Syllabus of Chemistry (Hons.) for SEM-I & SEM-II Courses under CBCS

(to be effective from Academic Year: 2017-18)

The University of Burdwan
Burdwan, West Bengal

Type of Courses

Course type	Description	Number of Courses		Credit
		B. Sc. (Honours)	B.Sc. (Regular)	
CC	Core Course	14	12 (4 papers each from 3 disciplines of choice)	6
DSE	Discipline Specific Elective	4	6 (2 papers each from 3 discipline of choice including interdisciplinary papers)	6
GE	Generic Elective	4	-	6
AECC (ENVS & ENGLISH/MIL)	Ability Enhancement Compulsory Course	(1+1)	(1+1)	(4+2)
SEC	Skill Enhancement Course	2	4	2
TOTAL CREDIT		**142**	**122**	

Structure at a glance for Chemistry (H) at UG level, B.U.:

1st Semester

Course Code	Course Title	Course Type	Credit per course	Marks
CC-1	Organic Chemistry-I (Theo) Organic Chemistry-I (Prac)	Core Course – I	4+2	75
CC-2	Physical Chemistry-I (Theo) Physical Chemistry-I (Prac)	Core Course – II	4+2	75
GE-1	Any discipline other than chemistry	Generic Elective – 1	6	75
AECC-1	ENVS	Ability Enhancement Compulsory Course – I	4	100
TOTAL			22	325

2nd Semester

Course Code	Course Title	Course Type	Credit per course	Marks
CC-3	Inorganic Chemistry-I (Theo) Inorganic Chemistry-I (Prac)	Core Course – III	4+2	75
CC-4	Organic Chemistry-II (Theo) Organic Chemistry-II (Prac)	Core Course – IV	4+2	75
GE-2	Any discipline other than chemistry	Generic Elective – 2	6	75
AECC-2	Communicative Eng./MIL	Ability Enhancement Compulsory Course – II	2	50
TOTAL			20	275

3rd Semester

Course Code	Course Title	Course Type	Credit per course	Marks
CC-5	Physical Chemistry-II (Theo) Physical Chemistry-II (Prac)	Core Course – V	4+2	75
CC-6	Inorganic Chemistry-II (Theo) Inorganic Chemistry-II (Prac)	Core Course – VI	4+2	75
CC-7	Organic Chemistry-III (Theo) Organic Chemistry-III (Prac)	Core Course – VII	4+2	75
SEC-1	IT skill in Chemistry or Basic analytical chemistry	Skill Enhancement Course – 1	2	50
GE-3	Any discipline other than chemistry	Generic Elective – 3	6	75
TOTAL			26	350

4th Semester

Course Code	Course Title	Course Type	Credit per course	Marks
CC-8	Physical Chemistry-III (Theo) Physical Chemistry-III (Prac)	Core Course – VIII	4+2	75
CC-9	Inorganic Chemistry-II (Theo) Inorganic Chemistry-II (Prac)	Core Course – IX	4+2	75
CC-10	Organic Chemistry – IV (Theo) Organic Chemistry – IV (Prac)	Core Course - X	4+2	75
SEC-2	Pharmaceutical chemistry or Analytical, clinical biology	Skill Enhancement Course – II	2	50
GE-4	Any discipline other than chemistry	GE – 4	6	75
TOTAL			26	350

5th Semester

Course Code	Course Title	Course Type	Credit per course	Marks
CC-11	Inorganic Chemistry-IV (Theo) Inorganic Chemistry-IV (Prac)	Core Course – XI	4+2	75
CC-12	Organic Chemistry-V (Theo) Organic Chemistry-V (Prac)	Core Course – XII	4+2	75
DSE-1	Compulsory Course (Advanced Physical Chemistry) (Theo + Prac)	Discipline Specific Elective	4+2	75
DSE-2	Analytical methods in chemistry or instrumental methods of chemical analysis (Theo + Prac)	Discipline Specific Elective	4+2	75
TOTAL			24	300

6th Semester

Course Code	Course Title	Course Type	Credit per course	Marks
CC-13	Inorganic Chemistry-V (Theo) Inorganic Chemistry-V (Prac)	Core Course – XIII	4+2	75
CC-14	Physical Chemistry-IV (Theo) Physical Chemistry-IV (Prac)	Core Course – XIV	4+2	75
DSE-3	Green chemistry or polymer chemistry (Theo + Prac)	Discipline Specific Elective	4+2	75
DSE-4	inorganic materials of industrial importance (Theo + Prac) or Dissertation followed by power point presentation	Discipline Specific Elective	4+2 or 6	75
TOTAL			24	300

Introduction

The syllabus for Chemistry (Hons.) at undergraduate level using the Choice Based Credit system has been framed in compliance with model syllabus given by UGC, New Delhi and State Council under Department of Higher Education, Government of West Bengal.

The main objective of framing this new syllabus is to give the students a comprehensive understanding of the subject giving substantial heftiness to both the core content and techniques used in Chemistry. The syllabus has given equal importance to the three main branches of Chemistry – Physical, Inorganic and Organic.

The ultimate goal of the syllabus is that the students at the completion of the course would be able to secure a job. Keeping in mind and in tune with the fast changing nature of the subject, adequate emphasis has been given on new techniques and understanding of the subject.

The affiliated undergraduate colleges under 'The University of Burdwan' are requested to take necessary measure to ensure that the students must know the modern instruments used in Chemical analysis like ultrasonication, UV-VIS Spectrophotometric analysis, FT-IR Spectroscopy etc.; moreover, the colleges are also requested to take suitable measures to provide computers with Internet facilities to the students as well as the faculty members. As a result of this, the chemistry department of various undergraduate colleges may take the initiative to arrange educational tour for the students studying in 5^{th} and 6^{th} Semester to academic institute/university where the students can access and be enriched with the modern and sophisticated instruments as mentioned above.

It is essential that Chemistry students select their general electives courses from Physics, Mathematics and/or any branch of Life Sciences disciplines.

Also, to maintain equal importance of all three major sections of Chemistry, it is recommended that elective course "Advanced Physical Chemistry" may be made compulsory and students are free to select any three out of remaining five recommended elective courses.

Project Work followed by a power point presentation may be introduced instead of the 4th Elective with a credit of 6 split into 2+4, where 2 credits will be for continuous evaluation and 4 credits reserved for the merit of the dissertation.`

CHEMISTRY (H)

1st Semester:

Course Code: CC-1

Course Title: Organic Chemistry-I (Theo): Basics of Organic Chemistry 4 Credits

Bonding and Physical Properties:

1. Valence Bond Theory: Concept of hybridisation, shapes of molecules, resonance (including hyperconjugation); calculation of formal charges and double bond equivalent (DBE); orbital pictures of bonding (sp^3, sp^2, sp: C-C, C-N & C-O systems and *s*-cis and *s*-trans geometry for suitable cases). 4 classes

2. Electronic displacements: inductive effect, field effect, mesomeric effect, resonance energy; bond polarization and bond polarizability; electromeric effect; steric effect, steric inhibition of resonance. 4 classes

3. MO theory: qualitative idea about molecular orbitals, bonding and antibonding interactions, idea about σ, σ*, π, π *, n – MOs; basic idea about Frontier MOs (FMO); concept of HOMO, LUMO and SOMO; interpretation of chemical reactivity in terms of FMO interactions; 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-membered ring systems); Hückel's rules for aromaticity up to [10]-annulene (including mononuclear heterocyclic compounds up to 6-membered ring); concept of antiaromaticity and homoaromaticity; non-aromatic molecules; Frost diagram; elementary idea about α and β; measurement of delocalization energies in terms of β for buta-1,3-diene, cyclobutadiene, hexa-1,3,5-triene and benzene. 10 classes

4. Physical properties: influence of hybridization on bond properties: bond dissociation energy (BDE) and bond energy; bond distances, bond angles; concept of bond angle strain (Baeyer's strain theory); melting point/boiling point and solubility of common organic compounds in terms of covalent & non-covalent intermolecular forces; polarity of molecules and dipole moments; relative stabilities of isomeric hydrocarbons in terms of heat of hydrogenation, heat of combustion and heat of formation. 6 classes

General Treatment of Reaction Mechanism I

1. Mechanistic classification: ionic, radical and pericyclic (definition and example); reaction type: addition, elimination and substitution reactions (definition and example); nature of bond cleavage and bond formation: homolytic and heterolytic bond fission, homogenic and heterogenic bond formation; curly arrow rules in representation of mechanistic steps; reagent type: electrophiles and nucleophiles (elementary idea); electrophilicity and nucleophilicity in terms of FMO approach. 8 classes

2. Reactive intermediates: carbocations (carbenium and carbonium ions), carbanions, carbon radicals, carbenes: generation and stability, structure using orbital picture and electrophilic/nucleophilic behavior of reactive intermediates (elementary idea). 4 classes

Stereochemistry-I

1. 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. 4 classes

2. Concept of chirality and symmetyry; symmetry elements and point groups (C_v, C_{nv}, C_{nh}, C_n, D_h, D_{nh}, D_{nd}, D_n, S_n (C_s, C_i); molecular chirality and centre of chirality; asymmetric and dissymmetric molecules; enantiomers and diastereomers; concept of epimers; concept of stereogenicity, chirotopicity and pseudoasymmetry; chiral centres and number of stereoisomerism: systems involving 1/2/3-chiral centre(s) (AA, AB, ABA and ABC types). 10 classes

3. Relative and absolute configuration: D/L and R/S descriptors; erythro/threo and meso nomenclature of compounds; *syn*/*anti* nomenclatures for aldols; E/Z descriptors for C=C, conjugated diene, triene, C=N and N=N systems; combination of R/S- and E/Z-isomerisms. 4 classes

4. Optical activity of chiral compounds: optical rotation, specific rotation and molar rotation; racemic compounds, racemisation (through cationic, anionic, radical intermediates and through reversible formation of stable achiral intermediates); resolution of acids, bases and alcohols via diastereomeric salt formation; optical purity and enantiomeric excess. 6 classes

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. James, J., Peach, J. M. Stereochemistry at a Glance, Blackwell Publishing, 2003.
8. Robinson, M. J. T., Stereochemistry, Oxford Chemistry Primer, Oxford University Press, 2005**.**
9. Morrison, R. T. Study guide to organic Chemistry, Pearson.

Course Code: CC-1

Course Title: Organic Chemistry-I (Prac): Basics of Organic Chemistry 2 Credits

Separation

Based upon solubility, by using common laboratory reagents like water (cold, hot), dil. HCl, dil. NaOH, dil. NaHCO3, etc., of components of a binary solid mixture; purification of any one of the separated components by crystallization and determination of its melting point. The composition of the mixture may be of the following types: Benzoic acid/p-Toluidine; p-Nitrobenzoic acid/p-Aminobenzoic acid; p-Nitrotolune/p-Anisidine.

Determination of boiling point

Determination of boiling point of common organic liquid compounds e.g., ethanol, cyclohexane, ethyl methyl ketone, cyclohexanone, acetylacetone, anisole, crotonaldehyde, mesityl oxide. [Boiling point of the chosen organic compounds should preferably be less than 160 °C].

Identification of a Pure Organic Compound by Chemical Test(s)

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

Liquid Compounds: acetic acid, ethyl alcohol, acetone, aniline and nitrobenzene.

Reference Books:

1. Bhattacharyya, R. C, A Manual of Practical Chemistry.
2. Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, CBS Publishers and Distributors.
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).

Course Code: CC-2

Course Title: Physical Chemistry-I (Theo) 4 Credits

Kinetic Theory and Gaseous state

1. Kinetic Theory of gases: Concept of pressure and temperature; 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. 4 classes

2. Maxwell's distribution of speed and energy: 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; 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.

6 classes

3. Real gas and virial equation: 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 behaviour, other equations of state (Berthelot, Dietrici); 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). 10 classes

Chemical Thermodynamics

1. Zeroth and 1^{st} law of Thermodynamics: Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics; Concept of heat, work, internal energy and statement of first law; enthalpy, H; relation between heat capacities, calculations of q, w, U and H for reversible, irreversible and free expansion of gases (ideal and van der Waals) under isothermal and adiabatic conditions; Joule's experiment and its consequence. 6 classes

2. Thermochemistry: Standard states; Heats of reaction; enthalpy of formation of molecules and ions and enthalpy of combustion and its applications; Laws of thermochemistry; bond energy, bond dissociation energy and resonance energy from thermochemical data, Kirchhoff's equations and effect of pressure on enthalpy of reactions; Adiabatic flame temperature; explosion temperature. 6 classes

3. Second Law: Need for a Second law; statement of the second law of thermodynamics; Concept of heat reservoirs and heat engines; Carnot cycle; Physical concept of Entropy; 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; Entropy change of systems and surroundings for various processes and transformations; Entropy and unavailable work; Auxiliary state functions (G and A) and their variation with T, P and V. Criteria for spontaneity and equilibrium. 8 classes

4. Thermodynamic relations: Maxwell's relations; Gibbs- Helmholtz equation, Joule-Thomson experiment and its consequences; inversion temperature; Joule-Thomson coefficient for a van der Waals gas; General heat capacity relations. 4 classes

Chemical kinetics

1. Rate law, order and molecularity: Introduction of rate law, Extent of reaction; rate constants, order; Forms of rates of First, second and nth order reactions; Pseudo first order reactions (example using acid catalyzed hydrolysis of methyl acetate); Determination of order of a reaction by half-life and differential method; Opposing reactions, consecutive reactions and parallel reactions (with explanation of kinetic and thermodynamic control of products; all steps first order). 6 classes

2. Role of Temperature and theories of reaction rate: Temperature dependence of rate constant; Arrhenius equation, energy of activation; Rate-determining step and steady-state approximation – explanation with suitable examples; Collision theory; Lindemann theory of unimolecular reaction; outline of Transition State theory (classical treatment). 4 classes

3. Homogeneous catalysis: Homogeneous catalysis with reference to acid-base catalysis; Primary kinetic salt effect; Enzyme catalysis; Michaelis-Menten equation, Lineweaver-Burk plot, turn-over number. 4 classes

4. Autocatalysis; periodic reactions. 2 classes

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.
15. Sharma, K. K. & Sharma, L. K., A Textbook of Physical Chemistry.
16. Bajpai, D. N., Advanced Physical Chemistry.
17. Rajaram, J. Chemical Thermodynamics: Classical, Statistical and Irreversible, Pearson.

Course Code: CC-2

Course Title: Physical Chemistry-I (Prac) 2 Credits

List of Practical

1. Determination of pH of unknown solution (buffer), by color matching method;
2. Determination of the reaction rate constant of hydrolysis of ethylacetate in the presence of an equal quantity of sodium hydroxide;
3. Study of kinetics of acid-catalyzed hydrolysis of methyl acetate;
4. Study of kinetics of decomposition of H_2O_2 by KI;
5. Determination of solubility product of PbI_2 by titremetric method.

Reference Books:

1. Viswanathan, B., Raghavan, P.S. Practical Physical Chemistry Viva Books (2009).
2. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson.
3. Harris, D. C. Quantitative Chemical Analysis. 6th Ed., Freeman (2007).
4. Palit, S.R., De, S. K. Practical Physical Chemistry Science Book Agency.
5. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta.
6. Levitt, B. P. edited Findlay's Practical Physical Chemistry Longman Group Ltd.
7. Gurtu, J. N., Kapoor, R., Advanced Experimental Chemistry S. Chand & Co. Ltd.

Course Code: Generic Elective-1 (Theo.) 4 Credits

(For the students of discipline other than chemistry)

Course Title: Atomic Structure, Chemical Periodicity, Acids And Bases, Redox Reactions, General Organic Chemistry & Aliphatic Hydrocarbons

Inorganic Chemistry

1. **Atomic Structure**

Bohr's theory for hydrogen atom (simple mathematical treatment), atomic spectra of hydrogen and Bohr's model, Sommerfeld's model, quantum numbers and their significance, Pauli's exclusion principle, Hund's rule, electronic configuration of many-electron atoms, Aufbau principle and its limitations. 5 classes

2. **Chemical Periodicity**

Classification of elements on the basis of electronic configuration: general characteristics of s-, p-, d- and 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. 5 classes

3. **Acids and bases**

Brönsted–Lowry concept, conjugate acids and bases, relative strengths of acids and bases, effects of substituent and solvent, differentiating and levelling solvents. Lewis acid-base concept, classification of Lewis acids and bases, Lux-Flood concept and solvent system concept. Hard and soft acids and bases (HSAB concept), applications of HSAB process. 5 classes

4. **Redox reactions**

Balancing of equations by oxidation number and ion-electron method oxidimetry and reductimetry. 5 classes

Organic Chemistry

1. **Fundamentals of Organic Chemistry**

Electronic displacements: inductive effect, resonance and hyperconjugation; cleavage of bonds: homolytic and heterolytic; structure of organic molecules on the basis of VBT; nucleophiles electrophiles; reactive intermediates: carbocations, carbanions and free radicals. 5 classes

2. **Stereochemistry**

Different types of isomerism; geometrical and optical isomerism; concept of chirality and optical activity (up to two carbon atoms); asymmetric carbon atom; elements of symmetry (plane and

centre); interconversion of Fischer and Newman representations; enantiomerism and diastereomerism, meso compounds; threo and erythro, D and L, cis and trans nomenclature; CIP Rules: R/S (upto 2 chiral carbon atoms) and E/Z nomenclature. 5 classes

3. **Nucleophilic Substitution and Elimination Reactions**

Nucleophilic substitutions: SN1 and SN2 reactions; eliminations: E1 and E2 reactions (elementary mechanistic aspects); Saytzeff and Hofmann eliminations; elimination vs substitution. 5 classes

4. **Aliphatic Hydrocarbons**

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structures. 3 classes

5. **Alkanes**: (up to 5 Carbons). Preparation: catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: mechanism for free radical substitution: halogenation. 4 classes

6. **Alkenes**: (up to 5 Carbons). Preparation: elimination reactions: dehydration of alcohols and dehydrohalogenation of alkyl halides; cis alkenes (partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alkaline $KMnO_4$) and trans-addition (bromine) with mechanism, addition of HX [Markownikoff's (with mechanism) and anti-Markownikoff's addition], hydration, ozonolysis, oxymercuration-demercuration and hydroboration-oxidation reaction. 10 classes

7. **Alkynes**: (up to 5 Carbons). Preparation: acetylene from CaC_2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal dihalides. 4 classes

8. **Reactions**: formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alkaline $KMnO_4$. 4 classes

References Books:

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 Ind.

5. Sethi, A. Conceptual Organic Chemistry; New Age International Publisher.
6. Parmar, V. S. A Text Book of Organic Chemistry, S. Chand & Sons.
7. Madan, R. L. Organic Chemistry, S. Chand & Sons.
8. Wade, L. G., Singh, M. S., Organic Chemistry.
9. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
10. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
11. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
12. Sen Gupta, Subrata. Basic Stereochemistry of Organic molecules.
13. Kalsi, P. S. Stereochemistry Conformation and Mechanism, Eighth edition, New Age International, 2014.
14. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
15. Malik, W. U., Tuli, G. D., Madan, R. D., Selected Topics in Inorganic Chemistry.

Course Code: Generic Elective-1 (Prac) 2 Credits

(For the students of discipline other than chemistry)

Course Title: Atomic Structure, Chemical Periodicity, Acids And Bases, Redox Reactions, General Organic Chemistry & Aliphatic Hydrocarbons

Inorganic Chemistry

1. Estimation of oxalic acid by titrating it with $KMnO_4$.
2. Estimation of Mohr's salt by titrating with $KMnO_4/K_2Cr_2O_7$.
3. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using internal indicator.

Organic Chemistry

Qualitative Analysis of Single Solid Organic Compound(s)

1. Detection of special elements (N, Cl, and S) in organic compounds.
2. Solubility and Classification (solvents: H_2O, dil. HCl, dil. NaOH)
3. Detection of functional groups: Aromatic-NO_2, Aromatic -NH_2, -COOH, carbonyl (no distinction of –CHO and >C=O needed), -OH (phenolic) in solid organic compounds.

Experiments 1 to 3 with unknown (at least 6) solid samples containing not more than two of the above type of functional groups should be done.

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. Vogel, A. I. Elementary Practical Organic Chemistry, Part 2: Qualitative Organic Analysis, CBS Publishers and Distributors
6. 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.
7. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.

2nd Semester:

Course Code: CC-3

Course Title: Inorganic Chemistry-I (Theo) 4 Credits

Extra nuclear Structure of atom

Bohr's theory, its limitations and atomic spectrum of hydrogen atom; Sommerfeld's Theory. Wave mechanics: de Broglie equation, Heisenberg's Uncertainty Principle and its significance, Schrödinger's wave equation, significance of ψ and ψ^2. Quantum numbers and their significance. Radial and angular wave functions for hydrogen atom. Radial and angular distribution curves. Shapes of s, p, d and f orbitals. Pauli's Exclusion Principle, Hund's rules and multiplicity, Exchange energy, Aufbau principle and its limitations, Ground state Term symbols of atoms and ions for atomic number upto 30. 15 classes

Chemical periodicity

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. 15 classes

Acid-Base reactions

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

15 classes

Redox Reactions and precipitation 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. 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);

Solubility product principle, common ion effect and their applications to the precipitation and separation of common metallic ions as hydroxides, sulfides, phosphates, carbonates, sulfates and halides. 15 classes

Reference Books:

1. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.
2. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970.
3. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
4. Atkins, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).
5. Cotton, F.A., Wilkinson, G. and Gaus, P.L., Basic Inorganic Chemistry 3rd Ed.; Wiley India.
6. Sharpe, A.G., Inorganic Chemistry, 4th Indian Reprint (Pearson Education) 2005.
7. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. Inorganic Chemistry, Principles of Structure and Reactivity 4th Ed., Harper Collins 1993, Pearson, 2006.
8. Atkins, P.W. & Paula, J. Physical Chemistry, Oxford Press, 2006.
9. Mingos, D.M.P., Essential trends in inorganic chemistry. Oxford University Press (1998).
10. Winter, M. J., The Orbitron, http://winter.group.shef.ac.uk/orbitron/ (2002). An illustrated gallery of atomic and molecular orbitals.
11. Burgess, J., Ions in solution: basic principles of chemical interactions. Ellis Horwood (1999).

Course Code: CC-3

Course Title: Inorganic Chemistry-I (Prac) 2 Credits

Oxidation-Reduction Titrimetric

1. Estimation of Fe(II) using standardized $KMnO_4$ solution
2. Estimation of oxalic acid and sodium oxalate in a given mixture
3. Estimation of Fe(II) and Fe(III) in a given mixture using $K_2Cr_2O_7$ solution.
4. Estimation of Fe(III) and Mn(II) in a mixture using standardized $KMnO_4$ solution
5. Estimation of Fe(III) and Cu(II) in a mixture using $K_2Cr_2O_7$.
6. Estimation of Fe(III) and Cr(III) in a mixture using $K_2Cr_2O_7$.

Reference Books:

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

Course Code: CC-4

Course Title: Organic Chemistry-II (Theo) 4 Credits

Stereochemistry II

1. Chirality arising out of stereoaxis: stereoisomerism of substituted cumulenes with even and odd number of double bonds; chiral axis in allenes, spiro compounds, alkylidenecycloalkanes and biphenyls; related configurational descriptors (Ra/Sa and P/M); atropisomerism; racemisation of chiral biphenyls; buttressing effect. 6 classes

2. 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. 4 classes

3. Conformation: conformational nomenclature: eclipsed, staggered, gauche, syn and anti; dihedral angle, torsion angle; Klyne-Prelog terminology; P/M descriptors; 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. 8 classes

4. 2-methylbutane and 2,3-dimethylbutane; haloalkane, 1,2-dihaloalkanes and 1,2-diols (up to four carbons); 1,2-halohydrin; conformation of conjugated systems (*s*-cis and *s*-trans). 4 classes

General Treatment of Reaction Mechanism II

1. Reaction thermodynamics: free energy and equilibrium, enthalpy and entropy factor, calculation of enthalpy change via BDE, intermolecular & intramolecular reactions. 4 classes

2. 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 nucleophlicity and basicity; HSAB principle; application of thermodynamic principles in acid-base equilibria. 4 classes

3. Tautomerism: prototropy (keto-enol, amido-imidol, nitroso-oximino, diazo-amino and enamine-imine systems); 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; application of thermodynamic principles in tautomeric equilibria. 6 classes

4. 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 isotopic effect (kH /kD); principle of microscopic reversibility. 4 classes

Substitution and Elimination Reactions

1. Free-radical substitution reaction: halogentaion of alkanes, mechanism (with evidence) and stereochemical features; reactivity-selectivity principle in the light of Hammond's postulate. 4 classes

2. Nucleophilic substitution reactions: substitution at sp^3 centre: 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; role of crown ethers and phase transfer catalysts; [systems: alkyl halides, allyl halides, benzyl halides, alcohols, ethers, epoxides]. 10 classes

3. 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. 6 classes

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. Eliel, E. L. & Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994.
7. Nasipuri, D. Stereochemistry of Organic Compounds, Wiley Eastern Limited.
8. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
9. Finar, I. L. Organic Chemistry (Volume 1) Pearson Education.
10. Graham Solomons, T.W., Fryhle, C. B. Organic Chemistry, John Wiley & Sons, Inc.
11. James, J., Peach, J. M. Stereochemistry at a Glance, Blackwell Publishing, 2003.
12. Robinson, M. J. T., Stereochemistry, Oxford Chemistry Primer, Oxford University Press, 2005.
13. Maskill, H., Mechanisms of Organic Reactions, Oxford Chemistry Primer, Oxford University Press.

Course Code: CC-4

Course Title: Organic Chemistry-II (Prac) 2 Credits

Organic Preparations

A. The following reactions are to be performed, noting the yield of the crude product:

1. Nitration of acetanilide
2. Condensation reactions: Synthesis of 7-hydroxy-4-methylcoumarin
3. Hydrolysis of amides/imides/esters
4. Acetylation of phenols/aromatic amines (using Zn-dust/Acetic Acid)
5. Benzoylation of phenols/aromatic amines
6. Side chain oxidation of toluene and p-nitrotoluene
7. Diazo coupling reactions of aromatic amines
8. Bromination of acetanilide using green approach (Bromate-Bromide method)
9. Green 'multi-component-coupling' reaction: Synthesis of dihydropyrimidone
10. 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.
7. Vishnoi, N. K., Advanced Practical Organic Chemistry.

Course Code: Generic Elective-2 (Theo) 4 Credits

(For the students of discipline other than chemistry)

Course Title: States of Matter & Chemical Kinetics, Chemical Bonding & Molecular Structure, P-Block Elements

Physical Chemistry

1. **Kinetic Theory of Gases and Real gases**

a. Concept of pressure and temperature; Collision of gas molecules; Collision diameter; Collision number and mean free path; Frequency of binary collisions (similar and different molecules); Rate of effusion

b. Nature of distribution of velocities, Maxwell's distribution of speed and kinetic energy; Average velocity, root mean square velocity and most probable velocity; Principle of equipartition of energy and its application to calculate the classical limit of molar heat capacity of gases

c. 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 behaviour; Existence of critical state, Critical constants in terms of van der Waals constants; Law of corresponding states

d. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only)

2. **Liquids**

a. Definition of Surface tension, its dimension and principle of its determination using stalagmometer; Viscosity of a liquid and principle of determination of coefficient of viscosity using Ostwald viscometer; Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only)

3. **Solids**

a. Forms of solids, crystal systems, unit cells, Bravais lattice types, Symmetry elements; Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices; Miller indices of different planes and interplanar distance, Bragg's law; Structures of NaCl, KCl and CsCl (qualitative treatment only); Defects in crystals; Glasses and liquid crystals.

4. **Chemical Kinetics**

a. Introduction of rate law, Order and molecularity; Extent of reaction; rate constants; Rates of First, second and nth order reactions and their Differential and integrated forms (with derivation); Pseudo first order reactions; Determination of order of a reaction by half-life and differential method; Opposing reactions, consecutive reactions and parallel reactions

b. Temperature dependence of rate constant; Arrhenius equation, energy of activation; Collision theory; Lindemann theory of unimolecular reaction; outline of Transition State theory (classical treatment).

Inorganic Chemistry

1. **Chemical Bonding and Molecular Structure**

a. 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.

b. 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.

c. Concept of resonance and resonating structures in various inorganic and organic compounds.

d. 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) and heteronuclear diatomic molecules such as CO, NO and NO+. Comparison of VB and MO approaches.

2. Comparative study of p-block elements

a. Group trends in electronic configuration, modification of pure elements, common oxidation states, inert pair effect, and their important compounds in respect of the following groups of elements:

i. B-Al-Ga-In-Tl

ii. C-Si-Ge-Sn-Pb

iii. N-P-As-Sb-Bi

iv. O-S-Se-Te

v. F-Cl-Br-I

Reference Books:

1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
4. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
5. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
6. Chugh, K.L., Agnish, S.L. A Text Book of Physical Chemistry Kalyani Publishers.
7. Bahl, B.S., Bahl, A., Tuli, G.D., Essentials of Physical Chemistry S. Chand & Co. ltd.
8. Palit, S. R., Elementary Physical Chemistry Book Syndicate Pvt. Ltd.
9. Mandal, A. K. Degree Physical and General Chemistry Sarat Book House.
10. Pahari, S., Physical Chemistry New Central Book Agency.
11. Pahari, S., Pahari, D., Problems in Physical Chemistry New Central Book Agency.
12. Cotton, F.A. & Wilkinson, G. Basic Inorganic Chemistry, Wiley.
13. Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press.
14. Wulfsberg, G. Inorganic Chemistry, Viva Books Pvt. Ltd.
15. Rodgers, G.E. Inorganic & Solid State Chemistry, Cengage Learning India Ltd., 2008.

Course Code: Generic Elective-2 (Prac) 4 Credits

(For the students of discipline other than chemistry)

Course Title: States of Matter & Chemical Kinetics, Chemical Bonding & Molecular Structure, P-Block Elements

Physical Chemistry

1. Surface tension measurement (use of organic solvents excluded)
   a. Determination of the surface tension of a liquid or a dilute solution using a Stalagmometer
   b. Study of the variation of surface tension of a detergent solution with concentration
2. Viscosity measurement (use of organic solvents excluded)
   a. Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer
   b. Study of the variation of viscosity of an aqueous solution with concentration of solute.

Inorganic Chemistry

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

Acid Radicals: Cl^-, Br^-, I^-, NO_2^-, NO_3^-, S_2^-, SO_4^{2-}, PO_4^{3-}, BO_3^{3-}, H_3BO_3.

Basic Radicals: Na^+, K^+, Ca^{2+}, Sr^{2+}, Ba^{2+}, Cr^{3+}, Mn^{2+}, Fe^{3+}, Ni^{2+}, Cu^{2+}, NH^{4+}.

Reference Books:

1. University Hand Book of Undergraduate Chemistry Experiments, edited by Mukherjee, G. N., University of Calcutta, 2003.
2. Palit, S.R., Practical Physical Chemistry Science Book Agency.
3. Mukherjee, N.G., Selected Experiments in Physical Chemistry J. N. Ghose & Sons.
4. Dutta, S.K., Physical Chemistry Experiments Bharati Book Stall.
5. Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
6. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).