VIDYASAGAR UNIVERSITY

Midnapore, West Bengal

PROPOSED CURRICULUM & SYLLABUS (DRAFT) OF

B. Sc. (HONOURS/ HONOURS WITH RESEARCH)

MAJOR IN CHEMISTRY

DRAFT

4-YEAR UNDERGRADUATE PROGRAMME

(w.e.f. Academic Year 2023-2024)

Based on

Curriculum & Credit Framework for Undergraduate Programmes (CCFUP), 2023 & NEP, 2020

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VIDYASAGAR UNIVERSITY
BACHELOR OF SCIENCE (HONOURS/ HONOURS WITH RESEARCH) MAJOR IN CHEMISTRY
(Under CCFUP, 2023)

Level	YR.	SEM	Course Type	Course Code	Course Title	Credit	L-T-P	Marks		
								CA	ESE	TOTAL
B.Sc. (Hons./ Hons. with Research)	4th	VII	SEMESTER-VII							
			Major-14	CEMHMJ14	T: Inorganic Chemistry-IV; P: Inorganic Practical	4	3-0-1	15	60	75
			Major-15	CEMHMJ15	T: Physical Chemistry-IV; P: Inorganic Practical	4	3-0-1	15	60	75
			CRM	CEMHCRM	T: Research Methodology and Ethics	4	3-1-0	15	60	75
			Major Elective-03	CEMHDSE3	T: Organic Chemistry–V; P: Organic Practical	4	3-0-1	15	60	75
			Minor-07 (Disc.-I)	CEMMIN07	T: (Organic Chemistry–V + Physical Chemistry-V); P: Practical *(To be taken by the other Discipline)*	4	3-0-1	15	60	75
					Semester-VII Total	20				375
		VIII	SEMESTER-VIII							
			Major-16	CEMHMJ16	T: Organic Chemistry – VI; P: Organic Practical	4	3-0-1	15	60	75
			Major Elective-04	CEMHDSE4	T: Advanced Spectroscopic Techniques for Structure and Property	4	3-1-0	15	60	75
			Major Elective-05	CEMHDSE5	T: Physical Chemistry-V; P: Inorganic Practical — FOR HONOURS STUDENTS	4	3-0-1	15	60	75
			Major Elective-06	CEMHDSE6	T: Inorganic Chemistry-V; P: Inorganic Practical — FOR HONOURS STUDENTS	4	3-0-1	15	60	75
			Research	CEMHRD	DISSERTATION: *FOR HONOURS WITH RESEARCH STUDENTS*	*8*	*0-0-8*	*-*	*150*	*150*
			Minor-8 (Disc.-II)	CEMMIN08	(Inorganic Chemistry–V + Environmental Chemistry + Polymer Chemistry); P: Practical *(To be taken by the other Discipline)*	4	3-0-1	15	60	75
					Semester-VIII Total	20				375
					YEAR-4	40				750
			To be awarded *Bachelor of Science (Honours / Honours with Research) Major in Chemistry*			166	Marks (Year: I+II+III+IV)			3075

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MJ = Major, MI = Minor Course, DSE = Discipline Specific Elective Course, CRM= Compulsory Research Methodology, CA= Continuous Assessment, ESE= End Semester Examination, T = Theory, P= Practical, L-T-P = Lecture-Tutorial-Practical

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SEMESTER-VII

MAJOR (MJ)

MAJOR-14: INORGANIC CHEMISTRY-IV
Credits 04; FM- 75
(Theory-03, Practical-01)

MJ14T: INORGANIC CHEMISTRY-IV Credits 03 (Theory: 45 Lectures)

Unit 1: Group Theory-I

Concept of groups; subgroups, classes and the related theorems; commutative (Abelian) groups, cyclic groups; group multiplication tables and the rearrangement theorem; Symmetry elements and operations, products of symmetry operations, equivalent symmetry elements and equivalent atoms, molecular point groups; platonic solids; the matrix representations of symmetry operations; Matrix representation of point groups; similarity transformation; reducible and irreducible representations; the Great Orthogonally Theorem (no derivation) and its corollaries.

Unit 2: Advanced Bioinorganic Chemistry

Function and model studies of Oxygen uptake proteins; Synthetic oxygen carriers, Metal ions in electron transport proteins: Fe-S proteins, Blue copper proteins, cytochromes (Structure and function); Transport across biological membrane: Ion pumps, ionophores; Hydrolytic enzymes: carbonic anhydrase, carboxy peptidase, urease;; Toxic effects of metal: Copper toxicity and Wilson's disease, Arsenic poisoning, Aluminium toxicity and Alzheimer disease; Heavy metal toxicity; Metals in medicines.

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Unit 3: Crystallography:

Crystalline solid –single crystal and polycrystal (twining problem), process of crystallizations, lattice; unit cell – primitive and non-primitive unit cells, Unit cell parameters and crystal systems Concepts of crystal structure-Bravais lattice, Indexing of lattice planes; Miller indices ,Reciprocal lattice and its relation to direct lattice; Bragg equation, Bragg reflection in terms of reciprocal lattice – sphere of reflection and limiting sphere; relation between dhkl and lattice parameters translational and rotational symmetry, symmetry elements and their symbols (both numerical and graphical), point group, screw axis, glide plane. X-ray, Generation of X-ray, Cu Kα and Mo Kα radiation; X-ray diffraction;

Crystal symmetry – (i) point group elements and (ii) space group elements; 32 crystal classes, HM notations, distribution in different systems and stereographic projections; Isogonal symmetry groups Space group – HM notation, space groups in triclinic and monoclinic systems. Methods of growing single crystals.

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MJ-14P: INORGANIC CHEMISTRY LABORATORY- IV (Credit 01; 30 Hrs.)

A. Laboratory work **Marks: 15**

1. Quantitative estimation using Gravimetric / titrimetric methods:

(a) Quantitative estimation of Zn(II) and Cu(II) in brass sample by volumetry and gravimetry

(b) Quantitative estimation of manganese in pyrolusite

2. Physicochemical experiments

(a) Determination of composition of Fe(III)-sulfosalicylate complex in solution by Job‟s method of continuous variation.

(b) Colourimetric estimation of Fe(III) (as thiocyanate complex)

B. Sessional Work: **Marks: 2**

To be awarded by the class teacher on the basis performance of the students during the practical classes.

C. Viva Voce: **Marks: 3**

To be jointly conducted by the external and internal examiners during the examination.

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MAJOR-15: PHYSICAL CHEMISTRY-IV
Credits 04; FM- 75
(Theory-03, Practical-01)

MJ15T: PHYSICAL CHEMISTRY-IV Credits 03 (Theory: 45 Lectures)

Thermodynamics:
Thermodynamics of real gases in pure state and mixtures. Thermodynamics of ideal and non-ideal binary solutions: excess functions; partial molar properties. Fugacity, Different scales of activity co-efficients for solutes and solvents

Statistical Mechanics -I:
Basic concepts of statistical mechanics, Connection between microscopic and macroscopic description;
Boltzmann definition of entropy, Derivation of the MB distribution, concept of negative absolute temperature, Bose-Einstein and Fermi-Dirac statistics formulae from the expressions of thermodynamic weight, Different types of Partition functions, Evaluation of molecular partition functions, Thermodynamic quantities in terms of partition function, Gibbs paradox and the Sackur-Tetrode equation.

Spectroscopy-I
Rotational-vibrational spectroscopy of linear molecules, P Q R branches, Applications of rotational-vibrational spectroscopy
Raman spectroscopy: Classical treatment of Raman spectroscopy, Rayleigh, Stokes and anti-Stokes lines, Polarizabilty and polarizability ellipsoids, Quantum theory of Raman spectroscopy (qualitative idea only), Vibrational Raman spectroscopy, Mutual exclusion principle. Applications of Raman spectroscopy
Photophysical Processes: Potential energy surface (diatomic molecules),Types of different electronic states (stable, unstable, singlet, triplet etc.), Types of light absorbing process, Pre-dissociation, Frank-Condon principle and vibrational structure of electronic spectra; Decay of excited states by radiative and non-radiative paths; 1^{st} order photophysical processes; Fluorescence, phosphorescence, internal conversion and intersystem crossing, Jablonskii diagram, Kasha's rule.

Quantum mechanics-I: Basic formalism of quantum mechanics, Bra ket notations, overview of exactly solvable problem (PIB, Rigid rotator, particle in circular ring, SHO, H-atom). Many electron system: construction of Hamiltonian operator, eigen function (slater determinant notation), Energy eigen value problem of ground and excited He-atom.

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MJ-15P: PHYSICAL CHEMISTRY LABORATORY- IV (Credit 01; 30 Hrs.)

A. Laboratory work **Marks:15**

1. Determination of concentration of Glucose and fructose in a mixture using polarimeter.
2. Determination of CMC of a surfactant in aqueous solution by conductometric method.
3. Verification of Onsagar equation using KCl, K2SO4 and BaCl2 as electrolytes and determine their $\Lambda 0$ values.
4. Determination of the E^0 value of Ag^+ /Ag electrode and activity coefficients of different aqueous $AgNO_3$ solutions potentiometrically.
5. Determine the dissociation constants (K1, K2, and K3) of H3PO4 by pH meter.
6. Determination of composition of complexes (Ferric-salicylate complex/Ferrous-orthophenanthroline complex) by Job's method using colorimeter.
7. Determine the rate constant and the order of the reaction of KBrO3 & KI in acid medium using colorimeter.

B. Sessional Work: **Marks:2**

To be awarded by the class teacher on the basis performance of the students during the practical classes.

C. Viva Voce: **Marks:3**

To be jointly conducted by the external and internal examiners during the examination.

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COMPULSORY RESEARCH METHODOLOGY (CRM)

[for both Hons. and Hons. with Research students]

CRM: RESEARCH METHODOLOGY AND ETHICS

CRM (T): RESEARCH METHODOLOGY AND ETHICS (Theory) Credits 04; 60 hrs.

Course Content:

Planning of Research: Essentials of a Good Research Problem, Sources of Research Problem, Factors Affecting Selection of Research Problem, Hypothesis, Features of Good Hypothesis, Types of Hypotheses, Role of Hypothesis, Sources of Hypothesis

Sample design/Sampling: What is sampling? Advantages/merits of Sampling, Methods or Techniques of Sampling, Steps in Sample Design, Principles/essentials of Sampling, Process of Sample Survey,

Research Design: Introduction, Meaning and Definitions, Essentials of Good Research Design, Steps of Research Design, Evaluation of Research Design.

Processing and Analysis of data: Introduction, Stages of Processing of Data, Analysis of Data, Interpretation of Data, Transcription of Data.

Preparation of Report: What is Research Report? Types of Report, contents of Report, Layout of the Research Report, Principles of Report Writing, Steps in Report Writing, Steps Involved in Drafting a Research Report, Documentation, Footnotes, Bibliography.

Ethics and Research: Importance of Ethics in Research, Principles of Research Ethics. Intellectual Honesty and Research Integrity, Integrity of the Individual Scientist, Integrity at Institutional Level, Scientific Misconduct.

Publication Ethics: Definition and Importance of publication ethics, Regulatory Organisations for Publication Ethics, Best Practices/Standards Setting Initiative and Guidelines, Guidelines for Authors, Editors and Reviewers, set by COPE, Conflict of Interests, Publication Misconduct, Types of Publication Misconduct, Plagiarism.

Databases: Definition and Types of Databases, Indexing, Benefits of Indexing, Citation Index Database, Major Citation Indexing Services, Web of Science, Scopus, Google Scholar, PubMed Central (PMC) Database, Indian Citation Index (ICI) Database

Research Metrics: Bibliometrics, Journal Metrics, Journal Impact Factor, Cite Score, Difference between Cite Score and Impact Factor, Source Normalised Impact Per Paper (SNIP), Scimago Journal Rank (SJR), Impact Per Publication (IPP), Author Metrics, H-Index, Advantages of H-Index, Drawbacks of H-Index, i10/20 Index.

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MAJOR ELECTIVE (DSE)

MAJOR ELECTIVE-3
ORGANIC CHEMISTRY - V
Credits 04; FM- 75
(Theory-03, Practical-01)

MJ DSE-3 T: ORGANIC CHEMISTRY **Credits 03 (45 Lectures)**

Course contents:

Unit-01: Pericyclic reaction I:
Pericyclic reactions characteristic features, conservation of orbital symmetry MO of different polyenes, electrocyclic, cycloaddition, sigmatropic reactions, Rationalisation of different electrocylcic reactions on the basis of frontier orbital interaction, Woodward Hofmann symmetry rules for electrocylcic reactions, exceptions to symmetry rules, correlation diagram and perturbation molecular orbital theory (PMO) of different electrocylcic reactions, Nazarov cyclisation. Problems relating to these reactions.

Unit-02: Natural products-I Terpenoids:
Cation-olefin cyclization reaction: application to the synthesis of tritepenes: biogenetic isoprene rule: monocyclic, bicyclic, tricyclic, tetracyclic and pentacyclic ring systems. Synthesis of triterpenoids containing the following ring systems: 6-6-6-5 rings (dammaranes), 6-6-6-6-5 rings (lupyl), 6-6-6-6-6 rings (germanecyl) (at least 5 examples in each system).

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Unit-03: Organic transformations/ Reagent Chemistry/Synthesis-I:
Fragmentation reaction, Phase transfer catalyst. Multi-component reactions: Definition, early examples, Passerine reaction, Ugi reaction. Olefin metathesis reaction: Definition, Ring closing metathesis reaction, examples.

Unit-04: Organic transformations/ Reagent Chemistry/Synthesis-II:
Remote functionalization: biomimetic reactions / template effect, examples. Functional groups inter conversion. Retro-synthetic analysis with examples.

MJDSE-3P: ORGANIC CHEMISTRY-V (LAB) **Credit 01(30 Hrs.)**

Chemistry in Food Processing and Preservation **15 Marks**

Constituents of Food: **Food Pigments & Flavouring Agents**: Importance, types and sources of pigments, their changes during processing and storages
Food preservation: Principles and methods: **Canning;** Preservation principle of canning of food items; **Dehydration and drying of food items;** Water activity of food and its significance in food preservation, **Low temperature preservation; Use of preservative in foods**; **Hurdle technology.**

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EXPERIMENTS

I: Preparation of jams, jellies, syrups, squashes
II: Preparation of mixed fruit juices
III: Preservation of processed food
IV: Packaging of processed and preserved food
V: Value addition in food products

Sessional Work **2 Marks**

To be awarded by the class teacher on the basis performance of the students during the course work.

Viva Voce **3 Marks**

To be jointly conducted by the external and internal examiners during the examination.

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MINOR (MI)

Minor-07: (Organic Chemistry –V + Physical Chemistry -V) **Credits 04; FM-75**

MI-07T: Theory **Credits-03 (45 hrs.)**

Course Content

Organic Chemistry-V

Amino Acids, Peptides and Proteins: **(20 Lectures)**

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis. Reactions of Amino acids: ester of – COOH group, acetylation of $–NH_2$ group, ninhydrin test.

Synthesis of simple peptides (up-to dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) &C-activating groups. Determination of Primary structure of Peptides by degradation Edmann degradation (N-terminal) and C–terminal (with carboxypeptidase enzyme).

Carbohydrate:

Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

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Reference Books:

1. Clayden, J., Greeves, N., Warren, S. *Organic Chemistry*, Second edition, Oxford University Press 2012.
2. Finar, I. L. *Organic Chemistry (Volume 1)*, Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
3. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry of Natural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
5. Loudon, G. M. *Organic Chemistry*, Fourth edition, Oxford University Press.

Physical Chemistry-V

A. Phase Equilibrium **(15 Lectures)**

(I) Definitions of phase, component and degrees of freedom with various examples; Gibb's phase rule (without derivations). Phase diagrams for pure substance. μ vs. T phase diagram, effect of pressure on transition temperature. Triple point. Clapeyron equation; Clausius-Clapeyron equation. P vs T phase diagram. Phase diagram for water, CO_2 and Sulphur

(II) Colligative properties: Raoult's law; Thermodynamic derivation of various colligative properties such as (i) Elevation of boiling point, (ii) Depression of freezing point and (iii) Osmotic pressure and vant' Hoff equation, Inter-relations among various colligative properties, Abnormal

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colligative properties of electrolytic solution, van't Hoff factor, van'f Hoff factor and degree of dissociation of weak electrolyte.
(III) Nernst's distribution law; It's derivation, Partition coefficient, Principle of determination of partition coefficient. Principle of solvent extraction.

(B) Molecular Spectroscopy and Photochemistry (10 Lectures)

Nature of light with special reference of electromagnetic radiation and its interaction with the molecules. Principles of Rotational spectroscopy, Vibrational spectroscopy, Raman spectroscopy and Electronic spectroscopy for diatomic molecules.
Lambert Beers law, Various first order photophysical processes such as fluorescence, phosphorescence, internal conversion, intersystem crossing, Quantum Yield.

Reference Book:

1. Barrow, G.M. *Physical Chemistry* Tata McGraw- Hill (2007).
2. Castellan, G.W. *Physical Chemistry* 4th Ed. Narosa (2004).
3. P.C. Rakshit, *Physical Chemistry*
4. H. Chatterjee, *Physical Chemistry*
5. A Nag, *Physical Chemistry*
6. S Pahari *Physical Chemistry*
7. Banwell, Molecular Spectroscopy
8. K K Rohatgi Mukherjee, Photochemistry
9. Mahan, B.H. *University Chemistry* 3rd Ed. Narosa (1998).
10. Petrucci, R.H. *General Chemistry* 5th Ed. Macmillan Publishing Co.: New York (1985).
11. Chugh, K.L., Agnish, S.L. *A Text Book of Physical Chemistry* Kalyani Publishers
12. Bahl, B.S., Bahl, A., Tuli, G.D., *Essentials of Physical Chemistry* S. Chand & Co. Ltd.
13. Palit, S. R., *Elementary Physical Chemistry* Book Syndicate Pvt. Ltd.

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MI-07P: Practical Credit-01(30 hrs.)

Section A: Organic Chemistry Lab

Separation of amino acids from the mixtures of two or three amino acids by TLC and Paper Chromatography

Section B: Physical Chemistry Lab

- Determination of partition coefficient of iodine in between organic solvents (CCl_4 or $CHCl_3$) and water.
- Verification of Beers law and determination of molar extinction coefficient and concentration of a color absorbing species ($K_2Cr_2O_7$ and $KMnO_4$ solutions) using a colorimeter or spectrophotometer.
- Determination of pK_{In} of Bromocresol green indicator and the determination of pH of an unknown buffer spectrophotometrically

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Reference Book:

1. *University Hand Book of Undergraduate Chemistry Experiments,* edited by Mukherjee, G. N. University of Calcutta, 2003.
2. *Practical Workbook Chemistry (Honours), UGBS, Chemistry*, University of Calcutta, 2015
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.*, Pearson (2012).
4. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry,* Pearson Education.
5. Palit, S.R., *Practical Physical Chemistry* Science Book Agency
6. Mukherjee, N.G., *Selected Experiments in Physical Chemistry* J. N. Ghose & Sons
7. Dutta, S.K., *Physical Chemistry Experiments* Bharati Book Stall
8. Ghosh S. , Das Sharma M , Majumder D and Manna S, "Chemistry in Laboratory", Santra Publication Pvt Ltd, 2019

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SEMESTER-VIII

MAJOR (MJ)

MAJOR-16: ORGANIC CHEMISTRY-VI
Credits 04; FM- 75
(Theory-03, Practical-01)

MJ16T: ORGANIC CHEMISTRY-VI **Credits 03 (Theory: 45 Lectures)**

Course Content:

Unit – 01: Pericyclic reaction II:
Energy diagram of ethylene and butadiene system with different substitutions and study of their cycloaddition reactions, FMO approach and correlation diagram of cycloaddition reactions, Perturbation molecular orbital theory (PMO) and Woodward Hofmann symmetry rules for cycloaddition reaction, Regioselectivity, endo rule, secondary interactions in pericyclic reactions, cycloreversion reactions, 1,3-dipolar cycloaddition reactions, cheletropic reactions, Problems relating to these reactions.

Unit-02: Organic transformations/ Reagent Chemistry/Synthesis-III:
Oxidations reactions: Hydroxylation reagents, use of peroxy acids, Woodward prevost hydroxylation, Sharpless asymmetric expoxidation, AD-mix, Transformation of expoxides. Organophosphorus reagents, organo sulfer reagents, organo boranes, organo silanes, organostannanes, Organo catalytic reaction, metal hydrides, Birch reduction, Robinson annulation, Umpolung, Merrifield resin: solid phase synthesis.

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Unit-03: Natural Products:
Alkaloids, Flavanoids Terpenoids: Definition, Classification, Structure, Synthesis.
Use of retro-synthetic analysis for the synthesis of natural products.

Unit-04: Stereochemistry I:
Symmetry and molecular chirality, Axial chirality, Atropisomerism, Stereochemical features : polysubstituted cyclohexane, conformation and physical properties.Computation of stereoisomers of different systems. Conformation and relative reactivity of diastereomers. 2-, 3, and 4- Alkyl ketone effects.

Unit-05: Stereochemistry II:
Asymmetric synthesis : Addition ofa chiral reagents to chiral ketones and aldehydes, models of stereochemical control : Cram, Karabatsos. Felkin model (torsional strain), Burgi Dunitz trajectory, Molecular rearrangements with Neighbouring group participations.

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MJ16P: ORGANIC CHEMISTRY-VI **Credits 01 (Theory: 30 Lectures)**

Liquid Sample **Marks: 15**

Qualitative analysis (color, odour, solubility etc.); Thin Layer Chromatography (TLC), boiling point determination, Assign 1H-NMR, 13C-NMR spectra, Identify the liquid substance.

Extraction of Renewable chemicals

Take a particular part of a plant such as fruit, leaf, bark, heavy wood, etc. Weight it. Extract with a particular solvent. Remove the volatiles. Purify. Weigh the product. Calculate % yield, analyze the product by Thin Layer Chromatography, calculate Rf value. UV-VIS spectral characterizations: Measure λmax, εmax and explain. Submit the product with proper label.

Preparation

Preparation of pure organic compound single-step or two step procedure and submission of crystallized product: Table Preparation; Weigh the compound, calculate theoretical yield, prepare the compound, weigh the product, calculate % yield, crystallize, check M.P., submit crystallized product.

Sessional Work **Marks: 2**

To be awarded by the class teacher on the basis performance of the students during the course work.

Viva Voce **Marks: 3**

To be jointly conducted by the external and internal examiners during the examination.

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MAJOR ELECTIVE (DSE)

MAJOR ELECTIVE-4
ADVANCED SPECTROSCOPIC TECHNIQUES FOR STRUCTURE AND PROPERTIES
Credits 04; FM- 75

MJ DSE-4 T: Advanced Spectroscopic Techniques for Structure and Properties

Credits 04 (60 Lectures)

Course Content:

Unit-01: Detailed study of ^{1}H NMR and preliminary aspects of ^{13}C NMR, CW and FT techniques Ring current: Aromaticity, Antiaromaticity, Homoaromaticity, Annulene systems.

Unit-02: NMR spectroscopy: Principles, Relaxation phenomenon, factors influencing chemical shifts and coupling constants, simplification of complex spectrum, NOE, Rotating frame of reference.

Unit-03: Mass-spectrometry combined applications of spectroscopic methods to organic molecules: Principles of Mass spectrometry, Different techniques, and fragmentation modes.

Unit-04: Combined application of spectroscopic techniques (UV, IR, NMR, and MS) in elucidation ofstructure and study of reactions of organic compounds

Unit 05: Mössbauer Spectroscopy and CD ORD

Mössbauer Spectroscopy: Gamma ray emission and absorption by nuclei, principle, line-width, chemical shift, quadrupole interaction, magnetic interaction; spectra of Mössbauer active nuclei (iron, tin); information of spin, oxidation states and structure.

CD ORD: Circular dichroism spectroscopy (CD) and optical rotatory dispersion (ORD) basic principle, instrumentation and application.

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MAJOR ELECTIVE- 05

[to be studied by Honours students only]

MAJOR ELECTIVE-5
PHYSICAL CHEMISTRY
Credits 04; FM- 75
(Theory-03, Practical-01)

MJ DSE-5T: PHYSICAL CHEMISTRY V **Credits 03 (45 Lectures)**

Course Content:

Chemical Kinetics-I:
Kinetics of Fast reactions: flow method, relaxation method, flash photolysis. Shock tube method, Molecular beam technique: Method and mechanism.
Kinetics of redox reaction: inner sphere and outer sphere mechanism.
Reactions between ions: influence of solvent dielectric constant (double sphere model), single sphere activated complex model, influence of ionic strength, Enzyme catalysis and Enzyme inhibition in details Autocatalytic reaction, oscillating reaction.

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Surface Chemistry:
Curved surfaces: Young-Laplace and Kelvin equations, Adsorption on solids: BET eqn.
Micelles, reverse micelles; micellization equilibrium; thermodynamics of micellization; micro and macro emulsions.

Spectroscopy-II:
Photophysical processes: Photophysical processes of unimolecular processes, Delayed fluorescence, Kinetics of bimolecular processes: collision quenching, Stern-Volmer equation, Concentration dependence of quenching and excimer formation, Excited state electron transfer processes: Exciplex, Twisted intramolecular charge transfer processes, proton couple electron transfer processes (both intra and intermolecular).
Laser and its applications: General feature and properties of LASER, Method of obtaining population inversion, Laser cavity modes, Q-switching, Mode locking, Example of LASER: Ruby laser, Nd-YAG laser, diode laser, He-Ne laser, N2 laser, Ar laser, excimer and exciplex laser, Dye laser.
(VI) Magnetic Resonance Spectroscopy: Principles of Nuclear Magnetic Resonance (NMR) spectroscopy, Larmor precession, chemical shift and low-resolution spectra, different scales, spin-spin coupling and high-resolution spectra, interpretation of PMR spectra of organic molecules. Basic idea of FT-NMR.

Quantum mechanics-II: Approximate methods in QM, Variation principle: Statement and proof on Rayleigh-Ritz variation principle, Linear variational principle and its applications.
Perturbation Theory: Rayleigh-Schrodinger perturbation theory for nondegenerate and time independent case. Expression of first order correction of energy and wave function, second order correction of energy; Examples

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MJ DSE-5P: PHYSICAL CHEMISTRY V **Credits 01 (30 Lectures)**

Marks: 15

1. Conductometric determination of concentrations of KCl, HCl and NH4Cl in a mixture.
2. Potentiometric titration of halide mixture (Chloride, Bromide and Iodide).
3. Determination of the standard potential of *Fe(CN)63-/ *Fe(CN)64- electrode by potentiometer.
4. Study the kinetics of Iodination of acetone spectrophotometrically.
5. Study of the kinetic of alkaline hydrolysis of crystal violet. Determine the order with respect to alkali and salt effect on the system using colorimeter.
6. Spectroscopic experiments relating to quenching of fluorescence.
7. Experiment for the measurements of activation barrier of some model chemical reactions.
8. Synthesis of metal/semiconducting nanoparticle and their photophysical study.

Sessional Work **Marks: 2**

To be awarded by the class teacher on the basis performance of the students during the course work.

Viva Voce **Marks: 3**

To be jointly conducted by the external and internal examiners during the examination.

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MAJOR ELECTIVE- 06

[to be studied by Honours students only]

MAJOR ELECTIVE-6
INORGANIC CHEMISTRY V
Credits 04; FM- 75
(Theory-03, Practical-01)

MJ DSE-5T: INORGANIC CHEMISTRY V **Credits 03 (45 Lectures)**

Unit 1: Electron Spin Resonance (ESR) spectroscopy
Principle of ESR and comparison to NMR spectroscopy, energy of free electron spin state, energy levels of a free electron in an external magnetic field, intensity of ESR lines and factors affecting it, representation of ESR spectrum, X-band and Q-band spectra, external standard, line-width, nuclear hyperfine interactions, prediction of expected number of lines and their relative intensities, hyperfine splitting in various systems, zero-field splitting and Kramer's degeneracy; determination of oxidation state of metal ion in samples.

Unit 2: Group Theory-II
Character tables, construction of character tables (C_{2v}, C_{3v}, C_{4v}, D_4); direct product, the standard reduction formula; the direct product representation and its decomposition.
Wave functions as bases for Irreducible Representations, spectral transition probabilities, polarization effect, Metal based Electronic Excitations in $[Mo_2Cl_8]^{4-}$, allowedness – forbiddenness of n-π^* and π-π^* transitions; Study of normal modes, IR and Raman activity (H_2O molecule only).

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Unit 3: Advanced Organometallic Chemistry: Ligands in organometallic chemistry; Synthesis, structure, bonding and chemistry of Metal-alkyl, -alkene, -alkyne, - allyl, -carbene, -carbyne and -carbide complexes; Agostic interaction; Stereochemical non-rigidity and fluxional behaviour of organometallic compounds with typical examples.

Unit 4: Supramolecular Chemistry of Inorganic Molecules: Basic concept and principles of supramolecular chemistry, molecular recognition and hydrogen bonding; Secondary Electrostatic Interactions in Hydrogen Bonding Arrays. Different non-covalent interactions, Metal directed self-assembly, design of supramolecular host molecules. Examples of Host-guest complexes. Catalytic applications of molecular hosts. Metal Organic Frameworks (MOFs) and their applications, covalent organic frameworks (COFs)

Unit 5: Boranes: Boron cluster classification, skeletal electron counting. Wade's rules. Boron hydrides (Boranes) – Structure and bonding (MO description of B_2H_6 and $B_2H_6^{2-}$) in higher boranes based on Lipscomb's topological concept. "styx" system of numbering; Nomenclature. Carboranes, Metalloboranes and Metallocarboranes– Synthesis and structure; Borohydride B_nH_{n-2} anion, carboranes, metalloboranes, hydroboration reactions. NMR spectroscopy of typical inorganic boron hydride compounds (^{10}B, ^{11}B). Boron compound of potential medicinal interest. Boron neutron capture therapy (BNCT).

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MJ DSE-5P: INORGANIC CHEMISTRY V **Credits 01 (30 Lectures)**

Marks: 15

1. Quantitative Estimation using gravimetric method

(a) Gravimetric estimation of Cu(II) as CuSCN

(b) Gravimetric estimation of Ni(II) as Ni(DMGH)2

2. Syntheses and crystallization of coordination compounds:

(a) Reinkey‟s salt

(b) $K_3[Fe(ox)_3]$

(c) $K_3[Cr(ox)_3]$

Sessional Work **Marks: 2**

To be awarded by the class teacher on the basis performance of the students during the course work.

Viva Voce **Marks: 3**

To be jointly conducted by the external and internal examiners during the examination.

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PROJECT / DISSERTATION (RD)

[to be undertaken by students opting for and eligible for Hons. with Research]

DISSERTATION:
Credit: 8; Full Marks: 150

Guidelines:

- Students will prepare a **dissertation of 10,000 words (approx.)** with a suitable title
- **Writing the Dissertation**:
  Introducing the area of research, Literature Review, Locating research gaps, Preparing the theoretical framework, Making the core chapters, Conclusion and Scope for further research, Endnotes to individual chapters, List of Works Cited/Bibliography, Appendix, if any.

Structure of the dissertation

DRAFT

Preliminary Pages

- Title Page: Includes name of the student, university, degree, and submission date.
- Certificate/Declaration: Signed statement of originality and supervisor's approval
- Abstract: A 250-350 word summary covering research problem, methodology, and core findings.
- Acknowledgements: To supervisors and others, if any.
- Table of Contents: Clear hierarchical mapping of chapters with page number
- List of Abbreviations: Specialized terms, if any

Introduction

- Background & Context:
- Research Problem & Objectives: The specific question or gap the research is addressing.
- Thesis Statement/Hypothesis: The core argument the dissertation intends to prove.
- Scope and Significance: Why the study matters.
- Literature Review & Theoretical Framework

Literature Review: Analyzes existing scholarly works to show the gap the study fills.

- Theoretical Framework: Identifies the philosophers, critics, or schools of thought shaping the analysis in the dissertation.

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Methodology

- Describes *how* the research was conducted - Anyone or a combination of textual analysis/ archival research/ conducting interviews/ ethnographic/semi-ethno-graphic research involving both textual analysis and field visit etc.
- Thematic or Analytical Chapters

The Core Body: Usually 3 to 4 chapters focusing on the core concerns of the study.

- Structure: Each chapter introduces its specific theme, analyzes primary and secondary sources, and contributes to the overarching thesis.

Conclusion

- Summary & Synthesis: Recaps your main points without simply repeating them.

Final Verdict: Answers the research questions posed in the introduction.

Future Scope: Suggests how future scholars can build upon your work.

- Works Cited/ Reference, and/or Bibliography: A comprehensive list of all primary and secondary sources cited as per the latest MLA style.

Appendices: Transcripts, interview logs, or raw archival data, if any.

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Marks distribution-

Sl. No	Particulars	Marks
1	Research Project / Dissertation Report	70
	▪ Proposal and Abstract (along with some keywords)	10
	▪ Literature Review &Theoretical Framework	10
	▪ Methodology and Research design	10
	▪ Thematic Analysis (Chapter-wise)	20
	▪ Report Quality	20
2	Seminar Presentation	30
3	Viva-Voce	50
Total		**150**

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MINOR (MI)

Minor-08: (Inorganic Chemistry V + Environmental Chemistry + Polymer Chemistry)
Credits 04

MI-08T: Theory **Credits-03 (45 lectures)**

Course Content

Inorganic Chemistry-V **(10 Lectures)**

Inorganic Chemicals

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

Environmental Chemistry **(15 Lectures)**

The Atmosphere: composition and structure of the atmosphere; troposphere, stratosphere, mesosphere and thermosphere; ozone layer and its role; major air pollutants: CO, SO_2, NO_x and particulate matters – their origin and harmful effects; problem of ozone layer depletion; greenhouse effect; acid rain and photochemical smog; air pollution episodes: air quality standard; air pollution control measures: cyclone collector, electrostatic precipitator, catalytic converter.

The Hydrosphere: environmental role of water, natural water sources, water treatment for industrial, domestic and laboratory uses; water pollutants; action of soaps and detergents, phosphates, industrial effluents, agricultural runoff, domestic wastes; thermal pollution, radioactive pollution and their effects on animal and plant life; water pollution episodes: water pollution control measures : waste water treatment; chemical treatment and microbial treatment; water quality standards: DO, BOD, COD, TDS and hardness parameters; desalination of sea water : reverse osmosis, electro dialysis.

The Lithosphere: water and air in soil, waste matters and pollutants in soil, waste classification, treatment and disposal; soil pollution and control measures.

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Polymer Chemistry **(05 Lectures)**

Introduction and history of polymeric materials: Different schemes of classification of polymers, Polymer nomenclature

Functionality and its importance: Criteria for synthetic polymer formation, classification of polymerization processes, Preparation of some common polymers: Nylon 6, Nylon 66, PVC, Polystyrene, Polyethylene, Novalac Resin.

Reference Book:

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.

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6. R. Gopalan, D. Venkappayya, S. Nagarajan: *Engineering Chemistry*, Vikas Publications, New Delhi.
7. Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut (1996).
8. R.B. Seymour & C.E. Carraher: *Polymer Chemistry: An Introduction*, Marcel Dekker, Inc. New York, 1981.
9. G. Odian: *Principles of Polymerization*, 4th Ed. Wiley, 2004.
10. F.W. Billmeyer: *Textbook of Polymer Science*, 2nd Ed. Wiley Interscience, 1971.
11. P. Ghosh: Polymer Science & Technology, Tata McGraw-Hill Education, 1991.
12. R.W. Lenz: *Organic Chemistry of Synthetic High Polymers.* Interscience Publishers, New York, 1967.

MI-08P: Practical **(30 Lectures)**

1. Determination of pKa values of indicator using spectrophotometry.
2. Determination of Chemical Oxygen Demand (COD).
3. Determination of Biological Oxygen Demand (BOD).
4. Determination of dissolved oxygen in water.
5. Determination of available chlorine in bleaching powder.
6. Determination of available oxygen in pyrolusite.
7. Determination of Fe in cement
8. Determination of Cu in Brass.

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Suggested Readings:

1. Jeffery, G.H., Bassett, J., Mendham, J. & Denney, R.C. *Vogel's Textbook of Quantitative Chemical Analysis*, John Wiley & Sons.
2. Willard, H.H., Merritt, L.L., Dean, J. & Settoe, F.A. *Instrumental Methods of Analysis*, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA.
3. Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley & Sons, New York.
4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International Publisher.
6. Skoog, D.A. Holler F.J. & Nieman, T.A. *Principles of Instrumental Analysis*, Cengage Learning India Ed.
7. Mikes, O. *Laboratory Hand Book of Chromatographic & Allied Methods*, Elles Harwood Series on Analytical Chemistry, John Wiley & Sons.
8. Ditts, R.V. *Analytical Chemistry; Methods of Separation*, van Nostrand.

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