Draft Syllabus of

3-Year/4-Year B.Sc. Chemistry (Major)

As Per NEP 2020

(Up-to 4th Semester)

Semester Wise Course Distribution

Semester	Major Course	Level
SEM-I	**CHEMDSC-101**: Organic-I + Physical-I	**100 level**
SEM-II	**CHEMDSC-201**: Organic-II + Inorganic-I	
SEM-III	**CHEMDSC-301**: Physical-II + Inorganic-II	**200 level**
SEM-IV	**CHEMDSC-401**: Organic-III +Inorganic-III **CHEMDSC-402**: Organic-IV **CHEMDSC-403**: Inorganic-IV **CHEMDSC-404**: Physical-III	
SEM-V	**CHEMDSC-501**: Physical-IV **CHEMDSC-502**: Physical-V **CHEMDSC-503**: Organic-V **CHEMDSC-504**: Inorganic-V	**300 level**
SEM-VI	**CHEMDSC-601**: Organic-VI **CHEMDSC-602**: Inorganic-VI **CHEMDSC-603**: Inorganic-VII **CHEMDSC-604**: Physical-VI	
SEM-VII	**CHEMDSC-701**: Organic-VII **CHEMDSC-702**: Organic-VIII **CHEMDSC-703**: Inorganic-VIII **CHEMDSC-704**: Physical-VII	**400 Level**
SEM-VIII	**CHEMDSC-801**: Physical-VIII	

Course Structure for Chemistry (Major) [w.e.f 2024]

Semester	Paper Code	Paper Name	Brief Descriptions
1	**CHEMDSC-101T (FM 30)**	Organic-I + Physical-I	**Organic-I:** (a) Bonding & Physical Properties (**11 L**) (b) Stereochemistry-I (**5 L**) (c) Reaction Mechanism-I (**7 L**) **Physical-I:** (a) Thermodynamics-I: 1st Law & Thermochemistry (**8 L**) (b) Kinetics-I (**6 L**) (c) Kinetic Theory and Gaseous state (**8 L**)
	CHEMDSC-101P (FM 20)		**Organic-I (Prac):** Identification of a Pure Solid Organic Compound by chemical test(s): oxalic acid, tartaric acid, citric acid, succinic acid, resorcinol, urea, glucose, cane sugar, benzoic acid and salicylic acid **Physical-I (Prac):** (a) Study of kinetics of acid-catalyzed hydrolysis of methyl acetate. (b) Study of kinetics of decomposition of H_2O_2 (c) Determination of heat of neutralization of a strong acid by a strong base
2	**CHEMDSC-201T (FM 30)**	Organic-II + Inorganic-I	**Organic-II:** (a) Reaction Mechanism-II (**11 L**) (b) Chemistry of Alkenes and Alkynes (**12 L**) **Inorganic-I:** (a) Extra Nuclear Structure of Atoms (**12 L**) (b) Periodicity (**10 L**)
	CHEMDSC-201P (FM 20)		**Organic-II (Prac):** (a) The following reactions are to be performed, noting the yield of the crude product: i. Nitration of aromatic compounds ii. Condensation reactions iii. Hydrolysis of amides/imides/esters iv. Acetylation of phenols/aromatic amines v. Benzoylation of phenols/aromatic amines (b) Purification of the crude product is to be made by crystallization from water/alcohol. (c) Melting point of the purified product is to be noted. **Inorganic-I (Prac):** (a) Standardization of NaOH standard oxalic acid solution (b) Estimation of Fe(III) using standard $K_2Cr_2O_7$ solution. (c) Estimation of Fe(II) and Fe(III) in a given mixture using standard $K_2Cr_2O_7$ solution
	CHEMDSC-301T (FM 30)		**Inorganic-II:** (a) Chemical Bonding–I: Ionic Bond and Covalent Bond (**15 L**) (b) Periodicity (**16 L**) **Physical-II:** Thermodynamics-II: 2nd Law & Thermodynamics of Systems with Variable Composition (**22 L**)

3	**CHEMDSC-301P (FM 20)**	Physical-II + Inorganic-II	**Inorganic-II (Prac):** (a) Estimation of Fe (III) and Mn(II) in a mixture using standardized $KMnO_4$ solution (b) Estimation of Fe (III) and Cu(II) in a mixture using $K_2Cr_2O_7$. (c) Estimation of Fe (III) and Cr(III) in a mixture using $K_2Cr_2O_7$ **Physical-II (Prac):** (a) Conductometric titration of an acid (strong, weak/ monobasic, dibasic) against strong base. (b) Study of saponification reaction conductometrically. (c) Verification of Ostwald's dilution law and determination of K_a of weak acid.
4	**CHEMDSC-401T (FM 30)**	Organic-III + Inorganic-III	**Organic-III:** (a) Aromatic electrophilic and nucleophilic substitution (**8 L**) (b) Chemistry of Alcohols, Ethers and Phenols (**7 L**) (c) Stereochemistry-II (**8 L**) **Inorganic-III:** (a) Acids and Bases (**15 L**) (b) General Principles of Metallurgy (**7 L**)
	CHEMDSC-401P (FM 20)		**Organic-III (Prac):** (a) The following reactions are to be performed, noting the yield of the crude product: i. Bromination of anilides using green approach (Bromate-Bromide method) ii. Redox reaction including solid-phase method iii. Green 'multi-component-coupling' reaction iv. Selective reduction of m-dinitrobenzene to m-nitroaniline (b) Purification of the crude product is to be made by crystallization from water/alcohol. (c) Melting point of the purified product is to be noted. **Inorganic-III (Prac):** (a) Estimation of carbonate and hydroxide present together in mixture (b) Estimation of carbonate and bicarbonate present together in a mixture. (c) Estimation of free alkali present in different soaps/detergents
	CHEMDSC-402T (FM 30)	Organic-IV	**Organic-IV:** (a) Stereochemistry-III (**12 L**) (b) Chemistry of carbonyl Compounds (**28 L**) (c) Organic Spectroscopy-I: UV-Vis Spectroscopy (**5 L**)
	CHEMDSC-402P (FM 20)		**Organic-IV (Prac):** Qualitative Analysis of Single Solid Organic Compounds
	CHEMDSC-403T (FM 30)	Inorganic-IV	**Inorganic-IV:** (a) Redox-II (1**5 L**) (b) Radioactivity (**15 L**) (c) Non-Aq. Solvents**:** Classification of Solvents, Liquid Ammonia, Liquid SO_2, HF- Types of Reactions (**10 L**)

4	**CHEMDSC-403P (FM 20)**		**Inorganic-IV (Prac):** Qualitative semimicro analysis of mixtures containing three radicals.
	CHEMDSC-404T (FM 30)	Physical-III	**Physical-III:** (a) Real gas and Virial equation (**7 L**) (b) Transport processes and Liquid State (**5 L**) (c) Surface tension and energy (**4 L**) (d) Solid State (**12 L**) (e) Chemical Equilibrium (**8 L**) (f) Conductance (**9 L**)
	CHEMDSC-404P (FM 20)		**Physical-III (Prac):** (a) Study of viscosity of unknown liquid (glycerol, sugar) with respect to water. (b) Determination of partition coefficient for the distribution of I_2 between water and Benzene. (c) Determination of Keq for $KI + I_2 = KI_3$, using partition coefficient between water and Benzene

Chemistry (Major)

[Credit: Theory -03, Practical – 01], T=Theory, P=Practical

SEMESTER-I

Paper: **CHEMDSC-101T (Organic-I + Physical-I)**
Theory: 45 L (45 Hours)

Gr-A: Organic-I

Bonding and Physical Properties **(11 L)**

VBT: Concept of hybridization, shapes and structures of molecules, double bond equivalent (DBE), Influence of hybridization on bond properties

Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications bond polarization and bond polarizability; steric effect, steric inhibition of resonance.

MOT: 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 π orbital system (C=C, conjugated diene, triene, allyl and pentadienyl systems), (ii) cyclic π 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: Impact of hybridization on bond dissociation energy, bond energy, bond distances and bond angles. Understanding different types of strains: angle strain, torsional strain, strain due to non-bonded interaction, dipole-dipole, and twisting. Impact of covalent and non-covalent intermolecular forces on melting point, boiling point, and solubility. Heat of hydrogenation, heat of combustion, and heat of formation

Stereochemistry-I **(5 L)**

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).

Reaction Mechanism-I **(7 L)**

Reactive intermediates: Generation, structure, stability, electrophilic/nucleophilic behavior): carbocations, carbanions, carbon radicals, carbenes (elementary idea).

Elementary Idea about Reactions: Homolytic and heterolytic bond fission, homogenic and heterogenic bond formation. Basic idea about Ionic, Radical and Pericyclic. Types Of Reactions (Definition and Examples): Addition, Elimination, Substitution, Rearrangement, Oxidation-Reduction, Tautomerization, Condensation, Polymerization (Definition and Examples).

Tautomerism: Prototropy (keto-enol, nitro - aci-nitro, nitroso-oximino, diazo- amino and enamine-imine systems); valence tautomerism and ring-chain tautomerism; 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.

Reference Books:

1. Clayden, J., Greeves, N. & Warren, S. Organic Chemistry, Second Edition, Oxford University Press, 2012. 2. Smith, J. G. Organic Chemistry, Tata Mcgraw- Hill Publishing Company Limited. 3. Nasipuri, D. Stereochemistry of Organic Compounds, Wiley Eastern Limited. 4. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 5. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd., (Pearson Education). 6. Fleming, I. Molecular Orbitals and Organic Chemical Reactions, Reference/Student Edition, Wiley, 2009. 7. Eames, J., Peach, J. M. Stereochemistry at A Glance, Blackwell Publishing, 2003. 8. Robinson, M. J., Stereochemistry, Oxford Chemistry Primer, Oxford University Press, 2005.

Gr-B: Physical-I

Thermodynamics-I: **(8 L)**

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 ΔU, ΔH, 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 L)**

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.

Kinetic Theory and Gaseous state: **(8 L)**

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

Reference Books:

1.Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford University Press. 2. Castellan, G. W. Physical Chemistry, Narosa.3. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press.4. Engel, T. & Reid, P. Physical Chemistry, Pearson. 5. Levine, I. N. Physical Chemistry, Tata McGraw-Hill. 6. Maron,S.& Prutton Physical Chemistry. 7. Ball, D. W. Physical Chemistry, Thomson Press. 8. Mortimer, R. G. Physical Chemistry, Elsevier. 9. Laidler, K. J. Chemical Kinetics, Pearson. 10. Glasstone, S. & Lewis, G.N. Elements of Physical Chemistry. 11. Rakshit, P.C., Physical Chemistry Sarat Book House. 12. Zemansky, M. W. & Dittman, R.H. Heat and Thermodynamics, Tata- McGraw-Hill. 13. Rastogi, R. P. & Misra, R.R. An Introduction to Chemical Thermodynamics, Vikas. 14. Clauze& Rosenberg, Chemical Thermodynamics.

Paper: **CHEMDSC-101P (Organic-I + Physical-I)**
Practical: 30 Hours

Organic-I (Prac)

Identification of a Pure Organic Compound by chemical test(s): oxalic acid, tartaric acid, citric acid, succinic acid, resorcinol, urea, glucose, cane sugar, benzoic acid and salicylic acid, formic acid, acetic acid, methanol, ethanol, acetone, aniline, dimethyl aniline, benzaldehyde, chloroform and nitrobenzene.

Physical-I (Prac):
(a) Study of kinetics of acid-catalyzed hydrolysis of methyl acetate.
(b) Study of kinetics of decomposition of H_2O_2
(c) Determination of heat of neutralization of a strong acid by a strong base

SEMESTER-II

Paper: **CHEMDSC-201T (Organic-II + Inorganic-I)**
Theory: 45 L (45 Hours)

Gr-A: Organic-II

Reaction Mechanism-II **(11 L)**

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

Concept of organic acids and bases: Effect of structure, substituent and solvent on acidity and basicity; proton sponge; gas-phase acidity and basicity; comparison between nucleophilicity and basicity; HSAB principle; application of thermodynamic principles in acid-base equilibria.

Reaction kinetics: Rate constant and free energy of activation; concept of order and molecularity; free energy profiles for one-step, two-step and three-step reactions; catalyzed reactions: electrophilic and nucleophilic catalysis; kinetic control and thermodynamic control of reactions; isotope effect: primary and secondary kinetic isotope effect (k_H/k_D); principle of microscopic reversibility; Hammond's postulate- Simple Applications.

Chemistry of Alkenes and Alkynes **(12 L)**

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.

Reference Books:

1.Clayden, J., Greeves, N., Warren, S. Organic Chemistry, Second edition, Oxford University Press 2012. 2. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003. 3. Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited. 4. Carey, F. A., Guiliano, R. M. Organic Chemistry, Eighth edition, McGraw Hill Education, 2012. 5. Loudon, G. M. Organic Chemistry, Fourth edition, Oxford University Press, 2008. 6. Norman, R.O. C., Coxon, J. M. Principles of Organic Synthesis, Third Edition, Nelson Thornes, 2003. 7. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 8. Finar,I. L. Organic Chemistry (Volume 1), Pearson Education. 9. Graham Solomons, T.W., Fryhle, C. B. Organic Chemistry, John Wiley & Sons, Inc. 10. March, J. Advanced Organic Chemistry, Fourth edition, Wiley. 11. Jenkins, P. R., Organometallic Reagents in Synthesis, Oxford Chemistry Primer, Oxford University Press. 12. Ward, R. S., Bifunctional Compounds, Oxford Chemistry Primer, Oxford University Press,

Gr-B: Inorganic-I

Extra Nuclear Structure of Atoms: (12 L)

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.

Periodicity: (10 L)

Modern IUPAC Periodic table, Effective nuclear charge, screening effects and penetration, Slater's rules, atomic radii, ionic radii (Pauling's univalent), covalent radii, lanthanide contraction. Ionization potential, electron affinity and electronegativity (Pauling's, Mulliken's and Allred Rochow's scales) and factors influencing these properties, group electronegativities. Group trends and periodic trends in these properties in respect of s-, p- and d-block elements. Secondary periodicity, relativistic effect, inert pair effect.

Reference 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.G. L. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Edition, Pearson India, 2008, 4.R. Sarkar, General and Inorganic Chemistry Part-I,New Central Book Agency, 2014, 5.A. G. Sharpe, C. E. Housecroft, Inorganic Chemistry 3rd Edition, Pearson India ,2002, 6.J. E. Huheey, E. A. Keiter, R. L. Keiter, Okhil K. Medhi, Principles of Structure and Reactivity, 5th Edition,Pearson India,2022, 7. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 1 & 3, Second Edition), CBS Publishers & Distributors Pvt. Ltd., 8. Principles of Inorganic Chemistry (33rd Edition), B.R. Puri, L.R. Sharma, K.C. Kalia, Vishal Publishing Co., 8. R. L. Dutta and G. S. De, Inorganic Chemistry, Pt – I, 7th Edn, 2013, The New Book Stall, 2013.

Paper: **CHEMDSC-201P (Organic-II + Inorganic-I)**
Practical: 30 Hours

Organic-II (Prac):

(a) The following reactions are to be performed, noting the yield of the crude product:

vi. Nitration of aromatic compounds
vii. Condensation reactions
viii. Hydrolysis of amides/imides/esters
ix. Acetylation of phenols/aromatic amines
x. Benzoylation of phenols/aromatic amines

(b) Purification of the crude product is to be made by crystallization from water/alcohol.

(c) Melting point of the purified product is to be noted.

Inorganic-I (Prac):

(a) Standardization of NaOH by standard oxalic acid solution

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

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

SEMESTER-III

Paper: **CHEMDSC-301T (Physical-II + Inorganic-II)**
Theory: 45 L (45 Hours)

Gr-A: Physical-II

Thermodynamics-II: **(23 L)**

2nd 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. Definitions of Activities and activity coefficients. Choice of standard states. Dependence of Activity on pressure and temperature.

Reference Books:

1.Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford University Press. 2. Castellan, G. W. Physical Chemistry, Narosa.3. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press. 5. Levine, I. N. Physical Chemistry, Tata McGraw-Hill. 6. Rakshit, P.C., Physical Chemistry Sarat Book House. 7. Kapoor, K. L., A Text Book of Physical Chemistry, 6thEdn, McGraw-Hill.

Gr-B: Inorganic-II

Redox-I: **(7 L)**

Redox couple, Elementary idea on standard redox potentials with sign conventions, Electrochemical series, Elementary idea on standard redox potentials with sign conventions. Nernst equation (without derivation). Cell construction, Equilibrium Constant. Analysis of redox cycle, Water acting as oxidant and reductant, Ion-electron method of balancing equation of redox reaction. Influence of complex formation, precipitation and change of pH on redox potentials; formal potential.

Chemical Bonding – I: **(15 L)**

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 energetic of dissolution process.

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 (σ and π bond approach).

Reference 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.G. L. Miessler, D. A. Tarr, Inorganic Chemistry, 3rd Edition, Pearson India, 2008, 4.R. Sarkar, General and Inorganic Chemistry Part-I,New Central Book Agency, 2014, 5.A. G. Sharpe, C. E. Housecroft, Inorganic Chemistry 3rd Edition, Pearson India ,2002, 6.J. E. Huheey, E. A. Keiter, R. L. Keiter, Okhil K. Medhi, Principles of Structure and Reactivity, 5th Edition,Pearson India,2022, 7. A. K. Das, Fundamental Concepts of Inorganic Chemistry, (Vol. 1 & 3, Second Edition), CBS Publishers & Distributors Pvt. Ltd., 8. Principles of Inorganic Chemistry (33rd Edition), B.R. Puri, L.R. Sharma, K.C. Kalia, Vishal Publishing Co., 8. R. L. Dutta and G. S. De, Inorganic Chemistry, Pt – I, 7th Edn, 2013, The New Book Stall, 2013.

Paper: **CHEMDSC-301P (Physical-II + Inorganic-II)**
Practical: 30 Hours

Physical-II (Prac)

(a) Conductometric titration of an acid (strong, weak/ monobasic, dibasic) against strong base.
(b) Study of saponification reaction conductometrically.
(c) Verification of Ostwald's dilution law and determination of K_a of weak acid.

Inorganic-II (Prac)

(a) Estimation of Fe (III) and Mn(II) in a mixture using standardized $KMnO_4$ solution
(b) Estimation of Fe (III) and Cu(II) in a mixture using $K_2Cr_2O_7$.
(c) Estimation of Fe (III) and Cr(III) in a mixture using $K_2Cr_2O_7$

SEMESTER-IV

Paper: **CHEMDSC-401T (Organic-III + Inorganic-III)**
Theory: 45 L (45 Hours)

Gr-A: Organic-III

Aromatic Substitution **(5 L)**

Electrophilic Aromatic Substitution
Electrophilic substitution reactions in benzene citing examples of nitration, halogenation, sulphonation and Friedel-Craft's alkylation and acylation with emphasis on carbocationic rearrangement, side chain oxidation of alkyl benzenes. Directing effects of groups in electrophilic 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).

Chemistry of Alcohols, Ethers and Phenols **(10 L)**

Alcohols: (Up To 5 Carbons). Preparation Using Grignard Reagent, Reduction of Aldehydes, Ketones, Carboxylic Acid and Esters; Reactions: With Sodium, HX (Lucas Test), Oxidation (Alkaline $KMnO_4$, Acidic Dichromate, Concentrated HNO_3); Oppenauer Oxidation.

Dihydric Alcohols: Nomenclature, different methods of formation, chemical reactions of vicinal glycols: oxidative cleavage [$Pb(OAc)_4$ and HIO_4], Pinacol–pinacolone, semi pinacol–pinacolone, dienone-phenol rearrangements.

Trihydric Alcohols: Glycerol (Few rexn may be added like Nitration, halogenation, nitration etc)

Phenols: Preparation: cumene hydroperoxide method, from diazonium salts; and benzene sulphonic acid. Acidic nature of phenols; Reactions: electrophilic substitution: nitration and halogenations; Reimer-Tiemann reaction, Gattermann–Koch reaction, Houben–Hoesch condensation, Schotten–Baumann reaction, Kolbe-Schmidt, Fries rearrangement and Claisen rearrangement

Ethers: Nomenclature, preparation, Williamson's ether synthesis; Reaction: cleavage of ethers with HI Epoxide - Synthesis, acid/base catalyzed ring opening of epoxides, orientation of ring opening, reactions of Grignard and organolithium reagents with epoxides.

Stereochemistry-II **(8 L)**

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* isomerism. 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

Reference Books:

1.Clayden, J., Greeves, N., Warren, S. Organic Chemistry, Second edition, Oxford University Press 2012. 2. Sykes, P. A guidebook to Mechanism in Organic Chemistry, Pearson Education, 2003. 3. Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited. 4. Carey, F. A., Guiliano, R. M. Organic Chemistry, Eighth edition, McGraw Hill Education, 2012. 5. Loudon, G. M. Organic Chemistry, Fourth edition, Oxford University Press, 2008. 6. Norman, R.O. C., Coxon, J. M. Principles of Organic Synthesis, Third Edition, Nelson Thornes, 2003. 7. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 8. Finar,I. L. Organic Chemistry (Volume 1), Pearson Education. 9. Graham Solomons, T.W., Fryhle, C. B. Organic Chemistry, John Wiley & Sons, Inc. 10. March, J. Advanced Organic Chemistry, Fourth edition, Wiley. 11. Jenkins, P. R., Organometallic Reagents in Synthesis, Oxford Chemistry Primer, Oxford University Press. 12. Ward, R. S., Bifunctional Compounds, Oxford Chemistry Primer, Oxford University Press, 13. Nasipuri, D. Stereochemistry of Organic Compounds, Wiley Eastern Limited.

Gr-B: Inorganic-III

Acids and Bases: (15 L)

Acid-base concept: Arrhenius concept, theory of solvent system (in H_2O, NH_3, SO_2 and HF), Bronsted-Lowry's concept, Pauling's rules. Lux-Flood concept, Lewis concept, group characteristics of Lewis acids, solvent levelling and differentiating effects. Factors affecting relative strength of acids and bases (different types), Thermodynamic acidity parameters, Drago-Wayland equation. Hammett acidity function. Super acids, Gas phase acidity and proton affinity; HSAB principle. Acid-base equilibria in aqueous solution (Proton transfer equilibria in water), pH, buffer, salt hydrolysis. Acid-base neutralization curves; indicator, choice of indicators.

General Principles of Metallurgy (7 L)

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy. Methods of purification of metals: Electrolytic Kroll process, Parting process, van Arkel-de Boer process and Mond's process, Zone refining.

Reference Books:

1.Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson,2006. 2. Greenwood,N.N. & Earnshaw A. Chemistry of the Elements, Butterworth-Heinemann, 1997. 3. Cotton, F.A., Wilkinson, G., Murrillo, C. A., Bochmann, M., Advanced Inorganic Chemistry 6th Ed. 1999., Wiley. 4. Miessler, G. L. & Donald, A. Tarr. Inorganic Chemistry 4th Ed., Pearson, 2010. 5. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991. 6. Douglas, B.E. and McDaniel,D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970. 7. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962. 8. Atkin, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010). 9. Cotton, F.A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry 3rd Ed.; Wiley India. 10. Sharpe, A.G., Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005.

Paper: **CHEMDSC-401P (Organic-II + Inorganic-III)**
Practical: 30 Hours

Organic-III (Prac)

(a) The following reactions are to be performed, noting the yield of the crude product:

v. Bromination of anilides using green approach (Bromate-Bromide method)
vi. Redox reaction including solid-phase method
vii. Green 'multi-component-coupling' reaction
viii. Selective reduction of m-dinitrobenzene to m-nitroaniline

(b) Purification of the crude product is to be made by crystallization from water/alcohol.
(c) Melting point of the purified product is to be noted.

Inorganic-II (Prac)

(a) Estimation of carbonate and hydroxide present together in mixture
(b) Estimation of carbonate and bicarbonate present together in a mixture.
(c) Estimation of free alkali present in different soaps/detergents

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Paper: **CHEMDSC-402T (Organic-IV)**
Theory: 45 L (45 Hours)

Stereochemistry-III (**12 L**)

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 pro-pseudoasymmetric 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 (R_a/S_a); atropisomerism; racemisation of chiral biphenyls

Chemistry of Carbonyl Compounds (28 L)

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, $LiAlH_4$, $NaBH_4$, MPV 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): $B_{AC}2$, $A_{AC}2$, $A_{AC}1$, $A_{AL}1$ (in connection to acid and ester); acid derivatives: amides, anhydrides & acyl halides (formation and hydrolysis including comparison).

Organic Spectroscopy-I: UV-Vis Spectroscopy (5 L)

UV Spectroscopy: Types of electronic transitions, λ_{max}, Lambert-Beer's law and its limitations, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward rules for calculation of λ_{max} for the following systems: α,β the unsaturated aldehydes: ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homo-annular and hetero-annular; Extended conjugated systems (aldehydes, ketones and dienes); distinction between cis and trans isomers.

Reference Books

1.Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 2. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education). 3. Norman, R.O. C., Coxon, J. M. Principles of Organic Synthesis, Third Edition, Nelson Thornes, 2003. 4. Clayden, J., Greeves, N., Warren, S., Organic Chemistry, Second edition, Oxford University Press 2012. 5. Silverstein, R. M., Bassler, G. C., Morrill, T. C. Spectrometric Identification of Organic Compounds, John Wiley and Sons, INC, Fifth edition. 6. Kemp, W. Organic Spectroscopy, Palgrave. 6. Pavia, D. L. et al. Introduction to Spectroscopy, 5th Ed. Cengage Learning India Ed. (2015). 7. Dyer, J.

Application of Absorption Spectroscopy of Organic Compounds, PHI Private Limited. 8. March, J. Advanced Organic Chemistry, Fourth edition, Wiley.9. Harwood, L. M., Polar Rearrangements, Oxford Chemistry Primer, Oxford University Press. 10. Bailey, Morgan, Organonitrogen Chemistry, Oxford Chemistry Primer, Oxford University Press. Warren, S. Organic Synthesis the Disconnection Approach, John Wiley and Sons. Warren, S., Designing Organic Synthesis, Wiley India, 2009. 13.Carruthers, W. Modern methods of Organic Synthesis, Cambridge University Press. 14. Willis, C. A., Wills, M., Organic Synthesis, Oxford Chemistry Primer, Oxford University Press.

Paper: **CHEMDSC-402P (Organic-IV)**
Practical: 30 Hours

Organic-IV (Prac)

Systematic Qualitative Analysis of a Single Solid Organic Compound

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Paper: **CHEMDSC-403T (Inorganic-IV)**
Theory: 45 L (45 Hours)

Redox-II **(15 L)**

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

Radioactivity **(20L)**

Nuclear stability and nuclear binding energy. Nuclear forces: meson exchange theory. Nuclear models (elementary idea): Concept of nuclear quantum number, magic numbers.
Nuclear Reactions: Artificial radioactivity, transmutation of elements, fission, fusion and spallation. Nuclear energy and power generation.Separation and uses of isotopes.
Radio chemical methods: principles of determination of age of rocks and minerals, radio carbon dating, hazards of radiation and safety measures

Non-Aq. Solvents **(10L)**

Classification of solvents, Physical properties (m.p and b.p, dielectric constant, dipole moment, viscosity, proton affinity) of solvents and their role in chemical reactions, Types of chemical reactions taking place in non-aqueous solvents: liq NH_3, liquid SO_2, HF

Reference Books

1. Lee, J. D. Concise Inorganic Chemistry 5th Ed., John Wiley and sons 2008. 2. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson,2006. 3. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970. 4. Porterfield, H. W., Inorganic Chemistry, Second Edition, Academic Press, 2005. 5. Purecell, K.F. and Kotz, J.C., An Introduction to Inorganic Chemistry, Saunders: Philadelphia, 1980. 6. Cotton, F.A., Wilkinson, G., & Gaus, P.L. Basic Inorganic Chemistry 3rd Ed.; Wiley India. 7. Gillespie, R. J. and Hargittai, I., The

VSEPR Model of Molecular Geometry, Prentice Hall (1992). 8. Albright, T., Orbital interactions in chemistry, John Wiley and Sons (2005). 9. Mingos, D.M.P., Essential trends in inorganic chemistry. Oxford University Press (1998). 10. Miessler, G. L., Fischer, P. J., Tarr, D. A., Inorganic Chemistry, Pearson, 5th Edition.

Paper: **CHEMDSC-403 (Inorganic-IV)**
Practical: 30 Hours

Inorganic-IV (Prac)

Qualitative semimicro analysis of mixtures containing three radicals

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Paper: **CHEMDSC-404T (Physical-III)**
Theory: 45 L (45 Hours)

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

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, other equations of state ; 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 virial form and significance of second virial coefficient; Intermolecular forces (Debye, Keesom and London interactions; Lennard-Jones potential - elementary idea).

Transport processes and Liquid State **(9 L)**

Viscosity

General features of fluid flow (streamline flow and turbulent flow); Newton’s equation, viscosity coefficient; Poiseuille’s equation ; 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; Temperature dependence of surface tension

Solid State **(12 L)**

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.

Chemical Equilibrium **(8 L)**

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.

Conductance **(9 L)**

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.

Reference Books:

1.Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford University Press. 2. Castellan, G. W. Physical Chemistry, Narosa.3. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press. 5. Levine, I. N. Physical Chemistry, Tata McGraw-Hill. 6. Rakshit, P.C., Physical Chemistry Sarat Book House. 7. Kapoor, K. L., A Text Book of Physical Chemistry, 6thEdn, McGraw-Hill.

Paper: **CHEMDSC-404 (Physical-III)**
Practical: 30 Hours

Physical-III (Prac)

(a) Study of viscosity of unknown liquid (glycerol, sugar) with respect to water.
(b) Determination of partition coefficient for the distribution of I_2 between water and Benzene.
(c) Determination of Keq for $KI + I_2 = KI_3$, using partition coefficient between water and Benzene