# UNIVERSITY OF CALCUTTA

## Notification No. CSR/18/2025

**It is notified for information of all concerned that in terms of the provisions of Section 54 of the Calcutta University Act, 1979, (as amended), and, in the exercise of her powers under 9(6) of the said Act, the Vice-Chancellor has, by an order dated 18.03.2025 approved the new revised Syllabus for semester-1 to semester-6 for 4-Year Honours and Honours with Research Courses of Studies and 3-year MDC in Chemistry, under CCF, as laid down in the accompanying Pamphlets.**

**The new CSR shall take effect from the Even semester examinations, 2025 and onwards.**

08/4/2025

**SENATE HOUSE**
**Kolkata-700073**
**08.04.2025**

**Prof.(Dr.) Debasis Das**
**Registrar**

# Four-Year B.A./B.Sc. (Honours and Honours with Research) Courses of Studies (Under Curriculum & Credit framework, 2022)

## SYLLABUS

## FOR

## CHEMISTRY

## (1st to 6th Semester)


## UNIVERSITY OF CALCUTTA

**Course Structure (Chemistry-Major With Honours and Honours With Research)**

## Course Credits

## Theory+ Practical

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**Discipline Specific Core (DSC)**

| | |
|---|---|
| **Theory (Honours)** | |
| **(25 papers of 3 credits each)** | **25 X 3 = 75** |
| **Practical / Tutorial** | |
| **(25 papers of 1 credit each)** | **25 X 1 = 25** |

**Minor (For Chemistry Major)**

| | |
|---|---|
| **Theory** | |
| **(Including Practical/ Tutorial)** | |
| **(8 papers of 4 credits each)** | **8 X 4 =32** |

**Ability Enhancement Course (AEC)**

| | |
|---|---|
| **(4 papers of 2 credits each)** | **4 X 2 = 8** |

**Skill Enhancement Courses (SEC)**

| | |
|---|---|
| **(3 papers of 4 credits each)** | **3 X 4 = 12** |

**Interdisciplinary Courses (IDC)**

| | |
|---|---|
| **(3 papers of 3 credits each)** | **3 X 3 = 9** |

**Common Value-Added Courses (CVAC)**

| | |
|---|---|
| **(4 papers of 2 credits each)** | **4 X 2 = 8** |

| | |
|---|---|
| **Summer Internship** | **3** |
| **(6th Semester)** | |

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**Total Credits** **172**

*** Honours students undertaking Research will take 3 Research papers of 12 Credits in place of 3 DSC Papers of 12 credits.**

# Important recommendations

- **Minor Courses for Chemistry Major are to be taken preferably (Not Compulsory) from Physics and Mathematics disciplines.**

- **All graphs for Physical / Inorganic Courses must be done using standard Spreadsheet Software**

- **Each college should take necessary measures to ensure they should have the following facilities:**

  **1. Spectrophotometer with printer, pH-Meter, Conductivity Meter, Potentiometer, Polarimeter.**

  **2. Internet facility.**

  **3. Requisite number of computers (One computer for 3-4 students).**

**For proper maintenance of above-mentioned facilities, clean & dry AC rooms are mandatory.**

# Chemistry Course Structure

## Four-year Chemistry Major Course Structure (Theory)

| Semester | Paper Code | Paper Name | Brief Descriptions |
|---|---|---|---|
| 1 | CHEM-H-CC1-1-Th (DSCC-1) | Fundamentals of Chemistry-I | Extra nuclear structure of atoms and Periodicity, Basics of Organic Chemistry Bonding and Physical Properties, Stereochemistry – I, Thermodynamics –I, Chemical Kinetics-I. |
| | CHEM-H-SEC1-1-Th (SEC-1) | Quantitative Analysis and Basic Laboratory Practices | Introduction to Quantitative analysis and its interdisciplinary nature, Titrimetric analysis etc., Water analysis, Basic laboratory practices. |
| 2 | CHEM-H-CC2-2-Th (DSCC-2) | Fundamentals of Chemistry-II | Kinetic Theory and Gaseous state, Chemical Bonding – I, Theoretical principles of inorganic qualitative analysis, Stereochemistry – II, General Treatment of Reaction Mechanism-I |
| | CHEM-H-SEC2-2-Th (SEC-2) | AI for Everyone | Introduction to Artificial Intelligence, Subfields and technologies, Applications of AI. |
| 3 | CHEM-H-CC3-3-Th (DSCC-3) | Physical Chemistry - I | Thermodynamics -II, Applications of Thermodynamics – I, Electrochemistry-I. |
| | CHEM-H-CC4-3-Th (DSCC-4) | Organic Chemistry – I | Aromatic Substitution Reaction. General Treatment of Reaction Mechanism-II, Stereochemistry – III, Conformation,Substitution, elimination, Addition to alkenes, dienes, alkynes. |
| | CHEM-H-SEC3-3-Th (SEC-3) | Introduction to Numerical Methods for Chemists | Linear Regression, Root Finding, Numerical Differential and Integration, Fourier Transform |

| | | | |
|---|---|---|---|
| 4 | **CHEM-H-CC5-4-Th (DSCC-5)** | **Inorganic Chemistry – I** | **Chemical bonding- II, Acids and bases, Radioactivity.** |
| | **CHEM-H-CC6-4-Th (DSCC-6)** | **Organic Chemistry – II** | **Stereochemistry – IV, Chemistry of Carbonyl Compounds, Organometallics.** |
| | **CHEM-H-CC7-4-Th (DSCC-7)** | **Physical Chemistry - II** | **Transport processes and Liquid State, Solid State, Application of Thermodynamics– II, Electrochemistry-II.** |
| | **CHEM-H-CC8-4-Th DSCC-8)** | **Inorganic Chemistry – II** | **Coordination chemistry, Supramolecular Chemistry Redox reactions.** |
| 5 | **CHEM-H-CC9-5-Th (DSCC-9)** | **Organic Chemistry – III** | **Organic Spectroscopy-I, Rearrangements,Nitrogen compounds.** |
| | **CHEM-H-CC10-5-Th (DSCC-10)** | **Inorganic Chemistry – III** | **s and p block elements,d and f block elements,Nuclear Model and Radiotracer methods.** |
| | **CHEM-H-CC11-5-Th (DSCC-11)** | **Physical Chemistry – III** | **Foundation of Quantum Mechanics, Exactly Solvable Systems-I, Surface Chemistry.** |
| | **CHEM-H-CC12-5-Th (DSCC-12)** | **Organic Chemistry – IV** | **OrganicSynthesis-I, Carbocycles, Stereochemistry and Reactions of Alicyclic Compound.** |
| 6 | **CHEM-H-CC13-6-Th (DSCC-13)** | **Physical Chemistry – IV** | **Exactly Solvable Systems-II, Molecular Spectroscopy, Photochemistry.** |
| | **CHEM-H-CC14-6-Th (DSCC-14)** | **Organic Chemistry – V** | **Carbohydrates, Biomolecules-I, Concept of Aromaticity and Free Energy Relationship .** |
| | **CHEM-H-CC15-6-Th (DSCC-15)** | **Inorganic Chemistry – IV** | **Organometallic Chemistry-I, Bioinorganic Chemistry-I, Reaction kinetics and mechanism.** |

*** Students who secure 75% marks and above in the first six semesters and wish to undertake research at the UG level can choose a research supervisor in the fourth year.**

## Summer Internship:

**All the students are required to do one 3 credits Summer Internship at the end of the 2nd or 4th or 6th semester. Students completing Internship at the end of the 2nd semester will be allowed to take exit from the course and will be awarded Certificate of 45 credits. Students completing Internship at the end of the 4th semester will be allowed to take exit from the course and will be awarded Diploma of 88 credits. Students completing Internship at the end of the 6th semester will be allowed to take exit from the course and will be awarded three-year Single major Degree of 132 credits [Following the Notification No. CSR/05/2023, dated 23rd June, 2023 of University of Calcutta].**

# Four-year Chemistry Major Course Structure
# (Practical / Tutorial)

| Semester | Paper Code | Paper Name | Brief Descriptions |
|---|---|---|---|
| 1 | CHEM-H-CC1-1-P (DSCC-1) | Fundamentals of Chemistry-I | Acid-Base Titration, Oxidation-Reduction Titrimetry. |
| | CHEM-H-SEC1-1-Tu (SEC-1) | Quantitative Analysis and Basic Laboratory Practices | Tutorial |
| 2 | CHEM-H-CC2-2-P (DSCC-2) | Fundamentals of Chemistry-II | Qualitative semimicro analysis of mixtures containing three radicals |
| | CHEM-H-SEC2-2-Tu (SEC-2) | AI for Everyone | Tutorial |
| 3 | CHEM-H-CC3-3-P (DSCC-3) | Physical Chemistry - I | Chemical Kinetics (Analytical). |
| | CHEM-H-CC4-3-P (DSCC-4) | Organic Chemistry – I | Identification of Single Organic Compounds. |
| | CHEM-H-SEC3-3-Tu (SEC-3) | Introduction to Numerical Methods for Chemists | Tutorial |
| 4 | CHEM-H-CC5-4-P (DSCC-5) | Inorganic Chemistry – I | Complexometric Titration |
| | CHEM-H-CC6-4-P (DSCC-6) | Organic Chemistry – II | Qualitative analysis of single solid Organic compounds. |
| | CHEM-H-CC7-4-P (DSCC-7) | Physical Chemistry - II | Surface Tension, Viscosity, Conductometry. |
| | CHEM-H-CC8-4-P (DSCC-8) | Inorganic Chemistry – II | Estimation of mixtures of metal ions. |
| 5 | CHEM-H-CC9-5-P (DSCC-9) | Organic Chemistry – III | Organic Preparations. |
| | CHEM-H-CC10-5-P (DSCC-10) | Inorganic Chemistry – III | Analysis of Materials of Industrial Importance. |
| | CHEM-H-CC11-5-P (DSCC-11) | Physical Chemistry – III | Conductometric, Potentiometric Experiments. |
| | CHEM-H-CC12-5-P (DSCC-12) | Organic Chemistry – IV | TLC & Paper Chromatography. |

| | | | |
|---|---|---|---|
| 6 | **CHEM-H-CC13-6-P (DSCC-13)** | **Physical Chemistry – IV** | **Spreadsheet software applications.** |
| | **CHEM-H-CC14-6-P (DSCC-14)** | **Organic Chemistry – V** | **Spectroscopy ($^1$H-NMR and IR) Spectroscopic Analysis of Organic Compounds.** |
| | **CHEM-H-CC15-6-P (DSCC-15)** | **Inorganic Chemistry – IV** | **Preparation of Inorganic Complexes.** |

*** Students who secure 75% marks and above in the first six semesters and wish to undertake research at the UG level can choose a research stream in the fourth year**.

# CHEMISTRY MINOR COURSE STRUCTURE
## (Theory)

| Semester | Paper Code | Paper Name | Brief Descriptions |
|---|---|---|---|
| 1 or 3 | CHEM-H-CC1-1-Th Or CHEM-H-CC1-3-Th (MN-1) | Fundamentals of Chemistry-I | Extra nuclear structure of atoms and Periodicity, Basics of Organic Chemistry Bonding and Physical Properties, Stereochemistry – I, Thermodynamics –I, Chemical Kinetics-I. |
| 2 or 4 | CHEM-H-CC2-2-Th Or CHEM-H-CC2-4-Th (MN-2) | Fundamentals of Chemistry-II | Kinetic Theory and Gaseous state, Chemical Bonding – I, Theoretical principles of inorganic qualitative analysis, Stereochemistry – II, General Treatment of Reaction Mechanism-I |
| 5 | CHEM-H-CC4-5-Th (MN-3) | Organic Chemistry – I | Aromatic Substitution Reaction, General Treatment of Reaction Mechanism-II, Conformation, Substitution, elimination, Addition to alkenes, dienes, alkynes. |
| 6 | CHEM-H-CC5-6-Th (MN-4) | Inorganic Chemistry – I | Chemical bonding II, Acids and bases, Radioactivity |

**Note 1: The above course structure for Minor is applicable to students admitted in 4-year Honours / Honours with Research course with Major different from Chemistry**.

**Note 2: A student will have to take 8 Minor courses from 2 subjects (M1 and M2) from the same broad discipline as the Major excluding the Major subject. Students have to study 4 minor courses in the first two years (1 in each semester) and 4 Minor courses in the 3rd year ( 2 in each semester).**

**For example: A student with Chemistry Minor have two options for choosing Chemistry from Semesters 1 to 4.**

**Option-1: A student can take CHEM-H-CC1-1-Th in semester-I and CHEM-H-CC2-2-Th in semester –II**

**Or,**

**Option 2: A student can take CHEM-H-CC1-3-Th in semester-III and CHEM-H-CC2-4-Th in semester –IV**

**No other combinations of CHEM-H-CC1-1-Th and CHEM-H-CC2-2-Th will be allowed. In the semesters 1 & 2 minor papers from the same subject has to be chosen, e.g. either M1 or M2. In semesters 3 & 4 the other subject, not chosen previously has to be chosen.**

**Note 3:**

**In the 3rd year (in semesters 5 & 6) two minor subjects in each semester will have to be taken from two different subjects.**

## CHEMISTRY MINOR COURSE STRUCTURE
## (Practical)

| Semester | Paper Code | Paper Name | Brief Descriptions |
|---|---|---|---|
| 1 or 3 | CHEM-H-CC1-1-P Or CHEM-H-CC1-3-P (MN-1) | Fundamentals of Chemistry-I | Acid-Base Titration, Oxidation-Reduction Titrimetry. |
| 2 or 4 | CHEM-H-CC2-2-P Or CHEM-H-CC2-4-P (MN-2) | Fundamentals of Chemistry-II | Qualitative semimicro analysis of mixtures containing three radicals |
| 5 | CHEM-H-CC4-5-P (MN-3) | Organic Chemistry – I | Identification of Single organic Compound. |
| 6 | CHEM-H-CC5-6-P (MN-4) | Inorganic Chemistry – I | Complexometric Titrations |

# Interdisciplinary Course Structure in Chemistry

| Semester | Paper Code | Paper Name | Brief Descriptions |
|---|---|---|---|
| **1** | **CHEM-H-IDC1-1-Th** | **Quantitative Analysis and Basic Laboratory Practices** | **Introduction to Quantitative analysis and its interdisciplinary nature, Titrimetric analysis etc., Water analysis, Basic laboratory practices.** |
| **2** | **CHEM-H-IDC2-2-Th** | | |
| **3** | **CHEM-H-IDC3-3-Th** | | |

A student can take either **CHEM-H-IDC1-1-Thin the first semester** or **CHEM-H-IDC2-2-Thin the second semester** or **CHEM-H-IDC3-3-Thin the third semester**.

# CHEMISTRY MAJOR

**PAPER:CHEM-H-CC1-1-Th**

**(DSCC-1)**

**(Credit: Theory -03, Practical – 01)**

## Fundamentals of Chemistry - I

**Theory: (45 Lectures)**

### Module: I

**Extra nuclear structure of atoms and Periodicity: (15 Lectures)**

Wave-Particle duality; de Broglie hypothesis. Heisenberg'suncertainty principle. Introducing Schrödinger equation. Hydrogen and hydrogen like systems (detailed solution not required). Concept of Atomic Orbital; shapes of s, p and d orbitals. Radial and angular distribution curves. Extension to multielectronic systems. Aufbau principle and its limitations; Pauli's exclusion principle; Hund's rules and multiplicity. Effective nuclear charge. Shielding and penetration; Slater's rule.

The general idea about modern periodic table, atomic and ionic radii, ionization energy, electron affinity and electro negativity –definition, trends of variation in periodic table and their application in explaining and predicting the chemical behavior of elements and compounds. Electronegativity scales (Pauling's, Mulliken's and Allred-Rochow's scales). Inert pair effect.

### Module: II

**Basics of Organic Chemistry Bonding and Physical Properties**

**(10 Lectures)**

**Valence Bond Theory**

Nomenclature of Organic Compounds, Concept of hybridisation, shapes and structures of molecules, double bond equivalent (DBE), Resonance (including hyperconjugation) and Resonance energy.

## Electronic displacement

Inductive effect, bond polarization and bond polarizability; steric effect, steric inhibition of resonance.

## MO Theory

Qualitative idea about molecular orbitals, bonding and antibonding interactions, idea about σ, σ*, π, π *, n – MOs; concept of HOMO, LUMO and SOMO; sketch and energy levels of π MOs of i) acyclic p orbital system (C=C, conjugated diene, triene, allyl and pentadienyl systems) ii) cyclic p orbital system (neutral systems: [4], [6] annulenes; charged systems: 3-,4-,5-7 membered ring systems); Hückel's rules for aromaticity up to [8] annulene; concept of antiaromaticity; non-aromatic molecules.

## Physical properties

Melting point/boiling point and solubility of common organic compounds in terms of covalent & non-covalent intermolecular forces; polarity of molecules and dipole moments.

## Stereochemistry – I (5 Lectures)

Bonding geometries of carbon compounds and representation of molecules: tetrahedral nature of carbon and concept of asymmetry; Fischer, sawhorse, flying wedge and Newman projection formulae and their inter translations. Concept of chirality and symmetry: symmetry elements, molecular chirality and centre of chirality; asymmetric and dissymmetric molecules; enantiomers and diastereomers; concept of stereogenicity, chiral centres and number of stereoisomers: systems involving 1/2-chiral centre(s).

# Module: III

## Thermodynamics -I (9 Lectures)

Concept of systems (open, closed and isolated) and surroundings. State of a system; Intensive and extensive variables. Partial derivatives. Exact and inexact differentials. Path function and State function. Concept of heat and work.Zeroth law of thermodynamics. Concept of thermodynamic reversibility. Concept of internal energy and 1st law of thermodynamics. Enthalpy and heat capacity, Relations between $C_p$ and $C_v$. Isothermal and Adiabatic processes. Calculations of $\Delta U$, $\Delta H$, q and w involving ideal gases in different processes.

Enthalpy of reaction. Hess's law. Enthalpy of formation and combustion. Kirchhoff's equation.

## Chemical Kinetics-I (6 Lectures)

Concept of order and molecularity. Rate laws for zero, 1st and 2nd order reactions and in general for any n-th order reaction. Determination of order of a reaction by half-life and differential methods. Rate determining step and steady state approximation. Opposing, Consecutive and parallel reactions (first order steps only). Temperature dependence of rate constant and Arrhenius equation.

## Recommended Text Books


1. Lee, J. D. Concise Inorganic Chemistry,5th Ed., Wiley India Pvt. Ltd., 2008.
2. Atkins, Overton, Rourke,Weller, Armstrong; Shriver & Atkins' Inorganic Chemistry, 5th Ed., Oxford University Press, (2010).
3. Finar, I. L. Organic Chemistry (Volume 1), 6thEdition, Pearson Education, 2002
4. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
5. Nasipuri, D. Stereochemistry of Organic Compounds, 4th Edition, New Age International Pvt Ltd, 2020
6. Levine, I. N. Physical Chemistry, 6th Edition McGraw-Hill India, 2011
7. Castellan, G. W. Physical Chemistry, Narosa , 2004
8. Atkins, P. W. & Paula, J. de, Atkins' Physical Chemistry, 11th Edition, Oxford University Press, 2018
9. G. L. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Edition, Pearson India, 2008


## Practical :(30 Lectures)

## PAPER:CHEM-H-CC1-1-P

## (DSCC-1)

(1) Calibration and use of apparatus.

(2) Preparation of primary standard solutions (Oxalic Acid and $K_2Cr_2O_7$)

## Acid-Base Titrations

(3) Standardization of NaOH standard oxalic acid solution.

(4) Estimation of carbonate and bicarbonate present together in a mixture

(5) Estimation of acetic acid in commercial Vinegar.

## Oxidation-Reduction Titrimetry

(6) Standardization of $KMnO_4$ standard oxalic acid solution.

(7) Estimation of Fe (II) using standardized $KMnO_4$ solution.

(8) Estimation of Fe (III) using standard $K_2Cr_2O_7$ solution.

(9) Estimation of Fe (II) and Fe (III) in a given mixture using standard $K_2Cr_2O_7$ solution.

## Reference Books

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.

2.Practical Workbook Chemistry (Honours), UGBOS, Chemistry, Universityof Calcutta, 2015

# CHEMISTRY MAJOR

**PAPER:CHEM-H-CC2-2-Th**

**(DSCC-2)**

**(Credit: Theory -03, Practical – 01)**

## Fundamentals of Chemistry - II

**Theory: (45 Lectures)**

### Module: I

**Kinetic Theory and Gaseous state (8 Lectures)**

Concept of pressure and temperature from kinetic theory of gas.Nature of distribution of velocities, Maxwell's distribution of speeds in one, two and three dimensions; Kinetic energy distribution in one, two and three dimensions, calculations of average, root mean square and most probable values in each case; Collision of gas molecules; Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar and different molecules); Wall collision and rate of effusion Calculation of number of molecules having energy $\geq \varepsilon$, Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases

**Real gas and Virial equation (7 Lectures)**

Deviation of gases from ideal behavior; Compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation and its features; its derivation and application in explaining real gas behavior ; Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states; Virial equation of state; van der Waals equation expressed in the Virial form and significance of second virial coefficient; Intermolecular forces (Debye, Keesom and London interactions; Lennard-Jones potential - elementary idea.

### Module: II

## Chemical Bonding – I (10 Lectures)

i) Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its application and limitations. Packing of ions in crystals. Born-Lande equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. Defects in solids (elementary idea). Solubility energeticsof dissolution process.

ii) Covalent bond: Polarizing power and polarizabilty, ionic potential, Fajan's rules, Lewis structures, formal charge, Valence Bond Theory, the hydrogen molecule (Heitler – London approach), directional character of covalent bonds, hybridizations, equivalent and non-equivalent hybrid orbitals, Bent's rules, dipole moments, VSEPR theory, shapes of molecules and ions containing lone pairs (examples from main group chemistry) and multiple bonding ($\sigma$ and $\pi$ bond approach).

## Theoretical principles of inorganic qualitative analysis (5 Lectures)

Basic principles involved in analysis of cations and anions and solubility products, common ion effect.
Principle involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.

# Module: III

## Stereochemistry – II (8 Lectures)

Chirotopicityand its relationship with stereogenicity; concept of pseudoasymmetry forABA type systems. Relative and absolute configuration: *R/S* descriptors; *erythro/threo* and *meso* nomenclature of compounds; *E/Z* descriptors for C=C, combination of *R/S*- and *E/Z*isomerisms. Optical activity of chiral compounds: optical rotation, and specific rotation; racemic compounds, racemisation (through cationic, anionic intermediates); resolution of acids and bases *via* diastereomeric salt formation; optical purity and enantiomeric excess.

### General Treatment of Reaction Mechanism–I (7 Lectures)

## Reactive intermediates

Carbocations (carbenium and carbonium ions), non-classical carbocations, carbanions, carbon radicals: generation and stability, structure and electrophilic / nucleophilic behaviour of reactive intermediates (elementary idea).

## Reaction thermodynamics

Free energy and equilibrium, enthalpy and entropy factor, calculation of enthalpy change *via* BDE, intermolecular & intramolecular reactions.

## Reaction kinetics

Rate constant and free energy of activation; free energy profiles for one-step, and two-step reactions; catalyzed reactions, principle of microscopic reversibility; Hammond's postulate.

## Substitution Reaction

Free-radical substitution reaction: halogenation of alkanes, mechanism (with evidence) and stereochemical features; reactivity-selectivity principle in the light of Hammond's postulate.

## Recommended Text Books


1. Lee, J. D. Concise Inorganic Chemistry,5th Ed., Wiley India Pvt. Ltd., 2008.
2. Atkins, Overton, Rourke,Weller, Armstrong;Shriver & Atkins' Inorganic Chemistry, 5th Ed., Oxford University Press (2010).
3. Finar, I. L. Organic Chemistry (Volume 1), 6thEdition, Pearson Education, 2002
4. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
5. Nasipuri, D. Stereochemistry of Organic Compounds, 4th Edition, New Age International Pvt Ltd, 2020
6. Levine, I. N. Physical Chemistry, 6thEdition McGraw-Hill India, 2011
7. Castellan, G. W. Physical Chemistry, Narosa , 2004
8. Atkins, P. W. & Paula, J. de, Atkins' Physical Chemistry, 11th Edition,Oxford University Press, 2018
9. G. L. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Edition, Pearson India, 2008


## Practical :(30 Lectures)

## PAPER: CHEM-H-CC2-2-P

## (DSCC-2)

**Qualitative semimicro analysis of mixtures containing three radicals. Emphasis should be given to the understanding of the chemistry of different reactions (only water /acid soluble salts):**

## Cation Radicals

$Na^+$, $K^+$, $Ca^{2+}$, $Sr^{2+}$, $Ba^{2+}$, $Al^{3+}$, $Cr^{3+}$, $Fe^{3+}$, $Mn^{2+}/Mn^{4+}$, $Co^{2+}/Co^{3+}$, $Ni^{2+}$, $Cu^{2+}$, $Zn^{2+}$, $Pb^{2+}$, $NH_4^+$, $Sn^{2+}/Sn^{4+}$

## Anion Radicals

$F^-$, $Cl^-$ , $Br^-$, $I^-$, $S_2O_3^{2-}$, $S^{2-}$, $SO_4^{2-}$, $NO_3^-$, $NO_2^-$, $PO_4^{3-}$, $BO_3^{3-}$, $CrO_4^{2-}$ / $Cr_2O_7^2$ , $SCN^-$, $[Fe(CN)_6]^{3-}$, $[Fe(CN)_6]^{4-}$, $AsO_4^{3-}$, $BrO_3^-$, $IO_3^-$.

## Reference Books

1. Svehla &Sivasankar, Vogel'sQualitative Inorganic Analysis, 7th Ed., Pearson, 2012. 2. Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University Calcutta, 2015

# CHEMISTRY MAJOR

## PAPER:CHEM-H-CC3-3-Th

## (DSCC-3)

## (Credit: Theory -03, Practical – 01)

## Physical Chemistry - I

## Theory: (45 Lectures)

### Module: I

### Thermodynamics - II: (20 Lectures)

### Second Law

Need for a Second law; statement of the second law of thermodynamics; Concept of heat reservoirs and heat engines; Carnot cycle; Carnot engine and refrigerator; Kelvin – Planck and Clausius statements and equivalence of the two statements with entropic formulation; Carnot's theorem; Values of §dQ/T and Clausius inequality; Physical concept of Entropy; Entropy is a measure of the microscopic disorder of the system. Entropy changes of systems and surroundings for various processes and transformations; Entropy and unavailable work; Temperature – Entropy diagram.

Useful work and The Gibbs and Helmholtz function. Changes at constant T, P. Application to electric work. Criteria for spontaneity and equilibrium. Gibbs- Helmholtz equation, The Gibbs Function and useful work in biological systems. Gibbs free energy and spontaneous phase transition.

Maxwell's relations; Joule-Thomson experiment and its consequences; inversion temperature; Joule-Thomson coefficient for a van der Waals gas; General heat capacity relations

### Systems of Variable Compositions

State functions for system of variable compositions. Criteria of equilibrium and spontaneity in systems of variable composition. Partial molar quantities, dependence of thermodynamic parameters on composition; Chemical potential as an escaping tendency. Gibbs-Duhem equation, Entropy and Gibbs function for mixing of ideal gases, the chemical potential of ideal mixtures. The Fugacity function of a pure real gas. Calculation of the fugacity of a van der Waals gas using compressibility factor. Activities and activity coefficients. Choice of standard states. Dependence of Activity on pressure and temperature.

## Module: II

### Applications of Thermodynamics – I (8 Lectures)

### Chemical Equilibrium

Thermodynamic conditions for equilibrium, degree of advancement; van't Hoff's reaction isotherm (deduction from chemical potential); Variation of free energy with degree of advancement; Equilibrium constant and standard Gibbs free energy change; Van't Hoff's reaction isobar and isochore from different standard states; Le Chatelier's principle
and its derivation, variation of equilibrium constant under different conditions Nernst's distribution law; Application- (e.g. dimerization of benzene in benzoic acid). Solvent Extraction.

## Module: III

### ELECTROCHEMISTRY-I

### (i) Conductance (9 Lectures)

Ion conductance; Conductance and measurement of conductance, cell constant, specific conductance and molar conductance; Variation of specific and equivalent conductance with dilution for strong and weak electrolytes; Kohlrausch's law of independent migration of ions; Equivalent and molar conductance at infinite dilution and their determination for strong and weak electrolytes; Debye –Huckel theory of Ion atmosphere (qualitative)-asymmetric effect, relaxation effect and electrophoretic effect; Debye-Huckel limiting law-brief qualitative description. Estimation of activity coefficient for electrolytes using Debye-Huckel limiting law.

Ostwald's dilution law; Ionic mobility; Application of conductance measurement (determination of solubility product and ionic product of water); Conductometric titrations. Transport number, Principles of Hittorf's and Moving-boundary method.

## (ii) Ionic Equilibrium (8 Lectures)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale. Salt hydrolysis- calculation of hydrolysis constant, degree of hydrolysis and pH for different salts (exact Treatment). Determination of hydrolysis constant conductometrically. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action. Theory of acid–base indicators; selection of indicators and their limitations.

## Recommended Text Books


1.Levine, I. N. Physical Chemistry, 6$^{th}$Edition McGraw-Hill India, 2011

2. Castellan, G. W. Physical Chemistry, Narosa , 2004

3. Atkins, P. W. & Paula, J. de, Atkins' Physical Chemistry, 11$^{th}$ Edition, Oxford University Press, 2018


## Reference Books


1. Denbigh, K. The Principles of Chemical Equilibrium, Cambridge University Press

2. Zemansky, M. W. & Dittman, R.H, Heat and Thermodynamics, Special Indian Edition, 8$^{th}$ Edition, Tata-McGraw-Hil ,2017

3. Klotz, Irving M, Rosenberg, Robert M,Chemical Thermodynamics, WileyIndia, 2013


## Practical :(30 Lectures)

## PAPER: CHEM-H-CC3-3-P

## (DSCC-3)

1. Determination of rate constant of the reaction between $H_2O_2$ and acidified KI solution using Clock reaction.

2. Determination of the rate constant for the decomposition of $H_2O_2$ using $FeCl_3$ as catalyst.

3. Determination of the rate constant for the first order acid catalyzed hydrolysis of an ester.

4. To study the kinetics of the inversion of cane sugar using a polarimeter.

## Reference Books

1.Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University of Calcutta, 2015

# CHEMISTRY MAJOR

## PAPER:CHEM-H-CC4-3-Th

## (DSCC-4)

## (Credit: Theory -03, Practical – 01)

### Organic Chemistry – I

## Theory: (45 Lectures)

### Module: I

## Aromatic Substitution: (12 Lectures)

### Electrophilic aromatic substitution

Mechanisms and evidences in favour of it including PKIE; orientation and reactivity; reactions: nitration, nitrosation, sulfonation, halogenation, Friedel-Crafts reaction; one-carbonelectrophiles (reactions: chloromethylation, Houben-Hoesch, Vilsmeier-Haack, Reimer-Tiemann, Kolbe-Schmidt); *Ipso* substitution.

### Nucleophilic aromatic substitution

Addition-elimination mechanism and evidences in favour of it; $S_N1$ mechanism; *cine* substitution (benzyne mechanism), structure of benzyne.

### Birch Reduction of benzenoid aromatics

Benzene, Alkylbenzene, Anisole, Benzoic acid (with mechanism).

## General Treatment of Reaction Mechanism –II (8 Lectures)

### Concept of organic acids and bases

Concept of $pK_a$ and $pK_{aH}$, effect of structure, substituent and solvent on acidityand basicity; proton sponge.

### Tautomerism

Basic difference between tautomerism and resonance,prototropy (keto-enol, phenol-keto); composition of the equilibrium in different systems (simple carbonyl; 1,2- and 1,3-dicarbonyl systems, phenols and related systems), factors affecting keto-enol tautomerism,basic ideas about valence tautomerism and ring-chain tautomerism.

## Module: II

## Stereochemistry –III (3 Lectures)

### Conformation-I

Basic idea of conformation.Conformational Nomenclature(Newman & Sawhorse):eclipsed, staggered, gauche, syn and anti; Special reference to preferred geometry for β-elimination. Relative stability of conformers on the basis of steric effect: butane-gauche interaction.

## Substitution and Elimination Reactions: (10 Lectures)

### Nucleophilic substitution reactions

Substitution at $sp^3$centre[systems: alkyl halides, allyl halides, benzyl halides, alcohols, ethers, epoxides, α-halocarbonyls]: mechanisms (with evidence),relative rates& stereochemical features: $S_N1$, $S_N2$, $S_N2'$, $S_N1'$ (allylic rearrangement) and $S_Ni$; effects of solvent, substrate structure, leaving group and nucleophiles (including ambident nucleophiles, cyanide & nitrite); substitutions involving NGP (with heteroatoms and phenyl groups).

#### Elimination reactions

E1, E2, E1cB and Ei (pyrolytic *syn* eliminations); formation of alkenes and alkynes; mechanisms (with evidence), reactivity, regioselectivity (Saytzeff/Hofmann)and stereoselectivity; comparison between substitution and eliminationreactions, comparison between nucleophilicity and basicity.

## Module: III

## Chemistry of alkenes and alkynes (12 Lectures)

### Addition to C=C

Mechanism (with evidence wherever applicable), reactivity, regioselectivity (Markownikoff and anti-Markownikoff additions) and stereoselectivity; reactions: hydrogenation, halogenation, hydrohalogenation, hydration, oxymercuration-demercuration, hydroboration-oxidation, epoxidation, *syn* and *anti*-hydroxylation, ozonolysis, addition of singlet and triplet carbenes; Simmons-Smith cyclopropanation reaction; electrophilic addition to 1,3-butadiene; concept ofkinetic and thermodynamic control of products; radical addition: HBr addition; mechanism of allylic and benzylic bromination in competition with brominations across C=C; use of NBS; interconversion of *E* and *Z* alkenes.

### Addition to C≡C (in comparison to C=C)

Mechanism, reactivity, regioselectivity(Markownikoff and anti-Markownikoff addition) and stereoselectivity; reactions:hydrogenation, Hg (II) ion catalysed hydration, hydroboration-oxidation, dissolving metal reduction of alkynes (Birch); reactions of terminal alkynes by exploring its acidity.

### Recommended Text Books


1. Finar, I. L. Organic Chemistry (Volume 1), 6$^{th}$Edition, Pearson Education, 2002
2. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
3. Morrison, R. N. & Boyd, R. N. and Bhattacharjee, Organic Chemistry,7$^{th}$Edition, Pearson Education, 2010


## Practical :(30 Lectures)

## PAPER: CHEM-H-CC4-3-P

## (DSCC-4)

### Identification of PureSingle organic Compound.

### Solid compounds

Oxalic acid, tartaric acid, citric acid, succinic acid, resorcinol, urea, glucose, cane sugar, benzoic acid and salicylic acid

**Liquid Compounds**:

Formic acid, acetic acid, ethyl alcohol, acetone, aniline, dimethylaniline, benzaldehydeand nitrobenzene

## Reference Books

1.Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University of Calcutta, 2015

2.Furniss, Hannaford, Smith, Tatcholl, Vogel's Textbook of Practical Organic Chemistry ,5$^{th}$Edition, Pearson India, 2003

# CHEMISTRY MAJOR

## PAPER:CHEM-H-CC5-4-Th

## (DSCC-5)

## (Credit: Theory -03, Practical – 01)

## Inorganic Chemistry – I

## Theory: (45 Lectures)

## Module: I

## Chemical bonding -II (28 Lectures)

### Molecular orbital concept of bonding

The approximations of the theory, Linear combination of atomic orbitals (LCAO) (elementary pictorial approach): sigma and pi bonds and delta interaction, multiple bonding. Orbital designations: gerade, ungerade, HOMO, LUMO. Orbital mixing, MO diagrams of $H_2$, $Li_2$, $Be_2$, $B_2$, $C_2$, $N_2$, $O_2$, $F_2$, and their ions wherever possible; Heteronuclear molecular orbitals: CO, NO, $NO^+$, $CN^-$, HF, $BeH_2$, $CO_2$ and $H_2O$. Bond properties: bond orders, bond lengths.

### Metallic Bond

Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

## Weak Chemical Forces

Hydrogen bonding (theories of hydrogen bonding, valence bond treatment), receptor-guest interactions, Halogen bonds. Effects of chemical force, melting and boiling points.

**Module: II**

## Acids and bases (12 Lectures)

### Acid-Base concept

Arrhenius concept, theory of solvent system (in $H_2O$, $NH_3$, $SO_2$ and HF), Bronsted-Lowry's concept, Lux Flood concept, Lewis's concept, group characteristics of Lewis acids, solvent levelling and differentiating effects. Relative strength of acids, Pauling's rules. HSAB principle.

### Acid-base equilibria in aqueous solution

Proton transfer equilibria in water, pH, buffer. Acid-base neutralization curves; indicator, choice of indicators.

## Module: III

## Radioactivity (05 Lectures)

### Nuclear stability

Nuclear stability and nuclear binding energy.

### Nuclear Reactions

Artificial radioactivity, fission, fusion and spallation.

### Radiocarbon dating

## Recommended Text Books


1. G. L. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Edition, Pearson India, 2008
2. A. G. Sharpe, C. E. Housecroft, Inorganic Chemistry 3rdEdition, Pearson India ,2002
3. Svehla &Sivasankar, Vogel'sQualitative Inorganic Analysis, 7th Ed., Pearson, 2012.


## Practical :(30 Lectures)

## PAPER: CHEM-H-CC5-4-P

## (DSCC-5)

## Complexometric Titration

1. Ca (II) and Mg (II) in a mixture
2. Hardness of water
3. Fe (III) and Al (III) in a mixture
4. Cu (II) and Zn (II) in a mixture
5. Cu (II) and Ni (II) in a mixture

## Reference Books

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.

2.Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University of Calcutta, 2015

# CHEMISTRY MAJOR

## PAPER:CHEM-H-CC6-4-Th

## (DSCC-6)

## (Credit: Theory -03, Practical – 01)

### Organic Chemistry – II

## Theory: (45 Lectures)

### Module: I

## Stereochemistry – IV (12 Lectures)

### Conformation-II

Concept of dihedral angle, torsion angle; energy barrier of rotation, concept of torsional and steric strains; relative stability of conformers on the basis of steric effect, dipole-dipole interaction and H-bonding; butane gauche interaction; conformational analysis of ethane, propane, *n*-butane, and 2-methylbutane; 1,2-dihaloalkanes and ethylene glycol.

### Concept of prostereoisomerism

Prostereogeniccentre; concept of (pro)$^n$chirality: topicity of ligands and faces (elementary idea); pro-R/pro-S, pro-E/pro-Z and Re/Si descriptors; pro-*r* and pro-*s* descriptors of ligands on propseudoasymmetriccentre.

## Chirality arising out of stereoaxis

Stereoisomerism of substituted cumulenes with even and odd number of double bonds; chiral axis in allenes, and biphenyls; related configurational descriptors ($R_a/S_a$); atropisomerism; racemisation of chiral biphenyls

# Module: II

## Chemistry of carbonyl Compounds: (28 Lectures)

## Nucleophilic Addition to C=O

Structure and reactivity of carbonyl compounds; mechanism (with evidence), reactivity, equilibrium and kinetic control; formation of hydrates, cyanohydrins and bisulphite adduct; nucleophilic addition-elimination reactions with alcohols, thiolsand nitrogen-based nucleophiles;reactions: benzoin condensation, Cannizzaro and Tischenko reactions, reactions with ylides: Wittig and Corey-Chaykovsky reaction; Rupe rearrangement, oxidations and reductions: Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPVO redox equilibrium, acyloin condensation; oxidation of alcohols with PDC and PCC; periodic acid and lead tetraacetate oxidation of 1,2-diols.

## Exploitation of acidity of α-H of C=O

Formation of enols and enolates; kinetic and thermodynamic enolates; reactions (mechanism with evidence):halogenation of carbonyl compounds under acidic and basic conditions, Hell-Volhard-Zelinsky (H. V. Z.) reaction, nitrosation, $SeO_2$ (Riley) oxidation; condensations (mechanism with evidence): Aldol,Tollens', Knoevenagel, Claisen-Schmidt, Claisen ester including Dieckmann; Mannich reaction,Perkin reaction; alkylation of active methylene compounds; synthetic applications of diethyl malonate and ethyl acetoacetate; specific enol equivalents (lithium enolates, enamines and silyl enol ethers) in connection with alkylation, acylation and aldol type reaction.

## Nucleophilic addition to α, β-unsaturated carbonyl system

General principle and mechanism (with evidence); direct and conjugate addition, addition of enolates (Michael reaction), Robinson annulations reaction.

## Substitution at $sp^2$ carbon (C=O system)

Mechanism (with evidence): $B_{AC}2$, $A_{AC}2$, $A_{AC}1$, $A_{AL}1$ (inconnection to acid and ester); acid derivatives: amides, anhydrides & acyl halides (formation and hydrolysis including comparison).

## Module: III

### Organometallics (5 Lectures)

Grignard reagents, Organolithiums; Gilman cuprates: preparation and reactions (mechanism with evidence); addition of Grignard and organolithium to carbonyl compounds; substitution on -COX; directed *ortho* metalation of arenes using organolithiums, conjugate addition by Gilman cuprates; Corey-House synthesis; abnormal behaviour of Grignard reagents; comparison of reactivity among Grignard, organolithiums and organocopper reagents; Reformatsky reaction; concept of umpolung.

### Recommended Text Books


1. Finar, I. L. Organic Chemistry (Volume 1), 6$^{th}$Edition, Pearson Education, 2002
2. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
3. Morrison, R. N. & Boyd, R. N. and Bhattacharjee,Organic Chemistry, 7$^{th}$Edition, (Pearson Education), 2010
4. Nasipuri, D. Stereochemistry of Organic Compounds, 4$^{th}$ Edition, New Age International Pvt Ltd, 2020


### Practical :(30 Lectures)

### PAPER: CHEM-H-CC6-4-P

### (DSCC-6)

### Qualitative analysis of single solid organic compound

1. Detection of special elements (N, S, Cl) by Lassaigne's test

2. Solubility and classification (solvents: $H_2O$, 5% HCl, 5% NaOH and 5% NaHCO3)

3. Detection of the following functional groups by systematic chemical tests: aromatic amino (Ar-NH2), aromatic nitro (-NO2), amido (-CONH2, including imide), phenolic –OH, carboxylic acid (-COOH), carbonyl (distinction between -CHO and >C=O); only one test for each functional group is to be reported.

Each student, during laboratory session, is required to carry out qualitative chemical tests for all the special elements and the functional groups in known and unknown (**at least six)** organic compounds.

## Reference Books

1. Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University of Calcutta, 2015

2.Furniss, Hannaford, Smith, Tatcholl, Vogel's Textbook of Practical Organic Chemistry ,5th Edition, Pearson India, 2003

# CHEMISTRY MAJOR

## PAPER:CHEM-H-CC7-4-Th

## (DSCC-7)

## (Credit: Theory -03, Practical – 01)

## Physical Chemistry - II

## Theory: (45 Lectures)

### Module: I

## Transport processes and Liquid State

## Diffusion and Viscosity (5 Lectures)

### Diffusion

Fick's law, Flux, force, phenomenological coefficients & their inter-relationship (general form), different examples of transport properties

### Viscosity

General features of fluid flow (streamline flow and turbulent flow); Newton's equation, viscosity coefficient; Poiseuille's equation (with derivation); principle of determination of viscosity

coefficient of liquids by falling sphere method and using Ostwald's viscometer. Temperature variation of viscosity of liquids and comparison with that of gases. Relation between viscosity coefficient of a gas and mean free path.

### Surface tension and energy (4 Lectures)

Surface tension, surface energy, excess pressure, capillary rise and surface tension; Work of cohesion and adhesion, spreading of liquid over other surface; Vapour pressure over curved surface; Temperature dependence of surface tension

## Module: II

### Solid State (12 Lectures)

### Bravais Lattice and Laws of Crystallography

Types of solid, Bragg's law of diffraction; Laws of crystallography (Haüy's law and Steno's law); Permissible symmetry axes in crystals; Lattice, space lattice, unit cell, crystal planes, Bravais lattice. Packing of uniform hard sphere, close packed arrangements (fcc and hcp); Tetrahedral and octahedral voids. Void space in cubic systems

### Crystal plane

Distance between consecutive planes [cubic and orthorhombic lattices]; Indexing of planes, Miller indices; calculation of $d_{hkl}$; Relation between molar mass and unit cell dimension for cubic system; Bragg's law (derivation). Determination of crystal structure: Powder method; Structure of NaCl and KCl crystals.

## Module: III

### Application of Thermodynamics – II (16 Lectures)

### Colligative properties

Vapour pressure of solution; Ideal solution, ideally dilute solution and colligative properties; Raoult's law.Thermodynamic derivations(using chemical potential)relating (i) Elevation of boiling point of an ideally dilute solution containing a non-volatile nonelectrolyte solute, (ii) Depression of freezing point of an ideally dilute solution containing a non -volatile nonelectrolytesolute (iii) Osmotic pressure of an ideally dilute solution containing a nonvolatile nonelectrolyte solutewith the molality / molar concentration of solute in solution.Applications in calculating molar masses of normal, dissociated and associated solutes in solution; Abnormal colligative properties.

## Phase Equilibrium

## Phase Rule

Definitions of phase, component and degrees of freedom; Phase rule and its derivations; Definition of phase diagram; Phase diagram for water, $CO_2$, Sulphur. First order phase transition and Clapeyron equation; Clausius- Clapeyron equation - derivation and use; Ehrenfest Classification of phase transition.

## Binary solutions

Liquid vapour equilibrium for two component systems. Ideal solution at fixed temperature and pressure; Lever Rule. Principle of fractional distillation; Duhem-Margules equation; Henry's law; Konowaloff's rule; Positive and negative deviations from ideal behaviors; Azeotropic solution; Liquid-liquid phase diagram using phenol- water system; Solid-liquid phase diagram; Eutectic mixture

Three component systems, water-chloroform-acetic acid system, triangular plots.

## ELECTROCHEMISTRY-II: (8 Lectures)

## Electromotive Force:

Rules of oxidation/reduction of ions based on half-cell potentials, Chemical cells, reversible and irreversible cells with examples; Electromotive force of a cell and its measurement, Thermodynamic derivation of Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone and glass electrodes. Concentration cells with and without transference, liquid junction potential; Potentiometric Titration.

## Recommended Text Books


1. Levine, I. N. Physical Chemistry, 6$^{th}$Edition McGraw-Hill India, 2011
2. Castellan, G. W. Physical Chemistry, Narosa , 2004
3.Atkins, P. W. & Paula, J. de, Atkins' Physical Chemistry, 11$^{th}$ Edition,Oxford University Press, 2018

**Practical :(30 Lectures)**

**PAPER:CHEM-H-CC7-4-P**

**(DSCC-7)**

## 1. Surface tension measurements using Stalagmometer

a) Determine the surface tension of a given solution by drop weight method using a stalagmometer.

b) Study the variation of surface tension of acetic acid solutions with concentration and hence determinegraphically the concentrationof an unknown solution of acetic acid.

## 2. Viscosity measurement using Ostwald's viscometer

a)Determination of viscosity of aqueous solutions of (i) ethanol and (ii) sugar at room temperature.

b)Study the variation of viscosity of sucrose solution with the concentration of solute and hence determine graphically the concentration of an unknown solution.

## 3. ConductometricExperiments

a) Conductometric titration of an acid (Mixture Strong and Weak monobasic acid, and Dibasic acid) against strong base.

b) Study of kinetics saponification reaction conductometrically

## Reference Books

1.Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University of Calcutta, 2015

# CHEMISTRY MAJOR

## PAPER:CHEM-H-CC8-4-Th

## (DSCC-8)

## (Credit: Theory -03, Practical – 01)

## Inorganic Chemistry – II

## Theory: (45 Lectures)

### Module: I

## Coordination chemistry (26 Lectures)

### Basics of coordination chemistry

Werner's theory, ligands, IUPAC nomenclature, Isomerism (constitutional and stereo isomerism, Geometrical and optical isomerism in square planar and octahedral complexes)

### Valence bond theory and crystal field theory

VB description and its limitations. Elementary Crystal Field Theory: splitting of $d^n$ configurations in octahedral, square planar, tetrahedral, trigonal bipyramidal (basic idea), square pyramidal (basic idea) and pentagonal bipyramidal (basic idea) fields; crystal field stabilization energy (CFSE) in weak and strong fields; pairing energy. Spectrochemical series. Jahn- Teller distortion. Octahedral site stabilization energy (OSSE). Metal-ligand bonding (MO concept, elementary idea), sigma- and pi-bonding in octahedral complexes (qualitative pictorial approach) and their effects on the oxidation states of transitional metals (examples).

### Electronic spectra of complexes and magnetic properties

d-d transitions; L-S coupling; qualitative Orgel diagrams for $3d^1$ to $3d^9$ ions. Racah parameter. Selection rules for electronic spectral transitions; spectrochemical series of ligands; charge transfer spectra (elementary idea). Orbital and spin magnetic moments, spin only moments of $d^n$ ions and their correlation with effective magnetic moments, including orbital contribution; quenching of magnetic moment: super exchange and antiferromagnetic interactions (elementary idea with examples only);

.

## Module: II

### Supramolecular chemistry (08 Lectures)

Hydrogen bonding. Non-covalent interactions – examples of Ion-Dipole Interactions, Dipole-Dipole interactions, Dipole-Induced Dipole and Ion-Induced Dipole interactions, van der Waals or Dispersion Interactions, Halogen bonding, Cation- interactions, Anion-pi interactions, pi - pi interactions, Aromatic-Aromatic Interactions: Edge-to-face *vs* pi-pi Stacking Interactions, N-H-pi interactions, Sulfur-aromatic interactions.

## Module: III

### Redox reactions: (11 Lectures)

### Basic principle of redox reactions

Elementary idea on standard redox potentials with sign conventions. Nernst equation (without derivation). Influence of complex formation, precipitation and change of pH on redox potentials; formal potential.

### Redox titrations

Feasibility of a redox titration, redox potential at the equivalence point, redox indicators. Redox potential diagram (Latimer and Frost diagrams) of common elements and their applications. Disproportionation and comproportionation reactions (typical examples).

### Recommended Text Books

1. J. E. Huheey, E. A. Keiter, R. L. Keiter, Okhil K. Medhi, Principles of Structure and Reactivity, 5$^{th}$Edition, Pearson India, 2022
2. H. J. Arnikar, Essentials of Nuclear Chemistry, 5$^{th}$Edition, New Age International Pvt, Ltd., 2022
3.G. Friedlander, J.W. Kennedy, E. S. Macias, J.M. Miller, Nuclear and radiochemistry, 3$^{rd}$Edition, John Wiley, 1981
4. J. W. Steed and J. L. Atwood, Supramolecular Chemistry,2$^{nd}$ Edition, Wiley India, 2017
5. J-M Lehn, Supramolecular Chemistry

**Practical :(30 Lectures)**

**PAPER: CHEM-H-CC8-4-P**

**(DSCC-8)**

## Estimation of mixtures of metal ions

1. Estimation of $Fe^{3+}$ and $Cu^{2+}$ in a mixture.
2. Estimation of $Fe^{3+}$ and $Cr^{3+}$ in a mixture.
3. Estimation of $Fe^{3+}$ and $Cr_2O_7^{2-}$ in a mixture.
4. Estimation of $Fe^{3+}$ and $Mn^{2+}$ in a mixture.
5. Estimation of $Cr^{3+}$and $Mn^{2+}$in a mixture.

## Reference Books

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2.Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University of Calcutta, 2015

# CHEMISTRY MAJOR

**PAPER: CHEM-H-CC9-5-Th**

**(DSCC-9)**

**(Credit: Theory -03, Practical – 01)**

# ORGANIC CHEMISTRY – III

## Theory: (45 Lectures)

## Module: I

## Organic Spectroscopy -I (20 Lectures)

### UV Spectroscopy

Introduction; types of electronic transitions, end absorption; transition dipole moment and allowed/forbidden transitions; chromophores and auxochromes; Bathochromic and Hypsochromicshifts; intensity of absorptions (Hyper-/Hypochromic effects); relative positions of $\lambda_{max}$ considering conjugative effect, steric effect, solvent effect, effect of pH.

### IR Spectroscopy

Introduction; modes of molecular vibrations(fundamental and non-fundamental); IR active molecules; application of Hooke's law, force constant; *fingerprint region* and its significance; effect of deuteration; overtone bands; vibrational coupling in IR; characteristic and diagnostic stretching frequencies of C-H, N-H, O-H, C-O, C-N, C-X, C=C (including skeletal vibrations of aromatic compounds), C=O, C=N, N=O, C≡C, C≡N; characteristic bending vibrations are included; factors affecting stretching frequencies: effect of conjugation, electronic effects, mass effect, bond multiplicity, ring-size, solvent effect, H-bonding on IR absorptions; application in functional group analysis.

### NMR Spectroscopy

Introduction; nuclear spin; NMR active molecules; basic principles of Proton Magnetic Resonance; choice of solvent and internal standard; equivalent and non-equivalent protons; chemical shift and factors influencing it; ring current effect; significance of the terms: up-/downfield, shielded and deshielded protons; spin coupling and coupling constant (1st order spectra); relative intensities of *first-order*multiplets: Pascal's triangle; chemical and magnetic equivalence in NMR ; anisotropic effects in alkene, alkyne, aldehydes and aromatics; Idea about NMR peak area, integration; relative peak positions; rapid proton exchange; interpretation of

NMR spectra of simple compounds: Ethanol, diethyl malonate, diethyl fumarate, *trans*-cinnamic acid, benzene, toluene, benzaldenyde, *p*-nitrobenzaldehyde, dinitrobenzenes, nitroanilines.

Applications of IR, UV and NMR spectroscopy for identification of simple organic molecules

## Module: II

## Rearrangements (15 Lectures)

Mechanism with evidence (including crossover experiments) and stereochemical features for the following:

### Rearrangement to electron-deficient carbon

Wagner-Meerwein rearrangement, pinacol rearrangement, dienone-phenol; Wolff rearrangement in Arndt-Eistert synthesis, benzil-benzilic acid rearrangement, Demjanov rearrangement, Tiffeneau–Demjanov rearrangement.

### Rearrangement to electron-deficient nitrogen

Rearrangements: Hofmann, Curtius, Lossen, Schmidt and Beckmann.

### Rearrangement to electron-deficient oxygen

Baeyer-Villiger oxidation, cumene hydroperoxide-phenol rearrangement and Dakin reaction.

### Aromatic rearrangements: Migration from oxygen to ring carbon

Fries rearrangement and Claisen rearrangement.

### Migration from nitrogen to ring carbon

*N*-azo to *C*-azo rearrangement, Bamberger rearrangement, Orton rearrangement and benzidine rearrangement.

## Module: III

## Nitrogen compounds (10 Lectures)

### Amines: Aliphatic & Aromatic

Preparation, separation (Hinsberg's method) and identification of primary, secondary and tertiary amines; reaction (with mechanism): Eschweiler–Clarke methylation, diazo coupling reaction, formation and reactions of phenylenediamines, diazomethane and diazoacetic ester.

### Nitro compounds (aliphatic and aromatic)

Preparation and reaction (with mechanism): reduction under different conditions; Nef carbonyl synthesis, Henry reaction and conjugate addition of nitroalkane anion.

### Alkylnitrile and isonitrile

Preparation and reaction (with mechanism): Thorpe nitrile condensation, von Richter reaction.

### Diazonium salts and their related compounds

Reactions (with mechanism) involving replacement of diazo group; reactions: Gomberg, Meerwein, Japp-Klingermann.

## Recommended Text Books


1. Kemp. W, Organic Spectroscopy, Macmillan, 3rd Edition, 2022
2. Dyer, Applications of Absorption Spectroscopy of Organic Compounds,Prentice Hall India Learning Private Limited, 1978
3. Pavia. Donald L, Introduction to Spectroscopy, 5th Edition, Cengage India Private Limited, 2015
4. Finar, I. L. Organic Chemistry (Volume 1), Vol 1, 6th Edition (Pearson Education India), 2002.
5. Morrison, R. N. & Boyd, R. N. and Bhattacharjee, Organic Chemistry,7th Edition, Pearson Education, 2010

## Practical :(30 Lecture hours)

## PAPER: CHEM-H-CC9-5-P

## (DSCC-9)

## Organic Preparations

A. The following reactions (at least 5) are to be performed, noting the yield of the crude product:

1. Nitration of aromatic compounds

2. Condensation reactions

3. Hydrolysis of amides/imides/esters

4. Acetylation of phenols/aromatic amines

5. Side chain oxidation of aromatic compounds

6. Diazo coupling reactions of aromatic amines

7. Bromination of anilides (Bromate-Bromide method)

**Students must also calculate percentage yield, based upon isolated yield (crude) and theoretical yield.**

B. Purification of the crude product is to be made by crystallization from water/alcohol, crystallization after charcoal treatment, or sublimation, whichever is applicable.

C. Melting point of the purified product is to be noted.

# CHEMISTRY MAJOR

## PAPER: CHEM-H-CC10-5-Th

## (DSCC-10)

## (Credit: Theory – 03, Practical – 01)

### Inorganic Chemistry – III

## Theory: (45 Lectures)

### Module: I

### s- and p- block elements (30 Lectures)

General properties of s- and p-block elements. Behavior of alkali metals in liquid ammonia.Preparation and structure of basic beryllium acetate and nitrate, beryllium halides. Relative stability of different oxidation states of Groups 13, 14 and 15.Allotropy and catenation.Hydrolytic behavior of the halides of Group 15.Structure and magnetism of gallium dichloride.Preparation,structure, bonding, properties and usesofboric acid, borates, diborane, graphitic compounds, fullerenes, oxides and oxoacids of nitrogen, phosphorus, sulphur and chlorine.Preparation, structure and properties of peroxo acids of sulphur, sulphur-nitrogen compounds, interhalogen compounds, polyhalides, pseudo halogens, fluorocarbons. Basic properties of halogens, super halogen. Special properties of helium. Preparation of fluorides, oxides of xenon and perxenates.Clathrates of noble gas elements. Usesof noble gases.

Inorganic polymers:General characteristics, comparison with organic polymers.Preparation, structure and uses of silicones and siloxanes, borazines,polymeric boron nitride $(BN)_x$,phosphazenes and polythiazyl $(SN)_x$

### Module: II

### d- and f- block elements (9 Lectures)

General comparison of 3d, 4d and 5d elements in terms of oxidation states, metal-metal bond, redox propertiesof Gr. 6-11

General comparison of lanthanoids and actinoids in terms of electronic configuration, oxidation states, spectral andmagnetic properties.Lanthanoid and actinoid contraction. Separation of

lanthanides (ion-exchangemethod only). Uses of lanthanoids and actinoids in spectral, magnetic and theranostic applications**.**

## Module: III

## Nuclear Model and Radiotracer methods (6 Lectures)

Liquid drop model, Shell model, magic numbers. Concept of nuclear quantum number. Spin Isomerism

Overview of radioisotope production, radiometric titrations. Radiotracer methods: study of mechanism of chemical reactions, nuclear medicine, isotope dilution analysis.

## Recommended Text- Books and Reference Books


1. Concise Inorganic Chemistry, J. D. Lee, 5$^{th}$Ed., Wiley India Pvt. Ltd., 2008.

2. Shriver & Atkins' Inorganic Chemistry, Atkins, Overton, Rourke, Weller, Armstrong; 6$^{th}$Ed., Oxford University Press, 2010.

3. N. N. Greenwood, & A. Earnshaw, Chemistry of the Elements, Butterworth-Heinemann, 1997.

4. H. J. Arnikar, Essentials of Nuclear Chemistry, 5$^{th}$Edition, New Age International Pvt, Ltd., 2022

5. G. Friedlander, J.W. Kennedy, E. S. Macias, J. M. Miller, Nuclear and Radiochemistry, 3$^{rd}$Ed., John Wiley, 1981

6. F.A. Cotton, G.W. Wilkinson, C.A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, Wiley, 6e

**Practical: (30 Lecture hours)**

**PAPER: CHEM-H-CC10-5-P**

**(DSCC-10)**

## Analysis of materials of industrial importance

**1. Cu and Zn in brass (Complexometry)**

**2. $CaCO_3$ and $MgCO_3$ in Dolomite**

**3. Cr and Mn in steel**

**4. Vitamin C**

**5. DO in water sample**

**6. $Fe_2O_3$ in Portland cement**

**7. Mg in talcum powder**

## Reference Books

1. J. Mendham, A. I. Vogel's Quantitative Chemical Analysis 6$^{th}$Ed., Pearson, 2009.

2. Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University of Calcutta, 2015

3. University Handbook of Undergraduate Chemistry Experiments, University of Calcutta, 2003

# CHEMISTRY MAJOR

## PAPER: CHEM-H-CC11-5-Th

## (DSCC-11)

## (Credit: Theory -03, Practical – 01)

### Physical Chemistry – III

## Theory: (45 Lectures)

### Module: I

## Foundation of Quantum Mechanics (18 Lectures)

### Particle Aspect of Radiation

Blackbody Radiation, Photoelectric Effect, Compton Effect.

### Wave Aspect of particles

de Broglie's Hypothesis: Matter Wave, Heisenberg's Uncertainty Principle. Wave packet, time evolution of wave function. Group and Phase Velocities.

### Schrodinger Equation and Wavefunction

The time dependent Schrodinger equation. The time-independent Schrodinger equation; nature of the equation, acceptability conditions for the wave functions and probability interpretations of wave function. Vector representation of wave function. Dirac's bra-ket notation. Orthonormality of wave function.

### Concept of Operators

Elementary concepts of operators, eigenfunctions and eigenvalues; Linear operators; Commutation of operators, commutator and uncertainty relation; Expectation value;

### The Postulates and General Principles of Quantum Mechanics

Postulates of Quantum Mechanics. Hermitian operators, definition and examples. Theorems about Hermitian operators. Expansion of a function in terms of eigenfunctions. Eigenfunctions of commuting operators.

## Module: II

### Exactly Solvable Systems -1 (12 Lectures)

### Particle in a box

Setting up of Schrodinger equation for one-dimensional box and its solution; Comparison with free particle eigenfunctions and eigenvalues. Properties of PB wave functions (normalization, orthogonality, probability distribution); Expectation values of x, $x^2$, $p_x$ and $p_x^2$ and their significance in relation to the uncertainty principle; Extension of the problem to two and three dimensions and the concept of degenerate energy levels.

### Stationary states under special potentials

The Potential Step – (I) When $E>V_o$, (II) when $E<V_o$, Reflection coefficient and transmission coefficient. Particle in a 1-D potential barrier of finite height and finite thickness ($E>V_o$ and $E<V_o$).Quantum Mechanical Tunneling. Particle in a finite potential well ($0<E<V_o$). Bound states in slowly varying potential.

## Module: III

### Surface Chemistry

### Adsorption (05 Lectures)

Physical and chemical adsorption; Freundlich and Langmuir adsorption isotherms; multilayer adsorption and BET isotherm; Gibbs adsorption isotherm and surface excess; Heterogeneous catalysis (single reactant);

### Colloids (05 Lectures)

Lyophobic and lyophilic sols, Origin of charge and stability of lyophobic colloids, Coagulation and Schultz-Hardy rule, Zeta potential and Stern double layer (qualitative idea), Tyndall effect; Electrokinetic phenomena (qualitative idea only); Stability of colloids and zeta potential; Micelles, reverse micelles; micellization equilibrium; thermodynamics of micellization.

## Electrical Properties of molecules

## Dipole moment and polarizability (05 Lectures)

Polarizability of atoms and molecules, dielectric constant and polarization, molar polarization for polar and non-polar molecules; Clausius-Mosotti equation and Debye equation (both without derivation) and their application; Determination of dipole moments

## Recommended Text Books


1. Levine, I. N. Physical Chemistry, 6th Edition, McGraw-Hill India,2011.
2. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press,1997.
3. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, 11th Edition, Oxford University Press, 2018.
4. Levine, I.N, Quantum Chemistry, 7th Edition, Pearson, , 2016.
5. McQuarrie, D.A, Quantum Chemistry, 2nd Edition,University Science Books, 2008.


## Practical: (30 Lecture hours)

## CHEM-H-CC11-5-P

## (DSCC-11)

### 1. Conductometric Experiments

To determine the ionization constant of a weak acid by conductometric method.

## 2. Potentiometric Experiments

a) Potentiometric titration of Mohr's salt solution against standard $K_2Cr_2O_7$ and $KMnO_4$ solutionand hence determine the standard reduction potential ($E^0$) of $Fe^{+3}$ / $Fe^{+2}$ couple in the hydrogen scale.
b) Determination of concentration of (i) $AgNO_3$ solution and (ii) solubility product of AgCl by potentiometric titration of $AgNO_3$ solution against standard KCl solution.

### 3. Solubility Product:

a) Determination of solubility and solubility product of a sparingly soluble salt in water, and in various electrolytic media by titrimetric method.
b) Determination of the activity solubility product of KHTa from the variation of concentrated solubility product with the ionic strength of the solution

## Reference Books

1.Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.

# CHEMISTRY MAJOR

## PAPER: CHEM-H-CC12-5-Th

## (DSCC-12)

## (Credit: Theory -03, Practical – 01)

# ORGANIC CHEMISTRY – IV

## Theory: (45 Lectures)

## Module: I

## Organic Synthesis-I (15 Lectures)

### Retrosynthetic analysis

Disconnections; synthons, donor and acceptor synthons; natural reactivity and *umpolung*; latent polarity in bifunctional compounds: illogical electrophiles and nucleophiles; synthetic equivalents; functional group interconversion and addition (FGI and FGA); C-C disconnections and synthesis: one-group and two-group (1,2- to 1,5-dioxygenated compounds), reconnection (1,6-dicarbonyl); protection-deprotection strategy (alcohol, amine, carbonyl, acid).

*Strategy of ring synthesis:* Thermodynamic and kinetic factors; synthesis of large rings, application of high dilution technique, Favorskii Rearrangement in relation to ring contraction.

## Module: II

## Carbocycles (5 Lectures)

### Polynuclear hydrocarbons and their derivatives

*S*ynthetic methods include Haworth, Bardhan-Sengupta, Bogert-Cook (with mechanistic details); fixation of double bonds and Fries rule; reactions (with mechanism) of naphthalene, anthracene and phenanthrene and their derivatives.

.

## Heterocycle-I (13 Lectures)

### Heterocyclic compounds

Reactivity, orientation and important reactions (with mechanism) of furan, pyrrole, thiophene and pyridine; synthesis (including retrosynthetic approach and mechanistic details): pyrrole: Knorr synthesis, Paal-Knorr synthesis, Hantzsch; furan: Paal-Knorr synthesis, Feist-Benary synthesis and its variation; thiophenes: Paal-Knorr synthesis, Hinsberg synthesis; pyridine:

Hantzsch synthesis; benzo-fused 5-and 6-membered rings with one heteroatom: reactivity, orientation and important reactions (with mechanistic details) of indole, quinoline and isoquinoline; synthesis (including retrosynthetic approach and mechanistic details): indole: Fischer, quinoline: Skraup, isoquinoline: Bischler-Napieralski synthesis

## Module: III

## Stereochemistry and Reactions of Alicyclic Compound (12 Lectures)

Concept of I-strain (Baeyer's strain theory);conformational analysis: cyclohexane, mono and disubstituted cyclohexane; symmetry properties and optical activity; topomerisation; ring size and ease of cyclisation; conformation & reactivity in cyclohexane system: consideration of steric and stereoelectronic requirements; elimination (E2, E1), nucleophilic substitution ($S_N1$, $S_N2$, $S_Ni$, NGP), merged substitution-elimination; rearrangements; oxidation of cyclohexanol, esterification, saponification, lactonisation, epoxidation, pyrolytic *syn* elimination and fragmentation reactions.

.

## Recommended Text Books


1. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 2002.

2. Eliel, E. L. &Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.

3. Organic Synthesis: The Disconnection Approach, Stuart Warren (Author), Paul Wyatt (Author), 2008.

4. John Joule , Keith Mills , George Smith , Heterocyclic Chemistry,3rd Edition,1995, CRC Press.

5. J. Joule, Heterocyclic Chemistry,5th Edition, Wiley, 2010.

**Practical: (30 Lecture hours)**

**CHEM-H-CC12-5-P**

**(DSCC-12)**

**TLC & PAPER CHROMATOGRAPHY – AMINO ACIDS, DYESCOLUMN CHROMATOGRAPHY (DEMO)**

## Chromatographic Separations

1. TLC separation of a mixture containing 2/3 amino acids

2. TLC separation of a mixture of dyes (fluorescein and methylene blue)

3. Paper chromatographic separation of a mixture containing 2/3 amino acids

4. Column chromatographic separation of mixture of dyes (DEMO)

## Reference Books

1.Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.

# CHEMISTRY MAJOR

**PAPER: CHEM-H-CC13-6-Th**

**(DSCC-13)**

**(Credit: Theory -03, Practical – 01)**

### Physical Chemistry - IV

**Theory: (45 Lectures)**

### Module: I

**Exactly Solvable Systems -2** **(15 Lectures)**

**Quantum Harmonic Oscillator**

Setting up ofOne-dimensional Schrödinger equation.Solving Hermite differential equation, Algebraic solution for the ground and excited states of QHO. Classical turning points, Expectation values of x, $x^2$, $p_x$ and $p_x^2$.

## Rigid Rotator

Commutation rules of angular momentum, Angular Momentum operators in spherical polar coordinates. Quantization of square of total angular momentum and z-component; Rigid rotator model of rotation of diatomic molecule; Schrödinger equation, transformation to spherical polar coordinates; Separation of variables. Spherical harmonics; Discussion of solution

## Hydrogen atom and hydrogen-like ions

Setting up of Schrödinger equation in spherical polar coordinates, Separation of variables, Solution of angular Part (φ part only), quantization of energy (only final energy expression); Real wave functions. Average and most probable distances of electron from nucleus; Setting up of Schrödinger equation for many-electron atoms (He, Li)

# Module: II

## Molecular Spectroscopy (20 Lectures)

Interaction of electromagnetic radiation with molecules and various types of spectra;

## Rotation spectroscopy

Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution

## Vibrational spectroscopy

Classical equation of vibration, computation of force constant, amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, Diatomic vibrating rotator, P, Q, R branches

## Electronic Spectroscopy

Potential energy curves (diatomic molecules), Frank-Condon principle and vibrational structure of electronic spectra; Frank Condon factor. Bond dissociation and principle of determination of dissociation energy (ground state); Decay of excited states by radiative and non- radiative paths; Pre-dissociation; Fluorescence and phosphorescence, Jablonskii diagram;

## Raman spectroscopy

Classical Treatment. Rotational Raman effect; Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion

## Module: III

## Photochemistry (10 Lectures)

Characteristics of electromagnetic radiation, Lambert-Beer's law and its limitations, physical significance of absorption coefficients; Laws of photochemistry, Stark-Einstein law of photochemical equivalence quantum yield, actinometry, examples of low and high quantum yields

## Rate of Photochemical processes

Photochemical equilibrium and the differential rate of photochemical reactions, Photo stationary state; HI decomposition, $H_2$-$Br_2$ reaction, dimerization of anthracene; photosensitized reactions, quenching, Stern-Volmer equation. Role of photochemical reactions in biochemical processes.

## Recommended Text Books


1. Levine, I. N. Physical Chemistry, 6th Edition, McGraw-Hill India ,2011.
2. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press,1997.
3. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, 11th Edition, Oxford University Press, 2018.
4. Levine, I.N, Quantum Chemistry, 7th Edition, Pearson,2016.
5. McQuarrie, D.A, Quantum Chemistry, 2nd Edition, University Science Books, 2008.
6. Colin Banwell and Elaine McCASH, Fundamentals of Molecular Spectroscopy, 6th Edition Affiliated East-West Press ,2024.
7. Barrow, G. M. Molecular Spectroscopy, McGraw-Hill, 1962.

## Practical: (30 Lecture hours)

## CHEM-H-CC13-6-P

## (DSCC-13)

## Using Spreadsheet Software

1. Determination of Molar Enthalpy of Vaporization using Linear and Non-Linear Least squares fit.

2. Calculation and Plotting of a Precipitation Titration Curve with MS Excel.

3. Acid-Base Titration Curve using Excel Goal Seek Function.

4. Plotting of First and Second Derivative Curve for pH metric and Potentiometric titration.

5. Use of spreadsheet to solve the 1D Schrodinger Equation (Numerov Method), Particle in a box.

6. Michaelis-Menten Kinetics for Enzyme Catalysis using Linear and Non - Linear Regression.

7. Roots of equation –Newton-Raphson method. (e.gvolume of van der Waals gas and comparison with ideal gas, pH of a weak acid)

8. Numerical Integration using Simpson's $1/3^{rd}$ rule and Trapezoidal rule. (e.g. entropy/enthalpychange from heat capacity data), (probability distributions (gas, kinetic theory) and mean values)

## Recommended Books


1. Levine, I. N. Physical Chemistry, 6th Edition, McGraw-Hill India ,2011.
2. Levine, I.N, Quantum Chemistry, $7^{th}$ Edition, Pearson,2016.
3. Stanley Crouch , Douglas Skoog , F. Holler , Donald West, Applications of Microsoft Excel in Analytical Chemistry, Cengage Learning,2021.

# CHEMISTRY MAJOR

## PAPER: CHEM-H-CC14-6-Th

## (DSCC-14)

## (Credit: Theory -03, Practical – 01)

## ORGANIC CHEMISTRY – V

## Theory: (45 Lectures)

### Module: I

## Carbohydrate (18 Lectures)

## Monosaccharides

Aldoses up to 6 carbons; structure of D-glucose & D-fructose (configuration & conformation); ring structure of monosaccharides (furanose and pyranose forms): Haworth representations and non-planar conformations; anomeric effect (including stereoelectronic explanation); mutarotation; epimerization; reactions (mechanisms in relevant cases): Fischer glycosidation, osazone formation, bromine-water oxidation, $HNO_3$ oxidation, selective oxidation of terminal –$CH_2OH$ of aldoses, reduction to alditols, Lobry de Bruyn-van Ekenstein rearrangement; stepping–up (Kiliani-Fischer method) and stepping–down (Ruff's &Wohl's methods) of aldoses; end-group-interchange of aldoses; acetonide (isopropylidene and benzylidene protections; ring size determination; Fischer's proof of configuration of (+)-glucose.

*Disaccharides:* Structure of sucrose, inversion of cane sugar.

## Biomolecules – I

## Amino acids

Synthesis with mechanistic details: Strecker, Gabriel; acetamido malonic ester, azlactone, Bücherer hydantoin synthesis, synthesis involving diketopiperizine, isoelectric point, zwitterions; electrophoresis, reaction (with mechanism): ninhydrin reaction, Dakin-West reaction; resolution of racemic amino acids.

## Peptides

Peptide linkage and its geometry; syntheses (with mechanistic details) of peptides using *N*-protection & C-protection, solid-phase (Merrifield) synthesis; peptide sequence: *C*-terminal and *N*-terminal unit determination (Edman, Sanger and 'dansyl' methods); partial hydrolysis; specific cleavage of peptides; use of CNBr.

.

## Nucleic acids

Pyrimidine and purine bases (only structure & nomenclature); nucleosides and nucleotides corresponding to DNA and RNA; elementary idea of double helical structure of DNA (Watson-Crick model); complimentary base–pairing in DNA.

# Module: II

## Concept of Aromaticity and Free Energy Relationship (15 Lectures)

MO treatment of acyclic and cyclic conjugated systems; Hückel's rule and concept of aromaticity, annulenes (upto [18]-annulene), fullerenes ($C_{60}$), charged systems (upto7 membered), anti-aromaticity, homo-aromaticity; graphical methods-Frost diagram. Huckel treatment – applications to ethylene, allyl, cyclopropenyl, butadiene, cyclobutadiene, Hammett equations – linear & non-linear.

# Module: III

## Pericyclic Reactions (12 Lectures)

Mechanism, stereochemistry, regioselectivity in case of

## Electrocyclic reactions

FMO approach involving 4π- and 6π-electrons (thermal and photochemical) and corresponding cycloreversion reactions.

## Cycloaddition reactions

FMO approach, Diels-Alder reaction, photochemical [2+2] cycloadditions.

## Sigmatropic reactions

FMO approach,sigmatropic shifts and their order; [1,3] and [1,5] H shifts and [3,3] shifts with reference to Claisen and Cope rearrangements.

## Recommended Text Books


1. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education), 2002.

2. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.

3. Morrison, R. N. & Boyd, R. N. *Organic Chemistry*, Pearson Education India. 7th Edition, (Pearson Education), 2010.


## Reference Text


1. Fleming, I. Pericyclic Reactions, Oxford Chemistry Primer, Oxford University Press.

2. Gilchrist, T. L. & Storr, R. C. Organic Reactions and Orbital symmetry, Cambridge University Press


## Practical: (30 Lecture hours)

## CHEM-H-CC14-6-P

## (DSCC-14)

## Spectroscopy ($^1$H-NMR and IR)

## Spectroscopic Analysis of Organic Compounds

1. Assignment of labelled peaks in the $^1$H NMR spectra of the known organic compounds explaining the relative δ-values and splitting pattern.

2. Assignment of labelled peaks in the IR spectrum of the same compound explaining the relative frequencies of the absorptions (C-H, O-H, N-H, C-O, C-N, C-X, C=C, C=O, N=O, C≡C, C≡N stretching frequencies; 3.

**Characteristic bending vibrations are included**

3. The students must record full spectral analysis of compounds from the following list:

(i) 4′-Bromoacetanilide (ii) 2-Bromo-4'-methylacetophenone (iii) Vanillin (iv) 2′-Methoxyacetophenone (v) Salicylamide (vi) 2′- Hydroxyacetophenone (vii) *trans*-Cinnamic acid (viii) 4′-Methylacetanilide (ix) 3-nitroanisole (x) 2,3-Dimethylbenzonitrile (xi) Pent-1-yn-3-ol (xii) 3-Nitrobenzaldehyde (xiii) 3-Aminobenzoic acid (xiv) Ethyl 3- aminobenzoate (xv) Ethyl 4-aminobenzoate.

## Reference Books

1.Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.

# CHEMISTRY MAJOR

## PAPER: CHEM-H-CC15-6-Th

## (DSCC-15)

## (Credit: Theory -03, Practical – 01)

## INORGANIC CHEMISTRY – IV

## Theory: (45 Lectures)

### Module: I

## Organometallic Chemistry–I (25 Lectures)

Definition and classification of organometallic compounds based on bond type. Concept of hapticity.18-electron and 16-electron rules and its stability (pictorial MO approach). Applications of 18-electron rule to transition metal organometallic complexes. General methods of preparation

of mono and binuclear carbonyls of 3d series.Structures of mono-, bi-, tri- and tetranuclear carbonyls .Different binding modes of CO and NO with examples. Comparison of σ- donor and π-acceptor behavior of CO, NO and $CN^-$. Synergistic effect and its interpretation through IR spectra. Bonding of iron nitrosyl (brown ring) complex as a special case. Zeise's salt: preparation, structure, bonding. Ferrocene: Structure, preparation, properties and reactions (acetylation, alkylation, oxidation, nitration, halogenation, metalation, Mannich condensation). Reactions of organometallic complexes: ligand dissociation, substitution, oxidative addition, reductive elimination, migration and insertion reactions. Organometallic catalysis – Homogeneous and Heterogeneous- Industrial importance- hydroformylation, hydrogenation of alkenes by Wilkinson's catalyst (Tolman catalytic loop), Ziegler – Natta polymerization.

## Module: II

### Bioinorganic Chemistry – I (10 Lectures)

Elements of life: essential and beneficial elements, major, trace and ultra-trace elements. Basic chemical reactions in biological systems and the role of metal ions (specially $Na^+$, $K^+$, $Mg^{2+}$, $Ca^{2+}$, $Fe^{3+/2+}$, $Cu^{2+/1+}$, $Zn^{2+}$ and $Mo^{3+/4+/6+}$) in biology. Dioxygen management proteins: Hemoglobin, Myoglobin, Hemocyanin and Hemerythrin. Electron Transport Proteins: Ferredoxins (2Fe-2S, 4Fe-4S, Reiske protein), Cytochrome C and Cytochrome C oxidase.

## Module: III

### Reaction kinetics and mechanism (10 Lectures)

Thermodynamic and kinetic stability. Significance of LFAE, Inert and Labile complexes. Substitution reaction pathways. Mechanism of nucleophilic substitution in square planar and octahedral complexes. Trans- effect and trans influence and its application in complex synthesis. Explanation of trans-effect through MO approach. Electron transfer reactions (basic ideas of Inner sphere and Outer sphere mechanisms).

## Recommended Text-Books

1. James E. Huheey/ Ellen A. Keiter/ Richard L. Keiter/ Okhil K. MedhiInorganic Chemistry, Principles ofStructure and Reactivity 5thEd., Pearson,2022.

2. G.L. Meissler, P.J. Fischer and D.A. Tarr, Inorganic Chemistry, 5e, Pearson

3.F.A. Cotton, G.W. Wilkinson, C.A. Murillo, M. Bochmann, Advanced Inorganic Chemistry, Wiley, 6e, 1999

## Reference Books

1. P. Powell, Principles of Organometallic Chemistry, Chapman and Hall, 1988.

2. J. P. Collman et al. Principles and Applications of OrganotransitionMetalChemistry, Mill Valley, CA: University Science Books, 1987.

3. R. H. Crabtree, The Organometallic Chemistry of the Transition Metals. NewYork, NY: John Wiley, 2000.

4. Robert R. Crichton, Biological Inorganic Chemistry:A New Introduction to Molecular Structure and Function,3rd Ed., Academic Press, 2018.

5.L. Bertini, H. B. Gray, S. J. Lippard, J. S. Valentine, Bioinorganic Chemistry, Viva, 2007.

6. F. Basolo and R.C. Pearson, Mechanisms of Inorganic Chemistry, John Wiley& Sons, NY, 1967.

17. K.F. Purcell and J.C. Kotz An Introduction toInorganic Chemistry,Saunders: Philadelphia, 1980.

18. B. Douglas, D Mcdaniell and J Alexander Concepts and Models in Inorganic Chemistry, 3e

9. Shriver & Atkins' Inorganic Chemistry, Atkins, Overton, Rourke, Weller, Armstrong; 6th Ed., Oxford University Press, 2010.

## Practical: (30 Lecture hours)

## PAPER: CHEM-H-CC15-6-P

## (DSCC-15)

## Preparation of Inorganic Complexes

1.*cis*-$K[Cr(C_2O_4)_2(H_2O)_2]$

2. $[Co(NH_3)_4(CO_3)]Cl$

3.$[Ni(en)_3]Cl_2$

4. $[Fe(acac)_3]$

5. $[Cu(acac)_2]$

6.$[VO(acac)_2]$

7. $[Ni(salen)_2]$ [salen = synthesised by condensation of salicylaldehyde and ethylenediamaine]

## Reference Books

1. Inorganic Syntheses, Wiley Publications

# CHEMISTRY MINOR

**PAPER:CHEM-H-CC1-1-Th**

**Or CHEM-H-CC1-3-Th**

**(MN-1)**

**(Credit: Theory -03, Practical – 01)**

## Fundamentals of Chemistry - I

**Theory: (45 Lectures)**

## Module: I

### Extra nuclear structure of atoms and Periodicity: (15 Lectures)

Wave-Particle duality; de Broglie hypothesis. Heisenberg's uncertainty principle. Introducing Schrödinger equation. Hydrogen and hydrogen like systems (detailed solution not required). Concept of Atomic Orbital; shapes of s, p and d orbitals. Radial and angular distribution curves. Extension to multielectronic systems. Aufbau principle and its limitations; Pauli's exclusion principle; Hund's rules and multiplicity. Effective nuclear charge. Shielding and penetration; Slater's rule.

The general idea about modern periodic table, atomic and ionic radii, ionization energy, electron affinity and electro negativity –definition, trends of variation in periodic table and their application in explaining and predicting the chemical behavior of elements and compounds. Electronegativity scales (Pauling's, Mulliken's and Allred-Rochow's scales). Inert pair effect.

## Module: II

## Basics of Organic Chemistry Bonding and Physical Properties

**(10 Lectures)**

## Valence Bond Theory

Nomenclature of Organic Compounds, Concept of hybridisation, shapes and structures of molecules, double bond equivalent (DBE), Resonance (including hyperconjugation) and Resonance energy.

## Electronic displacement

Inductive effect, bond polarization and bond polarizability;steric effect, steric inhibition of resonance.

## MO Theory

Qualitative idea about molecular orbitals, bonding and antibonding interactions, idea about σ, σ*, π, π *, n – MOs; concept of HOMO, LUMO and SOMO; sketch and energy levels of π MOs of i) acyclic p orbital system (C=C, conjugated diene, triene, allyl and pentadienyl systems) ii) cyclic p orbital system (neutral systems: [4], [6] annulenes; charged systems: 3-,4-,5-7 membered ring systems); Hückel's rules for aromaticity up to [8] annulene; concept of antiaromaticity; non-aromatic molecules.

## Physical properties

Melting point/boiling point and solubility of common organic compounds in terms of covalent & non-covalent intermolecular forces; polarity of molecules and dipole moments.

## Stereochemistry – I (5 Lectures)

Bonding geometries of carbon compounds and representation of molecules: tetrahedral nature of carbon and concept of asymmetry; Fischer, sawhorse, flying wedge and Newman projection formulae and their inter translations. Concept of chirality and symmetry: symmetry elements, molecular chirality and centre of chirality; asymmetric and dissymmetric molecules; enantiomers and diastereomers; concept of stereogenicity, chiral centres and number of stereoisomers: systems involving 1/2-chiral centre(s).

## Module: III

### Thermodynamics -I (9 Lectures)

Concept of systems (open, closed and isolated) and surroundings. State of a system; Intensive and extensive variables. Partial derivatives. Exact and inexact differentials. Path function and State function. Concept of heat and work. Zeroth law of thermodynamics. Concept of thermodynamic reversibility. Concept of internal energy and $1^{st}$ law of thermodynamics. Enthalpy and heat capacity, Relations between $C_p$ and $C_v$. Isothermal and Adiabatic processes. Calculations of $\Delta U$, $\Delta H$, q and w involving ideal gases in different processes.

Enthalpy of reaction. Hess's law. Enthalpy of formation and combustion. Kirchhoff's equation.

### Chemical Kinetics-I (6 Lectures)

Concept of order and molecularity. Rate laws for zero, $1^{st}$ and $2^{nd}$ order reactions and in general for any n-th order reaction. Determination of order of a reaction by half-life and differential methods. Rate determining step and steady state approximation. Opposing, Consecutive and parallel reactions (first order steps only). Temperature dependence of rate constant and Arrhenius equation.

### Recommended Text Books


1. Lee, J. D. Concise Inorganic Chemistry,$5^{th}$ Ed., Wiley India Pvt. Ltd., 2008.
2. Atkins, Overton, Rourke, Weller, Armstrong; Shriver & Atkins' Inorganic Chemistry, $5^{th}$ Ed., Oxford University Press, (2010).
3. Finar, I. L. Organic Chemistry (Volume 1), $6^{th}$ Edition, Pearson Education, 2002
4. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
5. Nasipuri, D. Stereochemistry of Organic Compounds, $4^{th}$ Edition, New Age International Pvt Ltd, 2020
6. Levine, I. N. Physical Chemistry, $6^{th}$ Edition McGraw-Hill India, 2011
7. Castellan, G. W. Physical Chemistry, Narosa , 2004
8. Atkins, P. W. & Paula, J. de, Atkins' Physical Chemistry, $11^{th}$ Edition, Oxford University Press, 2018
9. G. L. Miessler, D. A. Tarr, Inorganic Chemistry, $3^{rd}$ Edition, Pearson India, 2008


### Practical :(30 Lectures)

## PAPER: CHEM-H-CC1-1-P

## (MN-1)

(1) Calibration and use of apparatus.

(2) Preparation of primary standard solutions (Oxalic Acid and $K_2Cr_2O_7$)

## Acid-Base Titrations

(3) Standardization of NaOH standard oxalic acid solution.

(4) Estimation of carbonate and bicarbonate present together in a mixture

(5) Estimation of acetic acid in commercial Vinegar.

## Oxidation-Reduction Titrimetry

(6) Standardization of $KMnO_4$ standard oxalic acid solution.

(7) Estimation of Fe (II) using standardized $KMnO_4$ solution.

(8) Estimation of Fe (III) using standard $K_2Cr_2O_7$ solution.

(9) Estimation of Fe (II) and Fe (III) in a given mixture using standard $K_2Cr_2O_7$ solution.

## Reference Books

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.

2. Practical Workbook Chemistry (Honours), UGBOS, Chemistry, Universityof Calcutta, 2015

# CHEMISTRY MINOR

**PAPER:CHEM-H-CC2-2-Th**

**Or CHEM-H-CC2-4-Th**

**(MN-2)**

**(Credit: Theory -03, Practical – 01)**

## Fundamentals of Chemistry - II

**Theory: (45 Lectures)**

## Module: I

### Kinetic Theory and Gaseous state (8 Lectures)

Concept of pressure and temperature from kinetic theory of gas. Nature of distribution of velocities, Maxwell's distribution of speeds in one, two and three dimensions; Kinetic energy distribution in one, two and three dimensions, calculations of average, root mean square and most probable values in each case; Collision of gas molecules; Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar and different molecules); Wall collision and rate of effusion Calculation of number of molecules having energy $\geq \varepsilon$, Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases

### Real gas and Virial equation (7 Lectures)

Deviation of gases from ideal behavior; Compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation and its features; its derivation and application in explaining real gas behavior ; Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states; Virial equation of state; van der Waals equation expressed in the Virial form and significance of second virial coefficient; Intermolecular forces (Debye, Keesom and London interactions; Lennard-Jones potential - elementary idea.

## Module: II

### Chemical Bonding – I (10 Lectures)

i) Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its application and limitations. Packing of ions in crystals. Born-Lande equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. Defects in solids (elementary idea). Solubility energetics of dissolution process.

ii) Covalent bond: Polarizing power and polarizabilty, ionic potential, Fajan's rules, Lewis structures, formal charge, Valence Bond Theory, the hydrogen molecule (Heitler – London approach), directional character of covalent bonds, hybridizations, equivalent and non-equivalent hybrid orbitals, Bent's rules, dipole moments, VSEPR theory, shapes of molecules and ions containing lone pairs (examples from main group chemistry) and multiple bonding ($\sigma$ and $\pi$ bond approach).

### Theoretical principles of inorganic qualitative analysis (5 Lectures)

Basic principles involved in analysis of cations and anions and solubility products, common ion effect.
Principle involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.

## Module: III

### Stereochemistry – II (8 Lectures)

Chirotopicity and its relationship with stereogenicity; concept of pseudoasymmetry for ABA type systems. Relative and absolute configuration: *R/S* descriptors; *erythro/threo* and *meso* nomenclature of compounds; *E/Z* descriptors for C=C, combination of *R/S*- and *E/Z*isomerisms. Optical activity of chiral compounds: optical rotation, and specific rotation; racemic compounds, racemisation (through cationic, anionic intermediates); resolution of acids and bases *via* diastereomeric salt formation; optical purity and enantiomeric excess.

**General Treatment of Reaction Mechanism–I** **(7 Lectures)**

### Reactive intermediates

Carbocations (carbenium and carbonium ions), non-classical carbocations, carbanions, carbon radicals: generation and stability, structure and electrophilic / nucleophilic behaviour of reactive intermediates (elementary idea).

## Reaction thermodynamics

Free energy and equilibrium, enthalpy and entropy factor, calculation of enthalpy change *via* BDE, intermolecular & intramolecular reactions.

## Reaction kinetics

Rate constant and free energy of activation; free energy profiles for one-step, and two-step reactions; catalyzed reactions, principle of microscopic reversibility; Hammond's postulate.

## Substitution Reaction

Free-radical substitution reaction: halogenation of alkanes, mechanism (with evidence) and stereochemical features; reactivity-selectivity principle in the light of Hammond's postulate.

## Recommended Text Books


1. Lee, J. D. Concise Inorganic Chemistry,5th Ed., Wiley India Pvt. Ltd., 2008.
2. Atkins, Overton, Rourke, Weller, Armstrong;Shriver & Atkins' Inorganic Chemistry, 5th Ed., Oxford University Press (2010).
3. Finar, I. L. Organic Chemistry (Volume 1), 6th Edition, Pearson Education, 2002
4. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
5. Nasipuri, D. Stereochemistry of Organic Compounds, 4th Edition, New Age International Pvt Ltd, 2020
6. Levine, I. N. Physical Chemistry, 6th Edition McGraw-Hill India, 2011
7. Castellan, G. W. Physical Chemistry, Narosa , 2004
8. Atkins, P. W. & Paula, J. de, Atkins' Physical Chemistry, 11th Edition,Oxford University Press, 2018
9. G. L. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Edition, Pearson India, 2008

**Practical :(30 Lectures)**

**PAPER: CHEM-H-CC2-2-P**

**(MN-2)**

**Qualitative semimicro analysis of mixtures containing three radicals. Emphasis should be given to the understanding of the chemistry of different reactions (only water /acid soluble salts):**

## Cation Radicals

$Na^{+}$, $K^{+}$, $Ca^{2+}$, $Sr^{2+}$, $Ba^{2+}$, $Al^{3+}$, $Cr^{3+}$, $Fe^{3+}$, $Mn^{2+}/Mn^{4+}$, $Co^{2+}/Co^{3+}$, $Ni^{2+}$, $Cu^{2+}$, $Zn^{2+}$, $Pb^{2+}$, $NH_4^{+}$, $Sn^{2+}/Sn^{4+}$

### Anion Radicals

$F^{-}$, $Cl^{-}$ , $Br^{-}$, $I^{-}$, $S_2O_3^{2-}$, $S^{2-}$, $SO_4^{2-}$, $NO_3^{-}$, $NO_2^{-}$, $PO_4^{3-}$, $BO_3^{3-}$, $CrO_4^{2-}$ / $Cr_2O_7^{2}$ , $SCN^{-}$, $[Fe(CN)_6]^{3-}$, $[Fe(CN)_6]^{4-}$, $AsO_4^{3-}$, $BrO_3^{-}$, $IO_3^{-}$.

## Reference Books

1. Svehla & Sivasankar, Vogel's Qualitative Inorganic Analysis, 7th Ed., Pearson, 2012. 2. Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University Calcutta, 2015

# CHEMISTRY MINOR

**PAPER:CHEM-H-CC4-5-Th**

**(MN-3)**

**(Credit: Theory -03, Practical – 01)**

## Organic Chemistry-I

**Theory: (45 Lectures)**

### Module: I

**Aromatic Substitution: (12 Lectures)**

### Electrophilic aromatic substitution

Mechanisms and evidences in favour of it including PKIE; orientation and reactivity; reactions: nitration, nitrosation, sulfonation, halogenation, Friedel-Crafts reaction; one-carbonelectrophiles (reactions: chloromethylation, Houben-Hoesch, Vilsmeier-Haack, Reimer-Tiemann, Kolbe-Schmidt); *Ipso* substitution.

### Nucleophilic aromatic substitution

Addition-elimination mechanism and evidences in favour of it; $S_N1$ mechanism; *cine* substitution (benzyne mechanism), structure of benzyne.

### Birch Reduction of benzenoid aromatics

Benzene, Alkylbenzene, Anisole, Benzoic acid (with mechanism).

**General Treatment of Reaction Mechanism –II (8 Lectures)**

### Concept of organic acids and bases

Concept of $pK_a$ and $pK_{aH}$, effect of structure, substituent and solvent on acidityand basicity; proton sponge.

## Tautomerism

Basic difference between tautomerism and resonance,prototropy (keto-enol, phenol-keto); composition of the equilibrium in different systems (simple carbonyl; 1,2- and 1,3-dicarbonyl systems, phenols and related systems), factors affecting keto-enol tautomerism, basic ideas about valence tautomerism and ring-chain tautomerism.

# Module: II

## Stereochemistry –III (3 Lectures)

## Conformation-I

Basic idea of conformation. Conformational Nomenclature (Newman & Sawhorse): eclipsed, staggered, gauche, syn and anti; Special reference to preferred geometry for β-elimination. Relative stability of conformers on the basis of steric effect: butane-gauche interaction.

## Substitution and Elimination Reactions: (10 Lectures)

## Nucleophilic substitution reactions

Substitution at $sp^3$centre[systems: alkyl halides, allyl halides, benzyl halides, alcohols, ethers, epoxides, α-halocarbonyls]:mechanisms (with evidence),relative rates& stereochemical features: $S_N1$, $S_N2$, $S_N2'$, $S_N1'$ (allylic rearrangement) and $S_Ni$; effects of solvent, substrate structure, leaving group and nucleophiles (including ambident nucleophiles, cyanide & nitrite); substitutions involving NGP (with heteroatoms and phenyl groups).

### Elimination reactions

E1, E2, E1cB and Ei (pyrolytic *syn* eliminations); formation of alkenes and alkynes; mechanisms (with evidence), reactivity, regioselectivity (Saytzeff / Hofmann) and stereoselectivity; comparison between substitution and elimination reactions, comparison between nucleophilicity and basicity.

# Module: III

## Chemistry of alkenes and alkynes (12 Lectures)

## Addition to C=C

Mechanism (with evidence wherever applicable), reactivity, regioselectivity (Markownikoff and anti-Markownikoff additions) and stereoselectivity; reactions: hydrogenation, halogenation, hydrohalogenation, hydration, oxymercuration-demercuration, hydroboration-oxidation,

epoxidation, *syn* and *anti*-hydroxylation, ozonolysis, addition of singlet and triplet carbenes; Simmons-Smith cyclopropanation reaction; electrophilic addition to 1,3-butadiene; concept ofkinetic and thermodynamic control of products; radical addition: HBr addition; mechanism of allylic and benzylic bromination in competition with brominations across C=C; use of NBS; interconversion of *E* and *Z* alkenes.

## Addition to C≡C (in comparison to C=C)

Mechanism, reactivity, regioselectivity (Markownikoff and anti-Markownikoff addition) and stereoselectivity; reactions: hydrogenation, Hg(II) ion catalysed hydration, hydroboration-oxidation, dissolving metal reduction of alkynes (Birch); reactions of terminal alkynes by exploring its acidity.

## Recommended Text Books


1. Finar, I. L. Organic Chemistry (Volume 1), 6th Edition, Pearson Education, 2002
2. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
3. Morrison, R. N. & Boyd, R. N. and Bhattacharjee, Organic Chemistry,7th Edition, Pearson Education, 2010


## Practical :(30 Lectures)

## PAPER: CHEM-H-CC4-3-P

## (MN-3)

## Identification of Pure Single organic Compound.

## Solid compounds

Oxalic acid, tartaric acid, citric acid, succinic acid, resorcinol, urea, glucose, cane sugar, benzoic acid and salicylic acid

**Liquid Compounds**:

Formic acid, acetic acid, ethyl alcohol, acetone, aniline, dimethylaniline, benzaldehyde and nitrobenzene

## Reference Books


1. Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University of Calcutta, 2015
2. Furniss, Hannaford, Smith, Tatcholl, Vogel's Textbook of Practical Organic Chemistry ,5th Edition, Pearson India, 2003

# CHEMISTRY MINOR

**PAPER:CHEM-H-CC5-6-Th**

**(MN-4)**

**(Credit: Theory -03, Practical – 01)**

## Inorganic Chemistry-I

**Theory: (45 Lectures)**

### Module: I

## Chemical bonding -II (28 Lectures)

### Molecular orbital concept of bonding

The approximations of the theory, Linear combination of atomic orbitals (LCAO) (elementary pictorial approach): sigma and pi bonds and delta interaction, multiple bonding. Orbital designations: gerade, ungerade, HOMO, LUMO. Orbital mixing, MO diagrams of $H_2$, $Li_2$, $Be_2$, $B_2$, $C_2$, $N_2$, $O_2$, $F_2$, and their ions wherever possible; Heteronuclear molecular orbitals: CO, NO, $NO^+$, $CN^-$, HF, $BeH_2$, $CO_2$ and $H_2O$. Bond properties: bond orders, bond lengths.

### Metallic Bond

Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

### Weak Chemical Forces

Hydrogen bonding (theories of hydrogen bonding, valence bond treatment), receptor-guest interactions, Halogen bonds. Effects of chemical force, melting and boiling points.

### Module: II

## Acids and bases (12 Lectures)

### Acid-Base concept

Arrhenius concept, theory of solvent system (in $H_2O$, $NH_3$, $SO_2$ and HF), Bronsted-Lowry's concept, Lux Flood concept, Lewis's concept, group characteristics of Lewis acids, solvent levelling and differentiating effects. Relative strength of acids, Pauling's rules. HSAB principle.

## Acid-base equilibria in aqueous solution

Proton transfer equilibria in water, pH, buffer. Acid-base neutralization curves; indicator, choice of indicators.

## Module: III

## Radioactivity (05 Lectures)

## Nuclear stability

Nuclear stability and nuclear binding energy.

## Nuclear Reactions

Artificial radioactivity, fission, fusion and spallation.

## Radiocarbon dating

## Recommended Text Books


1. G. L. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Edition, Pearson India, 2008
2. A. G. Sharpe, C. E. Housecroft, Inorganic Chemistry 3rd Edition, Pearson India ,2002
3. Svehla & Sivasankar, Vogel's Qualitative Inorganic Analysis, 7th Ed., Pearson, 2012.


## Practical :(30 Lectures)

## PAPER: CHEM-H-CC5-4-P

## (MN-4)

## Complexometric Titration

1. Ca (II) and Mg (II) in a mixture
2. Hardness of water
3. Fe (III) and Al (III) in a mixture
4. Cu (II) and Zn (II) in a mixture
5. Cu (II) and Ni (II) in a mixture

## Reference Books


1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University of Calcutta, 2015

# SKILL ENHANCEMENT COURSE

**Paper:CHEM-H-SEC1-1-Th**
**(SEC-1)**

**(Credit: Theory -03, Tutorial – 01)**

## Quantitative Analysis and Basic Laboratory Practices

**Theory: (45 Lectures)**

### Module: I

**Introduction to Quantitative analysis and its interdisciplinary nature**:(**15 Lectures)**

Definitions of analysis, determination, measurement, techniques and methods. Classification of analytical techniques. Choice of an analytical method -accuracy, precision, sensitivity, selectivity, method validation. Figures of merit of analytical methods and limit of detection (LOD). Limitations of analytical methods. Errors: Determinate and indeterminate errors, absolute error, relative error, minimization of errors. Statistical treatment of finite samples - mean, median, range, standard deviation and variance. External standard calibration -regression equation (least squares method), correlation coefficient ($R^2$). Presentation of experimental data and results from the point of view of significant figures.

**Numerical problems are to be solved wherever applicable.**

### Module: II

**Titrimetric analysis**: (**15 Lectures)**

Principle, classification, normality, molarity, molality, molefraction, ppm, ppb etc. Standard solutions, preparation and dilution of reagents/ solutions using $N_1 V_1 = N_2 V_2$, preparation of ppm level solutions from source materials (salts).

**Numerical problems are to be solved wherever applicable**.

**Acid-basetitrimetry**:

Titration curves for strong acid vs strong base, weak acid vs strong base and weak base vs strong acid titrations. Quantitative applications – selecting and standardizing a titrant, inorganic analysis - alkalinity, acidity.

**Numerical problems are to be solved wherever applicable.**

**Redox titrimetry**:

Theory, balancing redox equations, titration curves, theory of redox indicators and applications.
**Numerical problems are to be solved wherever applicable.**

## Precipitation titrimetry:

Theory, titration curves, indicators for precipitation titrations involving silver nitrate- Volhard's and Mohr's methods and their differences.
**Numerical problems are to be solved wherever applicable.**

## Complexometric titrimetry:

Theory, titration methods employing EDTA (direct, back, displacement and indirect determinations). Indicators for EDTA titrations - theory ofmetal ion indicators. Determination ofhardness of water.
**Numerical problems are to be solved wherever applicable.**

## Gravimetric Analysis:

Stages in gravimetric analysis, requisites of precipitation, theories of precipitation, factors influencing precipitation, co-precipitation and post precipitation. Structure, specificity, conditions and applications of organic reagents such as salcylaldoxime, oxine, dimethyl glyoxime, cupron and cupferron in inorganic analysis. Advantages of organic reagents over inorganic reagents.

# Module: III

**15 Lectures)**

## Water analysis:

Water availability, requirement of water. Quality of surface water and ground water. Impurities in water. Standards of water quality for potable, domestic, industrial and agricultural purpose (color, pH, alkalinity, hardness, TDS, sulphate, fluoride, chloride etc.)

## Water treatment technologies:

House hold water treatment, municipal water treatment and industrial treatment (primary and secondary treatment of industrial effluent). Softening of water. Disinfection of water. Definition and determinations of DO, BOD and COD, and their significance.
**Numerical problems are to be solved wherever required**

## Basic laboratory practices:

Basic laboratory practices, calibration of glassware (pipette, burette and volumetric flask), Sampling (solids and liquids), weighing, drying, dissolving, Acid treatment, Rules of work in analytical laboratory, General rule for performing quantitative determinations (volumetric and

gravimetric), Safety in Chemical laboratory, Rules of fire prevention and accidents, First aid. Precautions to be taken while
handling toxic chemicals, concentrated/fuming acids and organic solvents.

## Recommended Text

1. Douglas A. Skoog, D.M.West, F. jamesHoller, Stanely R. Crouch, Fundamentals of Analytical Chemistry , Cengage learning India Pvt Ltd. 10th Edition, 2022
2. Daniel C. Harris, Quantitative Chemical Analysis, 10th Edition, W.H. Freeman, 2020

## Tutorial:(15hours)

## PAPER: CHEM-H-SEC1-1-Tu

1. Safety Practices in the Chemistry Laboratory, knowledge about common toxic chemicals and safety measures in their handling, cleaning and drying of glass wares.
2. Calibration of glassware, pipette, burette and volumetric flask.
3. Preparation of TLC plates and separation of amino acids
4. Calibration of instruments like colorimeter, pH-meter, conductivity meter,spectrophotometer using reference standards or reference materials.
5. Conductometric titration between HCl and NaOH.
6. Determination of alkali present in soaps/detergents.

# SKILL ENHANCEMENT COURSE
### CHEMISTRY

**Paper:CHEM-H-SEC2-2-Th**
**(SEC-2)**
**(Credit: Theory -04)**

**AI for Everyone**

**Theory: (45 Lectures)**

## Module I

### Introduction to Artificial Intelligence, Subfields and Technologies:

**( 15 Lectures)**

- Definition and scope of AI
- Historical overview and key milestones
- Differentiating AI from human intelligence
- Machine learning: Supervised, unsupervised, and reinforcement learning
- Deep learning and neural networks
- Natural language processing (NLP) and computer vision

## Module II

### Applications of AI and Ethical and Social Implications of AI:

**( 15 Lectures)**

- AI in healthcare: Diagnosis, treatment, and medical imaging
- AI in finance: Fraud detection, algorithmic trading, and risk assessment
- AI in transportation: Autonomous vehicles and traffic optimization
- AI in customer service and chatbots
- AI in education: Personalized learning and intelligent tutoring systems
- Bias and fairness in AI systems
- Privacy and data protection concerns
- Impact of AI on employment and the workforce
- AI and social inequality

## Module III

### Other Important Issues:

(**15 Lectures)**

- Ethical guidelines and responsible AI practices
- AI and Innovation
- Emerging trends and future directions in AI
- AI and creativity: Generative models and artistic applications

### Reference Book

1.Russell / Norvig , ARTIFICIAL INTELLIGENCE: A MODERN APPROACH , 4th Edition , Pearson Education, 2022

# SKILL ENHANCEMENT COURSE

**Paper: CHEM-H-SEC3-3-Th**
**(SEC-3)**
**(Credit: Theory -03, Tutorial – 01)**
**Theory: (45 Lectures)**

## Introduction toNumerical Methods for Chemists

**Theory: (45 Lectures)**

## Numbers and Precision

Fixed -point representation, Floating - point representation, Floating-point arithmetic, Errors in numbers, Binaryrepresentation of numbers.

**Finding Roots**

Iterative methods, Newton - Raphson Method.

## Linear Regression

Least square fit to a straight line, Polynomial regression. Coefficient of Determination, Correlation, Linear Correlation coefficient (r).

## Interpolation

Lagrange Interpolation

## Numerical Differentiation

Method of finite differences (Forward difference,Backward difference, Central difference). The second derivative.

## Numerical Integration

Trapezoidal approximation (Taylor series interpretation, Geometric interpretation, Composite Trapezoidal Rule), Midpoint Rule, Simpson's $1/3^{rd}$ Rule.

## Numerical solution of Differential Equation (ODE Only)

First Order Method(Euler) and extension to fourth order (Runge-Kutta)

## The Fourier Transform

Fourier series and Fourier Transform

## Reference Book


1. Erwin Kreyszig, Advanced Engineering Mathematics, $10^{Th}$ Edition, Wiley India.


## Tutorial:(15 hours)

## PAPER: CHEM-H-SEC3-3-Tu

**1.** Make a table of the form below to present the results in each case. Draw graphs as required. In the problems, take a=π and b=e , and $x_j$ =0.1, 0.3, 0.5, 0.8,1,2,3,5,7,10,20,25 to get $y_j$ . Use these values in the table for calculations. Report M and C with graph(s). Find out a,b from M and C. Match with the input values.

| No. of Obs. | $x_j$ | $y_j$ | $x_jy_j$ | $x_j^2$ | <x> | <y> | <xy> | <$x^2$> | M | C |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | ... | .. | .. | .. | | | | | | |
| 2 | .. | .. | .. | .. | | | | | | |
| . | .. | .. | .. | .. | | | | | | |
| . | | | | | .. | .. | .. | .. | .. | .. |
| . | | | | | | | | | | |
| . | | | | | | | | | | |
| N | .. | .. | .. | .. | | | | | | |
| Sum = | | | | | | | | | | |

a) y=ax + b, b) y = ax / (1+bx)

**2**. Find the molar volume of Argon (a= 1.50 $L^2$ atm $mol^{-2}$, b= 0.032 L $mol^{-1}$) at 144 K and 30 atm pressure, and hence densities of liquid and vapor formed using the van der Waals equation of state.

**3.** The ionization potential and electron affinity values of a few elements of a periodic table are given below, along with Pauling electronegativities. Show that the Mulliken electronegativitiesvalues, defined by (IP + EA) /2, bears a good correlation with the Pauling values. [ EN(P) ≈ EN(M) / 270].

| System | IP (kJ/mol) | EA (kJ/mol) | EN | System | IP (kJ/mol) | EA (kJ/mol) | EN |
|---|---|---|---|---|---|---|---|
| H | 1311 | -72 | 2.1 | F | 1681 | -333 | 4.0 |
| Li | 520 | -57 | 1.0 | Na | 496 | -21 | 0.9 |
| Be | 899 | 66 | 1.5 | Mg | 737 | 67 | 1.2 |
| B | 801 | -15 | 2.0 | Al | 577 | -26 | 1.5 |
| C | 1086 | -121 | 2.5 | P | 1012 | -60 | 2.1 |
| N | 1403 | -31 | 3.0 | S | 999 | -200 | 2.5 |
| O | 1410 | -142 | 3.5 | Cl | 1255 | -348 | 3.0 |

# Interdisciplinary Course in Chemistry

**Paper: CHEM-H-IDC1-1-Th**
**or**
**CHEM-H-IDC2-2-Th**
**Or**
**CHEM-H-IDC3-3-Th**

**(Credit: Theory -02, Tutorial – 01)**

## IDC-I/II/III

**Theory: (45 Lectures)**

### Quantitative Analysis and Basic Laboratory Practices

**Theory: (45 Lectures)**

### Module: I

**Introduction to Quantitative analysis and its interdisciplinary nature**:(**15 Lectures)**

Definitions of analysis, determination, measurement, techniques and methods. Classification of analytical techniques. Choice of an analytical method -accuracy, precision, sensitivity, selectivity, method validation. Figures of merit of analytical methods and limit of detection (LOD). Limitations of analytical methods. Errors: Determinate and indeterminate errors,

absolute error, relative error, minimization of errors. Statistical treatment of finite samples - mean, median, range, standard deviation and variance. External standard calibration -regression equation (least squares method), correlation coefficient ($R^2$). Presentation of experimental data and results from the point of view of significant figures.
**Numerical problems are to be solved wherever applicable.**

## Module: II

### Titrimetric analysis: (15 Lectures)

Principle, classification, normality, molarity, molality, mole fraction, ppm, ppb etc. Standard solutions, preparation and dilution of reagents/ solutions using $N_1 V_1 = N_2 V_2$, preparation of ppm level solutions from source materials (salts).

**Numerical problems are to be solved wherever applicable.**

### Acid-basetitrimetry:

Titration curves for strong acid vs strong base, weak acid vs strong base and weak base vs strong acid titrations. Quantitative applications – selecting and standardizing a titrant, inorganic analysis - alkalinity, acidity.
**Numerical problems are to be solved wherever applicable.**

### Redox titrimetry:

Theory, balancing redox equations, titration curves, theory of redox indicators and applications.
**Numerical problems are to be solved wherever applicable.**

### Precipitation titrimetry:

Theory, titration curves, indicators for precipitation titrations involving silver nitrate- Volhard's and Mohr's methods and their differences.
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### Complexometric titrimetry:

Theory, titration methods employing EDTA (direct, back, displacement and indirect determinations). Indicators for EDTA titrations - theory of metal ion indicators. Determination of hardness of water.
**Numerical problems are to be solved wherever applicable.**

### Gravimetric Analysis:

Stages in gravimetric analysis, requisites of precipitation, theories of precipitation, factors influencing precipitation, co-precipitation and post precipitation. Structure, specificity, conditions and applications of organic reagents such as salcylaldoxime, oxine, dimethyl glyoxime, cupron and cupferron in inorganic analysis. Advantages of organic reagents over inorganic reagents.

## Module: III

**15 Lectures)**

### Water analysis:

Water availability, requirement of water. Quality of surface water and ground water. Impurities in water. Standards of water quality for potable, domestic, industrial and agricultural purpose (color, pH, alkalinity, hardness, TDS, sulphate, fluoride, chloride etc.)

### Water treatment technologies:

House hold water treatment, municipal water treatment and industrial treatment (primary and secondary treatment of industrial effluent). Softening of water. Disinfection of water. Definition and determinations of DO, BOD and COD, and their significance.

**Numerical problems are to be solved wherever required.**

### Basic laboratory practices:

Basic laboratory practices, calibration of glassware (pipette, burette and volumetric flask), Sampling (solids and liquids), weighing, drying, dissolving, Acid treatment, Rules of work in analytical laboratory, General rule for performing quantitative determinations (volumetric and gravimetric), Safety in Chemical laboratory, Rules of fire prevention and accidents, First aid. Precautions to be taken while
handling toxic chemicals, concentrated/fuming acids and organic solvents.

### Recommended Text

1. Douglas A. Skoog, D.M.West, F. jamesHoller, Stanely R. Crouch, Fundamentals of Analytical Chemistry, Cengage learning India Pvt Ltd. 10th Edition, 2022.
2. Daniel C. Harris, Quantitative Chemical Analysis, 10th Edition, W.H. Freeman,2020..

### Tutorial:(15hours)

### PAPER: CHEM-H-SEC1-1-Tu

1. Safety Practices in the Chemistry Laboratory, knowledge about common toxic chemicals and safety measures in their handling, cleaning and drying of glass wares.
2. Calibration of glassware, pipette, burette and volumetric flask.
3. Preparation of TLC plates and separation of amino acids
4. Calibration of instruments like colorimeter, pH-meter, conductivity meter, spectrophotometer using reference standards or reference materials.
5. Conductometric titration between HCl and NaOH.

6. Determination of alkali present in soaps/detergents.

## Examination Regulations and Modalities of Semester-wise UG Examinations

### Theoretical Examinations

**(Questions will cover the entire syllabus with weightage according to the number oflecture-hours per module)**

| Semester | Paper Code | Full Marks | Duration | Question Pattern and Marks Distribution |
|---|---|---|---|---|
| 1 | DSCC-1 | 75 | 3 hours | 10 short questions of 2 mark each, 3 questions of 5 marks each and 4 questions of 10 marks each (4+3+3) |
| | MN-1 | | | |
| | SEC-1 | | | |
| 2 | DSCC-2 | | | |
| | MN-2 | | | |
| 3 | DSCC-3 | | | |
| | DSCC-4 | | | |
| | MN-1 | | | |
| | SEC-3 | | | |
| 4 | DSCC-5 | | | |
| | DSCC-6 | | | |
| | DSCC-7 | | | |
| | DSCC-8 | | | |
| | MN-2 | | | |
| 5 | DSCC-9 | | | |
| | DSCC-10 | | | |
| | DSCC-11 | | | |
| | DSCC-12 | | | |
| | MN-3 | | | |
| 6 | DSCC-13 | | | |
| | DSCC-14 | | | |
| | DSCC-15 | | | |
| | MN-4 | | | |

## Practical Examinations

| Semester | Paper Code | Full Marks | Duration | Question Pattern and Marks Distribution |
|---|---|---|---|---|
| 1 | DSCC-1 | 25 | 3 hours | 20 marks Examination + 5 marks Laboratory notebook. Experiments by lottery. |
| | MN-1 | | | |
| 2 | DSCC-2 | | | |
| | MN-2 | | | |
| 3 | DSCC-3 | | | |
| | DSCC-4 | | | |
| | MN-1 | | | |
| 4 | DSCC-5 | | | |
| | DSCC-6 | | | |
| | DSCC-7 | | | |
| | DSCC-8 | | | |
| | MN-2 | | | |
| 5 | DSCC-9 | | | |
| | DSCC-10 | | | |
| | DSCC-11 | | | |
| | DSCC-12 | | | |
| | MN-3 | | | |
| 6 | DSCC-13 | | | |
| | DSCC-14 | | | |
| | DSCC-15 | | | |
| | MN-4 | | | |

## Examination to be conducted by,

**1) For Chemistry Major Papers (DSCC): Both Internal and External Examiners,following the instructions of UGBOS. (Away Centre)**

**2) For Chemistry Minor Papers (MN): Internal examiners (2) following the instructionsof UGBOS. (Home Centre)**

## Tutorial Examinations(Home Centre)

| Semester | Paper Code | Full Marks | Duration | Question Pattern and Marks Distribution |
|---|---|---|---|---|
| 1 | SEC-1 | 25 | 1 hour Examination | 20 Marks (10 short questions of 2 markseach) + 5 marks forTutorial Handbook |
| | IDC-1 | | | |
| 2 | IDC-2 | | | |
| 3 | SEC-3 | | | |
| | IDC-3 | | | |

## Theoretical Examinations (Home Centre)

**(Questions will cover the entire syllabus with weightage according to the number oflecture-hours per module)**

| Semester | Paper Code | Full Marks | Duration | Question Pattern and Marks Distribution |
|---|---|---|---|---|
| 1 | IDC-1 | 50 | 2 hours | 10 short questions of 2 mark each, 3 questions of 10 marks each (4+3+3) |
| 2 | IDC-2 | | | |
| 3 | IDC-3 | | | |

# THREE-YEAR B.A./B.Sc

# (Multidisciplinary Courses of Studies, under Curriculum & Credit framework, 2022)

## SYLLABUS

**FOR**

## CHEMISTRY

## (1st to 6th Semester)

## UNIVERSITY OF CALCUTTA

**Chemistry Course Structure**
**For**

# Three-year MULTIDISCIPLINARY Studies
# (Theory)

| Semester | Paper Code | Paper Name | Brief Descriptions |
|---|---|---|---|
| 1 | CHEM-MD-CC1-1-Th (CC-1) | Fundamental of Chemistry-I | Extra nuclear structure of atoms and Periodicity, Basics of Organic Chemistry Bonding and Physical Properties, Stereochemistry – I, Thermodynamics –I, Chemical Kinetics-I. |
| 2 | CHEM-MD-CC2-2-Th (CC-2) | Fundamental of Chemistry-II | Kinetic Theory and Gaseous state, Chemical Bonding – I ,Theoretical principles of inorganic qualitative analysis.Stereochemistry – II, General Treatment of Reaction Mechanism-I. |
| 3 | CHEM-MD-CC3-3-Th (CC-3) | Organic Chemistry-I | Aromatic Substitution Reaction, General Treatment of Reaction Mechanism-II, Substitution, elimination, Addition to alkenes, dienes, alkynes. |
| 4 | CHEM-MD-CC4-4-Th (CC-4) | Inorganic Chemistry-I | Chemical bonding -II, Acids and bases, Radioactivity. |
| | CHEM-MD-CC5-4-Th (CC-5) | Physical Chemistry-I | Thermodynamics- II, Applications of Thermodynamics – I, Electrochemistry-I. |
| 5 | CHEM-MD-CC6-5-Th (CC-6) | Organic Chemistry-II | Stereochemistry – III, Chemistry of Carbonyl Compounds, Organometallics. |
| & 6 | CHEM-MD-CC7-5-Th Or CHEM-MD-CC7-6-Th (CC-7) | Physical Chemistry-II | Transport processes and Liquid State, Solid State, Application of Thermodynamics - II, Electrochemistry-II. |
| | CHEM-MD-CC8-6-Th (CC-8) | Inorganic Chemistry-II | Coordination chemistry, Radioactivity, Redox reactions. |

## Important Points

**If Chemistry is considered by a student as CC1(Core Course 1 in the CSR/04/2023, dated 23rd June, 2023 of University of Calcutta) then He / She will take CHEM-MD-CC6-5-Th and CHEM MD-CC7-5-Th in Semester 5 and CHEM-MD-CC8-6-Th in Semester 6. On the other hand, if Chemistry is opted as CC2 (Core Course 2 in the CSR/04/2023, dated 23rd June, 2023 of University of Calcutta) then He / She will take CHEM-MD-CC6-5-Th in Semester 5 and CHEM-MD-CC7-6-Th &CHEM-MD-CC8-6-Th in Semester 6.**

## Chemistry Course Structure (CC1 & CC2)

**For**

**Three-year MULTIDISCIPLINARY Studies**

**(Practical)**

| Semester | Paper Code | Paper Name | Brief Descriptions |
|---|---|---|---|
| 1 | CHEM-MD-CC1-1-P (CC-1) | Fundamental of Chemistry-I | Acid-Base Titration, Oxidation-Reduction Titrimetry. |
| 2 | CHEM-MD-CC2-2-P (CC-2) | Fundamental of Chemistry-II | Qualitative semimicro analysis of mixtures containing three radicals |
| 3 | CHEM-MD-CC3-3-P (CC-3) | Organic Chemistry-I | Identification of Single organic Compound. |
| 4 | CHEM-MD-CC4-4-P (CC-4) | Inorganic Chemistry-I | Complexometric Titration |
| | CHEM-MD-CC5-4-P (CC-5) | Physical Chemistry-I | Chemical Kinetics (Analytical). |
| 5 & 6 | CHEM-MD-CC6-5-P (CC-6) | Organic Chemistry-II | Qualitative analysis of single solid organic compound. |
| | CHEM-MD-CC7-5-P Or CHEM-MD-CC7-6-P (CC-7) | Physical Chemistry-II | Surface Tension, Viscosity, Conductometry. |
| | CHEM-MD-CC8-6-P (CC-8) | Inorganic Chemistry-II | Estimation of mixtures of metal ions. |

## Important Points

**If Chemistry is considered by a student as CC1(Core Course 1 in the CSR/04/2023, dated 23rd June, 2023 of University of Calcutta) then He / She will take CHEM-MD-CC6-5-P and CHEM MD-CC7-5-P in Semester 5 and CHEM-MD-CC8-6-P in Semester 6. On the other hand if Chemistry is opted as CC2 (Core Course 2 in the CSR/04/2023, dated 23rd June, 2023 of University of Calcutta) then He / She will take CHEM-MD-CC6-5-P in Semester 5 and CHEM-MD-CC7-6-P &CHEM-MD-CC8-6-P in Semester 6.**

## Chemistry Course Structure (Minor)

## For
## Three-year MULTIDISCIPLINARY Studies

## (Theory)

| Semester | Paper Code | Paper Name | Brief Descriptions |
|---|---|---|---|
| 3 | CHEM-MD-CC1-3-Th (MN-1) | Fundamental of Chemistry-I | Extra nuclear structure of atoms and Periodicity, Basics of Organic Chemistry Bonding and Physical Properties, Stereochemistry – I, Thermodynamics –I, Chemical Kinetics-I. |
| 4 | CHEM-MD-CC2-4-Th (MN-2) | Fundamental of Chemistry-II | Kinetic Theory and Gaseous state, Chemical Bonding – I,Theoretical principles of inorganic qualitative analysis.Stereochemistry – II, General Treatment of Reaction Mechanism-I. |
| 5 | CHEM-MD-CC3-5-Th (MN-3) | Organic Chemistry-I | Aromatic Substitution Reaction, General Treatment of Reaction Mechanism-II, Substitution, elimination, Addition to alkenes, dienes, alkynes. |
| 5 | CHEM-MD-CC4-5-Th (MN-4) | Inorganic Chemistry-I | Chemical bonding II, Acids and bases, Radioactivity |
| 6 | CHEM-MD-CC5-6-Th (MN-5) | Physical Chemistry-I | Thermodynamics II, Applications of Thermodynamics – I, Electrochemistry-I. |
| 6 | CHEM-MD-CC6-6-Th (MN-6) | Organic Chemistry-II | Stereochemistry – III, Chemistry of carbonyl Compounds, Organometallics. |

# Chemistry Course Structure (Minor)

## For

### Three-year MULTIDISCIPLINARY Studies

### (Practical)

| Semester | Paper Code | Paper Name | Brief Descriptions |
|---|---|---|---|
| 3 | CHEM-MD-CC1-3-P (MN-1) | Fundamental of Chemistry-I | Acid-Base Titration, Oxidation-Reduction Titrimetry. |
| 4 | CHEM-MD-CC2-4-P (MN-2) | Fundamental of Chemistry-II | Qualitative semimicro analysis of mixtures containing three radicals |
| 5 | CHEM-MD-CC3-5-P (MN-3) | Organic Chemistry-I | Identification of Single organic Compound. |
| 5 | CHEM-MD-CC4-5-P (MN-4) | Inorganic Chemistry-I | Complexometric Titration |
| 6 | CHEM-MD-CC5-6-P (MN-5) | Physical Chemistry-I | Chemical Kinetics (Analytical). |
| 6 | CHEM-MD-CC6-6-P (MN-6) | Organic Chemistry-II | Qualitative analysis of single solid organic compound. |

## Summer Internship:

**All the students are required to do one 3 credits Summer Internship at the end of the 2nd or 4th or 6th semester. Students completing Internship at the end of the 2nd semester will be allowed to take exit from the course and will be awarded Certificate of 45 (42+3) credits. Students completing Internship at the end of the 4th semester will be allowed to take exit from the course and will be awarded Diploma of 88 (85+3) credits. Students completing Internship at the end of the 6th semester and after successful completion of all the 6 semesters will be awarded B.A./ B.Sc. Degree of 128 (125+3) credits. [Following the Notification No. CSR/04/2023, dated 23rd June, 2023 of University of Calcutta].**

# CHEMISTRY MDC

**PAPER: CHEM-MD-CC1-1-Th /CHEM-MD-CC1-3-Th**

**(CC-1)/(MN-1)**

**(Credit: Theory -03, Practical – 01)**

## Fundamentals of Chemistry - I

**Theory: (45 Lectures)**

### Module: I

**Extra nuclear structure of atoms and Periodicity: (15 Lectures)**

Wave-Particle duality; de Broglie hypothesis. Heisenberg's uncertainty principle. Introducing Schrödinger equation. Hydrogen and hydrogen like systems (detailed solution not required). Concept of Atomic Orbital; shapes of s, p and d orbitals. Radial and angular distribution curves. Extension to multielectronic systems. Aufbau principle and its limitations; Pauli's exclusion principle; Hund's rules and multiplicity. Effective nuclear charge. Shielding and penetration; Slater's rule.

The general idea about modern periodic table, atomic and ionic radii, ionization energy, electron affinity and electro negativity –definition, trends of variation in periodic table and their application in explaining and predicting the chemical behavior of elements and compounds. Electronegativity scales (Pauling's, Mulliken's and Allred-Rochow's scales). Inert pair effect.

### Module: II

**Basics of Organic Chemistry Bonding and Physical Properties**

**(10 Lectures)**

**Valence Bond Theory**

Nomenclature of Organic Compounds, Concept of hybridisation, shapes and structures of molecules, double bond equivalent (DBE), Resonance (including hyperconjugation) and Resonance energy.

## Electronic displacement

Inductive effect, bond polarization and bond polarizability;steric effect, steric inhibition of resonance.

## MO Theory

Qualitative idea about molecular orbitals, bonding and antibonding interactions, idea about σ, σ*, π, π *, n – MOs; concept of HOMO, LUMO and SOMO; sketch and energy levels of π MOs of i) acyclic p orbital system (C=C, conjugated diene, triene, allyl and pentadienyl systems) ii) cyclic p orbital system (neutral systems: [4], [6] annulenes; charged systems: 3-,4-,5-7 membered ring systems); Hückel's rules for aromaticity up to [8] annulene; concept of antiaromaticity; non-aromatic molecules.

## Physical properties

Melting point/boiling point and solubility of common organic compounds in terms of covalent & non-covalent intermolecular forces; polarity of molecules and dipole moments.

## Stereochemistry – I (5 Lectures)

Bonding geometries of carbon compounds and representation of molecules: tetrahedral nature of carbon and concept of asymmetry; Fischer, sawhorse, flying wedge and Newman projection formulae and their inter translations. Concept of chirality and symmetry: symmetry elements, molecular chirality and centre of chirality; asymmetric and dissymmetric molecules; enantiomers and diastereomers; concept of stereogenicity, chiral centres and number of stereoisomers: systems involving 1/2-chiral centre(s).

# Module: III

## Thermodynamics -I (9 Lectures)

Concept of systems (open, closed and isolated) and surroundings. State of a system; Intensive and extensive variables. Partial derivatives. Exact and inexact differentials. Path function and State function. Concept of heat and work. Zeroth law of thermodynamics. Concept of thermodynamic reversibility. Concept of internal energy and 1st law of thermodynamics. Enthalpy and heat capacity, Relations between $C_p$ and $C_v$. Isothermal and Adiabatic processes. Calculations of $\Delta U$, $\Delta H$, q and w involving ideal gases in different processes.

Enthalpy of reaction. Hess's law. Enthalpy of formation and combustion. Kirchhoff's equation.

## Chemical Kinetics-I (6 Lectures)

Concept of order and molecularity. Rate laws for zero, 1st and 2nd order reactions and in general for any n-th order reaction. Determination of order of a reaction by half-life and differential methods. Rate determining step and steady state approximation. Opposing, Consecutive and parallel reactions (first order steps only). Temperature dependence of rate constant and Arrhenius equation.

## Recommended Text Books


1. Lee, J. D. Concise Inorganic Chemistry,5th Ed., Wiley India Pvt. Ltd., 2008.
2. Atkins, Overton, Rourke, Weller, Armstrong; Shriver & Atkins' Inorganic Chemistry, 5th Ed., Oxford University Press, (2010).
3. Finar, I. L. Organic Chemistry (Volume 1), 6th Edition, Pearson Education, 2002
4. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
5. Nasipuri, D. Stereochemistry of Organic Compounds, 4th Edition, New Age International Pvt Ltd, 2020
6. Levine, I. N. Physical Chemistry, 6th Edition McGraw-Hill India, 2011
7. Castellan, G. W. Physical Chemistry, Narosa , 2004
8. Atkins, P. W. & Paula, J. de, Atkins' Physical Chemistry, 11th Edition, Oxford University Press, 2018
9. G. L. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Edition, Pearson India, 2008

## Practical :(30 Lectures)

## PAPER: CHEM-MD-CC1-1-P /CHEM-MD-CC1-3-P

## (CC-1)/(MN-1)

(1) Calibration and use of apparatus.

(2) Preparation of primary standard solutions (Oxalic Acid and $K_2Cr_2O_7$)

## Acid-Base Titrations

(3) Standardization of NaOH standard oxalic acid solution.

(4) Estimation of carbonate and bicarbonate present together in a mixture

(5) Estimation of acetic acid in commercial Vinegar.

## Oxidation-Reduction Titrimetry

(6) Standardization of $KMnO_4$ standard oxalic acid solution.

(7) Estimation of Fe (II) using standardized $KMnO_4$ solution.

(8) Estimation of Fe (III) using standard $K_2Cr_2O_7$ solution.

(9) Estimation of Fe (II) and Fe (III) in a given mixture using standard $K_2Cr_2O_7$ solution.

## Reference Books

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.

2. Practical Workbook Chemistry (Honours), UGBOS, Chemistry, Universityof Calcutta, 2015

# CHEMISTRY MDC

## PAPER: CHEM-MD-CC2-2-Th / CHEM-MD-CC2-4-Th

## (CC-2)/(MN-2)

## (Credit: Theory -03, Practical – 01)

### Fundamentals of Chemistry - II

### Theory: (45 Lectures)

### Module: I

### Kinetic Theory and Gaseous state (8 Lectures)

Concept of pressure and temperature from kinetic theory of gas. Nature of distribution of velocities, Maxwell's distribution of speeds in one, two and three dimensions; Kinetic energy distribution in one, two and three dimensions, calculations of average, root mean square and most probable values in each case; Collision of gas molecules; Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar and different molecules); Wall collision and rate of effusion Calculation of number of molecules having energy $\geq \varepsilon$, Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases

### Real gas and Virial equation (7 Lectures)

Deviation of gases from ideal behavior; Compressibility factor; Boyle temperature; Andrew's and Amagat's plots; van der Waals equation and its features; its derivation and application in explaining real gas behavior ; Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states; Virial equation of state; van der Waals equation expressed in the Virial form and significance of second virial coefficient; Intermolecular forces (Debye, Keesom and London interactions; Lennard-Jones potential - elementary idea.

## Module: II

### Chemical Bonding – I (10 Lectures)

i) Ionic bond: General characteristics, types of ions, size effects, radius ratio rule and its application and limitations. Packing of ions in crystals. Born-Lande equation with derivation and importance of Kapustinskii expression for lattice energy. Madelung constant, Born-Haber cycle and its application, Solvation energy. Defects in solids (elementary idea). Solubility energetics of dissolution process.

ii) Covalent bond: Polarizing power and polarizabilty, ionic potential, Fajan's rules, Lewis structures, formal charge, Valence Bond Theory, The hydrogen molecule (Heitler – London approach), directional character of covalent bonds, hybridizations, equivalent and non-equivalent hybrid orbitals, Bent's rules, dipole moments, VSEPR theory, shapes of molecules and ions containing lone pairs (examples from main group chemistry) and multiple bonding ($\sigma$ and $\pi$ bond approach).

### Theoretical principles of inorganic qualitative analysis (5 Lectures)

Basic principles involved in analysis of cations and anions and solubility products, common ion effect.
Principle involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.

## Module: III

### Stereochemistry – II (8 Lectures)

Chirotopicity and its relationship with stereogenicity; concept of pseudoasymmetry for ABA type systems. Relative and absolute configuration: *R/S* descriptors; *erythro/threo* and *meso* nomenclature of compounds; *E/Z* descriptors for C=C, combination of *R/S*- and *E/Z*isomerisms. Optical activity of chiral compounds: optical rotation, and specific rotation; racemic compounds, racemisation (through cationic, anionic intermediates); resolution of acids and bases *via* diastereomeric salt formation; optical purity and enantiomeric excess.

**General Treatment of Reaction Mechanism–I** **(7 Lectures)**

## Reactive intermediates

Carbocations (carbenium and carbonium ions), non-classical carbocations, carbanions, carbon radicals: generation and stability, structure and electrophilic / nucleophilic behaviour of reactive intermediates (elementary idea).

## Reaction thermodynamics

Free energy and equilibrium, enthalpy and entropy factor, calculation of enthalpy change *via* BDE, intermolecular & intramolecular reactions.

## Reaction kinetics

Rate constant and free energy of activation; free energy profiles for one-step, and two-step reactions; catalyzed reactions, principle of microscopic reversibility; Hammond's postulate.

## Substitution Reaction

Free-radical substitution reaction: halogenation of alkanes, mechanism (with evidence) and stereochemical features; reactivity-selectivity principle in the light of Hammond's postulate.

## Recommended Text Books


1. Lee, J. D. Concise Inorganic Chemistry,5th Ed., Wiley India Pvt. Ltd., 2008.
2. Atkins, Overton, Rourke, Weller, Armstrong;Shriver & Atkins' Inorganic Chemistry, 5th Ed., Oxford University Press (2010).
3. Finar, I. L. Organic Chemistry (Volume 1), 6th Edition, Pearson Education, 2002
4. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
5. Nasipuri, D. Stereochemistry of Organic Compounds, 4th Edition, New Age International Pvt Ltd, 2020
6. Levine, I. N. Physical Chemistry, 6th Edition McGraw-Hill India, 2011
7. Castellan, G. W. Physical Chemistry, Narosa , 2004
8. Atkins, P. W. & Paula, J. de, Atkins' Physical Chemistry, 11th Edition,Oxford University Press, 2018
9. G. L. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Edition, Pearson India, 2008

**Practical :(30 Lectures)**

**PAPER: CHEM-MD-CC2-2-P / CHEM-MD-CC2-4-P**

**(CC-2)/(MN-2)**

**Qualitative semimicro analysis of mixtures containing three radicals. Emphasis should be given to the understanding of the chemistry of different reactions (only water /acid soluble salts):**

### Cation Radicals

$Na^+$, $K^+$, $Ca^{2+}$, $Sr^{2+}$, $Ba^{2+}$, $Al^{3+}$, $Cr^{3+}$, $Fe^{3+}$, $Mn^{2+}/Mn^{4+}$, $Co^{2+}/Co^{3+}$, $Ni^{2+}$, $Cu^{2+}$, $Zn^{2+}$, $Pb^{2+}$, $NH_4^+$, $Sn^{2+}/Sn^{4+}$

### Anion Radicals

$F^-$, $Cl^-$ , $Br^-$, $I^-$, $S_2O_3^{2-}$, $S^{2-}$, $SO_4^{2-}$, $NO_3^-$, $NO_2^-$, $PO_4^{3-}$, $BO_3^{3-}$, $CrO_4^{2-}$ / $Cr_2O_7^{2}$ , $SCN^-$, $[Fe(CN)_6]^{3-}$, $[Fe(CN)_6]^{4-}$, $AsO_4^{3-}$, $BrO_3^-$, $IO_3^-$.

### Reference Books


1. Svehla & Sivasankar, Vogel's Qualitative Inorganic Analysis, 7th Ed., Pearson, 2012. 2. Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University Calcutta, 2015


## CHEMISTRY MDC

**PAPER: CHEM-MD-CC3-3-Th / CHEM-MD-CC3-5-Th**

**(CC-3)/(MN-3)**

**(Credit: Theory -03, Practical – 01)**

**Organic Chemistry-I**

**Theory: (45 Lectures)**

**Module: I**

**Aromatic Substitution: (12 Lectures)**

## Electrophilic aromatic substitution

Mechanisms and evidences in favour of it including PKIE; orientation and reactivity; reactions: nitration, nitrosation, sulfonation, halogenation, Friedel-Crafts reaction; one-carbonelectrophiles (reactions: chloromethylation, Houben-Hoesch, Vilsmeier-Haack, Reimer-Tiemann, Kolbe-Schmidt); *Ipso* substitution.

## Nucleophilic aromatic substitution

Addition-elimination mechanism and evidences in favour of it; $S_N1$ mechanism; *cine* substitution (benzyne mechanism), structure of benzyne.

## Birch Reduction of benzenoid aromatics

Benzene, Alkylbenzene, Anisole, Benzoic acid (with mechanism).

## General Treatment of Reaction Mechanism –II (8 Lectures)

## Concept of organic acids and bases

Concept of $pK_a$ and $pK_{aH}$, effect of structure, substituent and solvent on acidityand basicity; proton sponge.

## Tautomerism

Basic difference between tautomerism and resonance,prototropy (keto-enol, phenol-keto); composition of the equilibrium in different systems (simple carbonyl; 1,2- and 1,3-dicarbonyl systems, phenols and related systems), factors affecting keto-enol tautomerism, basic ideas about valence tautomerism and ring-chain tautomerism.

# Module: II

## Stereochemistry –III (3 Lectures)

## Conformation-I

Basic idea of conformation. Conformational Nomenclature (Newman & Sawhorse): eclipsed, staggered, gauche, syn and anti; Special reference to preferred geometry for β-elimination. Relative stability of conformers on the basis of steric effect: butane-gauche interaction.

## Substitution and Elimination Reactions: (10 Lectures)

## Nucleophilic substitution reactions

Substitution at $sp^3$centre[systems: alkyl halides, allyl halides, benzyl halides, alcohols, ethers, epoxides, α-halocarbonyls]:mechanisms (with evidence),relative rates& stereochemical features: $S_N1$, $S_N2$, $S_N2'$, $S_N1'$ (allylic rearrangement) and $S_Ni$; effects of solvent, substrate structure, leaving group and nucleophiles (including ambident nucleophiles, cyanide & nitrite); substitutions involving NGP (with heteroatoms and phenyl groups).

### Elimination reactions

E1, E2, E1cB and Ei (pyrolytic *syn* eliminations); formation of alkenes and alkynes; mechanisms (with evidence), reactivity, regioselectivity (Saytzeff / Hofmann) and stereoselectivity; comparison between substitution and elimination reactions, comparison between nucleophilicity and basicity.

# Module: III

## Chemistry of alkenes and alkynes (12 Lectures)

## Addition to C=C

Mechanism (with evidence wherever applicable), reactivity, regioselectivity (Markownikoff and anti-Markownikoff additions) and stereoselectivity; reactions: hydrogenation, halogenation, hydrohalogenation, hydration, oxymercuration-demercuration, hydroboration-oxidation, epoxidation, *syn* and *anti*-hydroxylation, ozonolysis, addition of singlet and triplet carbenes; Simmons-Smith cyclopropanation reaction; electrophilic addition to 1,3-butadiene; concept ofkinetic and thermodynamic control of products; radical addition: HBr addition; mechanism of allylic and benzylic bromination in competition with brominations across C=C; use of NBS; interconversion of *E* and *Z* alkenes.

## Addition to C≡C (in comparison to C=C)

Mechanism, reactivity, regioselectivity (Markownikoff and anti-Markownikoff addition) and stereoselectivity; reactions: hydrogenation, Hg (II) ion catalysed hydration, hydroboration-oxidation, dissolving metal reduction of alkynes (Birch); reactions of terminal alkynes by exploring its acidity.

## Recommended Text Books


1. Finar, I. L. Organic Chemistry (Volume 1), 6th Edition, Pearson Education, 2002
2. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
3. Morrison, R. N. & Boyd, R. N. and Bhattacharjee, Organic Chemistry,7th Edition, Pearson Education, 2010

**Practical :(30 Lectures)**

**PAPER: CHEM-MD-CC3-3-P / CHEM-MD-CC3-5-P**

**(CC-3)/(MN-3)**

**Identification of Pure Single organic Compound.**

**Solid compounds**

Oxalic acid, tartaric acid, citric acid, succinic acid, resorcinol, urea, glucose, cane sugar, benzoic acid and salicylic acid

**Liquid Compounds**:

Formic acid, acetic acid, ethyl alcohol, acetone, aniline, dimethylaniline, benzaldehyde and nitrobenzene

**Reference Books**


1. Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University of Calcutta, 2015
2. Furniss, Hannaford, Smith, Tatcholl, Vogel's Textbook of Practical Organic Chemistry ,5th Edition, Pearson India, 2003


# CHEMISTRY MDC

**PAPER: CHEM-MD-CC4-4-Th / CHEM-MD-CC4-5-Th**

**(CC-4)/(MN-4)**

**(Credit: Theory -03, Practical – 01)**
**Theory: (45 Lectures)**

## Inorganic Chemistry-I

### Module: I

**Chemical bonding -II** **(28 Lectures)**

## Molecular orbital concept of bonding

The approximations of the theory, Linear combination of atomic orbitals (LCAO) (elementary pictorial approach): sigma and pi bonds and delta interaction, multiple bonding. Orbital designations: gerade, ungerade, HOMO, LUMO. Orbital mixing, MO diagrams of $H_2$, $Li_2$, $Be_2$, $B_2$, $C_2$, $N_2$, $O_2$, $F_2$, and their ions wherever possible; Heteronuclear molecular orbitals: CO, NO, $NO^+$, $CN^-$, HF, $BeH_2$, $CO_2$ and $H_2O$. Bond properties: bond orders, bond lengths.

## Metallic Bond

Qualitative idea of valence bond and band theories. Semiconductors and insulators, defects in solids.

## Weak Chemical Forces

Hydrogen bonding (theories of hydrogen bonding, valence bond treatment), receptor-guest interactions, Halogen bonds. Effects of chemical force, melting and boiling points.

**Module: II**

## Acids and bases (12 Lectures)

## Acid-Base concept

Arrhenius concept, theory of solvent system (in $H_2O$, $NH_3$, $SO_2$ and HF), Bronsted-Lowry's concept, Lux Flood concept, Lewis's concept, group characteristics of Lewis acids, solvent levelling and differentiating effects. Relative strength of acids, Pauling's rules. HSAB principle.

## Acid-base equilibria in aqueous solution

Proton transfer equilibria in water, pH, buffer. Acid-base neutralization curves; indicator, choice of indicators.

## Module: III

## Radioactivity (05 Lectures)

## Nuclear stability

Nuclear stability and nuclear binding energy.

## Nuclear Reactions

Artificial radioactivity, fission, fusion and spallation.

## Radiocarbon dating

## Recommended Text Books

1. G. L. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Edition, Pearson India, 2008
2. A. G. Sharpe, C. E. Housecroft, Inorganic Chemistry 3rd Edition, Pearson India ,2002
3. Svehla & Sivasankar, Vogel's Qualitative Inorganic Analysis, 7th Ed., Pearson, 2012.

## Practical :(30 Lectures)

## PAPER: CHEM-MD-CC4-4-P / CHEM-MD-CC4-5-P

## (CC-4)/(MN-4)

## Complexometric Titration

1. Ca (II) and Mg (II) in a mixture
2. Hardness of water
3. Fe (III) and Al (III) in a mixture
4. Cu (II) and Zn (II) in a mixture
5. Cu (II) and Ni (II) in a mixture

## Reference Books

1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University of Calcutta, 2015

# CHEMISTRY MDC

## PAPER: CHEM-MD-CC5-4-Th / CHEM-MD-CC5-6-Th

## (CC-5)/(MN-5)

**(Credit: Theory -03, Practical – 01)**
**Theory: (45 Lectures)**

### Physical Chemistry-I

### Module: I

**Thermodynamics - II:** **(20 Lectures)**

## Second Law

Need for a Second law; statement of the second law of thermodynamics; Concept of heat reservoirs and heat engines; Carnot cycle; Carnot engine and refrigerator; Kelvin – Planck and Clausius statements and equivalence of the two statements with entropic formulation; Carnot's theorem; Values of §dQ/T and Clausius inequality; Physical concept of Entropy; Entropy is a measure of the microscopic disorder of the system. Entropy changes of systems and surroundings for various processes and transformations; Entropy and unavailable work; Temperature – Entropy diagram.

Useful work and The Gibbs and Helmholtz function. Changes at constant T, P. Application to electric work. Criteria for spontaneity and equilibrium. Gibbs- Helmholtz equation, The Gibbs Function and useful work in biological systems. Gibbs free energy and spontaneous phase transition.

Maxwell's relations; Joule-Thomson experiment and its consequences; inversion temperature; Joule-Thomson coefficient for a van der Waals gas; General heat capacity relations

## Systems of Variable Compositions

State functions for system of variable compositions. Criteria of equilibrium and spontaneity in systems of variable composition. Partial molar quantities, dependence of thermodynamic parameters on composition; Chemical potential as an escaping tendency. Gibbs-Duhem equation, Entropy and Gibbs function for mixing of ideal gases, the chemical potential of ideal mixtures. The Fugacity function of a pure real gas. Calculation of the fugacity of a van der Waals gas using compressibility factor. Activities and activity coefficients. Choice of standard states. Dependence of Activity on pressure and temperature.

# Module: II

## Applications of Thermodynamics – I (8 Lectures)

## Chemical Equilibrium

Thermodynamic conditions for equilibrium, degree of advancement; van't Hoff's reaction isotherm (deduction from chemical potential); Variation of free energy with degree of advancement; Equilibrium constant and standard Gibbs free energy change; Van't Hoff's reaction isobar and isochore from different standard states; Le Chatelier's principle

and its derivation, variation of equilibrium constant under different conditions Nernst’s distribution law; Application- (e.g. dimerization of benzene in benzoic acid). Solvent Extraction.

## Module: III

## ELECTROCHEMISTRY-I

### (i) Conductance (9 Lectures)

Ion conductance; Conductance and measurement of conductance, cell constant, specific conductance and molar conductance; Variation of specific and equivalent conductance with dilution for strong and weak electrolytes; Kohlrausch's law of independent migration of ions; Equivalent and molar conductance at infinite dilution and their determination for strong and weak electrolytes; Debye –Huckel theory of Ion atmosphere (qualitative)-asymmetric effect, relaxation effect and electrophoretic effect; Debye-Huckel limiting law-brief qualitative description. Estimation of activity coefficient for electrolytes using Debye-Huckel limiting law. Ostwald's dilution law; Ionic mobility; Application of conductance measurement (determination of solubility product and ionic product of water); Conductometric titrations. Transport number, Principles of Hittorf's and Moving-boundary method.

### (ii) Ionic Equilibrium (8 Lectures)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale. Salt hydrolysis- calculation of hydrolysis constant, degree of hydrolysis and pH for different salts (exact Treatment). Determination of hydrolysis constant conductometrically. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action. Theory of acid–base indicators; selection of indicators and their limitations.

### Recommended Text Books


1. Levine, I. N. Physical Chemistry, 6th Edition McGraw-Hill India, 2011
2. Castellan, G. W. Physical Chemistry, Narosa , 2004
3. Atkins, P. W. & Paula, J. de, Atkins' Physical Chemistry, 11th Edition, Oxford University Press, 2018


### Reference Books


1. Denbigh, K. The Principles of Chemical Equilibrium, Cambridge University Press
2. Zemansky, M. W. & Dittman, R.H, Heat and Thermodynamics, Special Indian Edition, 8th Edition, Tata-McGraw-Hil ,2017
3. Klotz, Irving M, Rosenberg, Robert M,Chemical Thermodynamics ,Wiley India , 2013

**Practical :(30 Lectures)**

**PAPER: CHEM-MD-CC5-4-P / CHEM-MD-CC5-6-P**

**(CC-5)/(MN-5)**

1. Determination of rate constant of the reaction between $H_2O_2$ and acidified KI solution using Clock reaction.

2. Determination of the rate constant for the decomposition of $H_2O_2$ using $FeCl_3$ as catalyst.

3. Determination of the rate constant for the first order acid catalyzed hydrolysis of an ester.

4. To study the kinetics of the inversion of cane sugar using a polarimeter.

## Reference Books

1.Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University of Calcutta, 2015

# CHEMISTRY MDC

**PAPER: CHEM-MD-CC6-5-Th /CHEM-MD-CC6-6-Th**

**(CC-6)/(MN-6)**

**(Credit: Theory -03, Practical – 01)**

**Organic Chemistry-II**

**Theory: (45 Lectures)**

**Module: I**

**Stereochemistry – IV** **(12 Lectures)**

## Conformation-II

Concept of dihedral angle, torsion angle; energy barrier of rotation, concept of torsional and steric strains; relative stability of conformers on the basis of steric effect, dipole-dipole interaction and H-bonding; butane gauche interaction; conformational analysis of ethane, propane, *n*-butane, and 2-methylbutane; 1,2-dihaloalkanes and ethylene glycol.

## Concept of prostereoisomerism

Prostereogeniccentre; concept of (pro)$^n$chirality: topicity of ligands and faces (elementary idea); pro-R/pro-S, pro-E/pro-Z and Re/Si descriptors; pro-*r* and pro-*s* descriptors of ligands on propseudoasymmetriccentre.

## Chirality arising out of stereoaxis

Stereoisomerism of substituted cumulenes with even and odd number of double bonds; chiral axis in allenes, and biphenyls; related configurational descriptors ($R_a/S_a$); atropisomerism; racemisation of chiral biphenyls

# Module: II

## Chemistry of carbonyl Compounds: (28 Lectures)

## Nucleophilic Addition to C=O

Structure and reactivity of carbonyl compounds; mechanism (with evidence), reactivity, equilibrium and kinetic control; formation of hydrates, cyanohydrins and bisulphite adduct; nucleophilic addition-elimination reactions with alcohols, thiolsand nitrogen-based nucleophiles;reactions: benzoin condensation, Cannizzaro and Tischenko reactions, reactions with ylides: Wittig and Corey-Chaykovsky reaction; Rupe rearrangement, oxidations and reductions: Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPVO redox equilibrium, acyloin condensation; oxidation of alcohols with PDC and PCC; periodic acid and lead tetraacetate oxidation of 1,2-diols.

## Exploitation of acidity of α-H of C=O

Formation of enols and enolates; kinetic and thermodynamic enolates; reactions (mechanism with evidence):halogenation of carbonyl compounds under acidic and basic conditions, Hell-Volhard-Zelinsky (H. V. Z.) reaction, nitrosation, $SeO_2$ (Riley) oxidation; condensations (mechanism with evidence): Aldol,Tollens', Knoevenagel, Claisen-Schmidt, Claisen ester including Dieckmann; Mannich reaction,Perkin reaction; alkylation of active methylene compounds; synthetic applications of diethyl malonate and ethyl acetoacetate; specific enol equivalents (lithium enolates, enamines and silyl enol ethers) in connection with alkylation, acylation and aldol type reaction.

## Nucleophilic addition to α, β-unsaturated carbonyl system

General principle and mechanism (with evidence); direct and conjugate addition, addition of enolates (Michael reaction), Robinson annulations reaction.

## Substitution at $sp^2$ carbon (C=O system)

Mechanism (with evidence): $B_{AC}2$, $A_{AC}2$, $A_{AC}1$, $A_{AL}1$ (inconnection to acid and ester); acid derivatives: amides, anhydrides & acyl halides (formation and hydrolysis including comparison).

## Module: III

## Organometallics (5 Lectures)

Grignard reagents, Organolithiums; Gilman cuprates: preparation and reactions (mechanism with evidence); addition of Grignard and organolithium to carbonyl compounds; substitution on -COX; directed *ortho* metalation of arenes using organolithiums, conjugate addition by Gilman cuprates; Corey-House synthesis; abnormal behaviour of Grignard reagents; comparison of reactivity among Grignard, organolithiums and organocopper reagents; Reformatsky reaction; concept of umpolung.

## Recommended Text Books


1. Finar, I. L. Organic Chemistry (Volume 1), 6th Edition, Pearson Education, 2002
2. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003.
3. Morrison, R. N. & Boyd, R. N. and Bhattacharjee, Organic Chemistry, 7th Edition, (Pearson Education), 2010
4. Nasipuri, D. Stereochemistry of Organic Compounds, 4th Edition, New Age International Pvt Ltd, 2020


## Practical :(30 Lectures)

## PAPER: CHEM-MD-CC6-5-P /CHEM-MD-CC6-6-P

## (CC-6)/(MN-6)

## Qualitative analysis of single solid organic compound

1. Detection of special elements (N, S, Cl) by Lassaigne's test

2. Solubility and classification (solvents: $H_2O$, 5% HCl, 5% NaOH and 5% NaHCO3)

3. Detection of the following functional groups by systematic chemical tests: aromatic amino (Ar-NH2), aromatic nitro (-NO2), amido (-CONH2, including imide), phenolic –OH, carboxylic

acid (-COOH), carbonyl (distinction between -CHO and >C=O); only one test for each functional group is to be reported.

Each student, during laboratory session, is required to carry out qualitative chemical tests for all the special elements and the functional groups in known and unknown (**at least six)** organic compounds.

## Reference Books


1. Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University of Calcutta, 2015
2. Furniss, Hannaford, Smith, Tatcholl, Vogel's Textbook of Practical Organic Chemistry ,5th Edition, Pearson India, 2003


# CHEMISTRY MDC

## PAPER: CHEM-MD-CC7-5-Th / CHEM-MD-CC7-6-Th

## (CC-7)

## (Credit: Theory -03, Practical – 01)

## Physical Chemistry-II

## Theory: (45 Lectures)

### Module: I

## Transport processes and Liquid State

## Diffusion and Viscosity (5 Lectures)

### Diffusion

Fick's law, Flux, force, phenomenological coefficients & their inter-relationship (general form), different examples of transport properties

### Viscosity

General features of fluid flow (streamline flow and turbulent flow); Newton's equation, viscosity coefficient; Poiseuille's equation (with derivation); principle of determination of viscosity coefficient of liquids by falling sphere method and using Ostwald's viscometer. Temperature

variation of viscosity of liquids and comparison with that of gases. Relation between viscosity coefficient of a gas and mean free path.

### Surface tension and energy (4 Lectures)

Surface tension, surface energy, excess pressure, capillary rise and surface tension; Work of cohesion and adhesion, spreading of liquid over other surface; Vapour pressure over curved surface; Temperature dependence of surface tension

## Module: II

### Solid State (12 Lectures)

### Bravais Lattice and Laws of Crystallography

Types of solid, Bragg's law of diffraction; Laws of crystallography (Haüy's law and Steno's law); Permissible symmetry axes in crystals; Lattice, space lattice, unit cell, crystal planes, Bravais lattice. Packing of uniform hard sphere, close packed arrangements (fcc and hcp); Tetrahedral and octahedral voids. Void space in cubic systems

### Crystal plane

Distance between consecutive planes [cubic and orthorhombic lattices]; Indexing of planes, Miller indices; calculation of $d_{hkl}$; Relation between molar mass and unit cell dimension for cubic system; Bragg's law (derivation). Determination of crystal structure: Powder method; Structure of NaCl and KCl crystals.

## Module: III

### Application of Thermodynamics – II (16 Lectures)

### Colligative properties

Vapour pressure of solution; Ideal solution, ideally dilute solution and colligative properties; Raoult's law. Thermodynamic derivations (using chemical potential) relating (i) Elevation of boiling point of an ideally dilute solution containing a non- volatile nonelectrolyte solute, (ii) Depression of freezing point of an ideally dilute solution containing a non -volatile nonelectrolyte solute (iii) Osmotic pressure of an ideally dilute solution containing a nonvolatile nonelectrolyte solute with the molality / molar concentration of solute in solution. Applications in calculating molar masses of normal, dissociated and associated solutes in solution; Abnormal colligative properties.

## Phase Equilibrium

Definitions of phase, component and degrees of freedom; Phase rule and its derivations; Definition of phase diagram; Phase diagram for water, $CO_2$, Sulphur. First order phase transition and Clapeyron equation; Clausius- Clapeyron equation - derivation and use; Ehrenfest Classification of phase transition.

Binary solutions: Liquid vapour equilibrium for two component systems. Ideal solution at fixed temperature and pressure; Lever Rule. Principle of fractional distillation; Duhem-Margules equation; Henry's law; Konowaloff's rule; Positive and negative deviations from ideal behaviour; Azeotropic solution; Liquid-liquid phase diagram using phenol- water system; Solid-liquid phase diagram; Eutectic mixture

Three component systems, water-chloroform-acetic acid system, triangular plots.

## ELECTROCHEMISTRY-II: (8 Lectures)

### Electromotive Force:

Rules of oxidation/reduction of ions based on half-cell potentials, Chemical cells, reversible and irreversible cells with examples; Electromotive force of a cell and its measurement, Thermodynamic derivation of Nernst equation; Standard electrode (reduction) potential and its application to different kinds of half-cells. Application of EMF measurements in determining (i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pH values, using hydrogen, quinone-hydroquinone and glass electrodes. Concentration cells with and without transference, liquid junction potential; Potentiometric Titration.

## Recommended Text Books


1. Levine, I. N. Physical Chemistry, 6th Edition McGraw-Hill India, 2011
2. Castellan, G. W. Physical Chemistry, Narosa , 2004
3. Atkins, P. W. & Paula, J. de, Atkins' Physical Chemistry, 11th Edition, Oxford University Press, 2018


## Practical :(30 Lectures)

## PAPER: CHEM-MD-CC7-5-P / CHEM-MD-CC7-6-P

## (CC-7)

## 1. Surface tension measurements using Stalagmometer

a) Determine the surface tension of a given solution by drop weight method using a stalagmometer.

b) Study the variation of surface tension of acetic acid solutions with concentration and hence determine graphically the concentration of an unknown solution of acetic acid.

## 2. Viscosity measurement using Ostwald's viscometer

a) Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.

b) Study the variation of viscosity of sucrose solution with the concentration of solute and hence determine graphically the concentration of an unknown solution.

## 3. ConductometricExperiments

a) Conductometric titration of an acid (Mixture Strong and Weak monobasic acid, and Dibasic acid) against strong base.

b) Study of kinetics saponification reaction conductometrically

## Reference Books

1.Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University of Calcutta, 2015

# CHEMISTRY MDC

**PAPER:CHEM-MD-CC8-6-Th**

**(CC-8)**

**(Credit: Theory -03, Practical – 01)**

**Inorganic Chemistry-II**

**Theory: (45 Lectures)**

**Module: I**

**Coordination chemistry (26 Lectures)**

## Basics of coordination chemistry

Werner's theory, ligands, IUPAC nomenclature, Isomerism (constitutional and stereo isomerism, Geometrical and optical isomerism in square planar and octahedral complexes)

## Valence bond theory and crystal field theory

VB description and its limitations. Elementary Crystal Field Theory: splitting of $d^n$ configurations in octahedral, square planar and tetrahedral fields, crystal field stabilization energy (CFSE) in weak and strong fields; pairing energy. Spectrochemical series. Jahn- Teller distortion. Octahedral site stabilization energy (OSSE). Metal-ligand bonding (MO concept, elementary idea), sigma- and pi-bonding in octahedral complexes (qualitative pictorial approach) and their effects on the oxidation states of transitional metals (examples).

## Electronic spectra of complexes and magnetic properties

d-d transitions; L-S coupling; qualitative Orgel diagrams for $3d^1$ to $3d^9$ ions. Racah parameter. Selection rules for electronic spectral transitions; spectrochemical series of ligands; charge transfer spectra (elementary idea).Orbital and spin magnetic moments, spin only moments of $d^n$ ions and their correlation with effective magnetic moments, including orbital contribution; quenching of magnetic moment: super exchange and antiferromagnetic interactions (elementary idea with examples only);

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## Module: II

## Supramolecular chemistry (08 Lectures)

Hydrogen bonding. Non-covalent interactions – examples of Ion-Dipole Interactions, Dipole-Dipole interactions, Dipole-Induced Dipole and Ion-Induced Dipole interactions, van der Waals or Dispersion Interactions, Halogen bonding, Cation- interactions, Anion-pi interactions, pi - pi interactions, Aromatic-Aromatic Interactions: Edge-to-face *vs* pi-pi Stacking Interactions, N-H-pi interactions, Sulfur-aromatic interactions.

## Module: III

## Redox reactions: (11 Lectures)

## Basic principle of redox reactions

Ion-electron method of balancing equation of redox reaction. Elementary idea on standard redox potentials with sign conventions. Nernst equation (without derivation). Influence of complex formation, precipitation and change of pH on redox potentials; formal potential.

## Redox titrations

Feasibility of a redox titration, redox potential at the equivalence point, redox indicators. Redox potential diagram (Latimer and Frost diagrams) of common elements and their applications. Disproportionation and comproportionation reactions (typical examples).

## Recommended Text Books


1. J. E. Huheey, E. A. Keiter, R. L. Keiter, Okhil K. Medhi, Principles of Structure and Reactivity, 5th Edition, Pearson India, 2022
2. H. J. Arnikar, Essentials of Nuclear Chemistry, 5th Edition, New Age International Pvt, Ltd., 2022
3.G. Friedlander, J.W. Kennedy, E. S. Macias, J.M. Miller, Nuclear and radiochemistry, 3rd Edition, John Wiley, 1981
4. J. W. Steed and J. L. Atwood, Supramolecular Chemistry,2nd Edition, Wiley India, 2017
5. J-M Lehn, Supramolecular Chemistry


## Practical :(30 Lectures)

## PAPER: CHEM-MD-CC8-6-P

## (CC-8)

## Estimation of mixtures of metal ions

1. Estimation of $Fe^{3+}$ and $Cu^{2+}$ in a mixture.
2. Estimation of $Fe^{3+}$ and $Cr^{3+}$ in a mixture.
3. Estimation of $Fe^{3+}$ and $Cr_2O_7^{2-}$ in a mixture.
4. Estimation of $Fe^{3+}$ and $Mn^{2+}$ in a mixture.
5. Estimation of $Cr^{3+}$ and $Mn^{2+}$ in a mixture.

## Reference Books


1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Practical Workbook Chemistry (Honours), UGBOS, Chemistry, University of Calcutta, 2015


# SKILL ENHANCEMENT COURSE
# CHEMISTRY

**PAPER: CHEM-MD-SEC-Th**

**(Credit: Theory -03, Tutorial – 01)**

**Theory: (45 Lectures)**

## CHEMISTRY IN DAILY LIFE

### Module: I

**(15 Lectures)**

**Dairy Products**

Composition of milk and milk products. Analysis of fat content, minerals in milk and butter. Estimation of added water in milk.

Beverages: Analysis of caffeine in coffee and tea, detection of chicory in coffee, chloral hydrate in toddy, determination of methyl alcohol in alcoholic beverages.

**Food additives, adulterants, and contaminants**

Food preservatives like benzoates, propionates, sorbates, disulphites. Artificial sweeteners: Aspartame, saccharin, dulcin, sucralose, and sodium cyclamate. Flavors: Vanillin, alkyl esters (fruit flavors), and monosodium glutamate.

**Artificial food colorants**

Coal tar dyes and non-permitted colors and metallic salts. Analysis of pesticide residues in food.

### Module: II

**(15 Lectures)**

## Vitamins

Classification and Nomenclature. Sources, deficiency diseases, and structures of Vitamin A1, Vitamin B1, Vitamin C, Vitamin D, Vitamin E & Vitamin K1.

## Oils and fats

Composition of edible oils, detection of purity, rancidity of fats and oil. Tests for adulterants like argemone oil and mineral oils. Halphen test.

## Soaps & Detergents

Definition, classification, manufacturing of soaps and detergents, composition and uses

## Module: III

**(15 Lectures)**

## Chemical and Renewable Energy Sources

Principles and applications of primary & secondary batteries and fuel cells. Basics of solar energy.

## Polymers

Basic concept of polymers, classification and characteristics of polymers. Applications of polymers as plastics in electronics, automobile components, medical fields and aerospace materials. Problems of plastic waste management. Strategies for the development of environment-friendly polymers.

## Recommended Text Books


1. B. K. Sharma: Introduction to Industrial Chemistry, Goel Publishing, Meerut (1998)
2. Ashtoush Kar. Medicinal Chemistry ( TwoColour Edition), New Age International Pvt Ltd, 2022
3. Edward Cox Henry, The Chemical analysis of Foods , Hardcover , Hassell Street Press , 2021
4. Fred Billmeyer: Textbook of polymer science; Wiley 3rd addition.


## Tutorial: (15 hours)

## PAPER: CHEM-MD-SEC-Tu

1. Estimation of Vitamin C
2. Determination of Iodine number of oil.
3. Determination of saponification number of oil.
4. Determination of methyl alcohol in alcoholic beverages.

# Interdisciplinary Course in Chemistry

**PAPER: CHEM-MD-IDC-Th**

**(Credit: Theory -02, Tutorial – 01)**

**Theory: (30 Lectures)**

## CHEMISTRY IN DAILY LIFE

### Module: I

(1**0 Lectures)**

**Dairy Products**
Composition of milk and milk products. Analysis of fat content, minerals in milk and butter. Estimation of added water in milk.
Beverages: Analysis of caffeine in coffee and tea, detection of chicory in coffee, chloral hydrate in toddy, determination of methyl alcohol in alcoholic beverages.

**Food additives, adulterants, and contaminants**
Food preservatives like benzoates, propionates, sorbates, disulphites. Artificial sweeteners: Aspartame, saccharin, dulcin, sucralose, and sodium cyclamate. Flavors: Vanillin, alkyl esters (fruit flavors), and monosodium glutamate.

**Artificial food colorants**
Coal tar dyes and non-permitted colors and metallic salts. Analysis of pesticide residues in food.

### Module: II

**(10 Lectures)**

## Vitamins

Classification and Nomenclature. Sources, deficiency diseases, and structures of Vitamin A1, Vitamin B1, Vitamin C, Vitamin D, Vitamin E & Vitamin K1.

## Oils and fats

Composition of edible oils, detection of purity, rancidity of fats and oil. Tests for adulterants like argemone oil and mineral oils. Halphen test.

## Soaps & Detergents

Definition, classification, manufacturing of soaps and detergents, composition and uses

## Module: III

**(10 Lectures)**

## Chemical and Renewable Energy Sources

Principles and applications of primary & secondary batteries and fuel cells. Basics of solar energy.

## Polymers

Basic concept of polymers, classification and characteristics of polymers. Applications of polymers as plastics in electronics, automobile components, medical fields and aerospace materials. Problems of plastic waste management. Strategies for the development of environment-friendly polymers.

## Recommended Text Books


1. B. K. Sharma: Introduction to Industrial Chemistry, Goel Publishing, Meerut (1998)
2. Ashtoush Kar. Medicinal Chemistry (TwoColour Edition), New Age International Pvt Ltd, 2022
3. Edward Cox Henry, The Chemical analysis of Foods,Hardcover, Hassell Street Press,2021
4. Fred Billmeyer: Textbook of polymer science; Wiley 3rd addition.


## Tutorial: (15 hours)

## PAPER: CHEM-MD-SEC-Tu

1. Estimation of Vitamin C
2. Determination of Iodine number of oil.
3. Determination of saponification number of oil.
4. Determination of methyl alcohol in alcoholic beverages.

# Examination Regulations and Modalities of Semester-wise UG Examinations

| Types of Examinations | Paper | Full Marks | Duration | Question Pattern and Marks Distribution | Examination to be conducted/ Evaluation by |
|---|---|---|---|---|---|
| **Theoretical** | **CC-1 to CC-8 and MN-1 to MN -6** | 75 | 3 hours | **10 short questions of 2 mark each, 3 questions of 5 marks each and 4 questions of 10 marks each (4+3+3)** | The University |
| | **SEC** | 75 | 3 hours | **10 short questions of 2 mark each, 3 questions of 5 marks each and 4 questions of 10 marks each (4+3+3)** | The College |
| **Practical** | **CC-1 to CC-8 and MN-1 to MN -6** | 25 | 3 hours | **20 marks Examination + 5 marks Laboratory notebook. Experiments by lottery.** | To be conducted by Internal examiners (2) following the instructions of UGBOS (Home Centre) |
| **Tutorial** | **SEC and IDC** | 25 | 1 hour | **20 Marks (10 short questions of 2 marks each) + 5 marks for Tutorial Handbook** | The College |