# DEBRA THANA SAHID KSHUDIRAM SMRITI MAHAVIDYALAYA (AUTONOMUS)

Gangaram Chak, Chak Shyampur, Debra, West Bengal

*SYLLABUS*

## BACHELOR OF SCIENCE (HONOURS)

### MAJOR IN CHEMISTRY

**4-YEAR UNDERGRADUATE PROGRAMME**

***(w.e.f. Academic Year 2024-2025)***

***Based on***

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

# For

# $3^{rd}$ and $4^{th}$ semester

# (4yr.) major

# DEBRA THANA SAHID KSHUDIRAM SMRITI MAHAVIDYALAYA (AUTONOMUS)

## BACHELOR OF SCIENCE (HONOURS) MAJOR IN CHEMISTRY (under CCFUP, 2023)

| Level | YR. | SEM | Course Type | Course Code | Course Title | Credit | L-T-P | Marks | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | CA | ESE | TOTAL |
| B.Sc. (Hons.) | 2nd | III | **SEMESTER-III** | | | | | | | |
| | | | **Major-3** | **CHEM/4/MJ/C3** | **T: Physical Chemistry-I; P: Practical** | **4** | **3-0-1** | **15** | **60** | **75** |
| | | | **Major-4** | **CHEM/4/MJ/C4** | **T: Organic Chemistry-I; P: Practical** | **4** | **3-0-1** | **15** | **60** | **75** |
| | | | **SEC** | **CHEM/4/MJ/SE 3** | **P: Food chemistry &Computational and software** | **3** | **0-0-3** | **10** | **40** | **50** |
| | | | **AEC** | **AEC03** | Communicative English -2 (***common for all programs***) | **2** | **2-0-0** | **10** | **40** | **50** |
| | | | **MDC** | **MDC03** | Multidisciplinary Course -3 (***to be chosen from the list*** ) | **3** | **3-0-0** | **10** | **40** | **50** |
| | | | **Minor-3 (Disc.-I)** | **CHEM/4/MI/C3** | **T: Inorganic Chemistry and organic chemistry; P: Practical** | **4** | **3-0-1** | **15** | **60** | **75** |
| | | | | | **Semester-III Total** | **20** | | | | **375** |
| | | IV | **SEMESTER-II** | | | | | | | |
| | | | **Major-5** | **CHEM/4/MJ/C5** | **T: Inorganic Chemistry-II; P: Practical** | **4** | **3-0-1** | **15** | **60** | **75** |
| | | | **Major-6** | **CHEM/4/MJ/C6** | **T: Organic Chemistry-II; P: Practical** | **4** | **3-0-1** | **15** | **60** | **75** |
| | | | **Major-7** | **CHEM/4/MJ/C7** | **T: Physical Chemistry-II; P: Practical** | **4** | **3-0-1** | **15** | **60** | **75** |
| | | | **AEC** | **AEC04** | MIL-2 (***common for all programs***) | **2** | **2-0-0** | **10** | **40** | **50** |
| | | | **Minor-4 (Disc.-II)** | **CHEM/4/MI/D3** | **T Inorganic Chemistry and organic chemistry; ; P: Practical** | **4** | **3-0-1** | **15** | **60** | **75** |
| | | | **Summer Intern.** | **INT** | **Internship/ Apprenticeship - activities to be decided by the Colleges following the guidelines to be given later** | **4** | **0-0-4** | **-** | **-** | **50** |
| | | | | | **Semester-IV Total** | **24** | | | | **400** |
| | | | | | **TOTAL of YEAR-2** | **44** | | | | **775** |

MJ = Major, MI = Minor Course, SEC = Skill Enhancement Course, AEC = Ability Enhancement Course, MDC = Multidisciplinary Course, CA= Continuous Assessment, ESE= End Semester Examination, T = Theory, P= Practical, L-T-P = Lecture-Tutorial-Practical, MIL = Modern Indian Language

# Semester-III

## Theory

# Paper- Physical Chemistry –I

**Paper Code: CHEM/4/MJ-3T**

- **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 change 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 functions of a pure real gas. Calculation of the fugacity of a van der Waals gas using compressibility factor. Definitions of Activities and activity coefficients. Choice of standard states. Dependence of Activity on pressure and temperature.

- **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-(eg. dimerization of benzene in benzoic acid). Solvent Extraction.

- **Electrochemistry-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.

- *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**

**Paper Code: CHEM/4/MJ-3P**

1. Conductometric titration of a strong (monobasic / dibasic) acid against strong base.
2. Conductometric titration of a weak (monobasic / dibasic) acid against strong base.
3. Determination of pH of unknown solution (buffer) by colour matching method.

4. Determination of solubility of sparingly soluble salt in water, in electrolyte with common ions and in neutral electrolyte (using common indicator).
5. Determination of solubility product of $PbI_2$ by titrimetric method.

**Reference Books:**

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

# Paper- Organic Chemistry –I

**Paper Code: CHEM/4/MJ-4T**

**Theory**

- **General Treatment of Reaction Mechanism –II: (8 Lectures)**
  - *Concept of organic acids and bases*

Concept of pKa and pKaH, effect of structure, substituent and solvent on acidity and 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.

- **Substitution and Elimination Reactions: (13 Lectures)**
  - *Nucleophilic substitution reactions*

Substitution at sp3 centre[systems: alkyl halides, allyl halides, benzyl halides, alcohols, ethers, epoxides, αhalocarbonyls]:mechanisms (with evidence),relative rates & stereochemical features: SN1, SN2, SN2', SN1' (allylic rearrangement) and SNi; 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.

- **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 of kinetic 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.

- **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-carbon electrophiles (reactions: chloromethylation, HoubenHoesch, Vilsmeier-Haack, Reimer-Tiemann, Kolbe-Schmidt); Ipso substitution. Nucleophilic aromatic substitution Addition-elimination mechanism and evidences in favour of it; SN1 mechanism; cine substitution (benzynemechanism), structure of benzyne. Birch Reduction of benzenoid aromatics Benzene, Alkylbenzene, Anisole, Benzoic acid (with mechanism).

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

**Paper Code: CHEM/4/MJ-4T**

**Experiment: Qualitative Analysis of Single Solid Organic Compounds**

a) Detection of special elements (N, S, Cl, Br) by Lassaigne's test

b) Solubility and classification (solvents: H2O, 5% HCl, 5% NaOH and 5% NaHCO3)

c) Detection of the following functional groups by systematic chemical tests: aromatic amino (-NH2), aromatic nitro (-NO2), amido (-CONH2, including imide), anilido(-NH-CO-R),phenolic –OH, carboxylic acid (-COOH), carbonyl (-CHO and >C=O),unsaturation.

d) Melting point of the given compound

e) One of derivative of given compound

[Each student, during laboratory session, is required to carry out qualitative chemical tests for all the special elements and the functional groups of 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*

# Paper- Skill Enhancement Course (SEC)

## Paper Code: CHEM/4/SE-3

### I. Food chemistry

**(At least 5 experiment to be performed)**

Experiment- 1- Detection of Saccharine in beverages

Experiment- 2- Identification of pigments in a given food sample by paper chromatography

Experiment- 3- Effect of Baking Soda in $CO_2$ production

Experiment- 4- Determination of Vitamin- C (Ascorbic Acid) in a given food sample

Experiment- 5- Determination of reducing and non- reducing sugars in a given food sample

Experiment- 6- Determination of acidity of extracted fat in a given sample of biscuit

Experiment- 7- Determination of acidity of given honey sample

Experiment- 8- Determination of Total Carbohydrates

Experiment- 9- Crude Fat extraction- Soxhlet Apparatus Method

Experiment- 10- Determination of Crude Protein- Kjeldahl Method

### II. Computational and software

**Introductory writing activities**: Introduction to word processor and structure drawing (Chem Sketch) software. Incorporating chemical structures, chemical equations, expressions from chemistry (e.g. Maxwell-Boltzmann distribution law, Bragg's law, van der Waals equation, etc.) into word processing documents.

**Handling numeric data:** Spreadsheet software (Excel/Origin/Gnuplot)), creating a spreadsheet, entering and formatting information, basic functions and formulae, creating charts, tables and graphs.

Incorporating tables and graphs into word processing documents. Simple calculations, plotting graphs using a spreadsheet (Planck's distribution law, radial distribution curves for hydrogenic orbitals, gas kinetic theory- Maxwell-Boltzmann distribution curves as function of temperature and molecular weight), spectral data, pressure-volume curves of van der Waals gas (van der Waals isotherms), data from phase equilibria studies. Graphical solution of equations.

**Numeric modelling:** Simulation of pH metric titration curves. Excel functions LINEST and Least Squares. Numerical curve fitting (Origin), linear regression (rate constants from concentration time data, molar extinction coefficients from absorbance data), numerical differentiation (e.g. handling data from potentiometric and pH metric titrations, pKa of weak acid), integration (e.g. entropy/enthalpy change from heat capacity data).

Statistical analysis: Gaussian distribution and Errors in measurements and their effect on data sets. Descriptive statistics using Excel.
**Presentation:** Presentation graphics (Power Point Presentation).

**Practical-**

Presentation of a topic related to environmental chemistry or chemical hazardous or medicinal chemistry or green chemistry or Food chemistry.

**Reference Books:**


- *A.O.A.C. 17th edn,2000 Official Method 941.10 Saccharin in Food read with A.O.A.C. Official Method 975.30 Salicylic acid in Food and Beverages*
- *IS: 6287-1985 (Reaffirmed 2010) Methods of Sampling and Analysis for Sugar Confectionery*
- *IS 1011: 1992 Biscuits – Specification*
- *I.S.I. Handbook of Food Analysis (Part II) 1984*
- McQuarrie, D. A. *Mathematics for Physical Chemistry University* Science Books (2008).
- Mortimer, R. *Mathematics for Physical Chemistry*. 3rd Ed. Elsevier (2005).
- Steiner, E. *The Chemical Maths Book* Oxford University Press (1996).
- Yates, P. *Chemical calculations.* 2nd Ed. CRC Press (2007


# Minor

**Paper Code: CHEM/3/MI-C3T**

**Inorganic Chemistry– Chemical Periodicity, Chemical Bonding and Molecular Structure.**

- **Chemical Periodicity: (8 Lectures)**

Classification of elements on the basis of electronic configuration: general characteristics of s-, p-, dand f-block elements. Positions of hydrogen and noble gases. Atomic and ionic radii,ionization potential, electron affinity, and electronegativity; periodic and group-wise variation of above properties in respect of s- and p- block elements.

- **Chemical Bonding and Molecular Structure. (16 Lectures)**

*Ionic Bonding*: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and

polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character.

*Covalent bonding*:

VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds.

MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods (including idea of s-p mixing): $H_2$, $B_2$, $C_2$, $N_2$, $O_2$, $F_2$. MO diagram of CO and explanation of its ligating behaviour based on MO approach. Comparison of VB and MO approaches.

## Organic Chemistry- Aromatic Hydrocarbon, Organometallic Compounds

- **Aromatic Hydrocarbon (12Lectures)**

*Benzene:* Preparation: from phenol, by decarboxylation, from acetylene, from Benzene sulphonic acid. Reactions: electrophilic substitution (general mechanism); nitration (with mechanism), halogenations (chlorination and bromination), sulphonation and Friedel-Craft's reaction (alkylation and acylation) (up to 4 carbons on benzene); side chain oxidation of alkyl benzenes (up to 4 carbons on benzene).

- **Organometallic Compounds (9 Lectures)**

Introduction; Grignard reagents: Preparations (from alkyl and aryl halide); concept of umpolung; Reformatsky reaction.

Aryl Halides

Preparation: (chloro-, bromo- and iodobenzene): from phenol, Sandmeyer reactions. Reactions: (Chlorobenzene): nucleophilic aromatic substitution (replacement by –OH group) and effect of nitro substituent (activated nucleophilic substitution).

**Reference Book:**

*1. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.*
*2. Cotton, F. A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.*
*3. Douglas, B. E., McDaniel, D. H. & Alexander, J. J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.*
*4. Huheey, J. E., Keiter, E. A., Keiter, R. L. & Medhi, O. K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India.*
*3. Sethi, A. Conceptual Organic Chemistry; New Age International Publisher.*
*4. Parmar, V. S. A Text Book of Organic Chemistry, S. Chand & Sons.*
*5. Madan, R. L. Organic Chemistry, S. Chand & Sons.*
*6. Wade, L. G., Singh, M. S., Organic Chemistry.*
*7. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).*
*8. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).*

**MI-3P Practical**

**Inorganic Chemistry Laboratory**

1. Estimation of Fe(II).
2. Estimation of Fe(III).
3. Estimation of Cu(II).
4. Estimation of Fe(II) and Fe(III) in a mixture.

**Organic Chemistry Lab**

**Identification of a pure organic compound**

Solid compounds: oxalic acid, tartaric acid, succinic acid, resorcinol, urea, glucose, benzoic acid and salicylic acid.

Liquid Compounds: methyl alcohol, ethyl alcohol, acetone, aniline, dimethylaniline, benzaldehyde,chloroform and nitrobenzene.

Reference Books:

*1. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N.,University of Calcutta, 2003.*
*2. Das, S. C., Chakraborty, S. B., Practical Chemistry.*
*3. Mukherjee, K. S. Text book on Practical Chemistry, New Oriental Book Agency.*
*4. Ghosal, Mahapatra & Nad, An Advanced course in practical Chemistry, New Central Book Agency.*
*5. Bhattacharyya, R. C, A Manual of Practical Chemistry.*
*6. Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis,CBS Publishers and Distributors.*
*7. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.*
*8. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman,*

# Semester-IV

**Theory**

# Paper- Inorganic Chemistry –I

**Paper Code: CHEM/4/MJ-5T**

- **Chemical bonding -II: (25 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.

- **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 concept, group characteristics of Lewis acids, solvent levelling and differentiating effects. Relative strength of acids, Pauling's rules. HSAB principle. Super acid, Hammett acidity function.

- *Thermodynamic acidity parameters*

Drago-Wayland equation. Superacids, Gas phase acidity and proton affinity.

- *Acid-base equilibria in aqueous solution:*

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

- **Theoretical principles of inorganic qualitative analysis: (8 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.

**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

**Paper Code: CHEM/4/MJ-5P**

**Qualitative semi-micro analysis of mixtures containing three radicals. Emphasis should be given to the understanding of the chemistry of different reactions:**

**Cation Radicals**

$Na^+$, $K^+$, $Ca^{2+}$, $Sr^{2+}$, $Ba^{2+,}$ $Al^{3+}$, $Cr^{3+}$, $Mn^{2+}/Mn^{4+}$, $Fe^{3+}$, $Co^{2+}/Co^{3+}$, $Ni^{2+}$, $Cu^{2+}$, $Zn^{2+}$, $Pb^{2+}$, $Cd^{2+}$ , $Bi^{3+}$ , $Sn^{2+}/Sn^{4+}$, $As^{3+}/As^{5+}$, $Sb^{3+}/^{5+}$ , $NH4^+$, $Mg^{2+}$ .

**Anion Radicals**

$F^-$, $Cl^-$ , $Br^-$, $BrO^{3-}$, I-, $IO_3^-$, $SCN^-$, $S_2^-$, $SO_4^{2-}$, $NO_3^-$, $NO_2^-$, $PO_4^{3-}$, $AsO_4^{3-}$, $BO_3^{3-}$, $CrO_4^{2-}$ / $Cr_2O_7^{2-}$, $Fe(CN)_6^{4-}$, $Fe(CN)_6^{3-}$.

**Insoluble Materials**

$Al_2O_3$(ig), $Fe_2O_3$(ig), $Cr_2O_3$(ig), $SnO_2$, $SrSO_4$, $BaSO_4$, $CaF_2$, $PbSO_4$.

**Reference Books:**

*1. Svehla & Sivasankar , Vogel's Qualitative Inorganic Analysis, 7th Ed., Pearson, 2012.*

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

# Paper- Organic Chemistry –II

**Paper Code: CHEM/4/MJ-6T**

- **Stereochemistry - III: (12 Lectures)**
  - *Conformation*

Conformational nomenclature: eclipsed, staggered, gauche, syn and anti; 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*

Prostereogenic centre; 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 propseudoasymmetric centre.

  - *Chirality arising out of stereo axis*

Stereoisomerism of substituted cumulenes with even and odd number of double bonds; chiral axis in allenes and biphenyls; related configurational descriptors (*Ra/Sa*); atropisomerism; racemisation of chiral biphenyls.

- **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, thiols and 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, SeO2 (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 $\alpha,\beta$-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): BAC2, AAC2, AAC1, AAL1 (in connection to acid and ester); acid derivatives: amides, anhydrides & acyl halides (formation and hydrolysis including comparison).

- **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, Suzuki coupling reaction, Heck coupling reaction.

**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

**Paper Code: CHEM/4/MJ-6P**

### Organic Preparations

**A. The following reactions 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. Benzoylation of phenols/aromatic amines
6. Side chain oxidation of aromatic compounds

7. Diazo coupling reactions of aromatic amines

8. Bromination of anilides using green approach (Bromate-Bromide method)

9. Redox reaction including solid-phase method

10. Green 'multi-component-coupling' reaction

11. Selective reduction of m-dinitrobenzene to m-nitroaniline 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 crystallisation from water/alcohol, crystallization after charcoal treatment, or sublimation, whichever is applicable.

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

**Reference Books**

*1. Vogel, A. I. Elementary Practical Organic Chemistry, Part 1: Small scale Preparations, CBS Publishers and Distributors.*
*2. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N. University of Calcutta, 2003.*
*3. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).*
*4. Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. Practical Organic Chemistry, 5th Ed. Pearson (2012).*
*5. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000).*
*6. Practical Workbook Chemistry (Honours), UGBS, Chemistry, University of Calcutta, 2015.*

# Paper- Physical Chemistry –II

## Theory

**Paper Code: CHEM/4/MJ-7T**

**Transport processes and Liquid State:**

- **Diffusion and Viscosity: (12Lectures)**
  - *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*

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.

- **Application of Thermodynamics - II: (20 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 non electrolyte solute, (ii) Depression of freezing point of an ideally dilute solution containing a non -volatile non electrolyte solute (iii) Osmotic pressure of an ideally dilute solution containing a non-volatile non electrolyte 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, CO2, 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: (13 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

**Paper Code: CHEM/4/MJ-7P**

**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. Conductometric Experiments :**

a) Conductometric determination of CMC

b) Study of kinetics saponification reaction conductometrically

**4**. CST of phenol water system.

**Reference Books:**

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

# Minor

**Paper Code: CHEM/4/MI-C4**

**Same as CHEM/4/MI-C3**