ANNEXURE- I

# North Lakhimpur College (Autonomous)

**Draft PG Course-wise Programme Structure (as per NEP 2020 guidelines)**

| Year (Sem) & NHEQF Level | Mandatory / Core Course | Elective Course | Other Courses | RP/ Internship / Community Engagement etc. | Total Credit |
|---|---|---|---|---|---|
| Year-I Semester- I Level- 6 | Core I (4)<br>Core II (4)<br>Core III (4) | Elective I (4) (minimum of 2 options to be provided) | Research Methodology (4) | | 20 |
| Year-I Semester- II Level- 6 | Core IV (4)<br>Core V (4)<br>Core VI (4) | Elective II (4) (minimum of 2 options to be provided) | | Internship / Apprenticeship/ Community Engagement (4 credit) | 20 |
| **CUMULATIVE CREDIT FOR PG DIPLOMA**<br>(Mandatory/ Core Course: 24 credit, Elective: 8 credit, RM: 4 credit & RP/ Internship/ Community Engagement: 4 credit) | | | | | 40 |
| Year- II Semester- III Level- 6.5 | Core VII (4)<br>Core VIII (4)<br>Core IX (4) | Elective III (4) (minimum of 2 options to be provided) | | Research Project / Core Course (4) | 20 |
| Year- II Semester- IV Level- 6.5 | Core X (4)<br>Core XI (4)<br>Core XII (2) | Elective IV (4) (minimum of 2 options to be provided) | | Dissertation/ Core Course (6) | 20 |
| **CUMULATIVE CREDIT FOR 1 Yr PG (after 4 year UG)**<br>(Mandatory/ Core Course: 22 credit, Elective: 8 credit, RP: 10 credit) | | | | | 40 |
| **CUMULATIVE CREDIT FOR 2 Yr PG**<br>(Mandatory/ Core Course: 46 credit, Elective: 16 credit, RM: 4 credit, Internship/ Apprenticeship/ Community Engagement: 4 credit & RP: 10 credit) | | | | | 80 |

A student shall initiate a Research Project (4 credit) in the PG 3rd Semester class and the progress report for the same is to be presented at the end of the semester. A Dissertation (6 credit) shall have to be submitted in the PG 4th Semester in partial fulfillment of the requirements for the degree of M.A/ M.Sc.

Principal
North Lakhimpur College
(Autonomous)
Lakhimpur, Assam

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## Program Specific Outcomes (PSOs) for M.Sc. Chemistry:

1. **Advanced Theoretical Knowledge:**
    i. Graduates will gain in-depth knowledge in specialized areas of chemistry, such as organic, inorganic, physical, and analytical chemistry, as well as emerging fields like materials chemistry, biochemistry, and environmental chemistry.
    ii. They will be able to understand and apply complex theoretical concepts to solve advanced chemical problems.
2. **Advanced Laboratory Techniques and Instrumentation:**
    i. Graduates will develop proficiency in advanced laboratory techniques and the use of sophisticated instrumentation.
    ii. They will be able to design, conduct, and analyze experiments with a high degree of precision, ensuring the accuracy and reliability of results.
3. **Research and Innovation:**
    i. Graduates will be capable of designing and conducting independent research projects, demonstrating originality and creativity in addressing scientific questions.
    ii. They will be skilled in using modern research methodologies, data analysis tools, and computational techniques relevant to chemistry.
4. **Chemical Safety, Ethics, and Environmental Awareness:**
    i. Graduates will have a thorough understanding of chemical safety protocols and ethical considerations in research and professional practice.
    ii. They will be knowledgeable about the environmental impact of chemical processes and committed to sustainable and green chemistry practices.
5. **Interdisciplinary and Collaborative Skills:**
    i. Graduates will be able to integrate chemistry with other disciplines, such as physics, biology, and environmental science to address complex interdisciplinary problems.
    ii. They will develop collaborative skills necessary for working effectively in multidisciplinary teams, both in academic and industrial environments.
6. **Preparation for Ph.D. and Advanced Careers:**
    i. Graduates will be well-prepared for doctoral studies (Ph.D.) in chemistry or related fields, with the ability to contribute original research to the scientific community.
    ii. They will possess the advanced knowledge and skills required for leadership roles in research and development, quality control, teaching, and other professional careers in the chemical industry, academia, and government sectors.

# Semester wise Distribution of courses
# M.Sc. (Chemistry) as per NEP-2020

| Semester (NHEQF Level) | Mandatory / Core Course | Elective Course | Other Courses | Internship / Community Engagement etc. | Total |
|---|---|---|---|---|---|
| Semester I (Level 6) | Core-I **(4 credit, 4T+0P)** **(Inorganic Chemistry-I)**<br>Core-II **(4 credit, 4T+0P)** **(Organic Chemistry-I)**<br>Core-III **(4 credit, 4T+0P)** **(Physical Chemistry-I)** | DSE-I **(4 credit, 0T+4P)** **Laboratory Course-I (Two options)** | **Research Methodology / Tools and Techniques in Research Methodology** **(4 Credit, 4T + 0P)** | | **20** |
| Semester II (Level 6) | Core-IV **(4 credit, 4T+0P)** **(Inorganic Chemistry-II)**<br>Core-V **(4 credit, 4T+0P)** **(Organic Chemistry-II)**<br>Core-VI **(4 credit, 4T+0P)** **(Physical Chemistry-II: Molecular Spectroscopy)** | DSE-II **(4 credit, 0T+4P)** **Laboratory Course-II (Two options)** | | **Internship / Apprenticeship / Community Engagement** **(4 Credit, 0T + 4P)** | **20** |

| Semester<br>(NHEQF Level) | Mandatory / Core Course | Elective Course | Other Courses | Internship / Community Engagement etc. | Total |
|---|---|---|---|---|---|
| Semester III<br>(Level 6.5) | Core-I<br>**(4 credit, 4T+0P)**<br>**(Inorganic Chemistry-III)**<br>Core-II<br>**(4 credit, 4T+0P)**<br>**(Organic Chemistry-III)**<br>Core-III<br>**(4 credit, 4T+0P)**<br>**(Physical Chemistry-III)** | DSE-III<br>**(4 credit, 0T+4P)**<br>**Laboratory Course-III**<br>**(Two options)** | | **Research Project**<br>**(4 credit, 0T+4P)**<br>**/ Core Course (Applied Chemistry)**<br>**4 credit, 4T+0P)** | **20** |
| Semester IV<br>(Level 6.5) | Core-IV<br>**(4 credit, 4T+0P)**<br>**(Inorganic Chemistry-IV)**<br>Inorganic Materials of Industrial Importance<br>Core-V<br>**(4 credit, 4T+0P)**<br>**(Organic Chemistry-IV)**<br>Green and Sustainable Chemistry<br>Core-VI<br>**(2 credit, 2T+0P)**<br>**(Physical Chemistry-IV)**<br>Quantum Chemistry | DSE-IV<br>**(4 credit, 4T+0P)**<br>**Analytical Chemistry**<br>**(Option-I)**<br>**Material Chemistry**<br>(**Option-II)** | | **Dissertation**<br>**(6 Credit, 0T + 6P)**<br>**/ Core Course**<br>**(6 Credit, 6T + 0P)** | **20** |

**SEMESTER I**
**Course:** MCHE-CC-T4-101

**(Inorganic Chemistry-I)**

**Credit = 4, Contact hours = 60**
**[L=3, T=1, P=0]**
**Total Marks 100 (End Semester 70 + Internal Assessment 30)**

**Objectives:**
1. To gain basic knowledge about structures and bonding of simple inorganic molecules.
2. To gain insight into acid base concept in Inorganic Chemistry
3. To provide a broad foundation in inorganic biochemistry

**Expected Learner Outcome:**
1. Students will learn the importance of structural and bonding nature of inorganic molecules.
2. Students will develop concepts on acid base chemistry from the inorganic chemistry perspective.
3. Student will gather knowledge about role of different metals and nonmetals in biological system.

**Unit I: Chemical Bonding** **Lecture 20, Marks 30**

VSEPR Theory: Structure of molecules containing lone pair(s) of electrons, structure and hybridization, Bent's rule, Bent bond, non-bonded repulsion, and structure. LCAO-MO methods in homo and heteronuclear diatomic molecules (O2, N2, CO, NO).MO description of tri and tetra atomic molecules ($CO_2$, $NO_2$, $NO_2^+$, $CO_3^{2-}$, $O_3$ and $NO_3^-$). Bonding in electron deficient compounds. Structure and bonding in boranes, carboranes, metallocarboranes, S-N and Se-N and P-N compounds.
Metallic and Metal ligand bonding: Spinel and Perovskite structures. Ionic surrounding: Crystal Field Theory; Covalent surrounding: Transition metal MO and ligand field Theory, Transition metal complexes with σ and π bonding ligands. Molecular orbital model, General view of ML6 and ML4 structures: ML6(Oh), ML4(D4h) and ML4(Td). Chemical periodicity, Chemical hardness, Application of electronegativity.

**Unit II: Acid Base and Redox Chemistry** **Lecture 15, Marks15**

Acid-Base concepts, Measure of Acid-Base Strengths, Acid-Base in water. Nonaqueous solvent, aprotic solvent and superacid. Hard and Soft Acids and Bases, application of SHAB principle. Half-cell reaction, reduction potential, application of reduction potential data, electrochemical series; brief idea of corrosion and its prevention; Nernst equation. Latimer and Frost diagram (V, Mn Fe, Cu etc.), disproportionation reaction; cyclic voltammetry.

**Unit III: Bioinorganic Chemistry** **Lecture 25, Marks 25**

Fundamentals of inorganic biochemistry, essential, non-essential and role of 3d block elements and non-metals in bio-systems. Natural and synthetic oxygen carriers, Porphyrins, model compounds for oxygen binding and carriers: Hemoglobin, myoglobin, hemerythrin, hemocyanin, Electron transfer protein: Cytochromes, Iron-Sulphur, Nitrogen fixation. Metalloenzymes, corrinoids (vitamin B12 and co-enzyme), carboxy-peptidases, chlorophyll and photosynthesis, Na-K or ATPase or sodium pump, crown ethers, futuristic aspects of organo-transition metal complexes in bioinorganic chemistry.

**Recommended Books:**

1. Bioinorganic Chemistry by K. Hussain Reddy, New Age International Publisher.
1. The Inorganic Chemistry of Biological Processes, Hughes, M.N., 2nd edition, Wiley (1981)
2. Bio-coordination Chemistry, D.E. Fenton, Oxford University Monograph Series 1995.
3. Inorganic Chemistry, Gary L.Miessler & Donald A. Tarr 3rd Ed, Pearson
4. Inorganic Chemistry, C.E. Housecraft & A.G. Sharpe, 2nd Ed, Pearson

**Course: MCHE-CC-T4-102**
**(Organic Chemistry-I)**
**Credit = 4, Contact hours = 60**
**[L=3, T=1, P=0]**
**Total Marks 100 (End Semester 70 + Internal Assessment 30)**

**Objectives:**

1. To provide students with the fundamental knowledge of the structure, reactivity, and reaction mechanism of organic compounds.
2. To design organic transformations through disconnection approach.
3. Applications of organic acids and bases.

**Expected Learner Outcome:**

1. Students will gain an insight into the various types of bonding and their implications in reactivity and properties of organic compounds.
2. Students will acquire expertise in designing newer synthetic methodologies through disconnection approach and characterization of the products using spectroscopic techniques.

**Unit I** **Lecture 15, Marks 15**

Pericyclic reactions – Classification of pericyclic reactions, FMO method, PMO method for the explanation of pericyclic reactions under thermal and photochemical conditions; Cycloaddition reactions: [2+2], [4+2], [6+4] cycloadditions, 1,3-dipolar cycloadditions; the ene reaction, cheletropic reactions, Sigmatropic rearrangement – [m+n] sigmatropic shifts of hydrogen and carbon, Cope and Claisen rearrangement. Electrocyclic reactions, Stereoselectivity and regioselectivity of pericyclic reactions.

**Unit II** **Lecture 15, Marks20**

Structure, bonding and reactivity of organic compounds: Delocalised Chemical Bonding, Aromaticity, antiaromacity and homoaromaticity, metallocenes, tropolones and azulenes. Hyper conjugation, supra molecular chemistry: Bonds weaker than covalent bond (Hydrogen Bond, Addition Compounds), charge transfer complexes, inclusion complexes and crown ethers. Cryptand, rotaxanes, Fullerenes, Graphenes. Phase transfer catalyst. Hammet equation, Taft equation. Influence of reaction medium on rates.

**Unit III** **Lecture 15, Marks 20**

Organic reaction mechanism – Transition state vs. Reaction intermediate, Energy profile of multistep reaction, Significance of rate limiting step in multistep reactions, Catalysed and uncatalysed reactions, Kinetic vs. Thermodynamic control, Kinetic and non-kinetic methods of studying organic reaction mechanism; Isotope labeling studies and kinetic isotope effects, Cross-over experiment. Reactivity - selectivity principle: Chemoselectivity, regioselectivity, stereoselectivity and stereospecificity in substitution, elimination and addition reactions. Neighbouring group effects. Organic reactive intermediates: Generation, stability and reactivity of carbocations, carbanions, free radicals, carbenes, benzynes and nitrenes.

**Unit IV** **Lecture 15, Marks15**

Disconnection approach in organic synthesis: Acceptor and donor synthons, Use of umpolung, Retrosynthesis of Alcohols (Grignard approaches and hydride transfer approaches) and Carbonyl compounds. One group and two group C-X disconnections. One group and two group C-C disconnections. Retrosynthsis of 1,2-, 1,3-, 1,4-, 1,5- and 1,6-difunctional (O,O and N,O in a difunctional relation) compounds.

Use of protecting groups in organic synthesis: protection and deprotection of hydroxyl, dihydroxy, carbonyl, carboxyl and amino groups.

**Recommended Books:**


1. Organic Chemistry, Vols I and II – I. L. Finar, ELBS.
2. Stereochemistry and Mechanism through Solved Problems- P.S. Kalsi, New Age International Publishers
3. Introduction to Spectroscopy – by Donald L. Pavia, Cengage Learning India Private Limited
4. A Guidebook to Mechanism in Organic Chemistry– Peter Sykes, Longman, New York.
5. Organic Chemistry – R. T. Morrison, R. N. Boyd and S. K. Bhattacharjee, Prentice Hall India Limited
6. Organic Chemistry – Paula Yurkanis Bruice, Pearson
7. Advanced Organic Chemistry: Reaction Mechanism and Structure – Jerry March, Wiley Eastern.
8. Disconnection Approach in Organic Synthesis – S. Warren, Wiley
9. Organic Reaction Mechanism, Christine Willis and martin Willis, Oxford chemistry Primers (No. 74)
10. Disconnection Approach in Organic Synthesis – S. Warren, Wiley
11. Designing Organic Synthesis – S. Warren, Wiley, Chichester
12. The Logic of Organic Synthesis – E.J. Corey and Xue Min Chen, Wiley, New York

## Course: MCHE-CC-T4-103

## (Physical Chemistry-I)
**Credit = 4, Contact hours = 60**
**[L=3, T=1, P=0]**
**Total Marks 100 (End Semester 70 + Internal Assessment 30)**

**Expected Learner Outcome:**

1. Students will understand the fundamentals and develop skills to solve problems related to fugacity, activity, partial molar quantities and third law of thermodynamics.
2. Students will explore the field of Photochemistry, which deals with chemical reactions initiated by light.
3. They will learn about the principles governing photochemical reactions, including excited states, photochemical reactions, and photochemical kinetics.
4. Students will understand the role of light absorption, quantum yields, and photochemical mechanisms in different chemical reactions.
5. They will understand Statistical Thermodynamics and its theories.

**Unit 1: Equilibrium and Thermodynamics: Lecture 20, Marks 20**

Concept of fugacity and its determination. Ideal solution and non-ideal solutions, Activity and activity coefficient, Determination of activity coefficient, Partial molar quantities: chemical potential, Determination of Partial molar volume, Thermodynamics of mixing. Excess thermodynamic functions, Nernst's Heat Theorem, Third law of thermodynamics, its experimental verification, determination of absolute entropy, Residual entropy.

**Unit 2: Statistical thermodynamics: Lecture 20, Marks 25**

Maxwell-Boltzmann distribution law, Bose-Einstein, and Fermi-Dirac distribution law. Boltzmann relation between entropy and probability. Partition functions and thermodynamic functions. Thermodynamic functions of a monatomic gas, Sackur – Tetrode equation. Evaluation of translational Partition function using Particle in a box model for ideal monatomic gas. Rotational and vibrational entropy of gases, Free energy, and Partition functions. General expression for Partition function and equilibrium constant. Energy and heat capacity of gases. Einstein and Debye's theory of heat capacity of solids. Numerical calculations of thermodynamic quantities for monoatomic, diatomic, and polyatomic molecules.

**Unit 3: Photochemistry Lecture 20, Marks 25**

Light absorption: Jablonski Diagram, mechanism of absorption and emission of photochemical radiation: electric dipole transition, Einstein treatment of absorption and emission phenomena, concept of quantum yield and its determination; Fluorescence emission and structure; Triplet state and phosphorescence emission; delayed fluorescence; Study of kinetics of $H_2$-$Cl_2$ reaction, $H_2$-$Br_2$ reaction, photo dimerisation of anthracene, Photosensitisation and quenching, Stern Volmer equation.

**Recommended Books:**

1. Physical Chemistry by P.W. Atkins
2. Physical Chemistry by I. N. Levine
3. Thermodynamics for Chemist by S. Glasstone

## Discipline Specific Elective
## OPTION I
## Course: MCHE-DS-P4-101A (Laboratory Course-I)
### Credit = 4, Contact hours = 120
## [L=0, T=0, P=4]
### Marks - 100 (End Semester 100 + Internal Assessment 0)

**Inorganic Lab I Marks 40**

Preparation and characterization (viz. conductivity measurement, IR, UV-Vis) of the following complexes: (**any two**)

1. Potassium chromioxalate, $K_3[Cr(C_2O_4)_3]$
2. Reinecke's salt
3. Tris-(thiourea) copper (I) sulphate, $[Cu(tu)_3]2SO_4.2H_2O$
4. Potassium chromithiocyanate
5. Chloropentaminecobalt (III) chloride $[Co\ (NH_3)_5Cl]\ Cl_2$
6. Nitropentaminecobalt (III) chloride $[Co\ (NO_2)\ (NH_3)_5]\ Cl_2$

**Organic Lab I Marks 25**

1. Organic Estimation – (Anyone)

i) Estimation of glucose and sucrose in a mixture.
ii) Estimation of acetone by iodoform method.
iii) Estimation of hydroxyl and amino groups by acetylation method.

2. Separation and identification of three components of organic compounds present in a mixture by TLC.

**Physical Lab I Marks 25 (anyone)**

1. To determine the rate constant of hydrolysis of methyl acetate catalyzed by an acid and also the energy of activation.
2. To determine the velocity constant of hydrolysis of ethyl acetate by NaOH.
3. Determine the rate constant of inversion of cane sugar by analytical method.
4. Study the kinetics of the reaction between iodine and acetone in acidic medium by half life
period method and determine the order with respect to iodine and acetone.
5. Determine the molar mass of a polymer by viscometric method.

**Viva Marks 10**

**Reference Books**


1. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R.
    a. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry
    a. $8^{th}$ Ed.; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H.
    a. Freeman & Co.: New York (2003).
4. Yadav, J.B., Advanced Practical Physical Chemistry 32nd Ed; Goel Publishing Hour
5. Vogel's Qualitative Inorganic Analysis, Revised by G. Svehla.
6. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education
    a. (2009)
7. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic
    a. Chemistry, 5th Ed., Pearson (2012)

8. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry:
9. Preparation and Quantitative Analysis, University Press (2000).

## Discipline Specific Elective
## OPTIONII
## Course: MCHE-DS-P4-101B (Laboratory Course-I)
### Credit = 4, Contact hours = 120
## [L=0, T=0, P=4]
### Marks - 100 (End Semester 100 + Internal Assessment 0)

**Inorganic Lab I Marks 50**

Preparation and characterization (viz. conductivity measurement, IR, UV-Vis) of the following complexes: **(any two)**

1. Sodium ferrioxalate, $Na3[Fe(C_2O_4)_3]\ 9H_2O$
2. Tetraamine Cu (II)sulphate, $[Cu\ (NH_3)_4]\ SO_4.H_2O$
3. Hexa-amine Ni (II) chloride $[Ni\ (NH_3)_6]\ Cl_2$
2. Sodium Cobaltinitrite$Na_3[Co\ (NO_2)_6]$
5. Nitritopentaminecobalt(III) chloride, $[Co(ONO)\ (NH_3)_5]Cl_2$
6. Hexamine Co (III) sulphatepentahydrate, $[Co\ (NH_3)_6]_2(SO_4)_3.5H_2O$

**Organic Lab I Marks 20**

Preparation of Green solvent: Ionic liquid and its use in organic reactions.

**Physical Lab I Marks 20**

1. To determine the rate constant of hydrolysis of ethyl acetate catalyzed by an acid and the energy of activation.
2. Study the complex formation between $Cu^{2+}$ ion and ammonia by distribution method and find the composition of the complex.
3. To determine the radius of a molecule (glycerol) by viscosity measurements.
4. To study the kinetics of reaction between $K_2S_2O_8$ and KI.
    a) Determine the rate constant and order of the reaction
    b) Study the influence of ionic strength on the rate constant.
5. Determine the partial molar volume of ethanol by determining the densities of dilute aqueous solutions.

**Viva Marks 10**

**Reference Books**


1. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman & Co.: New York (2003).
4. Yadav, J.B., Advanced Practical Physical Chemistry 32nd Ed; Goel Publishing House
5. Vogel's Qualitative Inorganic Analysis, Revised by G. Svehla.
6. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
7. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
8. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry:
9. Preparation and Quantitative Analysis, University Press (2000).

## Course: MCHE-CC-T4-104A
## Option 1
## (Research Methodology)
## Credit = 4, Contact hours = 60
## [L=3, T=1, P=0]
## Total Marks 100 (End Semester 70 + Internal Assessment 30)

**Expected Learner Outcome:**

1. Students will learn the importance of research methodology.
2. Students will learn the skill of evidence-based research papers.
3. Students will learn literature review skills.
4. Students will learn the importance of citation and referencing.
5. Students will learn the importance of research design and proper problem. identification.

**Unit I: Research Methodology: Lecture 20, Marks 25**

Meaning of Research (Objectives and motivation of research). Research problems and research design. Research techniques, Sampling, and data analysis. Literature survey (different sources of literature survey including online databases), defining hypothesis, Research design, Sampling Design, Data collection, Data analysis: measures of central tendency, measures of dispersion, measures of asymmetry, measures of relationship. Preparation of research manuscript. Writing a research grant proposal (research funding)

**Unit III: Methods of Data Collection and Analysis of Data Lecture 20, Marks 20**

Types of Information, Collection of Primary, secondary, and tertiary Data, Observation Method, Interview Method, Collection of Data through Questionnaires, Collection of Data through Schedules, Difference between Questionnaires and Schedules, Some Other Methods of Data Collection, Collection of Secondary Data Selection of Appropriate Method for Data Collection, Case Study Method, Processing Operations, Some Problems in Processing, Elements/Types of Analysis, Statistics in Research.

**Unit IV: Testing of Hypotheses, Interpretation and Report Writing**
**Lecture 20, Marks 25**

What is a Hypothesis? Basic Concepts Concerning Testing of Hypotheses, Procedure for Hypothesis Testing, Flow Diagram for Hypothesis Testing, Measuring the Power of a Hypothesis Test, Tests of Hypotheses.

Meaning of Interpretation, Why Interpretation? Technique of Interpretation: Precaution in Interpretation, Significance of Report Writing, Different Steps in Writing Report, Layout of the Research Report, Types of Reports (Research Project and Research article), Oral Presentation, Mechanics of Writing a Research Report, Precautions for Writing Research Reports, Conclusions, writing ethics, avoiding plagiarism, use of computers and Computer Technology in research.

**Textbooks:**


1. C. R. Kothari and Gaurav Garg, Research Methodology Methods, and techniques, New Age International
2. Ghosh, B.N., *Scientific Methods and Social Research,* New Delhi: Sterling Publishers Pvt. Ltd.,

**3.** Gopal, M.H., *Research Reporting in Social Sciences,* Dharwar: Karnatak University
4. Hillway, T., *Introduction to Research,* 2nd ed., Boston: Houghton Mifflin
5. Kothari, C.R., *Quantitative Techniques,* 2nd ed., New Delhi: Vikas Publishing House Pvt. Ltd.
6. Lastrucci, Carles L., *The Scientific Approach: Basic Principles of the Scientific Method,* Cambridge, Mass.: Schenkman Publishing Co., Inc., 1967.

**Course: MCHE-CC-T4-104B**
**Option 2**
## (Tools and Techniques in Research Methodology)
**Credit = 4, Contact hours = 60**
**[L=3, T=1, P=0]**
**Total Marks 100 (End Semester 70 + Internal Assessment 30)**

**Objective of the Course:**
The objective of the course is to provide students with a comprehensive understanding of the principles and practices of research. The course aims to equip students with the skills necessary to design, conduct, analyze, and present research in a methodologically sound and ethically responsible manner. It focuses on various research methods, both qualitative and quantitative, and introduces students to the tools and techniques essential for conducting high-quality research in various fields.

**Expected Course Outcome:**

1. The course will help the students to understand Research Fundamentals.
2. The course will enable students to formulate Research Problems.
3. The course will enable the students to use quantitative methods (e.g., surveys, experiments, statistical analysis) in practical applications.
4. Students will learn the techniques of Interpreting Research Findings.
5. The course will help the students to develop critical thinking skills to evaluate research designs and methodologies.

**Unit-I: Introduction to Research Methodology** **Lecture 15, Marks 20**

Meaning of Research, Definitions of Research, Purpose of Research, Characteristics of Research, Types of Research.

Research process, (i) Formulating the Research Problem (ii) Extensive Literature Survey (iii) Developing the Research Hypothesis (iv) Preparing the Research Design (v) Determining the Research Design (vi) Collecting the Research Data (vii) Execution of the Project (viii) Analysis of Data (ix) Hypothesis Testing (x) Generalization and Interpretation (xi) Preparing of the Report or Presentation of the Result.

**Unit-II: Research Design and Problem Identification** **Lecture 15, Marks 20**

Research design, Purpose of a Research Design, Characteristics of Good Research Design

Research Problem, Definitions of the Problem, Identification of a Research Problem, The Sources of the Problem, Statement of Problem, Objectives of Assumptions about the Problem, Aspects of Delimiting a Problem, Evaluation of the Problem.

**Unit-III: Sampling Techniques and Tools for Data Collection in Research Methodology:**

**Lecture 15, Marks 20**

Sampling, Census Method or Parametric method and Sampling method or Non-parametric method, Assumptions of Sampling, Need of Sampling, Advantages of Sampling, Disadvantages or Limitation of Sampling, Essentials of an Ideal Sample, Characteristics of a Good Sample, Types of Sampling Designs/Methods of Sampling, Difference between Probability and Non-Probability Sampling, Simple Random Sampling, Systematic Sampling, Stratified Sampling, Multiple or Double Repetitive Sampling, Multi Stage Sampling, Cluster Sampling, Non-Probability Sampling Method, incidental or Accidental

Sampling, Judgment Sampling, Purposive Sampling, Quota Sampling, Snowball Sampling, Purposive or Expert Choice Sampling, Tools of Data Collection, Questionnaires, Interviews, Schedules, Observation Techniques, Rating Scales.

**Unit-IV: Data Processing and Statistical Analysis in Research: Lecture 15, Marks 10**

Processing and Analysis of Data, Processing Operations, Some Problems in Processing, Elements/Types of Analysis, Statistics in Research, Measures of Central Tendency, Measures of Dispersion, Measures of Asymmetry (Skewness), Measures of Relationship, Simple Regression Analysis, Multiple Correlation and Regression, Partial Correlation, Association in Case of Attributes, Other Measures.

**Reference:**


1. Ackoff, Russell L. (1961). *The Design of Social Research*, University of Chicago Press: Chicago.
2. Allen, T. Harrell, (1978). *New Methods in Social Research*, Praeger Publication: New York.
3. Baker, R.P. & Howell, A.C. (1958). *The Preparation of Reports*, Ronald Press: New York.
4. Barzun, Jacques & Graff. F. (1990). *The Modern Researcher*, Harcourt, Brace Publication: New York.
5. Berelson Conard & Colton, Raymond. (1978). *Research and Report Writing for Business and Economics*, Random House: New York.
6. Best, John, W.& Kahn, James. (1986). *Research in Education*, 5th ed., Prentice–Hall of India Pvt Ltd: New Delhi.

## SEMESTER II

**Course:** MCHE-CC-T4-201

## (Inorganic Chemistry-II)

**Credit = 4, Contact hours = 60**

**[L=3, T=1, P=0]**

**Total Marks 100 (End Semester 70 + Internal Assessment 30)**

**Expected Learning Outcome:**

1. It will help the students to comprehend the fundamental principles and concepts of reaction mechanisms in inorganic chemistry.
2. Students will learn how to classify and describe different types of inorganic reactions (e.g., substitution, addition, elimination).
3. Students will understand the factors that influence reaction mechanisms, such as electronic effects, steric factors, and coordination environment.
4. It will enable students to develop skills in determining the point group of a molecule based on its symmetrical elements and operations.
5. Help students to learn how to use character tables and apply group theory to analyze molecular symmetry.
6. It will Enhance the critical thinking and analytical skills through the study and application of inorganic reaction mechanisms and group theory.

**Unit I: Reaction mechanism II** **Lecture 20, Marks 25**

Lability and inertness, stability constant- formation constant of complexes, chelate effect, Thermodynamic and Kinetic stability; inert and labile complexes; Factor affecting stability, Correlation of stability constant with thermodynamic factors –G, H and S. Determination of stability constant –Jobs and Bjerrum's methods. Mechanism of ligand replacement reactions: Substitution reactions in octahedral [Cr(III), Co(III)] and square planar [Rh(I), Pt(II) and Pd(II)] complexes, Rate of water replacement reaction; Solvolysis and hydrolysis reaction; acid hydrolysis and base hydrolysis reaction; Factors affecting the rate of substitution reaction, trans effect and its importance, theories of trans effect, idea concerning electron transfer reactions, inner and outer sphere reactions.

**Unit II: Symmetry operation, elements of symmetry** **Lecture 20, Marks 25**

Matrices and matrix representation of symmetry operations, Definition of Group, finite and infinite group. Examples of groups using geometrical object and symmetry operations. Symmetry elements as elements of group. Point groups. Orthogonality theorem: reducible and irreducible representation, use of vectors and mathematical functions in group representation, Character table for molecular point group, construction of C2v and C3v Character table. Direct product representation. Projection operator, symmetry adapted linear combination (SALC) for C2v, C3v, D4h and Td point group molecules.

**Unit III: Chemical Application of Group Theory** **Lecture 20, Marks 20**

Use of group theory in construction of hybrid Orbitals (d2sp and sp3 hybrids). Infrared absorption and Raman scattering spectroscopy, vibrational modes as bases for group representation, Symmetry selection rules for IR and Raman Spectra. Classification of vibrational modes and vibrational analysis. Orbital Symmetry and Chemical reactions – Woodward and Hoffman rules for electrocyclic and cycloaddition reactions.

**Textbooks:**

1. Inorganic Chemistry: Principles of structure and reactivity, 4thEdition; J.E. Huheey, E.A. Keiter, R.L. Keiter, O.K. Medhi.

**Recommended Books:**

1. Advanced Inorganic Chemistry, 6thEdition, F.A. Cotton, G. Wilkinson, C.A. Murillo and M. Bochmann.
2. Inorganic Chemistry, K.F. Purcell, and J.C. Kotz.

## SEMESTER II

**Course:** MCHE-CC-T4-202

**(Organic Chemistry-II)**

**Credit = 4, Contact hours = 60**

**[L=3, T=1, P=0]**

**Total Marks 100 (End Semester 70 + Internal Assessment 30)**

**Objectives:**

To provide knowledge on

a. Isolation, characterization, and synthesis of various natural compounds of biological importance
b. Heterocyclic compounds of biological and pharmaceutical importance
c. Applications of NMR spectrometry for analysis of molecular compounds.
d. Concept of Stereochemistry of organic reactions.

**Expected Learner Outcome:**

1. Students will gain insight into isolation, characterization, and synthesis of various natural compounds of biological importance.
2. Students will acquire knowledge of different heterocyclic compounds.
3. They will also be familiarized with mass spectrometric technique.

**Unit I** **Lecture 12, Marks15**

NMR spectroscopy: Chemical shift, factors affecting chemical shift, spin- spin interaction, coupling constant and Factors affecting, relaxation processes, NOE, Nuclear magnetic double resonance, shift resonance, spin tickling; Proton and 13C NMR spectroscopy of simple organic molecules, living systems – MRI, Two-dimensional NMR, NOESY, DEPT, INEPT terminology, Instrumentation, FT NMR. IR: Application of IR in organic spectroscopy

**Unit II** **Lecture 12, Marks 15**

Alkaloids: Occurrence, classification, general methods of isolation, test for detection. Structure elucidation by physical and chemical methods and synthesis of: Piperine, and Morphine.

Terpenoids: Occurrence and classification, isoprene rule, general methods of isolation. Biogenetic pathway of mono- and sesquiterpenes. Structure determination by physical and chemical methods and synthesis of the following: Acyclic monoterpenoid – Linalool. Monocyclic monoterpenoid -Terpineol, Menthol.

**Unit III** **Lecture 12, Marks 15**

Carbohydrates: Structure and conformation of disaccharides – sucrose and lactose. Polysaccharides – starch and cellulose. Peptides and Proteins: Structure determination and synthesis of small peptides (di-, and tri-). Solid phase synthesis of peptides. Classification of proteins. Primary, secondary and tertiary structure of proteins.

**Unit IV** **Lecture 12, Marks 10**

Heterocyclic Chemistry: Principles of heterocyclic synthesis involving cyclization and cycloaddition reaction. Synthesis and properties heterocycles containing one and two heteroatoms viz., N, O and S (aziridine, oxirane, pyrazole, isoxazole, imidazole, oxazole and thiazole).

**Unit V** **Lecture 12, Marks 15**

Stereochemistry: Concept of pro stereoisomerism and prochirality – Homotopic and heterotopic ligands and faces; Optical purity and enantiomeric excess; Chirality in molecules devoid of chiral centers - allenes, spirans and biphenyls. Classification of stereoselective synthesis: diastereoselective and enantioselective reactions; Nucleophilic addition to aldehydes and acyclic ketones: Cram and Felkin – Ahn model. Enantioselective synthesis.

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**Textbooks:**

1. Organic Chemistry of Natural Products, Vol I and II, Gurdeep Chatwal, Himalaya Publishing House, Bombay.
2. Heterocyclic Chemistry: Synthesis, Reactions and Mechanisms – Raj K. Bansal, Wiley Eastern.

**Recommended Books:**

1. Chemistry of Organic Natural Products, Vol I and II, O.P. Agarwal, Goel Publishing House, Meerut.
2. The Alkaloids: K. W. Bentley.
3. Organic Chemistry, Vol- II, I.L. Finar
4. Heterocyclic Chemistry – T.L. Gilchrist, Longman Scientific and Technical/Pitman Publ. Ltd.
5. Spectrometric Identification of Organic Compounds – by Robert M. Silverstein, Francis X. Webster, David Kiemle, John Wiley & Sons.
6. Organic Spectroscopy – by William Kemp, Palgrave Macmillan.

## SEMESTER II

**Course:** MCHE-CC-T4-203

**(Physical Chemistry II: Molecular Spectroscopy)**

**Credit = 4, Contact hours = 60**

**[L=3, T=1, P=0]**

**Total Marks 100 (End Semester 70 + Internal Assessment 30)**

**Expected Learning Outcome:**

1. Students will grasp the principles underlying molecular spectroscopy techniques.
2. Students will develop problem-solving skills specific to scientific problems related to molecular spectroscopy.
3. They will apply critical thinking and analytical reasoning to interpret spectroscopic data.

**Unit 1: Raman Spectroscopy: Lecture 10, Marks 10**

Quantum theory of Raman Effect, Selection rules, mutual exclusion principle, vibration rotation Raman spectra. Intensity of Raman lines.

**Unit 2: UV-Visible spectroscopy: Lecture 10, Marks 15**

Electronic transitions and selection rules, Frank Condon principle and electronic spectra of polyatomic molecules, Fluorescence and phosphorescence, solvent effects, absorption and intensity shifts, Calculation of absorption maxima by Woodward-Fieser Rules.

**Unit 3: Mass spectrometry: Lecture 10, Marks 15**

Ion fragmentation mechanism, Base peak and molecular ion peak, metastable peak, instrumentation and techniques, ionization methods, isotopic distribution, Application in determining the structure of organic and inorganic compounds.

**Unit 4: Photoelectron Spectroscopy**: Introduction to Photoelectron Spectroscopy, Auger electron spectroscopy. Chemical information from ESCA **Lecture 10, Marks 10**

**Unit5: Mossbauer spectroscopy:** Principle of Mossbauer spectroscopy, Instrumentation, Application of Mossbauer spectroscopy: the isomer shift, magnetic interaction, quadruple splitting, line with. Application to iron to iron and tin compounds. **Lecture 10, Marks 10**

**Unit 6: ESR spectroscopy:** Principle, resonance condition, Origin of g-value, spin orbit coupling, Kramer degeneracy, zero-field splitting, hyperfine & super hyper interaction, line width and application of ESR in organic radicals. **Lecture 10, Marks 10**

Textbooks Recommended:


1. Fundamentals of Molecular Spectroscopy by C.N. Banwell and E.M. McCash, Tata McGraw Hill.
2. Introduction to Molecular Spectroscopy by G.M. Barrow, McGraw Hill.
3. Physical Chemistry by P.W. Atkins
4. Quantum Chemistry, by Ira N. Levine, Pentice Hall

## Discipline Specific Elective
## OPTION I
## Course: MCHE-DS-P4-201A (Laboratory Course-II)
### Credit = 4, Contact hours = 120
### [L=0, T=0, P=4]
### Marks - 100 (End Semester 100 + Internal Assessment 0)

**Inorganic Lab 2** **Marks 30**

1. Estimation of $Mg^{2+}$ and $Ca^{2+}$ by complexometric method in different ores and from given
   solution with one / two components.
2. Estimation of alloys – Brass, Cu-Ni, etc.
3. Synthesis and characterization of nanoparticles by sol-gel and co-precipitation methods.

**Organic Lab 2** **Marks 30**

1. Separation and identification of amino acids present in a mixture by paper chromatography.
2. Organic Preparation -
   One –step preparation
   a. Cannizaro reaction of benzaldehyde (separation of benzyl alcohol and benzoic acid by solvent extraction)
   b. Oxidation of p-nitrotoluene to p-nitrobenzoic acid
   c. Reduction of benzophenone to benzhydrol
   d. Phthalic anhydride to phthalimide

**Physical Lab 2** **Marks 30**

1. To study hydrolysis of methyl acetate in presence of HCl and $H_2SO_4$ and hence determine the relative strength of the acids (use Guggenheim method)
   i) analytically.
   ii) polarimetrically.
2. Determine the equivalent conductivity of acetic acid at infinite dilution by Kohlrausch's method.
3. Determine the relative strength of acetic acid and mono chloro acetic acid by conductance measurement.
4. Determine the specific rotation of sucrose and hence determine the unknown concentration of supplied solution by polarimetric measurements.
5. Determination of pH of a mixture of $CH_3COOH$ and $CH_3COONa$, and hence determine the dissociation constant of the acid.
6. Preparation of conducting polymers and study of their electrical conductivity.
   **Viva Marks 20**

**Reference Books:**


1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Christian, Gary D; Analytical Chemistry, 6th Ed., John Wiley & Sons, New York, 2004.
3. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
5. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
6. Yadav, J.B., Advanced Practical Physical Chemistry 32nd Ed; Goel Publishing Hour

**Discipline Specific Elective**
**OPTION II**
**Course: MCHE-DS-P4-201B (Laboratory Course-II)**
**Credit = 4, Contact hours = 120**
**[L=0, T=0, P=4]**
**Marks - 100 (End Semester 100 + Internal Assessment 0)**

**Inorganic Lab 2** **Marks 30**

1. Estimation of $Zn^{2+}$ and $Cu^{2+}$ by complexometric method in different ores and from given
   solution with one / two components.
2. Estimation of alloys – Bronze, Cu-Ni, etc.
3. Synthesis and characterization of nanoparticles by biogenic methods.

**Organic Lab 2** **Marks 30**

1. Two –step preparation
   i. p-nitrobenzene azo 2-naphthol (Para Red) from p-nitroaniline
   ii. Benzanilide from benzophenone
   iii. Dibenzyl from benzoin
2. Preparation of Green reagent: TetrabutylammoniumTribromide (TBATB) and its use

**Physical Lab 2** **Marks 30**

1. Determine the specific rotation of sucrose and hence determine the unknown concentration of supplied solution by polarimetric measurements.
2. Determine the amount of each component of the following ternary mixture by
3. Conductometric titration.
   i) HCl, $CH_3COOH$, $CuSO_4$
   ii) HCl, NaCl, $NH_4Cl$
4. Determine the ionization constant of acetic acid by conductivity method.
5. Determination of Critical Micelle Concentration (CMC) of Sodium dodecyl sulphate (SDS) by surface tension measurement.
6. To find the stability constant of the co-ordination compound formed between $Cu^{2+}$ and 5-Sulphosalicylic acid.
7. Establish the order reaction for $K_2C_2O_4 + 2HgCl_2 \rightarrow Hg_2Cl_2 + 2KCl + 2CO_2$ by the method of ratio variation.

**Viva Marks 20**

**Reference Books:**


1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Christian, Gary D; Analytical Chemistry, 6th Ed., John Wiley & Sons, New York, 2004.
3. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
5. Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
6. Yadav, J.B., Advanced Practical Physical Chemistry 32nd Ed; Goel Publishing Hour

## SEMESTER II

**Course:** MCHE-CC-P4-202

**(Internship/Apprenticeship/Community Engagement)**

**Credit 4**

**Total Marks 100 (End Semester 70 + Internal Assessment 30)**

**Expected Learning outcomes:**

1. During internships students will see the practical applications of Theoretical Knowledge.
2. Internship programmes will help in the development of technical Skills of the students.
3. Help the students to develop skills in the planning, executing, and managing projects within a specified timeframe and budget.
4. Such activities cultivate the ability to identify issues, analyze data, and implement effective solutions in a professional context.
5. Help in the improvement of written and oral communication skills through report writing, presentations, and collaborative projects.
6. Such activities will help students in achieving proficiency in specific technical skills and laboratory techniques that are critical for professional practice.
7. Community engagement activities will enhance skills in explaining complex scientific concepts to non-specialist audiences, improving public understanding of chemistry.
8. Develop a sense of social responsibility by using chemical knowledge to address community issues and promote public health and safety.
9. Cultivate leadership skills through organizing and leading community projects and activities.
10. Learn to interact respectfully and effectively with individuals from diverse backgrounds, enhancing cultural awareness.

A. Students will go for internship/Apprenticeship in the concerned subject or an allied field and will submit a report of the same after the completion of the internship/Apprenticeship.

B. Students may undertake community engagement activities during which they can leverage their specialized knowledge to benefit local communities. Some possible programmes are:

i. **Science Workshops for Schools**: Hands-on experiments, science fairs, chemistry magic shows, and career talks.

ii. **Public Health and Safety Campaigns**: Partner with local health organizations to educate the community on issues related to chemical safety, environmental hazards, and health.

iii. **Environmental Conservation Projects:** Water and soil testing for pollutants, community clean-up drives, and developing sustainable waste management practices.

iv. **Mentorship Programs:** Develop mentorship programs where chemistry graduates can guide high school or undergraduate students interested in chemistry.

v. **Chemistry in the Community Workshops:** Conduct workshops that demonstrate the role of chemistry in everyday life and practical applications.

vi. **Collaborations with Local Businesses:** Conducting audits of chemical use, suggesting greener alternatives, and implementing recycling programs.

vii**. Chemical Disaster Preparedness:** Work with local emergency services to develop and disseminate chemical disaster preparedness plans.
viii. **Public Lectures and Seminars:** Organize public lectures and seminars on various chemistry-related topics.

Preparation and Submission of Report of Internship/Apprenticeship/Community Engagement Activity: **Marks 70**

**Mark Distribution:**

| | |
|---|---|
| Objective/Importance of the present work | Marks 10 |
| Field/experimental work | Marks 25 |
| Discussion of the Present work/Results/Observations | Marks 25 |
| Presentation/Viva | Marks 10 |
| Internal Assessment | **Marks 30** |

## SEMESTER III

**Course:** MCHE-CC-T4-301

## (Inorganic Chemistry-III)

**Credit = 4, Contact hours = 60**

**[L=3, T=1, P=0]**

**Total Marks 100 (End Semester 70 + Internal Assessment 30)**

**Objectives:**

1. To give a brief knowledge about properties of d and f block elements
2. To provide basic concept about spectroscopic methods in Inorganic Chemistry

**Expected Learner Outcome:**

1. To enable our students to solve spectroscopic problems for Inorganic molecules.
2. Student will gather thorough knowledge about the chemistry of d and f block elements.

**Unit I: Chemistry of Lanthanides and Actinides Lecture 10, Marks 12**

Electronic configuration, lanthanide contraction, separation of lanthanides, Magnetic and spectral properties of lanthanides and actinides, lanthanide shift reagents. Stability of lanthanide and actinide complexes.

**Unit II: Properties of transition metal complexes Lecture 30, Marks 30**

**(A) Transition metals and periodic properties:**

Transition metal donor-acceptor compounds, Coordination number and geometries, 18-electron rule, Stability of metal complexes, common ligands and complexes, Stereochemically non-rigid systems.

Introduction to transition metal organometallic chemistry: Metal carbon bond formation, 18 and 16 electron organometallic complexes. Isolobel analogy in organometallic compounds.

Bonding in organo-transition metal compounds: Metal carbonyls, metal olefins, metal carbene, Role of co-ligands like phosphine, arsine, stibine, N2, O2 and NO. Oxidative addition, reductive elimination andβ-elimination reaction.

**(B) Electronic spectra and magnetic properties of transition metals complexes:**

Electronic states and terms for transition metals. Selection rules, Orgel diagram and Tanabe Sugano diagrams: Application in transition metal electronic spectroscopy. Electronic spectra and structure, d-d and charge transfer transitions.

**Unit III: Application of NMR spectroscopy (1H, 31P and 19F): Lecture 10, Marks 13**

Chemical shift, factors contributing to chemical shift, spin-spin coupling and its implication to structure determination; simplification of complex spectra; Use of 31P and 19F NMR incoordination chemistry: metal-ligand interaction; isomer determination; evaluation of stereo chemical non-rigidity in molecules; NMR spectra of paramagnetic compounds**.**

**Unit IV: Magnetochemistry Lecture 10, Marks 15**

Types of magnetic bodies (eg, Diamagnetic, Paramagnetic, ferromagnetic, and antiferromagnetic), antiferromagnetic coupling, Magnetic properties based on crystal field theory: spin only magnetic moments, spin-state equilibrium in octahedral stereochemistry: cross-over region, quenching of orbital magnetic moment by CF, orbital contribution, effect

of temperature on magnetic behaviour, magnetic properties of octahedral, tetrahedral, tetragonally distorted octahedral and sequence planer complexes.

**Textbooks:**

1. Inorganic Chemistry, Shriver & Atkins, 5th Edition Oxford
2. Fundamentals of Molecular Spectroscopy: C.N. Banwell and E.M. McCash, Tata McGraw Hills

**Recommended Books**:

1. Inorganic Chemistry, W.W. Porterfield, 2nd Edition, Academic Press
2. Physical Methods for Chemist, Russell S. Drago
3. Elements of Magnetochemistry, R. L. Dutta and A Syamal

## SEMESTER III

**Course:** MCHE-CC-T4-302

## (Organic Chemistry-III)

**Credit = 4, Contact hours = 60**

**[L=3, T=1, P=0]**

**Total Marks 100 (End Semester 70 + Internal Assessment 30)**

**Objective of the study**

1. To get an insight of C-C bond formation via organometallics.
2. To gain knowledge on oxidation/reduction reactions of organic molecules.
3. To acquire knowledge on various photochemical reactions.
4. To gain an elementary idea of new organic synthesis.

**Expected Learner Outcome:**

1. They will get a stereochemical insight into different organic molecules.
2. They will be familiarized with different oxidative and reductive reaction components.

**Unit I:** Organic synthesis I **Lecture 15, Marks-20**

Organometallic reagents information of carbon-carbon bonds: Organopalladium in C-C Formation (Heck reaction, Suzuki, and Negishi Coupling). Formation of C=C bonds by elimination reactions, syn elimination; Wittig and related reactions, Peterson olefination, and Julia reaction. Olefin metathesis, Grubbs catalyst, Shrock catalyst etc.

**Unit II:** Organic synthesis II **Lecture 20, Marks-20**

Definition and Classification. Oxidation by Mn (VII) and Cr (IV)reagents.

Oxidation(i)of carbon-carbon double bond: dihydroxylation by $KMnO_4$, $OsO_4$ (including Sharpless asymmetric dihydroxylation), iodine and silver carboxylate (Woodward and Prevost condition) and peroxyacid. Use of $SeO_2$ and DDQ. Swern-Pftzner-Moffatf and Albright-Goldman, TPAP.

(ii)of alcohols and of 1,2-diols: Use of Cr (VI) based reagents (PCC, PDC), DMSO base reagent.

Reduction(i) by catalytic hydrogenation: both heterogeneous ($H_2$/Pd-C, $H_2$/$Pt_2O$, Lindler's and Rosendmund's reduction) and homogeneous (Wilkinson catalyst), (ii) by hydride transfer ($LiAlH_4$, $NaBH_4$, 9-BBN (iii)by dissolving metal (alkali metals in liquid ammonia) and (iv)by diimide, DIBAL, $NaCNBH_4$, SMEAH (Red Al), Superhydride and Selectride, 9BBN.

**Unit III: Organic Synthesis III** **Lecture 10, Marks-10**

Elementary idea of PASE synthesis with types and examples, combinatorial chemistry, parallel synthesis, use of nano particles in organic synthesis, microwave synthesis, DOMINO type reactions (Cascade)

**Unit IV Photochemistry** **Lecture 15, Marks-20**

Photochemistry carbonyl compounds-representation of the excited states of ketones, photolysis of saturated and β, γ-unsaturated ketones. Photoreduction of saturated arylalkyl and α, β– unsaturated ketones and ρ–benzoquinone. Patterno-Buchi reaction, |2+2|-cycloaddition, Olefinic photochemistry- photo stereo mutation of cis-trans isomers, optical pumping, 2+2|-cycloaddition, Photochemistry of conjugated polyenes- cycloaddition and

dimerization of 1, 2-butadiene. Photo arrangements-photo-Fries rearrangement and photorearrangement of cyclohexadienones, Barton rearrangement. Optical Pumping.

Textbooks:

1. Modern Methods of Organic Synthesis – Carruthers and Coldham, Cambridge University Press
2. Organic Synthesis – M.B. Smith, McGraw Hill. (Reference book)
3. Principles of Organic Synthesis – R.O.C. Norman and J M Coxon
4. Advanced Organic Chemistry Part A and B: Carey and Sundberg
5. Synthetic Approaches in Organic Chemistry – R.K. Bansal- Narosa Publishing House, New Delhi

## SEMESTER III

**Course:** MCHE-CC-T4-303

## (Physical Chemistry-III)

**Credit = 4, Contact hours = 60**

**[L=3, T=1, P=0]**

**Total Marks 100 (End Semester 70 + Internal Assessment 30)**

**Objectives:**

1. To give a brief knowledge about Chemical kinetics
2. To provide basic concept about fast reactions, reactions in solution, and enzyme catalyzed reactions.

**Expected Learner Outcome:**

1. To enable our students to solve problems related to chemical kinetics.
2. Student will gather thorough knowledge about the kinetics of electrode reactions, ion solvent interactions.

**UNIT-1: Chemical Kinetics and Reaction Dynamics Lectures 40, Marks 45**

- **i)** Transition state theory, postulates, mathematical treatment of transition state theory, Eyring equation.
- **ii)** Kinetics of Chain reactions, determination of chain length, kinetics of $H_2$-$Br_2$ reaction, thermal decomposition of acetaldehyde. Kinetics of non-stationary chain reactions, hydrogen- oxygen reaction, and explosion limits
- **iii)** Unimolecular reactions - Lindemann theory, Hinshelwood, Kassel-Rice-Ramsperger theory
- **iv)** Study of fast reactions, derivation of rate constant, relaxation time for fast reactions, Methods for the study of fast reactions: Stoppard flow method, continuous flow method, flash photolysis, and pulse radiolysis.
- **v)** Kinetics of reactions in solution-Factors affecting the kinetic study of reactions in solution, Diffused controlled reactions in solution, Debye Smoluchowski equation. Influence of ionic strength on the rates of ionic reactions, salt effects.
- **vi)** Rate of enzyme catalyst reaction, Michaelis-Menten equation; temperature, pH and concentration dependence of enzyme catalysed reactions; acid-base catalysis and acidity function.

**Unit 2: Electrochemistry Lectures 20, Marks 25**

- **i)** **Ion-solvent interactions:** The Born model-thermodynamic parameters of ion-solvent interactions-structural treatment; the ion-dipole model –its modifications, ion-quadrupole, and ion-induced dipole interactions. Debye-Húckel theory of ion-ion interactions– derivation, validity, and limitations; extended Debye-Húckel-Onsager equation. Ion-Association: Bjerrums hypothesis. **15**
- **ii)** **Kinetics of electrode reactions:** Butler Volmer equation, Tafel equations and Tafel plots, Calculations of exchange current density and transfer co-efficient for electrode processes. Overvoltage: Definition and applications in the study of electro deposition of metals in aqueous solution, corrosion of metals. Inhibition of corrosion. **10**

**Textbooks:**


1. Chemical Kinetics – K. J. Laidler, Pearson Education India.
2. Modern Electrochemistry – Vol I, II by J. O. M. Bockris& A. K. N. Reddy

**Recommended Books:**


1. Chemical Kinetics and Reaction Dynamics – P. L. Houston, Dover Publications
2. Kinetics and Mechanism – A. A. Pearson, R. G. Frost, John Wiley and Sons
3. Electrochemical Methods: Fundamentals and Applications, A. J. Bard, L. R. Faulkner, John Wiley and Sons.
4. An Introduction to Electrochemistry – S. Glasstone, East West Press.
5. Physical Chemistry – P.W. Atkins, Oxford University Press.

**Discipline Specific Elective**
**OPTION I**
**Course: MCHE-DS-P4-301A (Laboratory Course-III)**
**Credit = 4, Contact hours = 120**
**[L=0, T=0, P=4]**
**Marks - 100 (End Semester 100 + Internal Assessment 0)**

**Inorganic Lab** **Marks 25**

1. Synthesis and characterization (melting point, conductivity, IR, UV-vis etc.) of Ni-DMG
   complex and estimate the percentage of nickel in the synthesized compound.
2. Synthesis and characterization of Schiff-base ligands and their metal complexes.
3. Synthesis and characterization of metal and metal oxide nanoparticles by surfactant assisted methods.

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**Organic Lab** **Marks 30**

**1.**Preparation, purification (by TLC) and spectroscopic identification (UV and IR) of the prepared organic compounds and (B) Estimation

**Preparation:**

- **a.** Benzilic acid from benzoin via benzyl (Benzilic acid rearrangement)
- b. Benzanilide from benzophenone via oxime (Beckman rearrangement)
- c. Indigo from anthranilic acid via phenylglycine-o-carboxylic acid and indoxyl
- d. Sandmeyer reaction:
  - i. *ortho*-Chlorotoluene from *ortho*-toluidine (steam distillation of the product)
  - ii. Acridone from anthranilic acid via o-chlorobenzoic acid and phenylanthranilic acid
- e. Sulphanilamide from acetanilide via p-acetamido benzene sulphonyl chloride and p-acetamido benzenesulphonamide
- f. Pinacolone from benzophenone via pinacol (Pinacol pinacolone rearrangement)

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**Physical Lab** **Marks 25**

1. Determination of hydrolysis constant of aniline hydrochloride by pH measurements.
2. Determine the strengths of the components of the following mixtures by conductometric titration:
   a) Hydrochloric acid and acetic acid
   b) Sulphuric acid and copper sulphate
3. Determine the strengths of HCl and CH3COOH in each mixture by pH-metric titration.
4. Verify Beer's law and determine the unknown concentration of supplied solutions like KMnO4 / K2Cr2O7
5. Determine the composition of iron-salicylic acid complex spectrophotometrically by Job's method.
6. Least squares fitting and plotting linear and exponential graphs performing theoretical calculations using a computer.

**Viva** **Marks 20**

**Recommended Books:**


1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed., Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, Gary D; Analytical Chemistry, 6th Ed., John Wiley & Sons, New York, 2004.
4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W. H. Freeman, 2001.
5. Khopkar, S. M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
6. Skoog, D. A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore.
7. Mikes, O. & Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
8. Vogel's Qualitative Inorganic Analysis, A. I. Vogel, Prentice Hall, 7th Ed
9. Textbook of Practical Organic Chemistry, A. I. Vogel, Prentice Hall, 5th Ed.
10. Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960

## Discipline Specific Elective
## OPTION II
## Course: MCHE-DS-P4-301B (Laboratory Course-III)
### Credit = 4, Contact hours = 120
## [L=0, T=0, P=4]
### Marks - 100 (End Semester 100 + Internal Assessment 0)

**Inorganic Lab-III** **Marks 30**

1. Synthesis and characterization (melting point, conductivity, IR, UV-vis etc.) of Ni-DMG complex and estimate the percentage of nickel in the synthesized compound.
2. Synthesis and characterization of Schiff-base ligands and their metal complexes.
1. Synthesis and characterization of metal and metal oxide nanoparticles by surfactantAssisted methods.

**Organic Lab III** **Marks 25**

1. Estimation:
    i) Estimation of glycine by formalin method
    ii) Estimation of halogen by fusion method
    iii) Estimation of hydroxyl and amino groups by acetylation method
2. Synthesis of Deep Eutectic Solvents (DES) and their use.
3. Green synthesis of Coumarin derivative (clay catalyzed).
4. Benzoin condensation using green catalysts (co-enzymes).

**Physical Lab III** **Marks: 25**

1. Determine the composition of the binary mixture ($K_2Cr_2O_7$ and $KMnO_4$) by spectroscopic method (MLRA).
2. Determine the indicator constant of methyl red.
3. Investigate the reaction between $H_2O_2$ and HI (clock reaction). Determine the energyof activation.
4. Determination of molecular surface energy and the association factor for ethanol.
5. Study and compare the spectroscopic properties of acetone in different solvents.
6. Perform theoretical calculations using a computer.
    a) Charge density distribution and shapes of s and p orbitals.
    b) Potential energy diagram of hydrogen molecule ion

**Viva** **Marks 20**

**Recommended Books:**


1. Vogel, Arthur I: A Test book of Quantitative Inorganic Analysis (Rev. by G.H. Jeffery and others) 5th Ed., The English Language Book Society of Longman.
2. Willard, Hobert H. et al.: Instrumental Methods of Analysis, 7th Ed., Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, Gary D; Analytical Chemistry, 6th Ed., John Wiley & Sons, New York, 2004.
4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W. H. Freeman, 2001.
5. Khopkar, S. M. Basic Concepts of Analytical Chemistry. New Age, International Publisher, 2009.
6. Skoog, D. A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Thomson Asia Pvt. Ltd. Singapore.
7. Mikes, O. & Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
8. Vogel's Qualitative Inorganic Analysis, A. I. Vogel, Prentice Hall, 7th Ed

9. Textbook of Practical Organic Chemistry, A. I. Vogel, Prentice Hall, 5th Ed.
10. Practical Organic Chemistry, F. G. Mann. & B. C. Saunders, Orient Longman, 1960

## OPTIONAL

## SEMESTER III

**Course: RESEARCH PROJECT** OR CORE COURSE

MCHE-CC-T4-304A

**Credit = 4, Contact hours = 120**

**[L=0, T=0, P=4]**

**Total Marks 100 (End Semester 70 + Internal Assessment 30)**

**Objective of the Course:** To develop written and verbal communication. To present information in a clear and effective manner, to write reports in a scientific style and to solve scientific problems.

**Expected Learner Outcome: Students will gain an understanding of: ---**

i. Communication effectively, verbally and written for the purpose of conveying chemical information to both professional scientists and to the public.

**ii.** Availability of instruments for conducting specific, scientific research.

In this paper students will have to carry out project work (Laboratory experiments or Comprehensive Review work on a specified topic) either at their respective colleges or any other R&D laboratory and UGC recognized University under guidance of a faculty member. The students will start their project work during the semester break in between the semester examinations. The area of work is to be decided by the advisor.

On completion of the project work students will have to submit the work in the form of a dissertation followed by an oral presentation in the presence of faculty members and an external expert.

Case 1: **Project work:** Student will submit the progress of the work at the end of the semester examination.

Case 2: **Comprehensive Review work on a specified topic:** Student will submit a report of the comprehensive review of literature at the end of the semester examination.

Mark distribution in either cases will be as follows:

**A. Project work**

| | |
|---|---|
| 1. Literature Review | 10 Marks |
| 2. Objectives | 10 Marks |
| 3. Progress of the work | 25 Marks |
| 5. Presentation/Viva | 25 Marks |
| 6. IA | 30 Marks |

B. **Comprehensive Review**

| | |
|---|---|
| 1. Objective | 5 Marks |
| 2. Review | 25 Marks |
| 3.References | 5 Marks |
| 4. Future prospects | 10 Marks |
| 5. Presentation/Viva | 25 Marks |
| 6. IA | 30 Marks |

**SEMESTER III**
**Course: MCHE-CC-T4-304B**

**Course:** RESEARCH PROJECT **OR <u>CORE COURSE</u>**
**(Applied Chemistry)**

**Credit = 4, Contact hours = 60**
**[L=3, T=1, P=0]**
**Total Marks 100 (End Semester 70 + Internal Assessment 30)**

**Objective of the Course:**
To give the students an idea about the chemistry behind Soaps, Detergents and Cosmetics, the basic principles of food nutrition and its importance for human health, e diverse and rich heritage of India, agrochemicals impact the environment, soil, and human health.

**Expected course outcomes:**

- Students will understand the chemistry behind Soaps, Detergents and Cosmetics
- Understanding the basic principles of food nutrition and its importance for human health.
- Knowledge of the major macronutrients (carbohydrates, proteins, and fats) and micronutrients (vitamins and minerals) found in food.
- Knowledge of the energy content of macronutrients and the role of calories in nutrition.
- Understanding the role of essential nutrients, such as vitamins and minerals, in maintaining optimal health.
- Understanding the consequences of nutrient deficiencies and excesses on human health.
- Students will gain knowledge about the diverse and rich heritage of India.
- They will learn about the historical contributions of ancient Indian scholars in the field of Chemistry.
- Students will learn how ancient India had a rich tradition of iron and steel metallurgy, with indigenous techniques.
- Students will learn how Ancient Indian chemists and artisans developed practical skills related to chemical processes.
- To Understand the definition of agrochemicals and their role in improving crop yields and managing pests.
- To Explore how agrochemicals impact the environment, soil, and human health.

**Unit I: Applied Chemistry in ancient India:** **Lectures 10, Marks 15**

Textile Technology in ancient India, dyeing, washing spinning and weaving technology. Paper and ink making, Paints and Dyes, Perfumes and Cosmetics, Alcoholic Liquors. Metallurgy in ancient India, Metals and their making: Suvarna(gold) and its different types, prosperities, Rajata(silver), Tamra(copper), Loha(iron), Vanga(tin), Naga / sisa (lead), Pittala(brass), gold-silver alloy, metallurgical processes and minerals. Glass Making. Preparation of different types of Bhasmas (Gold Bhasma, Silver Bhasma, Copper Bhasma and Lead Bhasma) and their medicinal values.

**Unit-II: Soap, Textiles and Cosmetics:** **Lectures 15, Marks 20**

*Soaps and Detergents*: Introduction, Raw Materials required for soap manufacturing, methods of manufacturing soap, chemistry of cleaning, Dry Cleaning, Removal of Spots and Stains, Detergents, Manufacturing of detergents.

*Textiles*: Classification of textiles, natural textiles, synthetic textiles: Cotton, Linen or Flax, Silk and wool, viscose rayon, Nylons, Polyesters, polyacrylic fibers and background chemistry.

*Cosmetics:* Introduction, Shampoos, Hair curling and Straightening products, Hair setting and styling products, hair coloring products, hair tonic and restorers, Facial make up materials, Cold creams and vanishing creams. Bleach cream. Nail lacquers removers, antiperspirants, deodorants, Shaving and aftershave preparations.

**Unit-III: Chemical approaches to Food: Lectures 15, Marks 20**

Introduction, types of nutrients, Energy from food, Energy values and energy needs of body. Perfect food. Metabolism of Carbohydrate, oxidation of glucose, energetics of metabolic processes. Diabetes mellitus and insulin. Foods and protein quality. Metabolism of proteins, proteins as source of energy. Nitrogen equilibrium, mineral elements, vitamins-types, structure, and uses. Preservation of food and food poisoning. Toxic materials in foods, Sweetening agents, Cholesterol, Role of Vitamins and co-enzymes. Kitchen Pollution.

**Unit-IV: Agrochemical in common use: Lectures 15, Marks 15**

Introduction, pesticides and their classification, synthetic organic insecticides, chlorinated hydrocarbons, cyclodiene insecticides, organophosphates, and their mode of action. Nerve poisons, carbamates, organic thiocyanates, Rotenoids, Rodenticides. Chemicals for the control of plant diseases, control of weeds, plant growth regulators, inhibitors or retardants, Fumigrants, Formulation and toxicity of pesticides, Lethal dose, Hormones and growth inhibitors. Household agrochemicals. Background chemistry.

**Recommended Textbooks:**


1. A textbook of Applied Chemistry, P S Kalsi, M R Manrao, Kalyani Publishres
2. Principles of Biochemistry – A.L. Lehninger, D.L. Nelson and M.N. Cox, CBS Publishers, and Distributors.
3. Srilakshmi B (2017): Nutrition Science,6th Multicolour Ed. New Age International (P) Ltd.
4. Roday S (2012): Food Science and Nutrition, 2nd Ed. Oxford University Press.
5. Mann J and Truswell (2017): Essentials of Human Nutrition, 5th Ed. Oxford University Press.
6. P.C. Ray, History of Chemistry in ancient and medieval India, Chowkhambha Krishnadas Academy, Reprint Edition, 1 January 2004.
7. Textbook on IKS by Prof. B Mahadevan, IIM Bengaluru
8. Kapur K and Singh A.K (Eds) 2005). Indian Knowledge Systems, Vol. 1. Indian Institute of Advanced Study, Shimla. Tatvabodh of Sankaracharya, Central Chinmay Mission Trust, Bombay, 1995.

**SEMESTER IV**

**Course:** MCHE-CC-T4-401

**(Inorganic Chemistry- IV:**

**Inorganic Materials of Industrial Importance)**

**Credit = 4, Contact hours = 60**

**[L=3, T=1, P=0]**

**Total Marks 100 (End Semester 70 + Internal Assessment 30)**

**Objective of the Course:** To learn about fertilizers, surface coating, silicate industries, batteries etc.

**Expected Learner Outcome: Students will gain an understanding of**

i. Properties and the types of different glasses, ceramics and cements

ii. Different types and manufacture of fertilizers, composition of paint pigments.

iii. Working principle of different batteries, elements present in alloys, different types of steel etc.

**Unit I: Silicate Industries** **20 Lectures, Marks - 20**

*Glass*: Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armored glass, safety glass, borosilicate glass, fluorosilicate, colored glass, photosensitive glass.

*Ceramics*: Important clays and feldspar, ceramic, their types, and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fiber.

*Cement*: Classification of cement, ingredients and their role, Manufacture of cement and thesetting process, quick setting cements.

**Unit II: Fertilizers** **10 Lectures, Marks -15**

Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate.

**Unit III: Surface Coatings** **20 Lectures, Marks - 20**

Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition, and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings, metal spraying and anodizing.

**Unit IV: Batteries** **10 Lectures, Marks - 15**

Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell.

**Reference Books:**

**1.** E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
**2.** R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.
**3.** W. D. Kingery, H. K. Bowen, D. R. Uhlmann: Introduction to Ceramics, Wiley Publishers, New Delhi.
**4.** J. A. Kent: Riegel's Handbook of Industrial Chemistry, CBS Publishers, New Delhi.
**5.** P. C. Jain, M. Jain: Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
**6.** R. Gopalan, D. Venkappayya, S. Nagarajan: Engineering Chemistry, Vikas Publications, New Delhi.
**7.** B. K. Sharma: Engineering Chemistry, Goel Publishing House, Meerut.

## SEMESTER IV

**Course:** MCHE-CC-T4-402

**(Organic Chemistry-IV:**
**Green and Sustainable Chemistry)**

**Credit = 4, Contact hours = 60**

**[L=3, T=1, P=0]**

**Total Marks 100 (End Semester 70 + Internal Assessment 30)**

**Objectives:**

**1.** To develop preliminary knowledge on the necessity of green chemistry practices.

**2.** To familiarize students with various greener approaches in chemical transformations.

**Expected Learner Outcome:**

**1.** Students will understand the importance of practicing green chemistry principles in synthetic laboratories.

**2.** Through this course they will be able to design greener methodologies for chemical transformations.

**Unit I: Introduction to Green Chemistry** Lectures 5, **Marks 10**

What is Green Chemistry? Need for Green Chemistry. Goals of Green Chemistry. Limitations? Obstacles in the pursuit of the goals of Green Chemistry; E-factor.

**Unit II: Principles of Green Chemistry and Designing a Chemical synthesis**

Lectures 35, **Marks 30**

Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following:

1. Designing a green synthesis using these principles; Prevention of waste/ byproducts.
2. Atom Economy, calculation of atom economy for chemical transformations. Prevention/ minimization of hazardous/ toxic products.
3. Green solvents- supercritical fluids, water, ionic liquid and PEGs as green solvents for organic reactions.
4. Energy requirements for reactions- alternative sources of energy: use of microwaves and ultrasonic energy.
5. Selection of starting materials; carbohydrate avoidance of unnecessary derivatization (protection, blocking group)
6. Use of catalytic reagents in preference to stoichiometric reagents. catalysis- use of zeolite, PTC catalyzed green reactions, co-enzymes as catalysts.
7. Prevention of chemical accidents by designing greener processes, inherent safer design.

**Unit III: Examples of Green Reagents/ Synthesis/ Reactions** Lectures 17, **Marks 20**

**a.** Green synthesis of the following compounds: adipic acid, catechol, disodium iminodiacetate, paracetamol, ibuprofen.
**b.** Microwave assisted reactions: *Microwave assisted reactions in water* (oxidation of toluene to benzoic acid, oxidation of alcohols); *microwave assisted reactions in organic solvents* (Diels-Alder reaction and Decarboxylation); *Microwave assisted solvent-free reactions* (solid state reaction) (Deprotection and Saponification)
**c.** Ultrasound assisted reactions: Reformatsky reaction, Ullmann's coupling and Cannizaro reaction under sonication.

**Unit IV: Green chemistry in sustainable development** Lectures 3, **Marks 10**
Oxidation reagents and catalysts; multifunctional reagents; Combinatorial green chemistry; Proliferation of solventless reactions.

**Textbooks:**
**1.** V. Kumar, An introduction to Green Chemistry, Vishal Publications (2020).
**Reference Books:**
**1.** P. T. Anastas & J. K. Warner: Oxford Green Theory and Practical, University Press (1998).
**2.** A. S. Matlack: Introduction to Green Chemistry, Marcel Dekker (2001).
**3.** M. C. Cann& M. E. Connely: Real-World cases in Green Chemistry, American Chemical Society, Washington (2000).

**SEMESTER IV**

**Course:** MCHE-CC-T2-403

**(Physical Chemistry-IV: Quantum Chemistry)**

**Credit = 2, Contact hours = 30**

**[L=1, T=1, P=0]**

**Total Marks 50 (End Semester 35 + Internal Assessment 15)**

**Objective of the Course:** To learn about the Quantum mechanical models, approximate methods and the quantum chemistry of conjugated dienes and polyenes.

**Expected Learning outcome:**

1. Understanding Quantum Mechanical Models
2. Mastery of Approximate Methods
3. Contrasting the LCAO-MO method with the Valence Bond (VB) theory for the hydrogen molecule and hydrogen molecule ion.
4. To Explore the quantum mechanical description of conjugated systems, focusing on linear conjugated dienes and polyenes.
5. To develop the ability to apply quantum mechanical principles and methods to solve real-world chemical problems.

**Unit 1:** Quantum mechanical models: Lecture 5, Marks 10

Simple Harmonic Oscillator-Schrodinger equation and its solution, Hermite polynomials, two-particle rigid rotor- rotational energy levels of diatomic molecules, particle in a ring, quantum mechanical tunneling.

**Unit 2:** Approximate methods: Lecture10, Marks 8

Variation theorem, linear variation functions. Time independent Perturbation theory for non-degenerate systems (up to second order in energy).

**Unit 3:** Lecture 5, Marks 7

Born-Oppenheimer approximation, LCAO-MO and VB treatment of the Hydrogen molecule and Hydrogen molecule ion, Extension of the LCAO-MO method to homo-and heteronuclear diatomics-: CO, NO, $NO^+$, $NO^-$, HF, CN, $CN^-$. Construction of wave functions of SP, $SP^2$, and $SP^3$ hybrid orbitals.

**Unit 4:** Lecture 5, Marks 7

Quantum mechanical treatment of linear conjugated dienes and polyenes: Free electron molecular orbital theory (FEMO). Calculation of excitation frequencies. Huckel molecular orbital theory: Postulates, application to ethylene, butadiene and cyclobutadiene.

Textbooks:

1. Physical Chemistry by P.W. Atkins
2. Quantum Chemistry, by Ira N. Levine, Pentice Hall

Recommended Books:

1. Physical Chemistry by I. N. Levine
2. Introduction to Quantum Chemistry by A.K. Chandra, Tata McGraw Hill.
3. Molecular Quantum Mechanics by P.W. Atkins & R.S. Friedman, Oxford University Press.

**Discipline Specific Elective**
**OPTION I**
**Course: MCHE-DS-T4-401A (Analytical Chemistry)**
**Credit = 4, Contact hours = 60**
**[L=3, T=1, P=0]**
**Marks - 100 (End Semester 70 + Internal Assessment 30)**

**Objective of the Course:** To learn about the skills in operating chromatographic instruments and interpreting chromatograms, to understand the principles and theory underlying various chromatographic techniques, basic principles of electron microscopy and the principles and instrumentation of UV-Visible and IR spectroscopy.

**Expected Learning Outcome:**

1. Students will Understand the principles and theory underlying chromatographic techniques such as gas chromatography (GC), liquid chromatography (LC), and high-performance liquid chromatography (HPLC).
2. Students will Gain practical skills in operating chromatographic instruments and interpreting chromatograms.
3. Students will Understand the basic principles of electron microscopy, including transmission electron microscopy (TEM) and scanning electron microscopy (SEM).
4. Students will learn various techniques for characterizing the physical and chemical properties of industrial catalysts.
5. Students will Understand the principles and instrumentation of UV-Visible and IR spectroscopy.

**Unit I** **Lecture 12, Marks 10**

Instrumentation and application of UV-Visible, IR, Principles and applications of powder and single crystal XRD.

**Unit 2** **Lecture 12, Marks 15**

Polarography: Basic principles, instrumentation, and applications of cyclic voltammetry. Thermal methods: Principles and applications of Thermogravimetry (TG), Derivative thermogravimetry (DTG), Differential thermal analysis (DTA) and Differential scanning calorimetry (DSC).

**Unit 3:** **Lecture 12, Marks 15**

Chromatographic methods: Adsorption, liquid-liquid Partition, ion–exchange, HPLC, gel permeation chromatography and gas chromatography, HPTLC, Flash chromatography.

**Unit 4:** **Lecture 12, Marks 15**

Electron Microscopy: Transmission Electron Microscopy (TEM), Scanning Electron Microscopy (SEM), Atomic Force Microscopy (AFM)

**Unit 5:** **Lecture 12, Marks 15**

**Characterization techniques of industrial catalysts:** Low energy electron diffraction (LEED), Field emission and ionization microscopy (FEM, FIM), Surface extended X-ray absorption fine structure spectroscopy (SEXAFS), Scanning-tunneling microscopy (STM) temperature programmed desorption (TDP) and molecular beam techniques, EPR, PES, AES techniques.

**Textbooks:**


1. Instrumental Methods of Chemical Analysis - H Kaur, Pragati Prakashan
2. Instrumental Methods of Chemical Analysis - H Kaur, Pragati Prakashan

**Recommended Books:**


1. Solid State Chemistry and its Applications- A. R. West, Wiley India
2. Introduction to Thermal Analysis: Techniques and Applications- M.E. Brown, Springer
3. Introduction to Instrumental analysis – R.D. Braun, McGraw Hill.

**Discipline Specific Elective**
**OPTION II**
**Course: MCHE-DS-T4-401B (Material Chemistry)**
**Credit = 4, Contact hours = 60**
**[L=3, T=1, P=0]**
**Marks - 100 (End Semester 70 + Internal Assessment 30)**

**Objectives:**

1. To provide the students with brief exposure to materials of technological importance.
2. To provide knowledge about synthesis and structural properties of nano materials.

**Expected Learning Outcome:**

1. Students will gather a brief knowledge about synthesis, characterization techniques and applications of various types of materials.
2. Students will learn state-of-the-art knowledge about new materials.

**Unit I: Materials of technological importance Lecture 20, Marks20**

Introduction to nano biotechnology (bio-imaging, bio-labelling, and drug delivery), nanotoxicity and nano catalysis.

Application of powder XRD, TEM, FT-IR, UV-Vis and Fluorescence spectroscopy in determining/characterization of nano particles.

**Unit II: Polymer materials Lecture 20, Marks 25**

Classification of polymers, Molecular forces and chemical bonding in polymers, Texture of Polymers. Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point. Physical, thermal, Flow&MechanicalPropertiesofpolymers.Conductingpolymers-Introduction, conduction mechanism, polyaniline (PANI), polyacetylene, polyparaphenylene and polypyrrole, applications of conducting polymers, Ion-exchange resins and their applications. Polymer matrix composites. Ceramic & Refractory: Introduction, classification, properties, raw materials, manufacturing and applications.

**Unit III: Nanostructured materials Lecture 20, Marks 25**

Introduction to Nanoscience and Nanotechnology, influence of nano over micro / macro.1D, 2D and 3D nanostructured materials, Quantum Dots shell structures, mechanical-physical chemical properties, Quantum confinement effect and Surface plasmon resonance. Synthesis and modification of nanoparticles: Top-Down and Bottom-Up approach, experimental procedure (coprecipitation, Sol-gel, Hydrothermal, colloidal etc.), HSAB rule for precipitation, nucleation (homogeneous and heterogeneous), crystal growth, morphology dependence properties. Introduction to surface active agents, types of surfactants. Basic characterizations for structural purity and morphology study. Applications of metal oxide and semiconductor nanoparticles in catalysis (photocatalysis, electrocatalysis etc.) and energy.

**Textbooks:**

1. Solid State Chemistry and its applications A.R. West, John Wiley & Sons
2. Polymer Science by V.R. Gowarikar, N. V. Viswanathan and Jayadev Sreedhar

**Recommended Books:**

1. Inorganic Chemistry, Shriver & Atkins, 5th Edition Oxford
2. Introduction to Polymer by R. J. Young and P. A. Lovell

## SEMESTER IV
## Course: RESEARCH PROJECT OR CORE COURSE
MCHE-CC-P6-401
**Credit 6, Total Hours =180**
**Total Marks 100 (End Semester 100 + Internal Assessment 30)**

**Objectives:**

1. To learn about the way of conducting scientific research correctly.
2. To provide knowledge about the underlying scientific methods of data collection and analysis.
3. To make students understand laboratory skills, research methodology, and to develop critical thinking abilities among them.

**Expected Course outcome:**

1. Students would learn how to correctly conduct scientific research.
2. They would acquire knowledge regarding how to assess and use sources of information.
3. They would understand scientific methods of data collection and analysis.
4. There would be development of specific laboratory skills, research methodology, and critical thinking abilities.

In this paper students will have to carry out project work (Laboratory experiments) either at their respective colleges or any other R&D laboratory and UGC recognized University under guidance of a faculty member. Students will do the project work during the semester break after $5^{th}$ semester and may take at the maximum of 45days for the project work. The area of work is to be decided by the advisor. On completion of the project work students will have to submit the work in the form of a dissertation followed by oral presentation in the presence of faculty members and an external expert.

[Mark Distribution for evaluation of the Project Work
Laboratory Experiment

| | |
|---|---|
| 1. Literature Review | 5 Marks |
| 2. Objectives | 5 Marks |
| 3. Experimental work | 20 Marks |
| 4. Results & Discussions | 20 Marks |
| 5. Presentation and Viva | 20 Marks |
| 6. IA | 30 Marks |

Note: Students are encouraged to carry out laboratory experiments individually (However in case of infrastructural issues a maximum of 4 students can perform experiments together). The format of the report to be submitted is attached as **Annexure 1** below:

Annexure 1:

# Guidelines for preparation of Dissertation / Project Report

## 1. Organization of the Dissertation/ Project Report:

The Dissertation/Project Report shall be presented in a number of chapters, starting with 'Introduction' and ending with 'Conclusion'. The chapters will have a precise title reflecting the contents of the chapter. A chapter can be subdivided into sections and sub-sections to present the content discretely. Total numbers of chapters may be ranged from1- 5(minimum) and 1-8(maximum).

### 1.1 Introduction:

The title of Chapter-I shall be 'Introduction'. It shall justify the research problem, define the topic and explain the aim and scope of the proposed research. The significant contribution from the investigation to civil society may also be focused in this chapter.

### 1.2 Review of Literature:

The title of Chapter-II shall be "Review of Literature". This chapter shall present a critical appraisal of the previous works published in the literature pertaining to the topic of the investigation.

### 1.3 Report on the Present Investigation:

The reporting on the investigation shall be presented in one or

more chapters with appropriate title.

- Due importance shall be given to procedures and methodologies adopted.
- Figures and tables should be presented immediately following their first mention in the text. Short tables and figures (say, less than half the writing area of the page) should be presented within the text, while large tables and figures may be presented on separate pages.

### 1.4 Results and Discussions:

This is the penultimate chapter of the report and shall include a thorough evaluation of the research problem carried out and bring out the contributions from the study. The discussion shall logically lead to meaningful conclusions.

### 1.5 Conclusions:

This is the last chapter of the report. A brief report of the work carried out shall form the first part of the chapter. Conclusions derived from the logical analysis presented in the "Results and Discussions" chapter shall be presented and

clearly enumerated. This chapter should indicate the possibilities/ scope for future work in the concerned field.

**NB:** In non-empirical research, particularly in the discipline of Humanities and Social Sciences, textual/content analysis may be conceived in several chapters with appropriate title instead of present investigation, results and discussion.

### 1.6 Appendix:

Detailed information, lengthy derivations, observations etc. are to be presented in the separate appendices, which shall be numbered in Roman Capitals (e.g. "Appendix-I")

### 1.7 Bibliography:

This should follow the appendices, (if any), otherwise the Conclusion chapter. The researchers shall follow either the MLA (latest edition), or APA (latest edition) referencing style, or any other style whichever is accepted by the concerned department.

## 2. Dissertations/ Project Reports Format:

### 2.1 Paper:

The report shall be in printed form and the size of the paper shall be standard A4; height 297mm, width 210mm.

### 2.2 Type – Setting, Text Processing and Printing:

The text shall be printed on single side of a page employing laser jet or inkjet printer. The text having been processed using a standard text processor. The standard font should be **Time New Roman** of **12**pts with **1.5** line spacing for **English** text while **Geetanjali** of **12**pts with **1.5** line spacing and **Mangal / Unicode** of 12pts with 1.5 spacing for **Assamese** and **Hindi** texts respectively**.**

#### 2.2.1 Page Format:

The Printed sheets shall have the following written area and margins: Top margin : 15mm
Head height : 3mm
Head separation : 12mm
Bottom margin : 22mm
Footer : 3mm
Foot separation : 10mm
Left margin : 30mm
Right margin : 20mm
Text height : 245mm
Text width : 160mm

When header is not used, the top margin shall be 30mm.

### 2.2.2 Pagination:

Page numbering in the text of the Dissertation/Report shall be Hindu- Arabic numerals at the right corner of the Page. Page number "1" for the first page of the Introduction chapter should not appear in print; only the second page will bear the number "2". The subsequent chapters shall begin on a fresh page. Pagination for pages before the Introduction chapter shall be in lower case Roman numerals, e.g., "i", " ii" etc.

### 2.2.3 Header:

When the header style is chosen, the header can have the Chapter number and Section number (e.g., Chapter-II, Section-iii) on even numbered page headers and Chapter title or Section title on the numbered page header.

### 2.2.4 Paragraph format:

Vertical space between paragraphs shall be about 2.5 line spacing. A paragraph should normally comprise more than one line. A single line of a paragraph shall not be left at the top or bottom of a page.

## 2.3 Chapter and Section Format:

### 2.3.1 **Chapter:**

Each chapter shall begin on a fresh page with an additional top margin of about 75mm. Chapter number (Roman Numerical) and title shall be printed at the centre of the line in 6mm font size (18pt) in bold face using both upper and lower case. (See the specimen: 'E')

### 2.3.2 Section and Sub-sections:

A chapter can be divided into Section and Sub-Sections so as to present different concepts separately. Sections and sub-sections can be numbered using decimal points, e.g. II. ii for the second section in Chapter-II and II. iii. 4 for the fourth Sub-section in third section of Chapter-II.

### 2.3.3 Table/ Figure Format:

Tables and figures should be presented in portrait style. Small size table and figures (less than half of writing area of a page) should be incorporated within the text, while larger ones may be presented on separate pages. Tables and figures shall be numbered chapter-wise. For example, the second figure in Chapter-IV will bear the number Figure IV.2 or Fig. IV.2.

## 3.0 Auxiliary Format:

### 3.1 Binding:

The final hard bound copies to be submitted after the viva-voce examination will be accepted during the submission of Dissertation/ Project Report with **black colour** for **P.G** and **brown colour** for **U.G** course respectively.

### 3.2 Front Covers:

The front covers shall contain the following details:

- Full title of Dissertation/ Project Report in 6mm 22point's size font properly centered and positioned at the top.
- Full name of the candidate in 4.5mm 15 point's size font properly centered at the middle of the page.
- A 50mm die replica of the institute emblem followed by the name of the supervisor, name of the department, name of the institute and the year of submission, each in a separate line and properly centered and located at the bottom of page.

#### 3.2.1 Lettering:

All lettering shall be embossed in gold.

#### 3.2.2 Bound back:

The degree, the name of the candidate and the year of submission shall also be embossed on the bound (side) in gold.

### 3.3 Blank Sheets:

In addition to the white sheets (binding requirement) two white sheets shall be put at the beginning and the end of the Dissertation/ Project Report.

### 3.4 Title Sheet:

This shall be the first printed page of the report and shall contain the submission statement: the Dissertation/ Project Report submitted in partial fulfilment of requirements of the------ Degree, the name and Roll No. of the candidate, name(s) of the Supervisor and Co-supervisor(s) (if any), Department, Institute and year of submission.

- Sample copy of the 'Title Sheet' is appended (Specimen 'A')

### 3.5 Approval Sheet:

This will form the first page of the Dissertation/ Project Report. Sample copy of the 'Internal Approval Sheet' is appended (Specimen 'B')

### 3.6 Internal Approval Sheet:

This will form the second page. A sample copy of the Approval Sheet is appended (Specimen 'C')

### 3.7 A Declaration of Academic Honesty and Integrity:

A declaration of academic honesty and integrity is required to be included along with every Dissertation/ Project Report after the internal approval sheet. The format of this declaration is given in Specimen 'D' attached.

### 3.8 Acknowledgements:

A list of acknowledgements is required to be included along with every Dissertation/ Project Report after the Declaration sheet.

### 3.9 Contents:

**NB:** From 3.5 to 3.8, the pagination should be in Roman number with lower case.

## Specimen 'A': Title Sheet

**Title**

(A Dissertation/Project Report submitted in partial fulfilment of the requirements of BA/BSc/MA/MSc degree in (subject))

by

(Name of the Student)
(Roll No. _____)
Registration No. ……

Supervisor(s):
(Name of Supervisor)

(Name of the Department)

**North Lakhimpur College (Autonomous)**

**(Year)**

**Specimen 'B': Approval Sheet**

## Dissertation Approval for .....

This Dissertation/ Project Report entitled (**Title**) by (**Author Name**) is approved for the degree of **_____**(**Degree details**).

Examiners

1. ……

2. ……

Date:

Place:

**Specimen 'C': Internal Approval Sheet**

# CERTIFICATE

This is to certify that the Dissertation/Project Report entitled "**Title of Dissertation/ Project**" is a bona-fide work of "**Name of student" (Roll No**…., **Regd. No……..**) submitted to the North Lakhimpur College (Autonomous) in partial fulfilment of the requirements for the award of "B.A./B. Sc./M.A/M. Sc. degree in..... (subject)"

(Name and Sign)
Supervisor

(Name and Sign)
Co-Supervisor

(Name and Sign)
Head of
Department

**Specimen 'D': Declaration**

# DECLARATION

I, (name), do hereby declare that the dissertation/ Project Report entitled "Title" represents my idea in my own words and where others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misinterpreted or fabricated or falsified any idea/ data/ fact/ source in my submission. I understand that any violation of the above will invite disciplinary action by the institute.

…….

(Signature)

……

… (Name of student and Roll No)

Date :

Place:

**Specimen 'E': Starting Chapter page Formatting.**

# Chapter – I

## Introduction

### 1.1 (Specimen 'E')

**1.2 Formatting Guidelines**

Works cited

…….

# Chapter – II

# Title

2.1 ……..

2.2 ……..

Works cited

……..

**Specimen 'F': Standards Style references**

# References

**MLA 9th Edition**

**Refer to Appendix- I (for quick guide) APA 7th Edition**

**Refer to Appendix- II (for quick guide)**