ONE YEAR
M.Sc. SYLLABUS

FOR POST GRADUATE COURSE IN CHEMISTRY AT ST. XAVIER'S COLLEGE
RANCHI (AUTONOMOUS COLLEGE OF RANCHI UNIVERSITY)

Modified & Implemented for Academic Session 2026-2027 Onwards

SEMESTER I

I. CORE COURSE [CCCHE311]
INDIAN KNOWLEDGE SYSTEM & METALLURGY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 15 + ESE: 30) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to:

1. Understand the historical context of Chemistry in Ancient India and its philosophical foundations.
2. Explore the evolution of metallurgy from the Stone Age to the Metal Age, including discoveries of tin, gold, silver, brass, bronze and iron.
3. Analyse the significance of Zawar mines as the beginning of the Industrial Revolution in India.
4. Study the development of iron and steel technology and its impact on society.
5. Learn about Ayurveda and Alchemy as foundational pillars of Indian chemical sciences.
6. Appreciate the contribution of Indian knowledge systems to global science and technology.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. Demonstrate an in-depth understanding of the evolution of chemistry and metallurgy in ancient India.
2. Interpret the processes of ancient mining, smelting and metal production techniques.
3. Analyse archaeological and textual evidence related to ancient chemical knowledge systems.
4. Evaluate the scientific significance of Indian iron pillars, alloys and industrial techniques.
5. Correlate the philosophical foundations of Ayurveda and Alchemy with the development of chemistry as a discipline.
6. Develop critical thinking and research aptitude in historical chemistry and its relevance to modern material science.

Course Content:

UNIT I: Introduction to Ancient Indian Chemistry: **(08 Lectures)**

Historical context of Ancient Indian Chemistry, philosophical foundations including Sāṅkhya–The atomic theory- Vaisesika Darshan- Theory of Maharshi Kanada Pātañjala, Vaiśeṣika and Nyāya chemical theories, early concepts of matter and five-element theory (Pañcīkaraṇa), chemistry in Vedic and post-Vedic periods, contributions of Buddhists and Jains to chemical theory.

UNIT II: Metallurgy in Ancient India: **(12 Lectures)**

Transition from the Stone Age to the Metal Age. Evolution of Metallurgy from Stone, Copper, Bronze to Iron Age, discovery and use of tin, gold, silver, brass and bronze, case study of Aranmula Kannadi (metal mirror) as a metallurgical marvel, role of Zawar mines and zinc distillation as beginning of industrial revolution, archaeological and literary evidence for ancient smelting and alloy-making, trade, economy and cultural significance of metals.

UNIT III: Iron and Steel Traditions in Ancient India: **(08 Lectures)**

Introduction to Iron in Ancient India, Wootz steel, iron and steel production techniques, timeline and study of Indian Iron Pillars including Delhi, Dhar, Kodachadri and others, chemical analysis of rust-free iron pillars and their metallurgical significance, European observations on Indian iron and steel during the 18th and 19th centuries.

UNIT IV: Ancient Indian Chemistry and Ayurveda: **(08 Lectures)**

Chemistry in Ayurveda with focus on Rasashastra, preparation of bhasma and rasa compounds, role of minerals, metals and herbs in therapeutic formulations, modern scientific validation of Ayurvedic processes and their relevance to pharmaceutical chemistry.

Dr. U. R. Sen | Dr. Smriti Singh | Dr. A. K. Saha | Dr. Sumit Mishra | Dr. S. C. Jain

Dr. N.K. Roy | Dr. H.N. Kumar | Dr. S.K. Pandey | Dr. A. Karmakar | Dr. S. Hazra

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UNIT V: Introduction to Alchemy (Rasayana) in Ancient India: **(12 Lectures)**

Concept of Rasayana (alchemy) in Indian tradition, objectives of alchemy including transformation of base metals into noble metals and preparation of elixirs, religious, spiritual and medicinal significance of alchemical practices, relevance of ancient Indian alchemical practices in modern chemical research.

UNIT VI: Integrative Approaches in Chemistry: **(12 Lectures)**

Ancient Knowledge and Modern Science, Integration with Modern Chemistry: Comparative study of ancient metallurgical techniques with present-day extraction and refining methods, Ancient natural product chemistry (Ayurvedic formulations, bhasmas, herbal preparations) and their modern analytical validations, Traditional practices in environmental chemistry (water purification, sustainable agriculture) vis-à-vis green chemistry principles. Applications for the Future: Relevance of ancient sustainable chemical practices in modern times, Case studies of indigenous techniques inspiring current chemical research (e.g., nanomedicine parallels with bhasma preparations), Role of IKS in developing eco-friendly, low-cost, and innovative solutions for future chemical industries.

UNIT VII: Case Study: Field-Based Learning through Indian Knowledge System Heritage Sites in Jharkhand.

1. **Deori Mandir (Ranchi)**
   a. Highlight: Self-manifested Shiva Linga; tribal and Vedic integration.
   b. IKS Link: Ancient rituals, Tribal-Vedic synthesis, local Ayurvedic practices.
2. **Navratangarh Fort (Gumla)**
   a. Highlight: Architectural blend of tribal and Mughal techniques.
   b. IKS Link: Political science, defense architecture, resource management.
3. **Palamu Forts (Betla National Park)**
   a. Highlight: Ancient military architecture and water systems.
   b. IKS Link: Traditional water conservation, strategic design.
4. **Shikharji Circuit (Jharkhand)**
   a. Highlight: Jain tirtha with rich environmental tradition.
   b. IKS Link: Sacred ecology, spiritual environmentalism.

Essential Readings

1. Indian Science and Technology in the Eighteenth Century (2000) by Dharampal, Other India Press.
2. History of Hindu Chemistry Vol 1 (1903) and Vol 2 (1909) by P.C. Ray; The Bengal Chemical and Pharmaceutical Works, Ltd.
3. The Positive Sciences of the Ancient Hindus by Brajendranath Seal; Longman Greens and Co., Kolkata, 1915.
4. A concise history of science in India; Edited by D. M. Bose, S.N. Sen and B. V. Subbarayappa; Indian National Science Academy, New Delhi; 1971.
5. History of Science and Technology in Ancient India- The Beginnings; by Debiprasad Chattopadhyay; FIRMA KLM Pvt. Ltd., Kolkata; 1986 (Reprinted in 1996).
6. History of Technology in India; Edited by A.K. Bag; Indian National Science Academy, New Delhi; 1997.

Suggested Readings

1. S. Prakash, Founders of Science in Ancient India, The Research Institute of Ancient Studies, New Delhi (1965).
2. Prakash B, 2001, Ferrous Metallurgy in Ancient India, NML Jamshedpur 831 007, India, page no. 52-91.
3. Dr. Siddhinandan Mishr, Ayurveda Rasashastra.

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Dr. R. K. Singh | Dr. Anurag Mehta 29/5/26

Case Study:

1. IGNCA – *Indian Cultural Heritage Studies*
2. Kapil Kapoor – *Text and Interpretation in Indian Traditions*
3. Michel Danino – *The Lost River & Indian Roots of Science*
4. Dharampal – *Indian Science & Technology in the 18th Century*
5. Subhash Kak – *The Astronomical Code of the Rigveda*
6. Ministry of Tribal Affairs – *Tribal Culture and Practices*
7. Jharkhand Tourism Board – *Heritage and Culture Booklets*
8. Prof. R. Balasubramaniam – *Studies on Iron and Metallurgy in Ancient India*
9. ASI (Eastern Circle) Reports – *Jharkhand Archaeological Survey*
10. IKS Division, AICTE – *Field Visit Guidelines and Learning Tools*

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II. SKILL ENHANCEMENT COURSE [ECCHE312]
BIO-CHEMISTRY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 15 + ESE: 30) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. The role of metal ions in the biological system,
2. ATP as the energy currency of living cells.
3. Transport and Storage of Dioxygen in living organisms.
4. The function of metalloproteins in electron transport processes
5. Enzymes and Mechanism of Enzyme Action
6. Biotechnological Applications

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. Forces involved in biopolymer interactions.
2. Photosystem I & II and their importance.
3. Heme proteins and oxygen uptake
4. Biological nitrogen fixation.
5. Mechanism of Enzyme Action.
6. Biological Cell and its constituents.
7. Thermodynamics of biopolymer Solutions.

Course Content:

GROUP-A (Bioinorganic Chemistry)

UNIT I: Metal Ions in Biological Systems **(02 Lectures)**

A brief introduction to bioinorganic chemistry. Geochemical effect on the distribution of metals. Essential and trace metals. Role of metal ions in biological processes, systems with special reference to Na^+, K^+ and Mg^{2+} ions: Na/K pump, Role of Mg^{2+} ions in energy production and chlorophyll. Iron and its application in bio-systems, Hemoglobin, Myoglobin, Storage and transfer of iron. Role of Ca^{2+} in blood clotting, stabilisation of protein structures and structural role (bones).

UNIT II: Bioenergetics and ATP Cycle **(05 Lectures)**

DNA polymerisation, glucose storage, metal complexes in the transmission of energy; chlorophylls, photosystem I and photosystem II in the cleavage of water. Model systems.

UNIT III: Transport and Storage of Dioxygen **(06 Lectures)**

Heme proteins and oxygen uptake, structure and function of hemoglobin, myoglobin, hemocyanins and hemerythrin, model synthetic complexes of iron, cobalt and copper.

UNIT IV: Electron Transfer in Biology **(05 Lectures)**

Structure and function of metalloproteins in electron transport processes - cytochromes and ion-sulphur proteins, synthetic models

UNIT V: Nitrogenase **(05 Lectures)**

Biological nitrogen fixation, molybdenum nitrogenase, spectroscopic and other evidence, other nitrogenases model systems.

GROUP-B (Bioorganic Chemistry)

UNIT VI: Enzymes and Mechanism of Enzyme Action **(10 Lectures)**

Basic considerations. Proximity effects and molecular adaptation. Introduction and historical perspective, chemical and biological catalysis, remarkable properties of enzymes like catalytic power, specificity and regulation. Nomenclature and classification, extraction and purification. Fischer's lock and key and Koshtand's induced fit hypothesis, concept and

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identification of active site by the use of inhibitors, affinity labeling and enzyme modification by site-directed mutagenesis. Enzyme kinetics, Michaelis-Menten and Lineweaver-Burk plots, reversible and irreversible Inhibition.

Mechanism of Enzyme Action: Transition-state theory, orientation and steric effect, acid-base catalysis, covalent catalysis, strain or distortion. Examples of some typical enzyme mechanisms for chymotrypsin, ribonuclease, lysozyme and carboxypeptidase A.

UNIT VII: Enzyme Catalysed Reactions **(05 Lectures)**

Nucleophilic displacement on a phosphorus atom, multiple displacement reactions and the coupling of ATP cleavage to endergonic processes. Addition and elimination reactions, enolic intermediates in isomerization reactions, p-cleavage and condensation, some isomerisation and rearrangement reactions. Enzyme-catalysed carboxylation and decarboxylation.

UNIT VIII: Co-Enzyme Chemistry **(04 Lectures)**

Enzyme Models. Cofactors as derived from vitamins, coenzymes, prosthetic groups, apoenzymes. Structure and biological functions of coenzyme A, thiamine pyrophosphate, pyridoxal phosphate, NAD^+, $NADP^+$ FMN, FAD, lipolc acid, vitamin B_{12}. Mechanisms of reactions catalyzed by the above cofactors.

UNIT IX Biotechnological Applications of Enzymes **(04 Lectures)**

Large-scale production and purification of enzymes, techniques and methods of immobilisation of enzymes, effect of immobilization on enzyme activity, application of immobilised enzymes, use of enzymes in food and drink industry-brewing and cheese-making, syrups from corn starch, enzymes as targets for drug design. Clinical uses of enzymes, enzyme therapy, enzymes and recombinant DNA technology.

GROUP-C (Biophysical Chemistry)

UNIT X: Biological Cell and its constituents **(02 Lectures)**

Biological cell, structure and functions of proteins, enzymes, DNA and RNA in living systems. Helix coil transition.

UNIT XI: Biopolymer Interactions **(04 Lectures)**

Forces involved in biopolymer interactions. Electrostatic charges and molecular expansion, hydrophobic forces, dispersion forces, dispersion force interactions, Multiple equilibria and various types of binding processes in biological systems. Hydrogen ion titration curves.

UNIT XII: Thermodynamics of biopolymer Solutions **(04 Lectures)**

Thermodynamics of biopolymer Solutions, osmotic pressure, membrane equilibrium, muscular contraction and energy generation in a mechanochemical system.

UNIT XIII: Cell Membrane and Transport of Ions **(04 Lectures)**

Structure and functions of the cell membrane, ion transport through the cell membrane, irreversible thermodynamic treatment of membrane support, Nerve conduction.

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Books Suggested:

1. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Science Books.
2. Bioinorganic Chemistry, I. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentine, University Science Books.
3. Inorganic Biochemistry vols I and II. ed. G.L. Eichhorn, Elsevier.
4. Progress in Inorganic Chemistry, Vols 18 and 3S ed. J.J. Lippard, Wiley.
5. Bioorganic Chemistry: A Chemical Approach to Enzyme Action, Hermann Dugas and C. Penny, Springer-Verlag.
6. Understanding Enzymes, Trevor Palmer, Prentice Hall.
7. Enzyme Chemistry: Impact and Applications, Ed. Collin J Suckling, Chapman and Hail.
8. Enzyme Mechanisms Ed, M. 1. Page and A. Williams, Royal Society of Chemistry.
9. Fundamentals of Enzymology, N.C. Price and L. Slovens, Oxford University Press.
10. Immobilized Enzymes: An Introduction and Applications In Biotechnology, Michael 0. Trevan, John Wiley.
11. Enzymatic Reaction Mechanisms, C. Walsh, W. H. Freeman.
12. Enzyme Structure and Mechanism, A Fersht, W.H. Freeman.
13. Biochemistry: The Chemical Reactions of Living Cells, D. E. MeUler, Academic Press.

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III. CORE COURSE
GROUP THEORY & TRANSITION

[CCCHE313]

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 15 + ESE: 30) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. The application of Group Theory in Spectroscopy.
2. The concept and relevance of symmetry elements.
3. The application aspects of various spectroscopic techniques.
4. Electronic Spectral Studies for d^1- d^9 systems.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. Understand the Mechanism of energy absorption in compounds.
2. Representation for the Cn, Cnv, Cnh. Dnh etc. groups.
3. Differentiate between Vibrational and Electronic spectroscopy.
4. Electronic spectra of transition metal complexes
5. Redox reactions, electron transfer reactions in complexes

Contents:

UNIT I: Symmetry & Group Theory **(20 Lectures)**

Symmetry elements and symmetry operations, definitions of group, subgroup, relation between orders of a finite group and its subgroups. Conjugacy relation and classes. Point symmetry group. Schonflies symbols, representations of groups by matrices (representation for the Cn, Cnv, Cnh. Dnh etc. groups to be worked out explicitly). Character of a representation. The great orthogonality theorem (without proof) and its importance. Character tables and their use in spectroscopy.

UNIT II: Advanced Chemistry of d- and f-block elements **(10 Lectures)**

Crystal field theory and splitting in Oh, Td, D4h and C4v systems. Magnetic properties of transition metal complexes and lanthanides, metal-metal bonds, cluster compounds of d-block elements, poly-oxo metallates of Ru, Os, Mo. Structure and bonding in complexes containing π-acceptor ligands.

UNIT III: Electronic spectra of transition metal complexes **(15 Lectures)**

Spectroscopic ground states, Term symbol, Selection rule, correlation, Orgel and Tanabe-Sugano diagrams for transition metal complexes (d^1- d^9 states), calculations of dq and β parameters, Racah parameters, oxidation states and electronic absorption spectra of complex ions. Spectrochemical series and effects of covalency. Nephelauxetic series charge transfer spectra, spectroscopic method of assignment of absolute configuration in optically active metal chelates and their stereochemical information, anomalous magnetic moments, magnetic exchange coupling and spin crossover.

UNIT IV: Mechanism in Inorganic Reactions **(15 Lectures)**

Energy profile of a reaction, reactivity of metal complexes, inert and labile complexes, kinetic application of valence bond and crystal field theories, kinetics of octahedral substitution, acid hydrolysis, factors affecting acid hydrolysis, base hydrolysis, conjugate base mechanism, direct and indirect evidence in favour of conjugate mechanism, anation reactions, reactions without metal ligand bond cleavage. Substitution reactions in square planar complexes, the trans effect, mechanism of the substitution reaction. Electron transfer reactions, mechanism of one-electron transfer reactions, outer-sphere type reactions, cross reactions and Marcus-Hush theory, inner-sphere type reactions

Books Suggested:

1. Jaffe, H.H. & Orchin, M. Symmetry in Chemistry Dover Publications (2002).
2. Cotton, F.A. Chemical Applications of Group Theory. Wiley Interscience: N.Y(1990).
3. Hatfield, W. E. & Parker, W. E. Symmetry in Chemical Bonding & Structure C. E. Merrill Publishing Co. USA (1974).
4. Bishop, D.M. Group Theory and Chemistry, Clarendon Press: Oxford, U.K. (1973).
5. Shriver, D.F., Atkins, P.W.& Langford, C.H. Inorganic Chemistry,2nd Ed., Oxford Univ. Press (1998).
6. Purcell, K.F. & Kotz, J.C. Inorganic Chemistry, W.B. Saundersand Co.: N.Y.(1985).
7. Wulfsberg, G. Inorganic Chemistry Univ. Science books: Viva Books: New Delhi (2000)

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8. Mabbs, F.E. & Machin, D.J. Magnetism and Transition Metal Complexes Chapman and Hall: U.K. (1973).
9. Drago, R.S. Physical Methods in Chemistry W.B. Saunders Co.: U.K. (1982).

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IV. CORE COURSE [CCCHE314]
APPLICATIONS OF SPECTROSCOPY

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 15 + ESE: 30) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. The principle involved in Microwave spectroscopy.
2. The IR range and the applicable range for spectral instruments.
3. The difference between IR and Raman spectra.
4. The application aspects of various spectroscopic techniques.
5. The applications of Ultraviolet and Visible Spectroscopy for various types of conjugated systems.
6. McLafferty rearrangement

Course Learning Outcomes:

On successful completion of this course the student should know:

1. Understand the Mechanism of energy absorption in compounds.
2. Differentiate between Vibrational and Electronic spectroscopy.
3. Fieser-Woodward rules for conjugated dienes and carbonyl compounds.
4. The characteristic vibrational frequencies of organic compounds.
5. The shielding mechanism, chemical shift values and correlation for protons bonded to carbon and other nuclei.
6. Ionisation techniques like EI, CI, FD and FAB.
7. Factors affecting fragmentation

Course Content:

GROUP-A Inorganic Chemistry

UNIT I: Electronic Spectroscopy **(07 Lectures)**

Electronic Spectral Studies for d^1- d^9 systems in octahedral, tetrahedral and square planar complexes,

UNIT II: Vibrational Spectroscopy **(05 Lectures)**

Symmetry and shapes of AB_2, AB_3, AB_4, AB_5 and AB_6, mode of bonding of ambidentate ligands, nitrosyl, ethylenediamine and diketonato complexes, application of resonance.

UNIT III: Electron Spin Resonance Spectroscopy **(07 Lectures)**

Basic principles, zero field splitting and Kramer's degeneracy, factors affecting the 'g' value. Isotropic and anisotropic hyperfine coupling constants, spin-orbit coupling and significance of g-tensors (g-parallel, g-perpendicular, electron cloud distortion, application in plot), application to transition metal complexes (having one unpaired electron), including biological systems and to inorganic free radicals such as PH_4, F_2^- and $[BH_3]^-$ (also deuterated compounds).

UNIT IV: Mössbauer Spectroscopy **(05 Lectures)**

Basic principles, spectral parameters and spectrum display. Application of the technique to the studies of (1) bonding and structures of Fe^{+2} and Fe^{+3} compounds, including those of intermediate spin, (2) Sn^{+2} and Sn^{+4} compounds - nature of M-L bond, coordination number, structure and (3) detection of oxidation state and inequivalent MB atoms.

GROUP-B Organic Chemistry

UNIT V: Ultraviolet and Visible Spectroscopy **(05 Lectures)**

Various electronic transitions (185-800 nm), Beer—Lambert law, effect of solvent on electronic transitions, ultraviolet bands for carbonyl compounds, unsaturated carbonyl compounds, dienes, conjugated polyenes. Fieser-Woodward rules for conjugated dienes and carbonyl compounds, ultraviolet spectra of aromatic and heterocyclic compounds.

UNIT VI: Infrared Spectroscopy **(08 Lectures)**

Instrumentation and sample handling. Characteristic vibrational frequencies of alkanes, alkenes, alkynes, aromatic compounds, alcohols, ethers, phenols and amines. Detailed study of vibrational frequencies of carbonyl compounds (ketones, aldehydes, esters, amides, acids, anhydrides, lactones, lactams and conjugated carbonyl compounds). Effect of

hydrogen bonding and solvent effect on vibration frequencies, overtones, combination bands and Fermi resonance. FT IR. IR of gaseous, solids and polymeric materials.

UNIT VII: Nuclear Magnetic Resonance Spectroscopy **(10 Lectures)**

Nuclear spin, nuclear resonance, saturation, shielding of magnetic nuclei, factors influencing coupling constant "J" Classification, spin decoupling; basic ideas about the instrument, NMR studies of nuclei other than proton-^{13}C, ^{19}F and ^{31}P. FT NMR, advantages of FT NMR.

PMR Spectroscopy

Introduction and definition, chemical shift, spin-spin interaction, shielding mechanism, deshielding, chemical shift values and correlation for protons bonded to carbon (aliphatic, olefinic, aldehydic and aromatic) and other nuclei (alcohols, phenols, enols, carboxylic acids, amines, amides & mercapto), chemical exchange, effect of deuteration, solvent effects. Fourier transform technique.

Carbon-13 NMR Spectroscopy **(05 Lectures)**

General considerations, chemical shift (aliphatic, olefinic, alkyne, aromatic, heteroaromatic and carbonyl carbon), coupling constants. Two-dimensional NMR spectroscopy - COSY, NOESY & DEPT techniques.

UNIT VIII: Mass Spectrometry **(10 Lectures)**

Introduction, ion production - El, Cl, FD and FAB, factors affecting fragmentation, ion analysis, ion abundance. Mass spectral fragmentation of organic compounds, common functional groups, molecular ion peak, metastable peak, McLafferty rearrangement. Nitrogen rule. High resolution mass spectrometry. Examples of mass spectral fragmentation of organic compounds with respect to their structure determination.

Identification of organic compounds by the analysis of their spectral data (UV, IR, PMR, CMR & MS).

Books Suggested:

1. Modern Spectroscopy, J.M. Hollas, John Wiley.
2. Applied Electron Spectroscopy for Chemical Analysis Ed. H. Windawi and F.L. Ho. Wiley Interscience.
3. NMR, NOR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Harwood.
4. Physical Methods in Chemistry, R.S. Drago, Saunders College.
5. Chemical Applications of Group Theory, F. A. Cotton.
6. Introduction to Molecular Spectroscopy, Q.M. Barrow, McCraw Hill.
7. Basic Principles of Spectroscopy. R. Chang, McGraw Hill.
8. Theory and Applications of UV Spectroscopy, H.H. Jatie and M. Orehin, IBH-Oxford.
9. Introduction to Photoelectron Spectroscopy, P. K. Ghosh, John Wiley.
10. Introduction to Magnetic Resonance, A. Carrington and A.D. Maclachlan, Harper & Row.
11. Physical Methods for Chemistry, R.S. Drago, Saunders Company.
12. Structural Methods in Inorganic Chemistry, E.A.V. Ebsworth, D.W.H. Rankin and S. Cradock, ELBS
13. Infrared and Raman Spectra: Inorganic and Coordination Compounds, K. Nakamoto, Wiley.
14. Progress in Inorganic Chemistry vol., 8, ed., F.A. Cotton, vol., 15, ed. S.J. Lippard, Wiley.
15. Transition Metal Chemistry, R.L. Carlin. S, Dekker
16. Inorganic Electronic Spectroscopy, A.P.B. Lever, Elsevier.
17. NMR, NQR, EPR and Mossbauer Spectroscopy in Inorganic Chemistry, R.V. Parish, Ellis Horwood.
18. Spectrometric identification of Organic Compounds, R. M. Silverstein, Q. C. gassier and T. C. Morrill, John Wiley
19. Introduction to NMR Spectroscopy. R. J. Abraham, J. Fisher and P. Loftus, Wiley.
20. Application of Spectroscopy of Organic Compounds, J. R. Dyer, Prentice Hall.
21. Spectroscopic Methods in Organic Chemistry, D. H. Williams, 1. Fleming, Tata McGraw-Hill.

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V. CORE COURSE [CCCHE315]
PRACTICAL

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Theory-04, 60 Hours)

Practicals:

1. Practical Component

1. The principle of natural vinegar formation and the use of various initial components such as iron piece in the process.
2. The use of natural vinegar in ancient chemistry experiments and its comparison with synthetic vinegar of modern world.
3. Vinegar, in an electrochemical cell as an acidic electrolyte, can be tested. A simple electrolytic cell can be assembled with a vinegar solution.
4. pH indicators as in the case of paan, where green colored betel leaf, when mixed with white colored calcium carbonate and brown colored areca-nut, gives a red color.

2. Extraction of Organic compounds from Natural sources: (Any two)

Isolation of caffeine from tea leaves. Isolation of nicotine dipicrate from tobacco. Isolation of cinchonine from cinchona bark. Isolation of piperine from black pepper. Isolation of lycopene from tomatoes. Isolation of β-carotene from carrots. Isolation of oleic acid from olive oil involves the preparation of a complex with urea and the separation of linoleic acid. Isolation of eugenol from cloves. Isolation of (+) limonine from citrus rinds

3. Experiments I (Lab-work)

Group A: Estimation of the following in water

(a) Ca (b) Fe (c) Mg
(d) Chemical oxygen demand (COD)
(e) Biochemical oxygen demand (BOD) &
(f) Dissolved oxygen (DO)

Group B: Analysis of soil for the following

(a) Ca (b) Mg (c) Total nitrogen
(d) Carbonate (e) Organic matter (f) Ammonia & (g) Nitrate nitrogen

4. Organic preparations:

1. Preparation of Aniline Yellow.
2. Preparation of Methyl Orange.
3. Preparation of urea-formaldehyde resin

1. Organic Qualitative Analysis

(a) Identification of organic compounds containing one functional group using Chemical & Spectral Analysis
(b) Separation, purification and identification of binary mixture (one liquid and one solid) involving TLC and Column Chromatography. Chemical tests and Functional group identification.

Reference Books:

1. F. Brians, J. H. Antony, P. W. G. Smith and R. T. Austin, Vogel's text book of practical organic chemistry, ELBS, 5th Edn. 1991.
2. R. K. Bansal, Laboratory manual of organic chemistry, 3rd Edn. Wiley Eastern Limited, 1994.
3. D. H. Williams and Ian Fleming, Spectroscopic methods in organic chemistry, TMH Edition, 1988.

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4. A. Buzarbarua, A Text Book of Practical Plant Chemistry, S. Chand and Company Ltd., 2000.
5. S. Sadasivam and A. Manikam, Biochemical Methods, Wiley Eastern, 1992.
6. D. L. Pavia, G. M. Lampman and G. S. Kriz, Introduction to Spectroscopy, 3rd Edn. Harcourt College Publishers, 2007.

SEMESTER II

I. ELECTIVE COURSE-1A [ECCHE411A]
INORGANIC CHEMISTRY-1A

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100 **Pass Marks: (MSE: 15 + ESE: 30) = 45**

(Credits: Theory-04, 60 Hours)

Course Objectives:
On completion of this course, the students will be able to understand:
1. The metalorganic reagents and their role in synthesis.
2. The chemistry of Compounds of Transition Metal-Carbon Multiple Bonds.
3. Transition Metal π-Complexes and their reactions.
4. Homogeneous Catalysis. Fluxional Organometallic Compounds.

Course Learning Outcomes:
On successful completion of this course, the student should know:
1. The reactions of organocopper reagents in organic chemistry.
2. The chemistry of Transition metal π-complexes with unsaturated organic molecules.
3. Homogeneous Catalysis
4. Fluxionality and dynamic equilibria in compounds

Course Content:

UNIT I: Metal Alkyls and Aryls of Transition Metals: **(06 Lectures)**
Types, routes of synthesis, stability and decomposition pathways, organocopper in organic synthesis. Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicenter bonding in these compounds. Role of triethylaluminium in polymerisation of ethene (Ziegler–Natta Catalyst). Species present in the ether solution of Grignard reagent and their structures, Schlenk equilibrium.

UNIT II: Compounds of Transition Metal-Carbon Multiple Bonds **(08 Lectures)**
Alkylidenes, alkylidynes, low valent carbenes and carbynes- synthesis, nature of bond, structural characteristics, nucleophilic and electrophilic reactions on the ligands, role in organic synthesis

UNIT III: Transition Metal π-Complexes **(10 Lectures)**
Transition metal π-complexes with unsaturated organic molecules, alkenes, alkynes, allyl, diene, dienyl, arene and trienyl complexes, preparations, properties, nature of bonding and structural features. Important reactions relating to nucleophilic and electrophilic attack on ligands and to organic synthesis

UNIT IV: Transition Metal Compounds with Bonds to Hydrogen **(10 Lectures)**
Transition Metal Compounds with Bonds to Hydrogen. Synthesis, Nature of Bond and important reactions.

UNIT V: Homogeneous Catalysis **(10 Lectures)**
Stoichiometric reactions for catalysis, homogeneous catalytic hydrogenation, Zeigler-Natta polymerisation of olefins, catalytic reactions involving carbon monoxide such as hydrocarbonylation of olefins (oxo reaction), oxopalladation reactions, activation of C-H bond.

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Dr. B. K. Singh Dr. Anurag Mehta

UNIT VI: Fluxional Organometallic Compounds **(10 Lectures)**

Fluxionality and dynamic equilibria in compounds such as h^2- olefin, h^3 allyl and dienyl complexes

UNIT VII: Catalysis by Organometallic Compounds **(06 Lectures)**

Study of the following industrial processes and their mechanism: Alkene hydrogenation (Wilkinsons Catalyst), Hydroformylation (Co salts), Wacker Process, Synthetic gasoline (Fischer Tropsch reaction), Synthesis gas by metal carbonyl complexes

Books Suggested:

1. Principles and Application of Organotransition Metal Chemistry, J.P. Collman, L.S. Hegsdus, J.R. Norton and R.G. Pinke, University Science Books.
2. The Organometallic Chemistry ol the Transition Metals, R.H. Crabtree, John Wiley
3. Metallo-organic Chemistry, A.J. Pearson, Wiley.
4. Organometallic Chemistry, R.C. Mehrotra and A. Singh, New Age International.

OR ELECTIVE COURSE-1B [ECCHE411B]

ORGANIC CHEMISTRY-1B

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	**Pass Marks: (MSE: 15 + ESE: 30) = 45**

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. The importance of disconnection approach.
2. The importance of carbon-carbon bond formation in organic synthesis.
3. The importance of different oxidation and reduction reactions in organic synthesis.
4. The importance of Terpenoids & Alkaloid chemistry.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. Disconnection and retrosynthesis of a molecule.
2. The different approaches for C-C and C=C bond formation.
3. The applications of different oxidising and reducing agents
4. The importance of Terpenoids, Carotenoids & Alkaloids.

Course Content:

UNIT – I **(10 Lectures)**

Philosophy of organic synthesis: Disconnection approach, one group and two group disconnections, reversal of polarity, chemoselectivity, one group C-C disconnections, two group C-C disconnections, 1,3-difunctional and 1,5-difunctional compounds, tandem reactions.

Protecting groups: Hydroxyl, carbonyl, carboxyl and Amino group

UNIT – II **(20 Lectures)**

Formation of -C-C- and –C=C- bonds:

Enolates, enolate equivalents and enamines, alkylation of enolate anions with stereochemistry, asymmetric methodology with enols and enamines, aldol addition reactions of enolates and Mukaiyama reaction. Conjugate addition of Grignard reagents in presence of copper salts, Synthetic applications of Gilman reagent in C-C bond formation, reactions with halides, sulfonates, epoxides, and α,β- unsaturated carbonyl compounds, esters and epoxides. Synthetic application of carbenes and carbenoids. Suzuki coupling, Sonogashira coupling and Heck coupling.

Wittig reaction and related reactions- Phosphonate modification, Peterson olefination reaction, Julia-Lythgoe olefination, McMurray olefination, Tebbe reagent, Bamford-Stevens reaction and Nickel (II) catalyzed cross-coupling with Grignard

reagents (Kumada reaction). β-elimination reactions, pyrolytic Syn-eliminations in amine oxides (cope elimination), sulphoxides and selenoxides.

Unit – III **(15 Lectures)**

Oxidations: Oxidation of C=C with transition metal oxidants-$KMnO_4$ and OsO_4, Oxidation with SeO_2, epoxidation with peroxy acids and subsequent transformation of epoxides. Cleavage of glycols using HIO_4 and $Pb(OAc)_4$. Oxidation of alcohols to carbonyl compounds using Cr(VI) oxidants- (PCC, PDC, Collins reagent and Jones reagent) and Swern oxidation. Synthetic applications of hypervalent Iodine: 2-Iodoxybenzoic acid (IBX), Dess-martin oxidation

Reductions: Group III-hydride transfer reagents: $NaBH_4$, $NaBH_3CN$, $LiAlH_4$, Lithiumhydridoalkoxyaluminates and DIBAL to reduce carbonyl groups and other functional groups, reduction of α,β-unsaturaed ketones (1,2 and 1,4-additions), stereochemistry of hydride reductions in cyclohexanone derivatives. Group-IV hydride donors: Trialkylsilanes (R_3SiH and Ar_3SiH) to reduce hindered alcohols and carbonyl compounds. HCOOH-Eschweiler-Clarke reactions and Hydride ion transfer in MPV and Cannizaro reaction. Reduction by tributyl Tin hydride. Birch reduction-alkynes, benzene and its derivatives, heterocyclic rings.

UNIT IV: Terpenoids and Carotenoids **(08 Lectures)**

Classification, nomenclature, occurrence, isolation, general methods of structure determination, isoprene rule. Structure determination, stereochemistry, biosynthesis and synthesis of the following representative molecules: Citral, α-Terpeneol, Zingiberene and β-Carotene.

UNIT V: Alkaloids **(07 Lectures)**

Definition, nomenclature and physiological action, occurrence, isolation, general methods of structure elucidation, degradation, classification based on nitrogen heterocyclic ring, role of alkaloids in plants. Structure, stereochemistry, synthesis and biosynthesis of the following: Nicotine, Quinine, Morphine and Narcotine.

Books Suggested:

1. Molecular Mechanics, U. Burkert and N. L. Allinger, ACS Monograph 177, 1982.
2. Organic Chemists' Book of Orbitals. L. Salem and W. L. Jorgensen, Academic Press.
3. Mechanism and Theory in Organic Chemistry, T. H. Lowry and K. C. Richardson, Harper and Row.
4. Introduction to Theoretical Organic Chemistry and Molecular. Modelling, W. B. Smith, VCH, Weinheim.
5. Physical Organic Chemistry, N. S. Isaacs, ELBS/Longman.
6. The Physical Basis of Organic Chemistry, H. Maskill, Oxford University Press.
7. Natural Products: Chemistry and Biological Significance, J.Mann, R.S. Davision, J.B. Hobbs, D.V. Banthrope and J.B. Harborne, Logman, Essex.

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OR ELECTIVE COURSE-1C [ECCHE411C]

PHYSICAL CHEMISTRY-1C

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 15 + ESE: 30) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. The Application of Statistics in Thermodynamics.
2. The free electron theory and Metallic conduction.
3. The Kohlrausch's law and its applications.
4. The factors affecting corrosion.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. The Applications of the partition function.
2. The differences between metallic conductors, insulators and semiconductors.
3. The Interconversion of translational and vibrational energies.
4. The nature of slow reactions, like Corrosion and Fast Reactions like Flash Photolysis.

Course Content:

UNIT I: Statistical thermodynamics: **(14 Lectures)**

Theorem of probability, Fundamentals of statistical methods, most probable distribution and Maxwell-Boltzmann distribution law of energy; Entropy and probability, partition functions and their relation to thermodynamic quantities – calculations for model systems. Equilibrium constant and partition function. Third Law of Thermodynamics and Partition Function. Applications of the partition function of monotonic gases; Partition function for diatomic molecules. The Bose-Einstein statistics & Fermi-Dirac statistics for metals.

UNIT II: Metallic bonds **(08 Lectures)**

Free electron theory, band theory, Fermi level, Brillouin zone, wave function for electrons in solids, metallic conductors, insulators, semiconductors (intrinsic & extrinsic), properties of junctions.

UNIT III: Potential Energy Surfaces **(15 Lectures)**

Mechanism of activation, potential energy surface for three-atom reaction, Potential energy curve for successive reactions, Properties of potential energy surfaces, Inter-conversion of translational and vibrational energies, Combination of atoms, Orthopara conversion, Activated state of three-atom and four-atom reactions, Potential energy profile, reaction coordinate, Transmission coefficient, non-adiabatic reaction.

UNIT IV: Electrochemistry **(10 Lectures)**

Electrochemical cells; electrolytic conductance, Kohlrausch's law and its applications; Debye-Huckel theory; Debye-Huckel-Onsager equation. Thermodynamics of electrified interfaces. Electrical double layer, Discharge potential, Overpotential or overvoltage. Electrocatalysis: Introduction, Relative power of electrocatalysts, Mechanism of electrocatalysis, Bioelectrocatalysis.

UNIT V: Corrosion **(05 Lectures)**

Introduction, Factors affecting corrosion, homogeneous theory, electrolytic theory of corrosion, Corrosion inhibitors, Passivity, Types of corrosion, special attention to rusting and its influence on the economy of the world, Corrosion monitoring and prevention methods.

UNIT VI: Study of Fast Reactions **(08 Lectures)**

Photo-physical Chemistry-Flash Photolysis, Relaxation technique, Nuclear Magnetic Resonance Method, Molecular Beam and Shock-tube Kinetics, Flow method.

Reference Books:

1. Rastogi, R. P., Introduction to Non-equilibrium Physical Chemistry, Elsevier B.V. (2008)

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2. Kalidas, C. & Sangaranarayanan, M.V. Non-Equilibrium Thermodynamics: Principles & Applications, Macmillan India Ltd. (2002).
3. Katchalsky, A. & Curren, P. F. Non-Equilibrium Thermodynamics in Biophysics. Harvard University Press: Cambridge (1965).
4. Atkins, P.W.; Paula, J.de. (2014), Atkin's Physical Chemistry Ed., 10th Edition, Oxford University Press.
5. Ball, D. W. (2017), Physical Chemistry, 2nd Edition, Cengage Learning, India.
6. Castellan, G. W. (2004), Physical Chemistry, 4th Edition, Narosa.
7. Kapoor, K.L. (2015), A Textbook of Physical Chemistry, Vol. 3, 6th Edition, McGraw-Hill Education.
8. Laidler K.J. (2003), Chemical Kinetics, 3rd Edition, Pearson Education India.

II. ELECTIVE COURSE-2A [ECCHE412A]

INORGANIC CHEMISTRY-2A

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 15 + ESE: 30) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. The Metal Storage Transport and Biomineralization.
2. The Metal-Nucleic Acid Interactions.
3. The Supramolecular Chemistry and its applications.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. The role of Ferritin, transferrin, and siderophores in biological processes.
2. The metals used for diagnosis and chemotherapy.
3. The role of metal ions in life, the effect of Metal deficiency and disease and the toxic effects of excess metals.
4. Supramolecular reactivity and catalysis.
5. About Supramolecular devices and self-assembly in supramolecular chemistry.

Course Content:

UNIT I: Metal Storage Transport and Biomineralisation **(05 Lectures)**

Ferritin, transferrin, and siderophores – Structure and role in Iron storage.

UNIT II: Calcium in Biology **(10 Lectures)**

Calcium in living cells, transport and regulation, molecular aspects of intramolecular processes, extracellular binding proteins

UNIT III: Metalloenzymes **(15 Lectures)**

Zinc enzymes - carboxypeptidase and carbonic anhydrase. Iron enzymes - catalase, peroxidase and cytochrome P-450. Copper enzymes - superoxide dismutase. Molybdenum oxatransferase enzymes - xanthine oxidase. Coenzyme vitamin BII

UNIT IV: Metal-Nucleic Acid Interactions **(07 Lectures)**

Metal ions and metal complex interactions. Metal complexes - nucleic acids and their applications

UNIT V: Metals in Medicine **(05 Lectures)**

Metal deficiency and disease, toxic effects of metals, metals used for diagnosis and chemotherapy, with particular reference to anticancer drugs

UNIT VI: Supramolecular Chemistry **(18 Lectures)**

Concepts and language.

(A) Molecular recognition: Molecular receptors for different types of molecules, including arisonic substrates, design and synthesis of coreceptor molecules and multiple recognition.

(B) Supramolecular reactivity and catalysis.

(C) Transport processes and carrier design.

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(D) Supramolecular devices. Supramolecular photochemistry, supramolecular electronic, ionic and switching devices. Some examples of self-assembly in supramolecular chemistry

Books Suggested:

1. Principles of Bioinorganic Chemistry, S.J. Lippard and J.M. Berg, University Science Books.
2. Bioinorganic Chemistry, 1. Bertini, H.B. Gray, S.J. Lippard and J.S. Valentine, University Science Books.
3. Inorganic Biochemistry vols I and II. ed. 0.L Eichhom, Elsevier.
4. Progress in inorganic Chemistry, Vols 18 and 38 ed. J.J. Lippard, Wiley.
5. Supramolecular Chemistry, J.M. Lehn, VCH.

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OR ELECTIVE COURSE-2B [ECCHE412B]

ORGANIC CHEMISTRY-2B

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 15 + ESE: 30) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. The principles, mechanisms, and applications of pericyclic reactions in organic chemistry.
2. The Chemistry of Heterocycles.
3. The isolation, need and structure of Vitamins.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. The Chemistry of Pericylic Reactions, Heterocyclics and Vitamins.

Course Content:

UNIT I: Pericyclic Reactions **(15 Lectures)**

Introduction -Characteristics and classification of pericyclic reactions. Representation of molecular orbitals-Bonding, Non bonding and Anti bonding, Frontier orbitals of ethylene, 1,3-butadiene, 1,3,5-hexatrienes and allyl system. Symmetry properties with special reference to plane of symmetry and two fold axis of symmetry. FMO, Orbital Correlation Diagram (OCD) approaches and Stereochemistry of Electrocyclic reactions (4n and 4n+2 electron system).

Cyclo addition reactions (4n & 4n+2 systems including 1,3 Dipolar cycloaddition). Antarafacial and suprafacial additions, Detail study of Diels-Alder reaction - Stereochemistry - Cis-rule - Alder's Endo rule and Regioselectivity. Elementary treatment of PMO approach. PMO, FMO approach and Stereochemistry of Sigmatropic rearrangements-[1,3], [1,5], [1,7], Cope, Oxy-Cope, Aza-Cope, Claisen, and Aza-Claisen rearrangements. Sommlet-Hauser reaction, Chelotropic reactions (Additions and Eliminations), Group transfer, Group elimination and Ene reactions, Click reaction.

UNIT II: Heterocycles: Nomenclature & Classification **(10 Lectures)**

Replacement and systematic nomenclature (Hantzsch MCH-Widman system) for monocyclic fused and bridged heterocycles. Criteria of aromaticity, including ring current and chemical shifts in 1H NMR spectra.

Heterocyclic Synthesis: Principles of heterocyclic synthesis involving cyclisation reactions and cycloaddition reactions.

UNIT III: Small ring Heterocycles **(09 Lectures)**

Three, four and five-membered heterocycles, including medicinal applications of benzopyrroles, benzofurans and benzothiophenes

UNIT IV: Heterocycles with one Heteroatom **(08 Lectures)**

Structure, preparation, properties and reactions of furan, pyrrole, thiophene, pyridine, indole, quinoline and isoquinoline.

UNIT V: Six-Membered Heterocycles with Two or More Heteroatoms **(06 Lectures)**

Synthesis and reactions of diazines, triazines, tetrazines and thiazines

UNIT VI: Vitamins **(12 Lectures)**

Determination and Synthesis of Vit. A, B_1, B_2, B_6, Vit. C and Vit. D.

Books Suggested:

1. Pericyclic Reactions, S.M. Mukherji, Macmillan, India.
2. Molecular Mechanics, U. Burkert and N.L. Allinger, ACS Monograph 177, 1982.

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3. Introduction to Theoretical Organic Chemistry and Molecular modelling, W.B. Smith, VCH, Weinheim.
4. Heterocyclic Chemistry Vol. 1-3, R. R. Supta, M. Kumar and V Gupta, Springer Verlag.
5. The Chemistry of Heterocycles, T. Eicher and S. Hauptmann, Thieme.
6. Heterocyclic Chemistry, J. A. Joule, K. Mills and G.F. Smith, Chapman and Hall.
7. Contemporary Heterocyclic Chemisiry, Q. R. Newkome and W. W. Paudler, Wiley-inter Science.
8. An introduction to the Heterocyclic Compounds. Linds, R. M. Acheson, JohnWiley.
9. Organic Chemistry, Vol 2, I. L. Finar, ELBS.
10. Stereoselective Synthesis; A Practical Approach, M. Nogradi. VCH.
11. New Trends in Natural Product Chemistry, Atta-ur-Rahman and M I Choudhary, Harwood Academic Publishers.

OR ELECTIVE COURSE-2C [ECCHE412C]

PHYSICAL CHEMISTRY-2C

Marks: 30 (MSE: 20 Th. 1 Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 15 + ESE: 30) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

On completion of this course, the students will be able to understand:

1. The difference between Conductivity and superconductivity.
2. The Chemistry of surfaces and colloids. The Polymer chemistry and its uses.

Course Learning Outcomes:

On successful completion of this course, the student should know:

1. The conventional organic and high temp. superconductors. Kinetics of surface processes. Surface active agents or surfactants.
2. Factors related to the Kinetics of Condensed Phase Reactions

Course Content:

UNIT I: Superconductivity **(10 Lectures)**

Superconductivity, Meissner effect, microscopic theory of superconductivity, conventional organic and high temperature superconductors, fullerenes, applications of superconductors. Transformation in crystals - thermodynamics of transformation, order-disorder transitions, martensitic transition, polymorphic transformation

UNIT II: Specific heat of solids **(07 Lectures)**

Specific heat of solids, classical theory, quantum theory of specific heats-Einstein and Debye theories, characteristic temp and its calculation, T-law. Solid state reactions, laws governing nucleation, homogeneous and heterogeneous nucleation, and the thermodynamic barrier.

UNIT III: Surface chemistry **(18 Lectures)**

Surface phenomena: Surface active agents, classification of surface-active agents, micellization, hydrophobic interaction, critical micelle concentration (CMC), Krafft temperature, Factors affecting the CMC of surfactants, counter ion binding to micelles, thermodynamics of micellization, solubilization, microemulsions, reverse micelles, surface films (electrokinetic phenomena), catalytic activity at surfaces. The BET isotherm for multilayers & its derivation, the measurement of the Surface area of adsorbents. Gibbs adsorption equation. Kinetics of surface processes, unimolecular and bimolecular surface reactions, electrocapillarity, electrokinetic effects, statistical mechanics of adsorption. Catalytic activities at surfaces.

Preparation & purification of sols. General properties of colloidal solutions, Coagulation, Electrical properties, and stability of colloids. Cataphoresis, Zeta potential, Micelles. Peptization theory. Emulsions and colloids around us.

UNIT IV: Polymers: **(15 Lectures)**

Polymer solution, thermodynamics of polymer dissolutions, Flory-Huggins Theory of Polymer Solutions. molar mass and molar mass distribution (Number Average and Weight Average Molecular weight), methods of measuring molar masses-Molecular Weight Determination by Light scattering, End-group analysis, Viscosity, Applications of FTIR, UV-visible, NMR and Mass Spectroscopy for identification of polymers.

Polymeric Structure and Property Relationship

Structure of polymers - Linear, branched, cross-linked and network polymers, polydispersity index, crystallinity in polymer,

melting temperature and glass transition temperature. Ziegler-Natta, Metallocene and others.

Electrically conducting polymers: Electrically conducting polymers, electrochemical polymerisation, band structure of polymers, mechanism of conduction in polymers, doping of polymers, application of conducting polymers.

Polymer liquid crystal: Polymer liquid crystal nematic, cholesteric and smectic phases, liquid crystalline order of the main chain and of the side groups in polymers, synthesis and properties of polymer liquid crystals, liquid crystalline order in biological materials.

UNIT VI: Kinetics of Condensed Phase Reactions **(10 Lectures)**

Rate-determining steps in diffusion-controlled reactions and activation-controlled reactions, Stokes-Einstein equation and dependence of rate constant on coefficient of viscosity of medium, Kinetics of ionic reactions in solution, electrostatic contribution to free energy in single and double spherical models of activated complex, entropy of activation for ion-ion reactions; Kinetics of dipole-dipole reaction, ion-dipole reaction, dependence of rate constant on ionic strength and dielectric constant of medium, Bronsted-Bjerrum equation.

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Books Suggested:

1. Crystallography - Philips
2. Solid State Chemistry-Garner (Butterworth; London)
3. Solid State Chemistry -D.K. Chakraborty (New Age Int. Publication)
4. Barrow, G. M., *Physical Chemistry* 5th Ed., Tata McGraw-Hill: New Delhi (2006).
5. Physical Chemistry- Waller J. Moore
6. Principles of Polymer Chemistry Cornell, P. J. Flory (Univ. Press)
7. Handbook of Conducting Polymers Vol I & II" T A. Skolhia
8. Laidler K.J. (2003), Chemical Kinetics, 3rd Edition, Pearson Education India.
9. Surface Chemistry, Gurdeep Raj, Goel Publishing House, Merrut, India

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III. CORE COURSE [CCCHE413]
MATERIAL CHEMISTRY

Marks: 30 (MSE: 20 Th. 1Hr + 5 Attd. + 5 Assign.) + 70 (ESE: 3 Hrs) = 100	Pass Marks: (MSE: 15 + ESE :30) = 45

(Credits: Theory-04, 60 Hours)

Course Objectives:

Upon completion of this course, the students will be able to understand

1. The mechanism of polymer material formation.
2. The concept of Smart Material and their applications.
3. Crystalline solids, crystal systems, Bravais lattices, coordination number, packing factors.
4. Applications of Zeolites, metallosilicates, silicalites and related microporous materials.
5. Overview of nanostructures and nanomaterials.
6. Overview of Advanced Materials, magnetic properties, and electric properties.
7. The importance and applications of Industrial Chemicals like Industrial Gases and Inorganic compounds in their uses.
8. The chemistry of dyes and their uses in various aspects of human civilisation.

Course Learning Outcomes:

Upon successful completion of this course, the students should know:

1. Lattices and types of Crystal systems.
2. Inorganic and organic molecules as functionalized mesoporous materials
3. Supramolecules and their applications
4. Inorganic solids/ionic liquids of technological importance.
5. The aspects of nanoscience, nanostructure and nanotechnology
6. Magnetic and electric properties
7. The role of matrix in composites and reinforcements.
8. The Manufacture, application, analysis and hazards in handling the industrially important chemicals.
9. The Classification, Colour and Chemical constitution of various dyes.

Course Content:

UNIT I: Material Chemistry- Basics of crystalline solids (05 Lectures)

Crystalline solids, crystal systems, Bravais lattices, coordination number, packing factors – cubic, hexagonal, diamond structures, lattice planes, Miller indices, interplanar distances, directions, types of bonding, lattice energy, Madelung constants, Born Haber cycle, cohesive energy, Symmetry elements, operations, translational symmetries - point groups, space groups, equivalent positions, close packed structures, voids, crystal structures, Pauling rules, defects in crystals, polymorphism, twinning.

Smart Materials: (06 Lectures)

General Characteristics of Metals, Ceramics, Polymers, Composites and Smart Materials. Classification of Smart Materials. General overview of a few smart materials (eg. Piezoelectric materials, Shape memory alloys, Magnetic shape memory alloys, Shape memory polymers, PH sensitive polymers)

Silica-based materials: (05 Lectures)

Introduction to Zeolites, metallosilicates, silicalites and related microporous materials, Mesoporous silica, metal oxides and related functionalized mesoporous materials: Covalent organic frameworks, Organic-Inorganic hybrid materials, periodic mesoporous organo silica, metal organic frameworks: H_2 /CO_2 gas storage and catalytic applications

Inorganic solids/ionic liquids of technological importance: (08 Lectures)

Preparation of inorganic solids: Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, Hydro-thermal method, Ion-exchange and Intercalation methods. Introduction to Solid electrolytes, inorganic liquid crystals. Ionic liquids, forces responsible for ionic liquids, synthesis and application of imidazolium and phosphonium-based ionic liquids. Host-guest chemistry (elementary ideas).

UNIT II: Supramolecular Chemistry (05 Lectures)

Properties of covalent bonds - bond length, inter-bond angles, force constant, bond and molecular dipole moments. Molecular and bond polarizability, bond dissociation enthalpy, entropy. Intermolecular forces, hydrophobic effects.

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Electrostatic, induction, dispersion and resonance energy, magnetic interactions, magnitude of interaction energy, forces between macroscopic bodies, medium effects. Hydrogen bond. Principles of molecular association and organisation as exemplified in biological macromolecules like enzymes, nucleic acids, membranes and model systems like micelles and vesicles. Molecular receptors and design principles. Cryptands, cyclophanes, calixeranes, cyclodextrines. Supramolecular reactivity and catalysis. Molecular channels and transport processes. Molecular devices and nanotechnology.

UNIT III: Nanochemistry and Nanomaterials **(14 Lectures)**

Introduction to the Nano-Regime: Overview, classification of nanostructures (0D, 1D, 2D, and 3D), and unique properties of nanomaterials. Natural vs. Artificial Nanomaterials: Synthesis philosophy, structural differences, and engineering applications. Bio-Inorganic & Bionanomaterials: Fundamental concepts of bio-inorganic nanomaterials; DNA-nanomaterial interactions, DNA scaffolding, and self-assembly.

Bionanocomposites: Structure, interfacial properties, and emerging biomedical and environmental applications.
Ceramic Crystal Structures & Defect Chemistry

Advanced Dielectric & Electrical Properties

Dielectric Behavior: Polarization mechanisms (electronic, ionic, dipolar, space charge), dielectric constant, frequency dependence, and dielectric loss. Ferroelectricity & Piezoelectricity: Crystal symmetry requirements, ferroelectric domains, hysteretic behavior (P-E loops), and Curie-Weiss law. Electrical Conduction in Ceramics: Mechanisms of conduction; Thermistors (NTC and PTC effects), varistors, and fast-ion conductors.

UNIT VI: Composite materials: **(05 Lectures)**

Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fibre-reinforced composites, environmental effects on composites, applications of composites.

UNIT V: Industrial Chemicals **(06 Lectures)**

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, chlorine, sulphur dioxide and phosgene.

Inorganic Chemicals: Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate.

Inorganic solids: Synthesis of Zeolite, Silicones.

UNIT VI: Chemistry of Dyes **(06 Lectures)**

Classification, Colour and chemical constitution, Mordant and Vat Dyes, Chemistry of dycing, Synthesis and applications of: Azo dyes – Methyl Orange and Congo Red (mechanism of Diazo Coupling), Triphenylmethane dyes -Malachite Green, Rosaniline and Crystal Violet, Phthalein dyes – Phenolphthalein and Fluorescein, Natural dyes –structure elucidation and synthesis of Alizarin and Indigo, Edible Dyes with examples.

Reference Books:

1. Poole, C.P. & Owens, F.J. Introduction to Nanotechnology John Wiley 2003.
2. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning, 2002.
3. Adam, D.M. Inorganic Solids: *An introduction to concepts in solid-state structural chemistry*. John Wiley,1974.
4. Zhen Guo and Li Tan, *Fundamentals and Applications of Nanomaterials*.2009, Artech House,London Publication.
5. Physical methods for chemistry: R. S. Drago, 1992, Saunders college publication.
6. Polymer science, V. R. Gowariker, N. V. Viswanathan, J. Sreedhar, New Age International (P)Ltd., 2015.
7. P. J. Flory, Principle of polymer chemistry, Cornell University Press.
8. Polymer Science and technology, Plastics, Rubber and composites, P. Ghosh, Tata McGraw Hill.
9. V. Gowriker, N. V. Viswanathan, J. Sreedhar, Polymer Science, New Age Int. Publication, 2019.
10. C. N. R. Rao, A. Muller, A. K. Cheetam, The Chemistry of Nanomaterials: Synthesis, Properties and Applications, Willey-VCH Verlag, Germany, 2005.
11. G. Cao, Nanostructures and Nanomaterials: Synthesis, Properties and Appications, Imperial College Press, London, 2004

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12. R. W. Kelsall, I. W. Hameley, M. Geoghegan, Nanoscale Science and Technology, John Wiley & Sons, England, 2005
13. Charles P. Poole and Frank J Owens, Introduction to nano technology, Wiley Interscience, 2003.
14. Pradeep, T., A text of book of nanoscience and nanotechnology, Tata McGraw Hill Education Pvt. Ltd., New Delhi, 2012.

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IV. ELECTIVE COURSE-4A [EPCHE414A]
INORGANIC PRACTICAL-A

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Theory-04, 60 Hours)

Course Content:

1. Qualitative separation and determination of the following pairs of metal ion using gravimetric and volumetric methods
   a. Ag^{+}(g) and Cu^{2+}(v)
   b. Cu^{2+}(g) and Zn^{2+}(v)
   c. Fe^{3+}(g) and Ca^{2+} (v)
   d. Mg^{2+}(g) and Ca^{2+} (v)

2. **Quantitative Analysis**
   a. Analysis of alloys (brass, type metal, solder, gun metal), cement, steel using conventional chemical analysis/and physical techniques (if possible).
   (Preferably, one alloy and cement analysis may be carried out).

3. **Chromatographic Separations**
   a. Cadmium and zinc
   b. Zinc and magnesium.
   c. Thin-layer / Paper chromatography-separation of nickel, manganese, cobalt and zinc. Determination of Rf values.

4. **Synthesis and characterisation of the following metal complexes:**
   a. Sodium tetrathionate $Na_2S_4O_6$.
   b. Metal complex of dimethyl sulfoxide: $CuCl_2.2DMSO$
   c. Synthesis of metal acetylacetonate
   d. Synthesis of copper and nickel Schiff base complexes.
   e. Synthesis of copper and nickel dithiocarbamates
   f. $[Co(NH_3)_5\ Cl]Cl_2$
   g. $[Co(NH_3)_5NO_2]Cl_2$
   h. $[Co(NH_3)_5ONC]Cl_2$

Reference Books:

1. Vogel, A.I. *A Textbook of Quantitative Inorganic Analysis*, ELBS
2. Kettle, S. F. A. Physical Inorganic Chemistry: A Coordination Chemistry Approach, Springer, Berlin, Heidelberg (1996).
3. Drago, Russell S. Physical Methods for Chemists (2nd ed.), East West Press Pvt. Ltd. (2016).
4. Mabbs, F. E. & Machin, D. J. Magnetism and Transition Metal Complexes, Dover Publications; 2008 edition (2008).
5. Roberts, A. P. Polyoxometalates: Properties, Structure and Synthesis, Nova Science Publishers, Incorporated (2016).

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OR ELECTIVE COURSE-4B [EPCHE414B]

ORGANIC PRACTICAL-B

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Theory-04, 60 Hours)

Course Content:

1. **Characterisation of organic compounds**
   It is expected to carry out separation, purification and identification of the components of a mixture of three organic compounds (three solids or two liquids and one solid, two solids and one liquid). Students should also check the purity of the separated components on TLC plates.

2. **Extraction of Organic compounds from Natural Sources**
   a. Isolation of Caffeine from Tea Leaves
   b. Isolation of Casein from milk (Some typical colour reactions of proteins).
   c. Isolation of lactose from milk (purity of sugar should be checked by LC and PC and Rf values reported).
   d. Isolation of Nicotine dipicrate from tobacco
   e. Isolation of β-carotene from carrots
   f. Isolation of Oleic acid from olive oil
   g. Isolation of (+)Limonine from citrus rinds

3. **Multistep Synthesis of Organic Compounds**
   a. Beckman rearrangement: Benzanilide from benzene
   b. Benzene → Benzophenone → Benzophenone oxime →Benzanilide
   c. Benzilic acid rearrangement: Benzilic acid from benzoin
   d. Benzoin → Benzil → Benzilic acid

4. **Estimation of some organic compounds:**
   a. Estimation of phenol/aniline using bromate bromide solution/or acetylation method
   b. Estimation of carbonyl group by using 2,4-dinitrophenyl hydrazine
   c. To determine the percentage or number of phenolic groups in the given sample by the acetylation method.

References:

1. Experimental Organic Chemistry H Dupon Durst. George W. Gokel, p.464 McGraw Hall Book Co., New York).

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OR ELECTIVE COURSE-4C [EPCHE414C]

PHYSICAL PRACTICAL-C

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Theory-04, 60 Hours)

Course Content:

1. **Conductometry**
   a. To titrate a mixture of HCl, CH_3COOH and $CuSO_4$ with NaOH.
   b. Conductometric titration of a mixture of halides (HCl, KCl and NH_4Cl)
   c. To determine the rate constant of saponification of an ester by NaOH.
   d. Determination of Critical Micelle Concentration (CMC) of a surface-active reagent (e.g. Sodium Lauryl Sulphate).
2. **Determination of the equivalent conductance of the following strong electrolyte:**
   a. KCl
   b. NaCl
   c. $AgNO_3$
   d. HCl
   e. KNO_3
3. **Potentiometry**
   a. To determine the solubility and solubility product of AgCl in water
   b. To determine the E^0 of Zn/Zn^{++}, Cu/Cu^{++} electrodes.
   c. To determine the basicity of a polybasic acid and its dissociation constant.
   d. To investigate the complex formed between $CuSO_4$ and NH_3.
4. **Chemical Kinetics**
   a. To study the kinetics of alkaline hydrolysis of an ester in an aquo-organic solvent system with respect to the effect of solvent composition and dielectric constant on the rate constant.
   b. To determine the rate constant of the reaction between $K_2S_2O_8$ and KI at two different temperatures and hence to determine the energy of activation of the reaction.
5. **Thermochemistry**
   a. Determination of the basicity of a polybasic acid.
   b. Determination of the heat of displacement of Cu by Zn from Cu^{2+} salt solution.
   c. Determination of the heat of hydration of Na_2SO_4 to $Na_2SO_4.10H_2O$.
6. **Molar mass determination**
   a. To determine the Molecular weight of a polymer (eg Polystyrene) from viscosity measurement.
   b. To determine the radius of a molecule from viscosity measurement.

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V. PROJECT [PRCHE415]
DISSERTATION/ PROJECT/ TEACHING APTITUDE

Marks: 100 (ESE Pr: 6 Hrs) = 100	Pass Marks = 45

(Credits: Theory-04, 120 Hours)

Guidelines to Examiners for
End Semester Examination (ESE):

The evaluation of the dissertation will be done in 100 marks (70 marks + 30 marks of the session). The sessional component will be evaluated by the concerned supervisor.

The end term evaluation (70 marks) will be done by a board of examiners. The end term evaluation in 70 marks will include the literary and scientific presentation of the dissertation and the performance in the viva-voce.

The overall project dissertation may be evaluated under the following heads:

- *Motivation for the choice of topic*
- *Project dissertation design*
- *Methodology and Content depth*
- *Results and Discussion*
- *Future Scope & References*
- *Participation in an Internship programme with a reputed organisation*
- *Application of Research techniques in Data collection*
- *Report Presentation*
- *Presentation style*
- *Viva-voce*

Course Objectives:

1. To develop research skills and scientific inquiry through independent investigations on a topic/ problem.

Course Outcomes:

On successful completion of this course, the student should know:

1. About conducting research with approved stages of research methodology.
2. A dissertation will enable students to further investigate and navigate different aspects and events of life through research.

PROJECT WORK

Each student has to submit three copies of hard-bound dissertation work (along with the raw data), duly forwarded by the HOD of the Department concerned. The forwarded copies will be submitted to the concerned University Department, Ranchi University, Ranchi for evaluation (one month before the viva voce examination).

The paper may involve:

a) Laboratory research/ Field work/ Lab work related to the project.
b) Survey research, Case Study or any other type of research related to the subject.
c) One Large study/ Experiment or several studies/ Experiments, depending on the objectives of the research.
d) The writing of the dissertation must be within 80 to 100 pages, including references and appendices.
e) Content must be typed in Font: Times New Roman with Line Spacing: 2.0 and Font Size 12 points.

The project work will be presented in a seminar on the assigned topic in the concerned department of Ranchi University, Ranchi, followed by an open viva voce examination.

Topics: As decided by the Supervisor/Guide

Teaching Aptitude: As an alternative to a dissertation, only a few selected meritorious candidates may be assigned the responsibility to teach the pre-decided topics in selected colleges. The performance may be evaluated based on the structured feedback for the candidate.

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