Savitribai Phule Pune University

(Formerly University of Pune)

Syllabus of

M.Sc. II Physical Chemistry

(As per NEP 2020)

for

Colleges Affiliated to Savitribai Phule Pune University

Approved by
Board of Studies in Chemistry

Implementation from Academic Year 2024 - 2025

Semester III

Sr. No.	Course	Course Code	Major Core/Major elective	Credits
1.	Quantum and Solid State Chemistry	CHP-601 MJ	Major Core	4T
2.	Polymer Chemistry	CHP-602 MJ	Major Core	4T
3.	Nuclear and Radiation Chemistry	CHP-603 MJ	Major Core	2T
4.	Physical Chemistry Practical - I	CHP-604 MJP	Major Core	2P
5.	Physical Chemistry Practical - II	CHP-605 MJP	Major Core	2P
6.	Photochemistry	CHP-610 (A) MJ	Major elective (Any Two)	4T
	Physicochemical Methods of Analysis	CHP-610 (B) MJ		
	Special Topics in Physical Chemistry	CHP-610 (C) MJ		
7.	Research Project	CHP-631 RP	Research Project	4

Semester IV

Sr.No.	Course	Course Code	Major Core/Major elective	Credits
1.	Molecular Structure and Spectroscopy	CHP-651 MJ	Major Core	4T
2.	Surface Chemistry and Electrochemistry	CHP-652 MJ	Major Core	4T
3.	Physical Chemistry Practical- III	CHP-653 MJP	Major Core	2P
4.	Physical Chemistry Practical- IV	CHP-654 MJP	Major Core	2P
5.	Material Chemistry	CHP-660 (A) MJ	Major elective (Any Two)	4T
	Chemistry of Catalysts	CHP-660 (B) MJ		
	Biophysical Chemistry	CHP-660 (C) MJ		
6.	Research Project	CHP-681 RP	Research Project	6

1. Teaching Hours

a) Theory – Each credit of theory is equivalent to 15 teaching hours. For 1 credit of theory there will be 1 lecture of 1 hour per week. In case of theory paper consisting of sections, each section is of 2 credits and time allotted will be 30 hours teaching.

b) Practical – Each credit of practical is equivalent to 30 teaching hours. Each experiment will be allotted 5 h time.

2. Examination

Theory and practical courses carry 50 marks equivalent to 2 credits and 100 marks equivalent to 4 credits. Each course will be evaluated with Continuous Internal Evaluation (CIE) and University Assessment (UA) mechanism. Continuous Internal Evaluation shall be of 30% while university Evaluation shall be of 70%. To pass the course, a student has to secure 40% mark in CIE as well as university assessment. For CIE teacher must select variety of procedures for examination such as: i) Written test / Mid Semester test (not more than one for each course), ii) Term paper, iii) Viva-Voce, Project / survey / field visits iv) Tutorials v) Group discussion vi) Journal / Lecture / Library notes vii) Seminar presentation, viii) Short quiz ix) assignment x) research project by individual student or group of student xi) An open book test, etc. Each practical course will be extended over one semester and practical examination will be conducted at the end of every semester. The practical examination should involve one internal and two external examiners. All three examiners will evaluate the all practical courses.

Guidelines for Practicals and Project

- All experiments should be carried out on micro-scale and by considering stoichiometric quantities of reactants and reagents with the proper understanding of the mechanism.
- Post graduate departments should arrange at least **one study visit to relevant industry/national research laboratory/premier academic institute**.
- Students must read MSDS and should handle chemicals and reactions accordingly.
- The necessary reactions should be carried out in fume hood and appropriate safety measures should be taken during the laboratory experiments and projects.
- All reactions should be **monitored using alumina coated TLC plates**.
- Certified journals should be presented at the time of final examination.

- Students should choose a research project topic that aligns with their interests and career goals, but also consider its feasibility within the available resources and time frame.
- Consult with faculty members, advisors, or mentors to identify a research area that has potential for contribution to the field of chemistry.
- Students opting for the projects are encouraged to participate in AVISHKAR, national and international conferences and other project competitions.
- Teachers are encouraged to give the project ideas based on the societal needs.

PROGRAM OUTCOMES (POs):

PO No.	**PO Statement** After completing the Programme Master of Science in Physical Chemistry, students will be able to	Knowledge and Skill
PO-1	Learn the terms, theories, assumptions, methods, principles, theory statements, and classification	Disciplinary knowledge
PO-2	Fixed out the problem and resolved it using theories and practical knowledge.	Critical thinking & Problem-solving
PO-3	Inculcate his knowledge for carrying projects and advanced research-related skills.	Research related skill
PO-4	Actively participate in the team on case studies and field-based situations.	Cooperation/Teamwork
PO-5	Analyse and interpret ideas, evidence, and experiences with learned scientific reasoning	Scientific reasoning
PO-6	Aware and implement the subject facts that can be applied to personal and social development	Reflective thinking
PO-7	Use digital literacy to retrieve and evaluate subject-related information	Information/Digitally literacy:
PO-8	Get moral and ethical values for society as well as in research	Moral and ethical awareness
PO-9	Give analytical reasoning to interpret research data.	Analytical Reasoning
PO-10	Improve their managerial skills and abilities in subject-related activities.	Leadership readiness/qualities
PO-11	Inculcate continuous learning habits through all available resources.	Lifelong readiness/qualities

PROGRAM SPECIFIC OUTCOMES (PSOs):

PO No.	PSO Statement After completing the Programme Master of Science in Physical Chemistry, students will be able to
PSO-1	Demonstrate proficiency in advanced terms, theories, principles, and techniques of chemistry through different courses, laboratory experiments, and research projects.
PSO-2	Develop a foundational understanding of research methodologies, including literature review, hypothesis formulation, experimental design, data analysis, and interpretation.
PSO-3	Acquire hands-on experience with advanced chemistry-related equipment.
PSO-4	Apply modern research techniques to investigate complex chemical phenomena and solve practical problems.
PSO-5	Demonstrate competence in quality assurance and quality control practices essential for industry.

Semester-III

CHP-601 MJ: Quantum and Solid State Chemistry

Course type: Major Core (Theory) **No. of Credits: 4**

Course Outcomes

At the end of the course, students will be able to

1. Define the fundamental postulates of quantum mechanics, including properties of quantum mechanical operators and Eigen functions/values.
2. Demonstrate an understanding of approximation methods in quantum mechanics, such as non-degenerate perturbation theory and the variation method, including their theorems and applications.
3. To apply their knowledge to calculate ground state energy and wave function for complex systems, like the Helium atom.
4. To analyze the effectiveness of the Hartree-Fock self-consistent method in determining the wave function for multi-electron systems, discerning its advantages and limitations.
5. To get knowledge of imperfections and crystal growth techniques, students will devise strategies for producing high-quality crystals tailored to specific applications, considering factors like defects and growth methods.
6. To assess various solid-state reactions and properties, the impact of different factors on material characteristics, such as electrical, optical, and magnetic properties, in both insulators and conductors.

Course Content

Chapter No.	Title with Contents	No. of hours
	Section-I	
1	Basic postulates of quantum mechanics, properties of quantum mechanical operators, Eigen functions and Eigen values, Hermitian, linear, ladder, and angular momentum operators. Spin –orbit coupling, regular and inverted multiples.	**12**

2	Approximation methods: non-degenerate perturbation method and the variation method, theorem and applications	**07**
3	Calculation of ground state energy and wave function of Helium atom (two electron system) using Variation principle, Pauli's exclusion principle and Slater determinant	**08**
4	Calculation of wave function for multi-electron system: Hartree - Fock self-consistent Method	**03**
Section-II		
1	Imperfections and related phenomenon: Defects in solids: point defects, line defects, diffusion in solids- mechanism, elastic and plastic deformations	**05**
2	Crystal growth techniques: General principles, Methods of crystal growth: solution method, flux growth method, evaporation method. Theory of crystal growth	**05**
3	Solid state reactions- Reactions of single solids: Thermal decomposition reactionsand their kinetic characteristics, gas solid reactions and their characteristics, Solid –Solid reactions: addition and double decomposition reactions with and without electron transfer photographic process	**06**
4	Properties of Insulators: Electrical properties- Dielectric properties, Piezoelectricity, electric breakdown, Optical Properties-Colour centres in ionic crystals: types, creation. Magnetic properties-exchange interactions, Antiferromagnetism, Ferrimagnetism	**07**
5	Properties of metals and semiconductors: band theory, types of solids, intrinsic and extrinsic semiconductors, p-n junctions, optical properties, photoconductivity of crystals	**07**

Reference Books

1. Quantum Chemistry (4th edition), Ira N.Levine, Prentice Hall, Englewood Cliffs, N. J.
2. Quantum Chemistry, A.K. Chandra
3. Quantum Chemistry, D. A. McQuarrie,, Viva Books, New Delhi (2003)
4. Introduction of Solids L.V Azaroff , Tata McGraw Hill
5. Principles of the Solid State H. V. Keer, Wiley Eastern (1993)

6. Selected Topics in Solid State Physics Vol. 12, The growth of crystals from liquids –J. C. Brice, North Holland/American Elsevier (1973)

7. Defects and Diffusion in Solids. S. Mrowec, Elseivier Publ.(1960)

8. Treatise on Solid State Chemistry, ED-N.B. Hannay, Plenum Press Vol –2 (1975)

CHP-602 MJ: Polymer Chemistry

Course type: Major Core (Theory) **No. of Credits: 4**

Course Outcomes

At the end of the course, students will be able to

1. Understand the foundational principles of polymer science, including synthesis methods and polymerization kinetics.
2. Know proficiency in testing thermal and mechanical properties of polymers.
3. Apply analytical techniques to measure molecular weight and copolymerization effects.
4. Analyze polymer morphology and rheology to predict material behavior.
5. Describe the relationship between polymer structure and physical properties.
6. Summarize the significance and applications of Polymers.

Course Content

Chapter No.	Title with Contents	No. of hours
	Section-I	
1	Basic concepts of polymer science, classification of polymers as biological - nonbiological, linear branched network, condensation, addition homo- and heterochain, thermoplastic - thermosetting, History of Macromolecular Science, molecular forces and Chemical bonding in polymers	06
2	Thermodynamics of polymer solutions: Entropy and heat of mixing of polymer solutions - ideal behaviour and deviations. Experimental results, flory - Krigbaum theory - Thermochemistry of chain polymerization	08
3	Copolymerization: Kinetics of copolymerization, the copolymer equation, monomer reactivity ratios, instantaneous composition of polymer	06
4	Measurements of molecular weights: characterization of polymers, Molecular weight averages, fractionation and molecular weight	10

	distribution - methods for determination of average molecular weight (end group analysis) colligative property measurements, osmometry, diffusion light scattering, viscosity, ultracentrifugation	
Section-II		
1	Morphology and rheology of polymers - configuration of polymer chains crystal structure, crystallization processes, viscous flow, rubber elasticity, viscoelasticity, the glassy state and glass transition, mechanical properties of crystalline polymers	**10**
2	Polymer structure and physical properties - The crystalline melting point Tm- the glass transition temperature (Tg) - properties involving small and large deformations- polymer requirements and polymer utilization	**06**
3	Polymer processing - Plastic technology - moulding, other processing techniques fibre technology - textile and fabric properties, spinning fibre after treatments, elastomer technology- natural rubber, vulcanization, reinforcement, carbon blocks	**06**
4	Radiation induced polymerization - kinetics and mechanism of polymerization in the liquid and solid phases, effect of irradiation on polymers - degradation and cross-linking, block copolymerization	**05**
5	Conducting polymers - Basics, synthesis, conduction mechanism, applications	**03**

Reference Books

1. Textbook of Polymer Science - F. W. Billmeyer Jr., John Wiley & Sons Inc. (1971)
2. Principles of Polymer Systems - F. Rodrigues, Tata McGraw Hill Publishing Company, New Delhi
3. Principles of Polymer Chemistry - P. J. Flory, Cornell University Press, Ithaca New York (1953)
4. Polymer Chemistry - An introduction, Seymour-Carraher, Marcel Dekker Inc, New York
5. Polymer Science - Gowarikar, Vishwanathan&Sreedhar, Wiley Eastern Ltd. New York (1988)
6. Handbook on Conducting Polymers - T. A. Skotheim, Ed., Marcel Dekker Inc, New York, 1&2 (1986)

CHP-603 MJ: Nuclear and Radiation Chemistry

Course type: Major Core (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, students will be able to

1. Recall the different types of nuclear reactions discussed in the course.
2. Explain the principles of the liquid drop model in nuclear physics.
3. Apply Bethe's notation to interpret a given nuclear reaction.
4. Analyse the experimental evidence supporting compound nucleus theory.
5. Evaluate the effectiveness of various ion beam analysis techniques in surface analysis.
6. Create a summary of the significance and applications of Nuclear and Radiation Chemistry.

Course Content

Chapter No.	Title with Contents	No. of hours
1	**Nuclear reactions:** Bethe's notation, types of nuclear reactions, conservation in nuclear reactions, compound nucleus theory, experimental evidence, specific nuclear reactions, photonuclear and thermonuclear reactions.	06
2	**Nuclear Structure:** The liquid drop model, calculation of nuclear binding energies, propertiesof isobars, missing elements, the nuclear shell model, magic numbers, filling of nucleon shells,the collective and unified models.	06
3	**Nuclear Reactor:** General aspects of reactor design, thermal, fast and intermediate reactors, reactor fuel materials, reactor moderators and reflects, coolants, control materials, shield, regeneration and breeding of fissile matter, types of research reactors.	07
4	**Ion Beam Analysis Techniques:** Particle induced X-ray emissions- projectile accelerator and target preparation, ionization and X-ray emission	06

	detection,analysisand applications.Rutherford back scattering – scattering reaction, surface analysis, depth profiling, channelling effects and applications	
5	**Radiation detectors:** Scintillators and their properties inorganic and organic, solid state semiconductor detectors-theory, surface barrier, Li drifted and intrinsic detectors	**05**

Reference Books

1. Essentials of Nuclear Chemistry, H. J Arnikar, Wiley Eastern Limited, 4th Edition.(1995)
2. Nuclear and Radiochemistry, G. Friedlander, J. W. Kennedy and J. M. Miller, John Wiley (1981)
3.Introduction to Radiation Chemistry, J. W. T. Spinks and R. J. Woods, John Wiley (1990)
4.Introduction to Nuclear Physics and Chemistry, B.G. Harvey, Prentice hall (1963).
5. Sourcebook on Atomic Energy-S. Glasstone, Van Nostrand Company (1967)
6. Radiochemistry and Nuclear methods of analysis-W.D.Ehman and D.E. Vance, John Wiley(1991)

CHP-604 MJP: Physical Chemistry Practical-I

Course type: Major Core (Practical) **No. of Credits: 2**

Course Outcomes

At the end of the course, students will be able to

1. Recall and state the fundamental concepts and principles related to chemical equilibrium and reaction kinetics.
2. Explain the underlying theories and mechanisms governing various chemical reactions and analytical techniques.
3. Apply knowledge of chemical principles to design and conduct experiments for the determination of equilibrium constants, reaction rates, and other properties.
4. Analyze experimental data obtained from chemical measurements and interpret results to draw conclusions about reaction mechanisms and molecular properties.
5. Critically evaluate the reliability and validity of experimental methods and results, identifying sources of error and potential improvements.
6. Create a report on the experimental procedure, observations and results.

Course Content

Any 12 experiments from the following-

1. Determination of the equilibrium constant of triiodide ion formation.
2. Kinetics of iodination of aniline: pH effect and base catalysis.
3. Dissociation constant of an acid- base indicator by spectrophotometry.
4. Actinometry – photolysis of uranyl oxalate.
5. A photometric titration of a mixture of Bi and Cu with EDTA (-745nm).
6. The reaction between potassium persulphate and potassium iodide by colorimetry.
7. Determination of the chain linkage in poly (vinyl alcohol) from viscosity measurements.
8. To determine concentration of Boric acid titrating with NaOH by Conductometry.
9. Stability constant of silver thiosulphate by potentiometry.
10. Thermodynamic data of electrochemical cell by e.m.f. measurements.
11. Magnetic susceptibility measurement by Gouy technique.
12. Determination of dipole moment of liquid at various temperatures.
13. Simultaneous determination of two ions by polarography.
14. Absorption coefficient and half thickness of lead for gamma radiation.
15. Radiation dose measurement by Fricke dosimeter/ceric sulphate dosimeter.

Reference Books

1. Findlay's Practical Chemistry, S P Levitt (Editor), Longman Group Ltd

2. Experimental Physical Chemistry, Farrington Daniels and others, McGraw-Hill Book Company.

3. Experiments in Physical Chemistry, J.M. Wilson and others, Pergamon Press

4. Practical Physical Chemistry, A.M. James and P.E. Pritchard, Longman Group Ltd.

5. Experimental Physical Chemistry, V. Dathavale, Parul Mathur, New Age International Publishers.

6. Experimental Physical Chemistry, Das and Behera, Tata McGraw-Hill. Practical Physical Chemistry, D.V. Jahagirdar

7. Advanced physical Chemistry experiments by A. Gurtu, J.N. Gurtu

CHP-605 MJP: Physical Chemistry Practical-II

Course type: Major Core (Practical) **No. of Credits: 2**

Course Outcomes

At the end of the course, students will be able to

1. Recall and state the fundamental concepts and principles.
2. Explain the underlying theories and mechanisms governing various chemical reactions.
3. Apply knowledge of chemical principles to design and conduct experiments for the determination of the concentration of sulfuric acid, acetic acid, and copper sulfate.
4. Analyze experimental data obtained from chemical measurements and interpret results to draw conclusions about reaction mechanisms and molecular properties.
5. Critically evaluate the reliability and validity of experimental methods and results, identifying sources of error and potential improvements.
6. Create a report on the experimental procedure, observations and results.

Course Content

Any 12 experiments from the following-

1. Hydrolysis constant of aniline hydrochloride by distribution coefficient method.
2. Determination of the dimerization constant of an organic acid in benzene.
3. Determination of the stability constant of a complex by spectrophotometry.
4. Studies on a clock reaction: determination of the energy of activation
   a. Reactions such as bromate-bromide reaction, iodate –iodide reaction,
b. Formaldehyde - bisulphite reaction etc.
5. Effect of salt on the distribution of acetic acid between water ethyl acetate.
6. To study the effect of addition of a salt on the solubility of an acid in water.
7. Determination of concentration of sulfuric acid, acetic acid and copper sulphate by conductometric titration with sodium hydroxide.
8. Determination of SO_4^{2-} by turbidimetric titration / calibration curve method.
9. Determination of $SO_4^{2-}$by turbidimetric titration / calibration curve method.
10. Flame Photometric determination of Na / K by calibration curve method.
11. Flame Photometric determination of Na and K from mixture.
13. Estimation of Na / K by using internal standard method (Li as internal standard).

14. Estimation of K by standard addition method.

15. Demonstration practical on AAS: setting of fuel to oxidizer ratio, choice of conc. of metal ionfor AAS (Linearity range) (Use metal ion of which lamp is available with your laboratory).

Reference Books

1. Findlay's Practical Chemistry, S P Levitt (Editor), Longman Group Ltd

2. Experimental Physical Chemistry, Farrington Daniels and others, McGraw-Hill Book Company.

3. Experiments in Physical Chemistry, J.M. Wilson and others, Pergamon Press

4. Practical Physical Chemistry, A.M. James and P.E. Pritchard, Longman Group Ltd.

5. Experimental Physical Chemistry, V. Dathavale, Parul Mathur, New Age International Publishers.

6. Experimental Physical Chemistry, Das and Behera, Tata McGraw-Hill. Practical Physical Chemistry, D.V. Jahagirdar

7. Advanced physical Chemistry experiments by A. Gurtu, J.N. Gurtu

8. Vogel's textbook of quantitative chemical analysis, 6th Ed.

CHP-610 (A) MJ: Photochemistry

Course type: Major Core (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, students will be able to

1. Recall the fundamental laws of photochemistry and the general features of photochemical and photophysical processes.
2. Understand Einstein's treatment of the mechanism of absorption and emission of radiation, including selection rules and the Jablonski diagram.
3. Apply knowledge of photophysical kinetics to analyze uni and bimolecular processes, including mechanisms of delayed fluorescence and collisional quenching.
4. Analyze the principles and types of lasers, including two, three, and four-level lasers, as well as solid-state lasers such as Ruby and Nd/YAG lasers.
5. Evaluate experimental techniques used in photolysis and laser studies, including single photon counting and flash photolysis methods.
6. Summarize the significance and applications of photochemistry, with potential applications in solar energy conversion and photosynthesis.

Course Content

Chapter No.	Title with Contents	No. of hours
1	Introduction: Laws of photochemistry, interaction of light with matter, theory of photoluminescence, general features of photochemical and photophysical processes	05
2	Mechanism of absorption and emission of radiation: Einstein’s treatment, selection rules, Life times of excited electronic states of atoms and molecules Types of electronic transitions in organic molecules photochemical pathways, Jablonski diagram, Fluorescence, Phosphorescence	06
3	Photophysical kinetics of uni and bimolecular processes, delayed fluorescence mechanisms, kinetics of collisional quenching, Stern-	07

	Volmer equation, quenching by added substances charge transfer mechanism, energy transfer mechanism	
4	Photolysis, Laser-general principles, types of lasers: two, three and four level lasers, solid state Ruby and Nd/YAG laser, self-phase modulation, single photon counting, experimental techniques, flash photolysis: conventional microsecond flash photolysis, Nanosecond laser flash photolysis, Actinometry	**07**
5	Frontiers of photochemistry: Picosecond, Femtosecond flash photolysis, Applications: Solar energy, conversion and storage, photosynthesis	**05**

Reference Books

1. Fundamentals of photochemistry by K.K.Rohatgi-Mukherjee New Age International Publishers Revised Edition (Reprint 2003)

2. Chemistry and light by Paul Suppan, The Royal Society of Chemistry

CHP-610 (B) MJ: Physicochemical Methods of Analysis

Course type: Major Core (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, students will be able to

1. Learn the basic principles and concepts associated with X-ray methods, electron spectroscopy, and thermal analysis techniques.
2. Explain the underlying theories and principles behind X-ray generation, electron spectroscopy spectral splitting, and thermal analysis instrumentation.
3. Demonstrate the application of X-ray methods, electron spectroscopy, and thermal analysis techniques to analyze samples and derive meaningful information.
4. Analyze data obtained from X-ray, electron spectroscopy, and thermal analysis experiments to draw conclusions and interpret results effectively.
5. Critically evaluate the reliability and limitations of X-ray methods, electron spectroscopy, and thermal analysis techniques in various analytical contexts.
6. Create a summary of X-ray methods, electron spectroscopy, and thermal analysis techniques and explore its applications.

Course Content

Chapter No.	Title with Contents	No. of hours
1	X-ray methods: Generation and properties of X-rays, X-ray absorption, Concept of absorptive edge, applications, X-ray absorptive apparatus, applications, X ray fluorescence, fundamental principles, instrumentation, wavelength dispersive and energy dispersive, qualitative and quantitative analysis, electron microprobe	12
2	Electron spectroscopy for chemical analysis: Theory, spectral splitting and chemical shift. ESCA satellite peaks, Apparatus used for ESCA, applications	09

3	Thermal methods of analysis: TGA, DTA, DSC and thermometric titrations – principle, instrumentation, factors affecting TGA curve, applications	**09**

Reference Books

1) Introduction to Instrumental Analysis-R. D. Braun, McGraw Hill (1987).

2) Principles of Instrumental Analysis – Skoog, Holler, Nieman, 5th edition.

3) Instrumental Methods of Analysis – Willard, Merritt, Dean and Settle

4) Instrumental Methods of Chemical Analysis- Gurdeep R. Chatwal and Sham K. Anand

CHP-610 (C) MJ: Special Topics in Physical Chemistry

Course type: Major Elective (Theory) **No.of Credits: 2**

Course Outcomes

At the end of the course, students will be able to

1. Recall the fundamental concepts and principles related to nanoscience, hydrogen storage, and smart materials.
2. Understand the underlying mechanisms and relationships between different concepts within nanoscience, hydrogen storage, and smart materials.
3. Apply the knowledge and principles learned to solve problems or address challenges related to nanoscience, hydrogen storage, and smart materials.
4. Break down complex concepts or systems into smaller components to understand their interrelationships and implications within nanoscience, hydrogen storage, and smart materials.
5. Assess the effectiveness or validity of methods, theories, or applications within nanoscience, hydrogen storage, and smart materials.
6. Generate novel ideas, solutions, or designs that utilize principles and concepts from nanoscience, hydrogen storage, and smart materials to address real-world problems or challenges.

Course Content

Chapter No.	Title with Contents	No. of hours
1	**Nanoscience and Nanotechnology:** Introduction to Nanoworld, Metals, Semiconductor, Nanocrystals, Ceramics, Metal nanoparticles: Double layers, Optical properties &Electrochemistry, Magnetism, Chemical and catalytic aspects of Nanocrystals, Applications of nanoparticles	**10**
2	**Hydrogen Storage:** Fundamentals of Physisorption, temperature and pressure influence, chemisorption, adsorption energy, electrochemical adsorption.	**12**

	Practical adsorption-Storage of hydrogen with carbon materials, activated carbon graphene, carbon nanostructures, fullerene, carbon nanofibers and graphite. Electrochemical storage of hydrogen in carbon materials	
3	**Smart Materials:** Definition of smart materials (SM), Design of intelligent materials, actively smart and passively smart materials and their characteristics. e.g. - smart ceramics, oxides, smart polymers and gels, shape memory alloys, electrorheological fluids, ferrofluides, smart windows, smart sensors, smart electroceramics. Magnetostrictive materials, bio mineralisation and bio sensing. Integration to smart clothes, smart rooms.	**08**

Reference Books

1. Tushar K. Ghosh, Energy Resources and Systems: Volume 2: Renewable Resources, Volume 2 of Energy Resources and Systems, Energy Resources and Systems, Springer Link: Bücher, Springer, 2011

2. Strobel a, J Garche b, P Moseley c, L J Orissen b, Golfdeview Hydrogen storage by carbon materials." Journal of Power Sources (WWW.Sciencedirect.com) 159 (June 2006): 781–801.

3. AgataGodula-Jopek, Walter Jehle, Joerg Wellnitz, Hydrogen Storage Technologies: New Materials, Transport, and Infrastructure, John Wiley & Sons, 2012

4.YuryGogotsi, Carbon Nanomaterials, illustrated Volume 1 of Advanced Materials Series, Advanced Materials and Technologies Series, CRC Press, 2006 5.Robert A.Varin, Tomasz Czujko, Zbigniew S. Wronski , Nanomaterials for Solid State Hydrogen Storage Fuel Cells and Hydrogen Energy illustrated Springer, 2009

5. Intelligent materials – Craig A. Rogers, Scientific American, 1995,p.122

6. Smart structures and materials by B.Culshaw (Artech House, Norwood,MA1998)

7. Intelligent Gels Y. Osada and S.B. Ross – Murphy-Scientific American May1993

8. Introduction to Nanoscale science &technology Massimiliano Di Ventra, StephaneEvoye and James Heflin, Springer Publication.

CHP-631 RP: Research Project

Course type: Research Project **No. of Credits: 4**

Course Outcomes

At the end of the course, students will be able to -

1. understand key concepts and principles relevant to the research topic.
2. learn diverse research methodologies proficiently.
3. write and communicate research findings persuasively through various mediums in the form of project report
4. analyze and synthesize scholarly literature effectively.
5. evaluate research findings and methodologies critically.
6. design and execute original research projects independently.

Following guidelines should be followed for the conduction and evaluation of research project.

- Each student will perform project separately.
- Project working hours should be 30 hours for each credit.
- Choose a topic that aligns with your interests and career goals, but also consider its feasibility within the available resources and time frame.
- Consult with faculty members, advisors, or mentors to identify a research area that has potential for contribution to the field of chemistry.
- Adhere to ethical principles and standards in all aspects of your research.
- Project report must be written systematically and presented in bound form: The project will consist of name page, certificate, content, summary of project followed by introduction, literature survey (recently published research papers must be included), experimental techniques, results and discussion, conclusions, Appendix consisting of i) references, ii) standard spectra / data if any and iii) safety precautions.
- If student is performing project in another institute, for such a student, internal mentor must be allotted and he will be responsible for internal assessment of a student. In this case student has to obtain certificate from both external and internal mentor. Systematic record of attendance of project students must be maintained by a mentor.
- Project will be evaluated jointly by three examiners and there will not be any practical performance during the examination. Typically, student has to present his practical

work and discuss results and conclusions in details (20-30 min.) which will be followed by question-answer session (10 min). It is open type of examination.

- Students are encouraged to participate in national and international conferences and other project competitions.
- For conducting research study in M.Sc. Chemistry, it is highly recommended to follow the journals given below or any other journal from reputed publication.

1. **Journal of the American Chemical Society (JACS)**
   Publisher: American Chemical Society (ACS)
   Focus: Comprehensive coverage of all fields of chemistry, known for high-impact research.
2. **AngewandteChemie International Edition**
   Publisher: Wiley-VCH on behalf of the German Chemical Society (GDCh)
   Focus: Broad coverage of all chemistry fields, emphasizing novel and significant research.
3. **Chemical Science**
   Publisher: Royal Society of Chemistry (RSC)
   Focus: Cutting-edge research across chemical sciences, open access.
4. **Nature Chemistry**
   Publisher: Nature Publishing Group
   Focus: Multidisciplinary and high-impact research across all areas of chemistry.
5. **Journal of Organic Chemistry (JOC)**
   Publisher: American Chemical Society (ACS)
   Focus: Specialized in organic chemistry, including synthesis and mechanisms.
6. **Inorganic Chemistry**
   Publisher: American Chemical Society (ACS)
   Focus: Research on inorganic and organometallic compounds.
7. **Analytical Chemistry**
   Publisher: American Chemical Society (ACS)
   Focus: Developments and applications in analytical techniques and methodologies.
8. **Physical Chemistry Chemical Physics (PCCP)**
   Publisher: Royal Society of Chemistry (RSC)
   Focus: Physical chemistry, chemical physics, and biophysical chemistry.
9. **Chemical Communications (ChemComm)**

Publisher: Royal Society of Chemistry (RSC)

Focus: Rapid publication of high-quality communications across all chemical sciences.

10. **Accounts of Chemical Research**

    Publisher: American Chemical Society (ACS)

    Focus: Comprehensive reviews and accounts of current research topics in chemistry.

11. **Chemical Society Reviews**

    Publisher: Royal Society of Chemistry (RSC)

    Focus: The journal publishes high-quality, authoritative, and state-of-the-art reviews across all areas of chemical science. It covers comprehensive and critical reviews on a broad range of topics in chemistry, including emerging and interdisciplinary fields.

Semester-IV

CHP-651 MJ: Molecular Structure and Spectroscopy

Course type: Major Core (Theory) **No. of Credits: 4**

Course Outcomes

At the end of the course, students will be able to

1. Recall spectroscopic concepts like nuclear spin and X-ray diffraction indices.
2. Grasp the principles behind spectroscopic methods, such as chemical shift in NMR and structure factor in X-ray diffraction.
3. Apply spectroscopic knowledge to analyze experimental data and interpret results.
4. Break down complex spectroscopic data to draw conclusions and make predictions.
5. Assess the effectiveness and limitations of spectroscopic techniques in different scenarios.
6. Generate new ideas based on spectroscopic understanding.

Course Content

Chapter No.	Title with Contents	No. of hours
	Section-I	
1	Nuclear Magnetic Resonance Spectroscopy: Nuclear spin, nuclear resonance saturation, Shielding of magnetic nuclei, chemical shift and its measurements. Factors influencing chemical shift, deshielding, spin-spin interactions, factors influencing coupling constant "J" Classification (ABX, AMX, ABC. A2 B2) spin decoupling, basic ideas about Instrument, NMR studies of nuclei other than proton ^{13}C, $^{19}F$and, ^{31}P, FT NMR, advantages of FT NMR, use of NMR in medical diagnostics.	15
2	Electron Spin Resonance Spectroscopy: Basic principles, zero field splitting and Kramer's degeneracy, factors affecting the "g" value. Isotropic and anisotropic hyperfine coupling constants, spin	10

	Hamiltonian, spin densities and Mc Connell relationship, measurement techniques, applications.	
3	Nuclear quadrupole resonance spectroscopy: Quadrupole nuclei, quadrupole moments, electric field gradient, coupling constant, splitting, and applications.	**05**
Section-II		
1	X- Ray diffraction: Index reflections, Identifications of unit cell from systematic absences in diffraction pattern. Structure of simple lattices and X-Ray intensities. Structure factor and its relation to intensity and electron density, phase problems in XRD	**10**
2	Electron Diffraction: Cattering intensity Vs Scattering angle, Wierl equation, measurement technique, elucidation of structure of simple gas phase molecules, low energy electron diffraction and structure of surfaces.	**05**
3	Neutron Diffraction analysis: Scattering of neutron by solids and liquids, Magnetic scattering, Measurement techniques, Elucidation of structure of magnetically ordered unit cell	**05**
4	Magnetic susceptibility: Pascal constant, Diamagnetic susceptibility, paramagnetic susceptibility, Langevin Equation ,Van Vlecks formula, Ferro, Ferri and Antiferromagnetism, Measurement of Magnetic susceptibility by Faraday and Gouy Techniques.	**10**

Reference Books

1. Modern Spectroscopy J.M. Hollas, (John Wiley)
2. Spectroscopy (Atomic and Molecular) Gurdeep Chatwal, Sham Anand (Himalaya Publishing house)
3. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi& F.L. Ho (Wiley interscience)
4. Introduction to Magnetic resonance A. Carrington and A.D Maclachalan , Harper & Row
5. Spectroscopy B.K. Sharma
6. NMR, NQR, & Mossbauer Spectroscopy in Inorganic Chemistry R.V.Parish, Ellis Harr wood
7. Physical methods in Chemistry R.S Drago, Saunders college

8. Introduction to Molecular Spectroscopy G.M. Barro, Mc Graw Hill

9. Basic principles of spectroscopy R. Chang, Mc Graw Hill

10. A text book of Spectroscopy.O.D. Tyagi& M. Yadhav Anmol Publications

11. Introduction to Magento chemistry AlenEarnshaw, Acad Press (1968)

12. Magneto chemistry Sanyl and Dutta

13. Chemist’s guide to NM spectroscopy – Mc Comber (Wiley) 2000.

CHP-652 MJ: Surface Chemistry and Electrochemistry

Course type: Major Core (Theory) **No. of Credits: 4**

Course Outcomes

At the end of the course, students will be able to

1. Recall key principles of surface chemistry, such as Gibbs equation for adsorption at liquid surfaces and the theories of multilayer adsorption.
2. Understand the thermodynamics of adsorption forces and the mechanisms behind chemisorption.
3. Apply knowledge of surface chemistry to analyze and compare different adsorption models and methods for measuring surface area.
4. Break down complex concepts in surface chemistry, such as porous solids and their adsorption behaviors, to understand their underlying theories.
5. Evaluate the effectiveness of various electrochemical theories and equations, such as the Debye-Huckel Theory and Butler-Volmer equation, in explaining ion-ion interactions and electrokinetic phenomena.
6. Generate innovative ideas for practical applications of electrochemistry, such as designing fuel cells and batteries for primary and secondary power sources.

Course Content

Chapter No.	Title with Contents	No. of hours
	Section-I	
1	Adsorption at liquid surfaces, Gibbs equation and its verification, Gibbs Monolayers, insoluble films on liquid substrates, states of monomolecular Films, Wetting, flotation, detergency.	10
2	Adsorption forces, thermodynamics of physical adsorption, heat of adsorption and its determination, measurement of adsorption by different methods, chemisorption and its mechanism.	10
3	Multilayer adsorption – critical comparison of various multilayer models- BET, Potential and Polanyi models (no derivation).	07

	Measurement of surface area of solids by different methods. Harkins and Jura equation.	
4	Porous solids – Definition, pore size distribution, methods to determine pore size, hysteresis of adsorption, theories of hysteresis, and Adsorption behaviours of porous materials.	**03**
	Section-II	
1	Ionics - Ion-ion interaction: Activity and activity coefficients, Debye-Huckel Theory, limited and extended law. Ion transport in solution: Fick's laws of diffusion, Einstein relation between diffusion coefficient and ionic mobilities, The Nernst-Einstein equation, relation between absolute and conventional mobilities.	**14**
2	Electrodics – Standard electrode potentials, Liquid junction potential, Zeta potential, electrokinetic phenomena, electrode-electrolyte interface, double layer theories, Butler- Volmer equation, and Tafel equation.	**10**
3	Applications -Fuel cells and batteries – primary and secondary power cells, fuel cells, Li ion battery	**06**

Reference Books:

1. Physical chemistry of surfaces – A. W. Adamson, Interscience publishers Inc New York, 1967.
2. Surface chemistry – Theory and applications, J. J. Bikerman, Academic press, New York 1972.
3. Adsorption, surface area and porosity – S. J. Gregg and K. S. W. Sing, Academic Press Ltd., London 1967.
4. Zeolites and clay minerals as Adsorbents and molecular sieves, R. M. Barrar, Academic Press London.
5. Physical adsorption of gases, D. M. Young and A. D. Crowell, Butterworths, London, 1962.
6. Adsorption, J. Oscik, John Wiley and Sons. New York.
7. Physical chemistry - Peter Atkins, Julio de Paula, 7th Edition Oxford University Press.
8. Modern Electrochemistry - Vol I & II J O'M Bockris and AKN eddy, Plenum Press, N.Y.
9. Fuel cells - heir Electrochemistry, J O'M Bockris and S Srinivasan, McGraw Hill, NY

(1969)

10. Fuel cell systems L.I. M Blomen and M.N. Mugerwa, Plenum Press NY (1993)

11. Principles of Physical Chemistry – Samuel

CHP-653 MJP: Physical Chemistry Practical - III

Course type: Major Core (Practical) **No. of Credits: 2**

Course Outcomes

At the end of the course, students will be able to

1. Recall experimental procedures Physical Chemistry Practical.
2. Grasp the principles behind Physical Chemistry experiments.
3. Apply gained knowledge to perform experiments accurately.
4. Analyze experimental data and results to draw conclusions.
5. Evaluate the reliability and precision of analytical methods and results.
6. Generate new experimental designs or methodologies for Physical Chemistry experiments.

Course Content

Any 12 experiments from the following-

1. Solubility of a sparingly soluble salt by conductometry.
2. Activity coefficient of electrolyte by emf measurements.
3. Titration of polybasic acid with sodium hydroxide by pH- metry.
4. Formation constant of a complex by pH- metry.
5. Determination of solubility diagram for a three component liquid system.
6. Molecular weight of a polymer by end group estimation.
7. Determination of the formula of complexes such as silver –ammonia complex by titration, cuprammonium ion complex by distribution coefficient measurement.
8. Determination of Riboflavin by Photoflurometry calibration curve method.
9. Determination of quinine sulfate by Photoflurometry by standard addition method.
10. Differential potentiometric titration.
11. Aerometric titration with platinum microelectrode.
12. Magnetic susceptibility measurements by the Faraday technique.
13. Determination of Molecular weight of a given polymer by turbidimetry.
14. Surface tension and parachor of liquids by stalagmometer and differential capillary method.
15. Determination of surface tension of water in presence of surfactant and hence surface excessby capillary rise method/Du-NouyTensionometer.

16. Study of kinetics of oxidation of ethanol by potassium dichromate.

17. To study the formation of complex ions by cryoscopy.

Reference Books

1. Findlay's Practical Chemistry, S P Levitt (Editor), Longman Group Ltd

2. Experimental Physical Chemistry, Farrington Daniels and others, McGraw-Hill Book Company.

3. Experiments in Physical Chemistry, J.M. Wilson and others, Pergamon Press

4. Practical Physical Chemistry, A.M. James and P.E. Pritchard, Longman Group Ltd.

5. Experimental Physical Chemistry, V. Dathavale, Parul Mathur, New Age International Publishers.

6. Experimental Physical Chemistry, Das and Behera, Tata McGraw-Hill. Practical Physical Chemistry, D.V. Jahagirdar

7. Advanced physical Chemistry experiments by A. Gurtu, J.N. Gurtu

8. Vogel's textbook of quantitative chemical analysis, 6th Ed.

CHP-654 MJP Physical Chemistry Practical - IV

Course type: Major Core (Practical) **No. of Credits: 2**

Course Outcomes

At the end of the course, students will be able to

1. Recall experimental procedures for analyzing the relative strength of acids using conductometry.
2. Understand the factors influencing critical temperature in a phenol-water system and their experimental manipulation.
3. Apply knowledge of electrochemical principles to determine transport numbers of ions in solution.
4. Analyze experimental data to determine the heat of ionization of phenol or weak acids.
5. Evaluate the experimental data to determine the second-order velocity constant of a reaction using conductometry.
6. Develop experimental procedures to determine the order of reaction in specific chemical reactions.

Course Content

Any 12 experiments from the following-

1. To determine the relative strength of acetic acid, chloroacetic acid and tri-chloroacetic acid byconductometry.

2. To study the effect of amount of different salts on critical temperature of phenol water system.

3. Determine the transport number of silver and nitrate ions in aqueous solution from the cell potential of the concentration cell with junction potential.

4. Determination of the heat of ionization of phenol/weak acid.

5. To determine second order velocity constant of ethyl acetate by conductometry.

6. To determine order of reaction of iodination of aniline.

7. Thermodynamic parameters of an electrochemical cell, temperature dependence of EMF.

8. Coulometric estimation of arsenite by bromine.

9. Dead stop end point titration.

10. Kinetics of the reaction between 2,4-dinitrochlorobenzene and piperidine.

11. Recording of TGA curve of $CuSO_4$ and NaCl and hence to find the percentage

composition of the mixture.

12. To determine the solubility of given salt at room temperature from its solubility curve.

13. Kinetics of condensation polymerization by dilatometry.

14. Study of counting errors

15. Analysis of tertiary mixture by Gas chromatography.

16. To determine concentration of Ni^{2+} and Co^{2+} ions by simultaneous determination method from their mixture spectrophotometrically.

17. To investigate reaction between H_2O_2 and KI.

Reference Books

1. Findlay's Practical Chemistry, S P Levitt (Editor), Longman Group Ltd.
2. Experimental Physical Chemistry, Farrington Daniels and others, McGraw-Hill Book Company.
3. Experiments in Physical Chemistry, J.M. Wilson and others, Pergamon Press.
4. Practical Physical Chemistry, A.M. James and P.E. Pritchard, Longman Group Ltd.
5. Experimental Physical Chemistry, V. Dathavale, Parul Mathur, New Age International Publishers.
6. Experimental Physical Chemistry, Das and Behera, Tata McGraw-Hill. Practical Physical Chemistry, D.V. Jahagirdar.
7. Advanced physical Chemistry experiments by A. Gurtu, J.N. Gurtu.

CHP-660 (A) MJ: Material Chemistry

Course type: Major Elective (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, students will be able to

1. Learn the key properties and characteristics of hitech materials, such as defect perovskites and superconductivity in cuprates.
2. Understand the preparation techniques and characterization methods used for hitech materials, including thin films and superconducting solids.
3. Apply knowledge of hitech materials to analyze their normal state properties, anisotropy, and temperature dependencies of electrical resistance.
4. Analyze the various physical properties of hitech materials, such as optical photon modes, elastic constants, and heat capacity.
5. Evaluate the applications of hitech materials in different industries and technologies.
6. Develop innovative solutions or designs utilizing hitech materials for the development of solid devices like rectifiers, transistors, and capacitors.

Course Content

Chapter No.	Title with Contents	No. of hours
1	**Hitech materials:** Defect perovskites, super conductivity in cuprates, preparation & characterization of 1-2-3 & 2- 1-4, Normal state properties, anisotropy, temperature dependents of electrical resistance, optical photon modes, coherent length, elastic constants posion life times, heat capacity, micro wave absorption, pairing &multigap structure in hitech materials. Application of Hitech materials.	14
2	**Thin films Langmuir – Blodgett films:** Preparation techniques, sputtering, chemical process, MOCVED, Langmuir – Blodgett films, Photolithography, Applications of LB films.	06

3	**Superconducting solid materials:** Superconducting state, high critical temperature superconductors, Low critical temperature superconductors	**04**
4	Materials of solid devices: Rectifiers, transistors, capacitors, IV-V compounds low dimensional quantum structures, optical properties.	**06**

Reference books:

1. Material science & Engineering, An Introduction - W.D. Callister, Willey.
2. Principles of solid state – H.V. Keer, Willey.
3. Materials Science – Anderson, Leaver, Alexander, & Rawlings, ELBS
4. Theromotropic liquid crystals Gray, Willey
5. Text Book of liquid crystals – Kelkar&Halz, ChemieVerlag

CHP-660 (B) MJ: Chemistry of Catalysts

Course type: Major Elective (Theory) **No .of Credits: 2**

Course Outcomes

At the end of the course, students will be able to

1. Know the theories of catalysis, including intermediate compound formation theory and adsorption theory, and understand the concepts of bio-catalysis, autocatalysis, and negative catalysis.
2. Recognize the characteristics of catalytic reactions such as activity, selectivity, and deactivation, as well as the types of catalysis including homogeneous, heterogeneous, and enzyme catalysis.
3. Employ knowledge of catalyst preparation methods such as precipitation, sol-gel, and impregnation, as well as catalyst activation techniques like calcination and reduction.
4. Explore the various characterization techniques used for catalysts, including surface area determination, particle size analysis, and spectroscopic methods like XPS, AES, UV-Vis, and FT-IR.
5. Assess the role of catalysis in green chemistry and environmental applications, including the purification of exhaust gases and VOC removal.
6. Develop innovative applications of photo-catalysis in organic pollutant degradation, water splitting, and energy and environmental sustainability.

Course Content

Chapter No.	Title with Contents	No. of hours
1	**Theories of catalysis-** intermediate compound formation theory and adsorption theory. Catalysis: bio catalysis, autocatalysis, negative catalysis, characteristics of catalytic reactions concept of activity, selectivity, poisoning, promotion and deactivation. Types of catalysis: homogeneous, heterogeneous. Enzyme catalysis, effect of temperature and pH on enzyme catalysis. Heterogeneous catalysis and catalytic kinetics: concept of Langmuir-Hinshelwood	10

2	**Preparation and Characterization of Catalysts:** General methods for preparation of catalysts: precipitation, sol-gel, hydrothermal, impregnation, hydrolysis, vapour deposition. Activation of catalysts: calcinations, reduction. Catalyst characterization: surface area, pore size distribution, particle size determination, XPS, AES, UV-Vis, FT-IR and thermal methods	**10**
3	**Catalysis in green chemistry and environmental applications**: Purification of exhaust gases from different sources: auto-exhaust catalysts (petrol vehicles, diesel vehicles), VOC removal; ozone decomposition.	**04**
4	**Photo-catalysis: Photoprocesses at metals, oxides and semiconductors:** concepts and mechanism. Photocatalysis application in organic pollutant degradation present in water and air. Photocatalytic water splitting, photocatalysis in the field of energy and environment.	**06**

Reference books

1. Physical Chemistry of Surfaces, W. Adamson, Wiley Intersciences,(5th edition) 1990.
2. Heterogeneous Catalysis: Principles and Applications. Bond, G C, Oxford University Press 1987
3. Heterogeneous Catalysis, D.K. Chakrabarty and B. Viswanathan, New Age Publishers
4. Principles of Physical Chemistry by Puri, Sharma, Pathania , 45th edition
5. Catalytic Chemistry, B.C. Gates, John Wiley and Sons Inc. (1992)
6. Solid state physics – N.W. Aschocruts& N.D. Mermin, Saunders College.

CHP-660 (C) MJ: Biophysical Chemistry

Course type: Major Elective (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, students will be able to

1. Recall the fundamental concepts of bioenergetics and thermodynamics, including the explanationof energy at the molecular level, non-covalent reactions, and the utilization of ATP in biological systems.
2. Grasp the principles underlying enzyme kinetics, encompassing Michaelis Menten kinetics and mechanisms of competition and inhibition.
3. Utilize knowledge of spectroscopy techniques to analyze spectra of biomolecules, such as proteins and nucleic acids, and apply interpretation to data related to secondary structures and optical properties.
4. Examine the macromolecular structure of proteins and nucleic acids, including chain configurations and issues of protein folding, using X-ray diffraction techniques and principles like Bragg's Law.
5. Assess the biochemical applications of thermodynamics and kinetics in metabolism and biological reactions, as well as the significance of catalytic antibodies and RNA enzymes in enzymatic processes.
6. Develop innovative approaches or experiments utilizing spectroscopy and X-ray diffraction to explore biomolecular structures and functions in depth.

Course Content

Chapter No.	Title with Contents	No. of hours
1	**Bioenergetics and Thermodynamics:** Molecular interpretation of Energy and Enthalpy, Non-covalent reactions, hydrophobic interactions, Protein and Nucleic Acids. Biochemical Applications of Thermodynamics, Thermodynamics of Metabolism, Role of ATP in biological Systems (hydrolysis of ATP). Biological Reactions, Double Stranded Formation in Nucleic Acids, Ionic Effect on Protein–Nucleic Acid Interactions.	10

2	**Kinetics:** Basic Concepts, Enzyme kinetics, catalytic antibodies and RNA enzymes- Ribozymes, Michaelis Menten Kinetics, Competition and Inhibition, Monod- WhymanChangeux Mechanism.	**06**
3	**Spectroscopy of Biomolecules:** Spectra of Proteins and Nucleic Acids, Amino acid, Polypeptides, Secondary structure, Rhodopsin: A Chromophoric Protein, Principles of Circular dichorism and optical rotator dispersion, applications to biomolecules.	**07**
4	**Macromolecular structure and X-ray diffraction:** Chain configuration and conformations of macromolecules, proteins and polypeptides, problems of protein folding, Fundamentals of X-rays, Braggs Law, Determination of molecular structure, calculation of diffracted intensities from atomic co-ordinates.	**07**

Reference Books

1. Biophysical Chemistry, Gurtu and Gurtu, Pragati Edition, 2007.
2. Physical Chemistry, Principles and Applications in Biological Sciences I. Tinico, K. Sauer, J. Wang and J. D. Puglisi, 4th Edition, Pearson Edition, 2007.
3. Biophysical Chemistry, A. Upadhyay, K Upadhyay and N. Nath, Himalaya Publishing House, 2005.
4. Biophysical Chemistry, James P. Allen,
5. Biophysical Chemistry, C. R.Cantor and P.R. Schimmel, WH Freeman & Company, New York, 2004.

CHP-681 RP: Research Project

Course type: Research Project **No. of Credits: 6**

Course Outcomes

At the end of the course, students will be able to -

1. understand key concepts and principles relevant to the research topic.
2. learn diverse research methodologies proficiently.
3. write and communicate research findings persuasively through various mediums in the form of project report
4. analyze and synthesize scholarly literature effectively.
5. evaluate research findings and methodologies critically.
6. design and execute original research projects independently.

Following guidelines should be followed for the conduction and evaluation of research project.

- Each student will perform project separately.
- Project working hours should be 30 hours for each credit.
- Choose a topic that aligns with your interests and career goals, but also consider its feasibility within the available resources and time frame.
- Consult with faculty members, advisors, or mentors to identify a research area that has potential for contribution to the field of chemistry.
- Adhere to ethical principles and standards in all aspects of your research.
- Project report must be written systematically and presented in bound form: The project will consist of name page, certificate, content, summary of project followed by introduction, literature survey (recently published research papers must be included), experimental techniques, results and discussion, conclusions, Appendix consisting of i) references, ii) standard spectra / data if any and iii) safety precautions.
- If student is performing project in another institute, for such a student, internal mentor must be allotted and he will be responsible for internal assessment of a student. In this case student has to obtain certificate from both external and internal mentor. Systematic record of attendance of project students must be maintained by a mentor.
- Project will be evaluated jointly by three examiners and there will not be any practical performance during the examination. Typically, student has to present his practical

work and discuss results and conclusions in details (20-30 min.) which will be followed by question-answer session (10 min). It is open type of examination.

- Students are encouraged to participate in national and international conferences and other project competitions.
- For conducting research study in M.Sc. Chemistry, it is highly recommended to follow the journals given below or any other journal from reputed publication.

1. **Journal of the American Chemical Society (JACS)**
   Publisher: American Chemical Society (ACS)
   Focus: Comprehensive coverage of all fields of chemistry, known for high-impact research.
12. **AngewandteChemie International Edition**
   Publisher: Wiley-VCH on behalf of the German Chemical Society (GDCh)
   Focus: Broad coverage of all chemistry fields, emphasizing novel and significant research.
13. **Chemical Science**
   Publisher: Royal Society of Chemistry (RSC)
   Focus: Cutting-edge research across chemical sciences, open access.
14. **Nature Chemistry**
   Publisher: Nature Publishing Group
   Focus: Multidisciplinary and high-impact research across all areas of chemistry.
15. **Journal of Organic Chemistry (JOC)**
   Publisher: American Chemical Society (ACS)
   Focus: Specialized in organic chemistry, including synthesis and mechanisms.
16. **Inorganic Chemistry**
   Publisher: American Chemical Society (ACS)
   Focus: Research on inorganic and organometallic compounds.
17. **Analytical Chemistry**
   Publisher: American Chemical Society (ACS)
   Focus: Developments and applications in analytical techniques and methodologies.
18. **Physical Chemistry Chemical Physics (PCCP)**
   Publisher: Royal Society of Chemistry (RSC)
   Focus: Physical chemistry, chemical physics, and biophysical chemistry.
19. **Chemical Communications (ChemComm)**

Publisher: Royal Society of Chemistry (RSC)

Focus: Rapid publication of high-quality communications across all chemical sciences.

20. Accounts of Chemical Research

Publisher: American Chemical Society (ACS)

Focus: Comprehensive reviews and accounts of current research topics in chemistry.

21. Chemical Society Reviews

Publisher: Royal Society of Chemistry (RSC)

Focus: The journal publishes high-quality, authoritative, and state-of-the-art reviews across all areas of chemical science. It covers comprehensive and critical reviews on a broad range of topics in chemistry, including emerging and interdisciplinary fields.