self-exchange rate, electron tunneling hypothesis, heteronuclear redox rection and simplified Marcus theory; Marcus cross relationship and its application, solvated electron; inner-sphere reaction, remote attack, doubly-bridged process, complementary and non-complementary redox reaction, ligand exchange, effect of bridging ligand in inner sphere reaction, intervalence electron transfer, induced reaction, electron-transport in metalloproteins

10/7/23
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Unit 4: Catalysis in Inorganic Chemistry

homogeneous/heterogeneous catalysis: Wacker-Smidt synthesis, hydroformylation reactions, Monsanto acetic acid process, hydrogenation by Wilkinson's catalyst, water gas shift reaction (WGSR), Fischer-Tropsch synthesis, alkene polymerization, hydrosilation, hydrophosphilynation, hydroamination, hydrocyanation and hydroboration reactions, Heck reaction, carbene catalysis. Metathesis: Grubb's 1st and 2nd generation catalyst, Olefin cross coupling metathesis (OCM), ring closing metathesis (RCM), ring opening metathesis (ROM), applications.

Books Recommended:

Reference Books:

1) A. Das and G. N. Mukherjee, *Elements of Bioinorganic Chemistry*, 2nd Ed., U. N. Dhur and Sons, Kolkata (2002).
2) I. Bertini, H. B. Gray, S. J. Lipperd and J. S. Valentine, *Bioinorganic Chemistry*, Viva Books Pvt. Ltd., New Delhi (1998).
3) W. Kaim and B. Schwederski, *Bioinorganic Chemistry: Inorganic Elements in the Chemistry of Life*, Wiley, New York (1994).
4) S. J. Lippard and J. M. Berg, *Principles of Bioinorganic Chemistry*, University Science Books, Mill Valley, CA (1993).
5) P. M. Harrison and R. J. Hoare, *Metals in Biochemistry*, Chapman and Hall (1980).
6) C. A. McAuliffe (Ed) Techniques and Topics in Bioinorganic Chemistry, Halsted, New York, (1975).
7) J. E. Huheey, E. A. Keiter and R. L. Keiter, *Inorganic Chemistry: Principles of Structure and Reactivity*, 4th Edn, Harper Collins College Publishers, New York (1993).
8) J. D. Lee, *Concise Inorganic Chemistry*, Chapman and Hall, London (1991).
9) R. W. Hay, *Bioinorganic Chemistry*, Ellis Horwood, Chichester, New York (1984).
10) J. W. Steed and J. L. Atwood, *Supramolecular Chemistry*, John Wiley and Sons, New York (2000).
11) G. W. Parshall, Homogeneous Catalysis, Wiley, New York, 1980.
12) C. N. Satterfield, Heterogeneous Catalysis in Practice, McGraw-Hill, New York, 1980.
13) J. D. Atwood, Inorganic and Organometallic Reaction Mechanisms, 2nd Edn, VCH, New York, 1997.
14) F. Basolo and R. G. Pearson, Mechanism of Inorganic Reactions, 2nd Edn, Wiley, 1967.
15) F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley and Sons, Inc., New York, 1999.
16) B. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn, John Wiley and Sons, Inc., New York, 2001.
17) J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edn, Harper Collins College Publishers, New York, 1993.

Debashis Adhikari

Semester III

Elective 302: B02U0904T
Bio - Organic Chemistry

Credits: 4

Outcome: After successfully completing this course students will be able to

CO1	Understand the introduction, classification & properties of carbohydrates.
CO2	Understand the introduction, classification & properties of amino acids & protein.
CO3	Learn the isolation, structure and synthesis of different natural products.
CO4	Learn the occurance, structure, properties and importance of Vitamins.
CO5	learn the introduction, structure & biological importance of Nucleic acid.

Course details:

Unit 1: Carbohydrates
Introduction, Classification, Properties of Disaccharides and Polysaccharides (Maltose Lactose, Sucrose, Cellulose, Starch etc.)

Unit 2: Amino acids & Protein
Amino acids Classification, Synthesis, Structure, Evaluation of protein quality, Peptide bond, denaturation of proteins, factors effecting denaturation, essential criteria for structure elucidation of protein, amino acid analysis, factors responsible for stabilization of secondary and tertiary structures.

Unit 3: Natural Products
A general introduction, isolation, synthesis and structure of Alkaloids: Nicotine, Morphine, Terpenoids: Camphor, Menthol, Steroids: Cholesterol and Ergocalciferol, Flavonoids: Quercetin and Kaempferol.

Unit 4: Vitamins
Properties, Occurrence, Structure and importance of Vitamins; fat soluble and water soluble vitamins.

Unit 5: Nucleic acid
Introduction, Nucleic Acids: Nucleosides, Nucleotides, Biological importance of nucleotides and pentose sugar structure and properties of uracil, thymine, guanine, cytosine, adenine. Structures of different forms of RNA, DNA (Watson and Crick Model), Concept of gene,

Nucleic acid metabolism – central dogma, features of genetic code, A brief introduction of replication, transcription and translation.

Books Recommended:

Reference Books:

1. E.A. Carey, & R.J. Sundberg, *Advanced Organic Chemistry*, Parts A & B, Plenum: U.S. (2004).
2. W. Carruthers, *Modern methods of Organic Synthesis*, Cambridge University Press (1971).
3. S. Warren, *Organic Synthesis: The Disconnection Approach*, John Wiley & Sons (1984).
4. J. March. *Advanced Organic Chemistry, Reaction Mechanisms and Structure*, John Wiley (2013).
5. W. Carruthers , *Some Modern Methods of Organic Synthesis*, Cambridge University Press (1987).
6. I. L. Finar, *Organic Chemistry*, ELBS, U.K. (1968).
7. R.T. Morrison & R. N. Boyd, *Organic Chemistry*, 7th Ed. Prentice Hall India (2010).
8. J. Clayden, *Organic Chemistry*, 2nd Ed., Oxford University Press (2012).

Semester III

Elective 303:B02U0905T

Nano Chemistry

Credits:4

Outcome: After successfully completing this course students will be able to

CO1	Understand the introduction, Historical developments, Classification of nanomaterials.
CO2	Learn the techniques for the preparation of nanoparticles.
CO3	Understand the structure and bonding in nanomaterials.
CO4	Learn the properties, characterization and applications of nanoparticles.

Course details:

Unit1: Introduction

Definitions and course organization, Historical development of nanomaterials , Classification of nanomaterials.

Unit2: Preparation of nano particles

Top down and bottom up approach, electrochemical, chemical, photochemical and biochemical synthesis of nano particles.

Unit3: Structure and Bonding in Nanomaterials

Chemical Bonds (types and strength) Intermolecular forces, Molecular and Crystalline structures, Hierarchical structures, Bulk to surface transition, surface reconstruction, self assembly and thermodynamics

Unit 4: Properties & Characterization

Size dependence of properties Chemical Optical, vibrational, thermal, electrical, magnetic ,mechanical, theoretical Aspects-e.g. density functional theory, Scanning and Transmission Electron Microscopy, Scanning Probe Microscopies: Atomic Force, scanning tunneling microscopy Diffraction and scattering techniques, Vibrational spectroscopy, Surface techniques

Unit 5: Applications

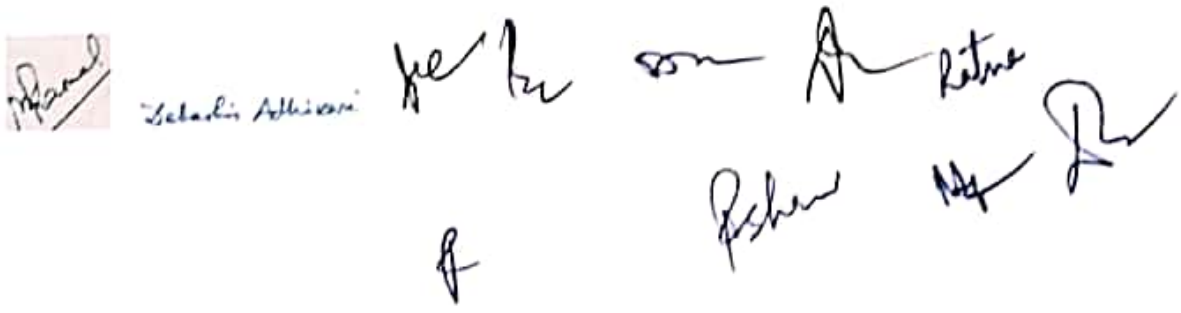
Nano-electronics, Nano optics, Nanoscale chemical- and bio-sensing, Biological/bio-medical applications, Photovoltaic, fuel cells, batteries and energy-related applications, High strength nanocomposites , Nanoenergetic materials.

Books Recommended

Reference Books:

1. T. Pradeep, *NANO: The Essentials*, Tata-McGraw Hill, New Delhi, 2007.
2. D. W. Bruce and D. O'Hare, *Inorganic Materials*, John Wiley and Sons, New York, 1992.
3. C. M. Sorensen, *Magnetism in Nanoscale Materials in Chemistry*, Wiley Interscience, New York, 2001.
4. K.J. Klabunde, *Nanoscale Materials in Chemistry*, Wiley-interscience, 2001
5. Bharat Bhushan (Ed.) *Springer Handbook of Nanotechnology*, Springer, 2007
6. C.P. Poole, and F.J. Owens, *Introduction to Nanotechnology*, Wiley India, 2006

7. G.A. Ozin, C. Andre, and L. Arsenault, Cademartiri, *Nanochemistry: A chemical Approach to Nanomaterials*, Royal Society of Chemistry, 2005
8. K. J. Klabunde, *Free Atoms, Clusters and Nanoscale Particles*, Academic Press, New York, 1994.



Semester III

Elective 304: B02U0906T

Chemistry of Materials, Petrochemicals and Fertilizers *Credits:4*

Course outcomes (CO): After completion of this course the students will be able to:

CO1	The chemical composition of cement, ceramics and glass and their industrial applications.
CO2	Learn the chemistry of magnetic materials and nano-materials and their new-age applications.
CO3	Understand the chemical composition of fertilizers and their application to society/agriculture
CO4	Understand the chemical composition of natural gas, crude petroleum, and lubricants and their application to daily life.

Course details:

Unit I

Cement, Composites, Ceramic and Glass

Composition of cement, mixing of cement clinker with Gypsum, Setting of cement. Microscopic and Macroscopic Composites, Dispersion, Strengthened, Particle and Fiber- reinforced Composites. Composition, Physical and Chemical properties of Glass, Varieties of glass, Introduction to ceramics

Unit II

Magnetic and Nanomaterials

Ferromagnetism, Antiferromagnetism, Ferrimagnetism, Hysteresis, Remanence and Coercivity, Design of Molecular- based magnets: Three dimensional magnetic ordering. Preparation, Properties, Characterization and Applications of Nano materials (SEM, TEM).

Unit III

Fertilizers

N - Ammonia, Ammonium nitrate and Urea; P - Phosphoric acid, Single and Triple superphosphate, DAP; K- Potassium Nitrate and Muriate of potash.

Unit IV

Petrochemicals and Lubricants

Introduction, Occurrence, Composition of Petroleum, Natural gas, cracking, refining, octane rating, cetane number, flash and fire point determination.

Lubricating oils and additives, Naphtha crackers and Profile of their products, Synthetic and Blended oils.

Recommended Text Books

Reference Books:

1. *Oliver Kahn, Molecular Magnetism, VCH Publishers, (UK)*
2. *W. D. Callisters, Materials Science and Engineering: An Introduction, Wiley*
3. *N. W. Ascheroft and N. D. Mermin, Solid State Physics,*
4. *J. C. Anderson, K. D. Leaver, J. M. Alexander and R. D. Rowlings, Materials Science, ELBS*
5. *Kelker and Hatz Hand Book of Liquid Crystals,*

Elective Papers

Semester III

Elective 305: B02U0907T

Advanced Organic Chemistry *Credits: 5*

CO1	Learn the disconnection approach and its applications to organic synthesis.
CO2	Learn the mechanism of different organic reactions and their applications.
CO3	Understand the chemistry of Organometallic complexes and their applications.
CO4	Able to determine the compound structure based on information generated from mass spectrometry, IR, NMR, and elemental analysis.
CO5	learn the techniques of drug design, synthesis and their applications.

Course details:

Unit 1 Advanced organic synthesis:

Disconnection approach, one group and two group disconnections, reversal of polarity, chemoselectivity, one group C-C disconnection, two group C-C disconnections, 1,3-difunctional and 1,5-difunctional compounds. Tandem reactions, Domino reactions and multi-component reactions.

Asymmetric synthesis: Development of methodologies for asymmetric synthesis, regioselectivity, stereoselectivity, diastereoselectivity and stereospecificity. The chiral pool; chiral auxiliaries, reagents and catalysts; Diels-Alder reaction, alkylation of chiral enolates; dihydroxylation. Heck reaction. Reagent controlled methods – Use of chiral reagents – Asymmetric oxidation – Sharpless epoxidation – Asymmetric reduction – Use of lithium aluminium hydride and borate reagents.

Unit 2 Modern organic reactions:

Baylis-Hillman reaction, Henry reaction, Sakurai reaction, Tishchenko reaction . Ugi reaction. Brook rearrangement: Tebbe olefination. McMurry, Heck, Suzuki, Negishi, Sonogashira, Kumada, Stille, Hiyama, Buchwald-Hartwig, etc. Olefin metathesis.

Unit 3 *Modern Reagents and organometallic chemistry:*

Phosphorus, Sulphur and nitrogen ylides: Preparation, applications in organic synthesis and mechanism. Umpolung reactions (sulphur compounds, nitro compounds, lithiated ethers and related compounds).Principles and applications of phase transfer catalysis, crown ethers and polymer- supported reagents in organic synthesis.

organo-Li, -Cu, -Zn, -Cd, -Hg and -Pd compounds; metallocenes (Fe, Ru, Os); carbene and carbyne complexes. Organoboranes: Hydroboration, Preparation of Organoboranes, Reagents: Disiamyl borane, thexyl borane, 9-BBN, dicylohexyl borane, mono- and di- isopinocamphenyel boranes.

Unit 4. Organic spectroscopy:

NMR; ^3J variation with dihedral angle, fused rings, spreading out effect, vicinal coupling in other ring sizes, geminal coupling; shapes of NMR signals, pi contribution, NOE; 2D-NMR, EI-MS, MALDI-TOF-MS. Mass Spectrometry: Introduction and fragmentation , Base peak, Molecular ion peak, Meta stable ion peak, α- cleavage bond , allylic bond cleavage and Mc Lafferty rearrangement, examples of mass spectroscopy of some organic compounds. UV-Visible Spectroscopy: applications in conjugated dienes, some correlation studies, trienes, polyenes,Woodward Fischer rule, α, β- unsaturated carbonyl compound , solvent effect, applications in aromatic and heterocyclic compounds. IR Spectroscopy: Concept of vibrational spectra, stretching and bending vibrations, application identification of functional groups Structural elucidation of Organic compounds by a combined application of the UV, IR, NMR and MASS spectral data.

Unit 5. Medicinal Chemistry:

Drugs: Introduction, classification of drugs, brief discussion of drug targets, drugs based on enzyme inhibition: Drug design and synthesis of Drugs, Sulfa drugs, aspirin, paracetamol etc., Drug targets on nucleic acids, Definition of antagonist, agonist, prodrugs, pharmacokinetics and pharmacodynamics, Concept of structure-activity relationship (SAR) and quantitative structure and relationship (QSAR).

Books Recommended:

Reference Books:

1) R. Noyori, Asymmetric Catalysis in Organic Synthesis, John Wiley, 1994.
2) W. Caruthers, Modern Methods of Organic Synthesis, 3rd Edn., Low Price Edition, Cambridge University Press, 1996.
3) F.A. Carey and R.J. Sundberg, Advanced Organic Chemistry, Parts A and B, 4th Edn.,Plenum Press, 2001.
4) H. Budzikiewicz, C. Djerassi and D.H. Williams, Mass Spectrometry of Organic Compounds, Holden-Day, 1967.
5) N. S. Bhacca, S. Norman and D. H. Williams, Application of NMR Spectroscopy in Organic Chemistry, Holden-Day, 1964.
6) D. H. Williams and I. Fleming, Spectroscopic Methods in Organic Chemistry, 5th Edn., Tata McGraw-Hill, New Delhi, 2005.
7) W. Kemp, Organic Spectroscopy, 3rd Edn., McMillan, Hong Kong, 1991.
8) R. H. Crabtree, The Organometallic Chemistry of Transition Metals, 2nd Edn., John Wiley, 1994.
9) J. Clayden, N. Greeves, S. Warren and P. Wothers, Organic Chemistry, Oxford University Press, Oxford, 2001.
10) S. Waren, organic synthesis the disconnection approach, john wiley & sons(asia) pte ltd, Singapore,2004.
11) G. Thomas, Medicinal Chemistry – An Introduction, John Wiley, 2001.

Semester-III

Paper XVII: B02U0908P
Physical Chemistry Practical *Credits: 4*

Course outcome: At the end of this course student is able to:

CO1	Perform saponification process (ethyl acetate with NaOH) , comparing acid strength(acid catalysed methyl acetate), find activation energy of a given reaction
CO2	Analyse the distribution coefficient of a given system, perform conductometric titration of different reaction mixtures.
CO3	Apply the concept of thermodynamics in determining the heat of solution, heat of neutralization
CO4	Gained knowledge is applied for determining activity coefficient of electrolyte, rate constant for hydrolysis/inversion of sugar with the help of polarimeter.
CO5	Comparison of acid strengths through acid catalyzed methyl acetate hydrolysis

Course details:

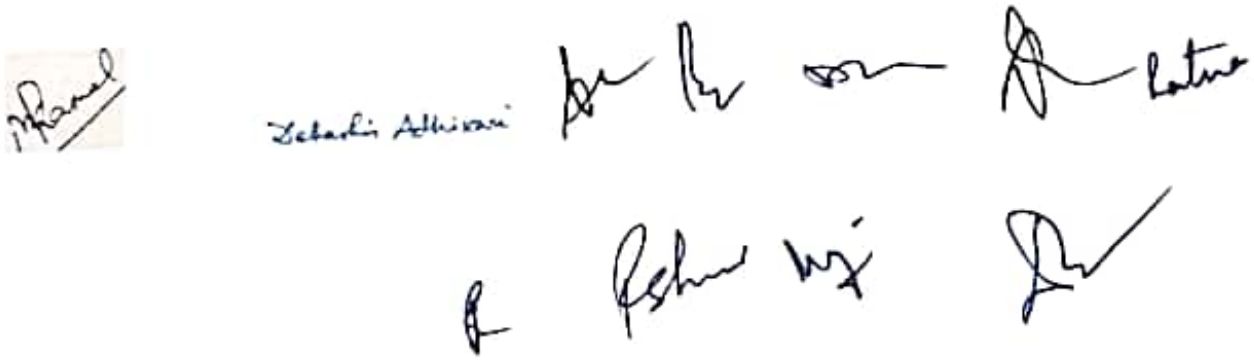
1. Energy of activation of acid catalyzed hydrolysis of methyl acetate.
2. Distribution coefficient of (i)Acetic acid
   (ii) I_2 between two immiscible solvents.
3. Conductometric titration of a weak acid with strong base.
4. Conductometric titration of a mixture of weak and strong acids.
5. Water equivalent of calorimeter and determination of
   (i) Heat of solution of potassium nitrate
   (ii) Heat of neutralization of strong acid and strong base
   (iii) Basicity of polybasic acids
6. Conductometric titration of KCl with $AgNO_3$.
7. Molecular weight of a non-electrolyte by cryoscopy method.
8. Acid -base titration in a non-aqueous media using a pH meter.
9. Determination of activity and activity coefficient of electrolytes.
10. Determination of rate constant for hydrolysis/inversion of sugar using polarimeter.

Books Recommended:

Reference Books:

1. M. James and F.E. Prichard , *Practical Physical Chemistry* , London, Longman (1981).
2. R.C. Das and B. Behera, *Experimental Physical Chemistry*, Tata McGraw Hill (1983)
3. B.P. Levitt, *Findley's Practical Physical Chemistry*, Longman (1973).
4. J. C. Ghosh , *Experiments in Physical chemistry*, 1st Ed., Bharati Bhavan (1974).

5. D.P. Shoemaker, C.W. Garland and J.W. Niber, *Experimental Physical Chemistry*, 6th Ed. McGraw Hill (1998)



Semester IV

Paper XVIII: Elective 01
Paper XIX: Elective 02

Semester IV

Elective 401: B02U1001T
Environmental Chemistry *Credit: 5*

At the end of this course student is able to:

CO1	Demonstrate knowledge of chemical and biochemical principles of fundamental environmental processes in air, water, and soil.
CO2	Recognize different types of toxic substances & responses and analyze toxicological information.
CO3	Apply basic chemical concepts to analyze chemical processes involved in different environmental problems (air, water & soil).
CO4	Describe water purification and waste treatment processes and the practical chemistry involved.
CO5	Describe causes and effects of environmental pollution by energy industry and discuss some mitigation strategies.

Course details:

Unit 1: Introduction to Environmental Chemistry

Concept and scope of environmental chemistry, Environmental terminology and nomenclatures, Environmental segments, The natural cycles of environment (Hydrological, Oxygen, Nitrogen)

Unit 2: Atmosphere

Regions of the atmosphere, Reactions in atmospheric chemistry, Earth's radiation balance, Particles, ion and radicals in atmosphere; Chemistry of ozone layer.

Unit 3: Hydrosphere and Lithosphere

Hydrosphere: Complexation in natural water and waste-water, Micro-organisms in aquatic chemical reactions, Eutrophication, Microbiology mediated redox reactions.

Lithosphere: Inorganic and organic components in soil, acid-base and ion-exchange reactions in soil, micro and macro nutrients, nitrogen pathways and N P K in soil.

Unit 4: 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.

Unit 5: Air and Water Pollution

Air pollution: Particulates, Aerosols, SOx, NOx, COx and hydrocarbon, Photochemical smog, Air-quality standards

Water Pollution: Water-quality parameters and standards: physical and chemical parameters, Dissolved oxygen, BOD, COD, Total organic carbon, Total nitrogen, Total sulfur, Total phosphorus and Chlorine, Chemical speciation (Pb, As, Hg)

Books Recommended:

Reference Books:

1. G.W. Vanloon, S.J. Duffer, *Environmental Chemistry - A Global Perspective*, OxfordUniversity Press (2000).
2. F.W. Fifield and W.P.J. Hairens, *Environmental Analytical Chemistry*, 2nd Ed.,Black Well Science Ltd (2000).
3. Colin Baird, *Environmental Chemistry*, W.H. Freeman and Company, New York (1995).
4. A.K. De, *Environmental Chemistry*, 4th Ed., New Age International PrivateLtd.,New Delhi (2000).
5. Peter O. Warner, *Analysis of Air Pollutants*, 1st Ed., John Wiley, New York (1996).
6. S.M. Khopkar, *Environmental Pollution Analysis*, 1st Ed., Wiley Eastern Ltd.,New Delhi (1993).
7. S.K. Banerji, *Environmental Chemistry*, 1st Ed., Prentice-Hall of India, NewDelhi (1993).

Debarki Adhikari

Semester IV

Elective 402: B02U1002T
Advance Physical Chemistry *Credit :5*

Course outcomes (CO) : After completion of this course the students will be able to:

CO1	Define condensed phase reactions, transition state theory, Oscillatory behaviour etc.
CO2	Understand the factors determining the reaction rate, kinetics of catalysed reactions.
CO3	Apply the kinetics concepts to catalyse and uncatalydsed. reaction
CO4	Analysis of corrosion causing factors and its protection.
CO5	Study the Evaluation and analysis of the specific heat of solids.

Course details:

Unit 1 Kinetics of Condensed Phase Reaction:
Factors determining reaction rate in solution , Transition state theory in solution , kinetics of ionic reaction , Dependence of rate constant on ionic strength and dielectric constant of medium, Bronsted- Bjerrum equation, study of fast reactions: Flesh Photolysis, relaxation techniques, Molecular beam and shock tube kinetics, stop flow method.

Unit 2 Transition state theory:
Application of statistical mechanics to transition state theory, comparison of transition state theory with experimental results, thermodynamic treatment of TST, theories of unimolecular reactions - treatments of: Lindmann, Hinshelwood, Rice- Ramsperger- Kassel (RRK), and Rice- Ramsperger-Kassel-Marcus (RRKM).

Unit 3 Catalysis and Oscillatory behaviour:
Kinetics of catalytic reactions, Arrhenius Intermediates, Vant-Half intermediates, Theory of acid-base catalyst , Bronsted catalysis law, Hammet equation , Oscillatory reactions.

Unit 4 Kinetics of Electrodes:
Faradic and Non- Faradic current , rate law in faradic process, Current Density, Factors affecting electrode reaction , Effect of double layer structure on electrode reaction rates.

Unit 5 A) Corrosion : Scope and economics of corrosion, cause and types of corrosion, electrochemical theories of corrosion, Methods of protecting corrosion

B) Thermodynamics of Solids:
Specific heats of solids, Einstein heat capacity equation, Debye theory of Specific heat.

Books Recommended:

Reference Books:

1. ***Reaction Kinetics*(1998), M. J. Pilling and A.P.W, Seakins, Oxford Science Publication, New York**
2. *Chemical Kinetics*, 3rd Edition (1967), K.J. Laidler, Harper & Row Publishers, New York.
3. *Kinetics and Mechanism of Chemical Transformation*, 1st Edition (1993), J. Rajaram and J.C. Kuriacose, MacMillan India Ltd., New Delhi.
4. *Modern Liquid Phase Kinetics*(1994), B. G. Cox, Oxford University Press, Oxford
5. *Molecular Reaction Dynamics and Chemical Reactivity*(1987), R. D. Levine and R. B.Bernstein, Oxford University Press, Oxford

Semester IV

Elective 403: B02U1003T

Advanced Inorganic Chemistry *Credit :5*

Outcome: After successfully completing this course students will be able to

CO1	Understand the nuclear reaction and application of nuclear chemistyry.
CO2	Understand the concept of supramolecular chemistry, different types of non-covalent interaction and applications of supramolecular chemistry.
CO3	Learn the basic principle of photochemistry, Jablonski diagram and photochemical reaction of inorganic metal complexes.
CO4	Learn the basic concepts of structural chemistry, such as unit cell, lattice parameters, crystal system, and space group.
CO5	Understand the different types of defects in crystal and electronic property in crystal.

Course details:

Unit1: Nuclear Chemistry:

Nuclear reactions, Fission and fusion reactions, Radio analytical techniques and activation analysis

Unit 2: Supramolecular Chemistry

Concept and definition, designing of building blocks, molecular supramolecular orbitals, polymeric ensembles (chain, sheet, network), supramolecular arrays: ribbon, ladder, rack, braded, grid; harnessing non-covalent forces (hydrogen bonding, pi-pi and C-H...pi interactions), lock and key principle, host-guest interaction to design functional materials, molecular machine.

Unit 3: Photochemistry of Inorganic Complexes

Photoexcitation, fluorescence, phosphorescence, photosensitization, quenching, charge and energy transfer, excimer structure, prompt and delayed reaction, excited state of metal complexes, photo-substitution, photo-oxidation, photo-reduction, excited state electron transfer, reaction of bi-pyridine & phenanthroline complexes (Cr,Ru,Ir), comparison with organic compounds, metal complexes sensitizers, application of photochemical reaction of co-ordination compounds

Unit 4: Solid State Chemistry

Structure of NaCl, CsCl, ZnS, SiO_2, CaF_2, AlF_3, TiO_2. Bonding in metals, ionic, covalent and hydrogen bonded solids; Crystal defects, non-stoichiometric defects: perfect and imperfect crystals, intrinsic and extrinsic defects; point, line, and plane defects. Schottky and Frankel defects formation, Non stoichiometric defects, color centres in ionic crystals, electronic

properties of solids, conductors, semiconductors, insulators, superconductors; ferroelectricity, antiferroelectricity, piezoelectricity, liquid crystals, cooperative magnetism.

Books Recommended:

Reference Books:

1) J. W. Steed and J. L. Atwood, *Supramolecular Chemistry*, John Wiley and Sons, New York (2000).
2) F. A. Cotton, G. Wilkinson, C. M. Murillo and M. Bochmann, Advanced Inorganic Chemistry, 6th Edn, John Wiley and Sons, Inc., New York, 1999.
3) B. Douglas, D. McDaniel and J. Alexander, Concepts and Models of Inorganic Chemistry, 3rd Edn, John Wiley and Sons, Inc., New York, 2001.
4) J. E. Huheey, E. A. Keiter and R. L. Keiter, Inorganic Chemistry: Principles of Structure and Reactivity, 4th Edn, Harper Collins College Publishers, New York, 1993.
5) G. L. Miessler and D. A. Tarr, Inorganic Chemistry, Prentice-Hall, New Jersey, 1999.
6) 4) T. P. Fehlner, J. -F. Halet and J. -Y. Saillard, Molecular Clusters — A Bridge to Solid State Chemistry, Cambridge University Press, Cambridge, 2007.
7) G. Friedlander, E. F. Macias, J. W. Kennedy and J. M. Miller, Nuclear and Radiochemistry, Wiley Interscience, New York, 1981.
8) G. Choppin, J. O. Lilienzin and J. Rydberg, Radiochemistry and Nuclear Chemistry, Butterworth Heinemann, 2001
9) A. D. Kirk, Inorganic Photochemistry, Coord. Chem. Rev., 1981, 39, 225.

Semester IV

Elective 403: B02U1004T

Applications of Chemistry in Industries

Credits:5

Outcome: After successfully completing this course students will be able to

CO1	The chemical composition of cement, ceramics and glass and their industrial applications
CO2	Learn the chemistry of magnetic materials and nano-materials and their new-age applications.
CO3	Understand the chemical composition of fertilizers and their application to society/agriculture
CO4	Understand the chemical composition of natural gas, crude petroleum, and lubricants and their application to daily life.

Course details:

Unit 1: Cement, Ceramic and Glass
Composition of cement, mixing of cement clinker with Gypsum, Setting of cement. Composition, Physical and Chemical properties of Glass, Varieties of glass, Introduction to ceramics

Unit 2: Composites
Introduction, constituents of composites, Types, of composites, Microscopic and Macroscopic Composites, Dispersion, Strength, Particle and Fiber- reinforced Composites.

Unit 3: Fertilizers
N - Ammonia, Ammonium nitrate and Urea; P - Phosphoric acid, Single and Triple superphosphate, DAP; K- Potassium Nitrate and Muriate of potash.

Unit 4:Petrochemicals and Lubricants
Introduction, Occurrence, Composition of Petroleum, Natural gas, cracking, refining, octane rating, cetane number, flash and fire point determination.
Lubricating oils and additives, Naphtha crackers and Profile of their products, Synthetic and Blended oils.

Unit 5: Paints
General characteristic, their function, Manufacture and Classification, Enamels, Emulsion paints, Water based paints. Formulation of paints: Function of vehicles, solvent, thinner, pigment, dyes, filler, resins, drier, insecticides, additives in paint formulation

Books Recommended:

Reference Books:

1. Oliver Kahn, *Molecular Magnetism*, VCH Publishers, UK (1993)

2. W. D. Callisters, *Materials Science and Engineering: An Introduction*, Wiley (2006).
3. N. W. Aschcroft and N. D. Mermin *Solid State Physics*, Holt, Rinehart and Winston, New York (1976).
4. J. C. Anderson, K. D. Leaver, J. M. Alexander and R. D. Rowlings *Materials Science*. ELBS (2003).
5. Kelker and Hatz , *Hand Book of Liquid Crystals*, 2nd Ed. Wiley (2014).
6. V.C. Malshe and Meenal Sikchi, *Basics of Paint Technology, Part I & II (2008)*.
7. G.P.A. Turner, *Introduction to Paint Chemistry*, Chapman& Hall (1967).

Semester IV

Elective 404: B02U1005T
Green Chemistry *Credits:5*

Outcome: After successfully completing this course students will be able to

CO1	Understand the concept and basic principle of Green chemistry.
CO2	Realize the importance of green chemistry and technologies in sustainable growth of society & industry.
CO3	Learn the applications of non-conventional energy sources.
CO4	Develop cleaner production and treatment mechanisms for pollution prevention.
CO5	Learn the techniques of green synthesis of nanomaterials.

Course details:

Unit 1: Introduction Principle and Concepts of green Chemistry
Need for green chemistry, Inception and evolution of green chemistry, Twelve principles of Green Chemistry with their explanation and examples, Designing a green synthesis using these principles, Green chemistry in day to day life.

Unit 2: Non Traditional Greener Alternative Approaches
Different approaches to green synthesis: Use of green reagents in organic synthesis-Dimethyl carbonate, Polymer supported reagents- Peracids and Chromic acids, Green Catalysis , role of catalysis in sustainable development , homogeneous and heterogeneous catalyst, Introduction , advantages and applications of Biocatalyst.

Unit 3: Application of Non-conventional Energy Sources
Introduction of microwave induce synthesis: Microwave activation, equipment, time and energy benefits, limitations, Organic transformations under microwaves- Fries rearrangement , Diels -Alder reaction, Decarboxylation, saponification of ester.
Introduction of ultrasound assisted green synthesis: Instrumentation, Physical aspects, application in organic transformations.

Unit 4 Environmentally Benign Solutions to organic solvents:
Ionic liquids as green Solvents: Introduction, properties and types of ionic liquids, Synthetic applications- Diels -Alder reaction.
Aqueous phase reactions: Synthesis applications- 1,3- Dipolar Cycloadditions, Carbon-Carbon bond- forming processes and bromination reactions. Role of supercritical Carbon dioxide in green chemistry, Ethyl lactate as a renewable green solvent: Properties and applications.

Unit 5: Synthesis of Nanomaterials:
Greener synthesis of Nanomaterials –Magnetic Nanoparticles, MW assisted nano catalysis in water, Synthesis of Nanoparticles using Bacteria , Yeast, Algae and Fungus.

Books Recommended:

Reference Books:

1. P.A.G. blackie , *Organic synthesis in water*, Springer (1998).
2. P.T. Anastas, *Green Chemistry : Theory and Practice*, Oxford University Press (2002).
3. M. Lancaster, *Green Chemistry : An Introductory Text* , Royal Society of Chemistry (2016)

Semester IV

Elective 405: B02U1006T
Photochemistry

Credits: 5

Course outcomes (CO) : After completion of this course the students will be able to:

CO1	Understand basic principle of photochemistry, Jablonski diagram, laws of photochemistry.
CO2	Understand the difference between thermal and photochemical reactions.
CO3	Learn what is quantum yield and it's measurement. Know about quenching and chemiluminescent
CO4	Learn the mechanism of different types of photochemical reactions.
CO5	Learn the photochemistry of carbonyls and aromatic compound.

Course details:

Unit 1: Photochemical Reactions
Introduction, types of excitations, fate of excited molecules, quantum yield, transfer of excitation energy

Unit 2: Determination of Reaction Mechanism
Classification, rate constant and life times of reactive energy state, determination of rate constant of reactions, effect of light intensity on the rate of photochemical reactions, types of photochemical reactions.

Unit 3: Photochemistry of Alkenes
Intramolecular reactions of olefinic bond- geometrical isomerism, cyclisation reactions,rearrangement of 1,4- and 1,5- diene.

Unit 4: Photochemistry of Carbonyls and Aromatic Compounds
Intramolecular reactions of carbonyl compounds, cyclic and acyclic $\beta\gamma$ saturated and $\alpha\beta$ unsaturated compounds, intermolecular cycloaddition reactions, Isomerization , additions and substitutions of aromatic compounds.

Unit 5: Miscellaneous Photochemical Reactions
Photo-fries reactions of anilides, Photo-fries rearrangements, Barton reactions, singlet molecular oxygen reaction, Photochemical formation of smog, photodegradation of polymers, photochemistry of vision.

Books Recommended:
1. N.J Turro, V. Ramamurthy, *Modern Molecular Photochemistry of Organic Compounds*, 10th Ed. University Science Books (2010)
2. B. Walder, Principles and Applications of Photochemistry, Wiley (2009).

Semester IV

Elective 406: B02U1007T
Atomic & Molecular Spectroscopy *Credit 5*

Outcome: After successfully completing this course students will be able to

CO1	Learn the basic principle, instrumentation of Atomic Absorption Spectroscopy and Flame Emission Spectroscopy.
CO2	Understand the molecular spectra of diatomic gases, P, Q & R branches.
CO3	Understand the fundamentals of Raman spectroscopy.
CO4	Learn the basic principle, Jablonski diagram and applications of fluorescence spectroscopy.

Course details:

Unit 1: Atomic Spectroscopy
The electromagnetic spectrum, A general discussion on various molecular excitation processes, Spectra of hydrogen and hydrogen-like atoms, alkali metals spectra, L-S coupling, Zeeman effect.
Flame Emission Spectroscopy (FES): Basic Principle, instrumentation-Atomizers, Burners, optical system, Detectors, interference in FES, Application of FES. Atomic Absorption Spectroscopy (AAS): Basic Principle, the difference between FES and AAS, Experimental Procedure, Application of AAS.

Unit 2: Vibrational and Rotational Spectroscopy
Molecular Spectra of Diatomic Gases, Classification of Molecules, Rotational Spectra, Vibrational Spectra, Vibrational-Rotational Spectra, P, Q and R Branches.

Unit 3: Raman Spectroscopy
Theory of Raman spectra, Rotational Raman spectra, Vibrational Raman spectra, Rotational-Vibrational Raman spectra, comparison with IR spectra

Unit 4: Fluorescence Spectroscopy
Basic Principle, Electronic Spectroscopy and Jablonski Diagram Steady-state fluorescence spectroscopy. Time-resolved (Time correlated single photon counting-TCSPC) fluorescence spectroscopy. Solvent and Environmental Effects on Fluorescence, Fluorophores, Novel Fluorophores, and Fluorescence Sensing. Introduction to Single-molecule fluorescence and fluorescence imaging.

Books Recommended:
Reference Books:

1. J.M. Hollas, *Modern Spectroscopy*, 4th edition, John Wiley and Sons, Chichester (2004).

2. C.N. Banwell and E.M. Mc Cash, *Fundamentals of Molecular Spectroscopy*, 4th Ed., Tata McGraw Hill, New Delhi (1994).
3. Fundamentals of Molecular Spectroscopy by C.N. Banwell
4. Fundamentals of Molecular Spectroscopy by G.M. Barrow
5.Joseph R. Lakowicz, *Fluorescence Spectroscopy*, 2nd edition, Plenum Press, New York.(1999).
6) Spectroscopy Vol. I & II by Walker & Straw.
7) Physical Chemistry by A.W. Atkins.

Debarki Adhikari

10/7/23

Semester IV

Paper XX : B02U1007R
Research Project *Credit: 16*

Course outcomes (CO) : After completion of this course the students will be able to:

CO1	To provide comprehensive learning platform to students where they can enhance their employ ability skills and become job ready along with real corporate exposure.
CO2	To enhance students' knowledge in one particular technology.
CO3	To provide learners hands on practice within a real job situation
CO4	Ability to communicate efficiently.

Course details: As per Ordinance.

Department of Chemistry, School of Basic Sciences, CSJM University, Kanpur

BOS Meeting

Prof. Deepak Srivastava,
Dept. of Plastic Technology
HBTU.

Dr. Debashis Adhikari
Associate Professor
Dept. of Chemical Sciences
IISER Mohali

Prof. Sudhir Kumar Srivastava
Dean, Science Faculty
DAV College

Prof. Meet Kamal
Dept. of Chemistry
Christ Church P.G. College

Dr. B.P. Singh
Dept. of Chemistry
CSJM University

Dr. Rashmi Dubey
Dept. of Chemistry
CSJM University.

Dr. Ratna Shukla
Dept. of Chemistry
CSJM University.

Dr. P.S. Niranjan
Dept. of Chemistry
CSJM University.

Dr. Meraj Jafri
Dept. of Chemistry
CSJM University.

Dr. R.K. Dwivedi (Convenor)
Director, School of Basic Science
CSJM University

Dr. Dhananjay Dey (Coordinator)
Dept of Chemistry
CSJM University.