THE UNIVERSITY OF BURDWAN

Syllabus of 3-Year Degree/4-Year Honours in Chemistry

Under Curriculum and Credit Framework for Undergraduate Programme (CCFUP) as per National Education Policy 2020

with effect from 2023-24

Paper codes, credit allocation, marks distribution, etc

Sem	Course type	Paper code	Course name	Credit				Marks			
				T	Lec	Prac	Tut	Th	Prac	IA	T
I	Major	CHEM101-1	Basic Chemistry-I	4	3	1	0	40	20	15	75
	Minor	CHEM102-1	General Chemistry-I	4	3	1	0	40	20	15	75
	Multi/ interdisciplinary	CHEM103-1	Chemistry for household importance	3	3	0	0	40	00	10	50
	Ability Enhancement Course (AEC)		-								
	Skill Enhancement Course (SEC)	CHEM105-1	Drugs and pharmaceuticals	3	3	0	0	40	00	10	50
	Common Value Added (CVA) Course		-								
II	Major	CHEM201-1	Basic Chemistry-II	4	3	1	0	40	20	15	75
	Minor	CHEM202-1	General Chemistry-II	4	3	1	0	40	20	15	75
	Multi/interdisciplinary	CHEM203-1	Chemistry of Dyes, pigments, cosmetics and perfumes	3	3	0	0	40	00	10	50
	Ability Enhancement Course (AEC)										
	Skill Enhancement Course (SEC)	CHEM205-1	Basic Analytical Chemistry	3	3	0	0	40	00	10	50
	Common Value Add-ed (CVA) Course										

Semester-I

Chemistry MAJOR

Paper code: CHEM101-1
Paper title: Basic Chemistry-I
Credits 3+1

Theory Credits 3

1. Atomic structure

Bohr's theory- its limitations and atomic spectra 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 *6 Hours*

2. Periodic properties

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 *6 Hours*

3. Acids and bases

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, concept of organic acids and bases, effect of structure, substituent and solvent on acidity and basicity, proton sponge, gas-phase acidity and basicity

6 Hours

4. Chemical bonding-I

Ionic bond: general characteristics, types of ions, size effects, radius ratio rule and its application and limitations, packing of ions in crystals Born-Landé equation with derivation

and importance, Kapustinskii expression for lattice energy, Madelung constant, Born-Haber cycle and its application, solvation energy, solubility energetics of dissolution process.

Covalent bond: polarizing power and polarizability, ionic potential, Fazan's rules,Lewis structures, formal charge, Valence Bond Theory- hydrogen molecule (Heitler-London approach), directional character of covalent bonds, hybridizations, equivalent and non-equivalent hybrid orbitals, Bent's rule, dipole moments, VSEPR theory, shapes of molecules and ions containing lone pairs and bond pairs (examples from main groups chemistry) and multiple bonding (σ and π bond approach) *6 Hours*

5. Fundamentals in organic chemistry

Electron displacement phenomena and physical properties: inductive effect, field effect, hyperconjugation, mesomeric effect, resonance energy, bond polarization and bond polarizability, electromeric effect, steric effect, steric inhibition of resonance, 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, calculation of formal charges and double bond equivalent (DBE)

Reactive intermediates: carbocations (carbenium and carbonium ions), carbanions, carbon radicals, carbenes, benzynes and nitrenes, generation and stability, structure using orbital picture and electrophilic/nucleophilic behaviour of the reactive intermediates (elementary idea)

Concept of aromaticity: 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

9 Hours

6. Kinetic theory of gases

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

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 ≥ ε, equipartition principle and its application to calculate the classical limit of molar heat capacity of gases.

Real gas and virial equation: Deviation of gases from ideal behaviour, 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, Dietrici equation 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) *6 Hours*

7. Thermodynamics-I

Zeroth and 1st law of Thermodynamics: intensive and extensive variables, state and path functions, isolated, closed and open systems, zeroth law of thermodynamics,concept of heat q, work wand internal energy U, 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

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 Hours*

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.

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. Mingos, D.M.P., Essential trends in inorganic chemistry. Oxford University Press (1998).

9. Winter, M. J., The Orbitron, http://winter.group.shef.ac.uk/orbitron/ (2002). An illustrated gallery of atomic and molecular orbitals.

10. Burgess, J., Ions in solution: basic principles of chemical interactions. Ellis Horwood (1999).

11. Clayden, J., Greeves, N. & Warren, S. Organic Chemistry, Second edition, Oxford University Press, 2012.

12. Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited.
13. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
14. Pathak & Saha, Organic Chemistry (Volume-1), Books and Allied (P) Ltd.
15. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd., (Pearson Education).
16. Morrison, R. T. Study guide to organic Chemistry, Pearson.
17. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford University Press.
18. Castellan, G. W., Physical Chemistry, Narosa Publishing House.
19. McQuarrie, D. A. & Simons, J. D. Physical Chemistry: A Molecular Approach, Viva Press.
20. Engel, T. & Reid, P. Physical Chemistry, Pearson.
21. Maron, S. &Prutton, Principles of Physical Chemistry, Collier Macmillan Ltd.
22. Mortimer, R. G. Physical Chemistry, Elsevier.
23. Ball, D. W., Physical Chemistry, Thomson Press.
24. Glasstone, S. & Lewis, G.N. Elements of Physical Chemistry.
25. Rakshit, P.C., Physical Chemistry, Sarat Book House.
26. Zemansky, M. W. &Dittman, R.H. Heat and Thermodynamics, Tata-McGraw-Hill.
27. Rastogi, R. P. & Misra, R.R. An Introduction to Chemical Thermodynamics, Vikas Publishing House.
28. Clauze& Rosenberg, Chemical Thermodynamics: Basic concepts & Methods, John Wiley & Sons, 2008.
29. Sharma, K. K. & Sharma, L. K., A Textbook of Physical Chemistry, Vikas Publishing House.
30. Rajaram, J. Chemical Thermodynamics: Classical, Statistical and Irreversible, Pearson.
30. Chatterjee Hrishikesh, Physical Chemistry (Volume-1), Platinum Publisher
31. Kapoor, K.L., Textbook of Physical Chemistry (Volume 1 and Volume-2), McGraw Hill Education
32. Ghoshal, A. Numerical problems & short questions on Physical Chemistry, Books and Allied (P) Ltd.
33. Bajpai, D. N., Advanced Physical Chemistry, S. Chand Publication.
34. Levine, I. N. Physical Chemistry, Tata McGraw-Hill.

Practical Credit 1

(i) Separation, purification and melting point determination

Separation of components of a binary solid mixture based on solubility by using common laboratory reagents like water (cold, hot), dil. HCl, dil. NaOH, dil. $NaHCO_3$, etc., purification of any one ofthe separated components by crystallization and determination of its melting point. Thecomposition of the mixture may be of the following types: Benzoic acid/*p*-

toluidine, *p*-nitrotolune/*p*-anisidine, benzoic acid/benzophenone, urea/benzophenone, salicylic acid/*p*-nitrotoluene, etc. *12 Hours*

(ii) Determination of boiling point

Boiling points of common organic liquid compounds e.g., ethanol,cyclohexane, ethyl methyl ketone, cyclohexanone, acetylacetone, anisole, crotonaldehyde, mesityl oxide, etc.

6 Hours

[Boiling points of the chosen organic compounds should preferably be less than 160°C]

(iii) 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

12 Hours

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. A.K. Manna, Practical Organic Chemistry, Books & Allied (P) Ltd.

Ghosh, Das Sharma, Majumdar, Manna, Chemistry in Laboratory, santra Publication (P) Ltd.

Chemistry MINOR

Paper code: CHEM102-I

Paper title: General Chemistry-I Credits 3+1

Theory Credits 3

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 *6 Hours*

2. **Periodic properties**

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

7 Hours

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, acidity and basicity of common organic compounds *7 Hours*

4. **Aliphatic hydrocarbons**

Functional group approach for the following compounds to be studied in context of their preparations, properties, structures and reactions

Alkanes (up to 5 carbons): preparation- catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis using Grignard reagent; Reaction mechanism for free radical substitution, halogenation

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 KMnO4) 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

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, formation of metal acetylides, addition of bromine and alkaline $KMnO_4$, ozonolysis and oxidation with hot alkaline $KMnO_4$ *10 Hours*

5. 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), rate of effusion

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

Deviation of gases from ideal behaviour, compressibility factor, Boyle temperature, Andrew's and Amagat's plots, van der Waals equation and its features, 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

Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only) *8 Hours*

6. Thermodynamics-I

Intensive and extensive properties 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

Standard states,heat of reaction, enthalpy of formation of molecules and ions, enthalpy of combustion and its applications,laws of thermochemistry, bond energy, bond dissociation energy and resonance energy from thermochemical data, Kirchoff's equation and effect of pressure on enthalpy, adiabatic flame temperature, explosion temperature

7 Hours

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1. Lee, J. D. Concise Inorganic Chemistry ELBS, 1991.

2. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry Oxford, 1970.

4. Atkins, P. Shriver & Atkins' Inorganic Chemistry 5th Ed. Oxford University Press (2010).

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27. Sharma, K. K. & Sharma, L. K., A Textbook of Physical Chemistry, Vikas Publishing House.
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29. Rajaram, J. Chemical Thermodynamics: Classical, Statistical and Irreversible, Pearson.
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31. Kapoor, K.L., Textbook of Physical Chemistry (Volume 1 and Volume-2), McGraw Hill Education
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33. Maron, S. &Prutton, Principles of Physical Chemistry, Collier Macmillan Ltd.
34. Levine, I. N. Physical Chemistry, Tata McGraw-Hill.

Practical Credit 1

(i) Determination of boiling points

Boiling points of common organic liquid compounds e.g., ethanol, cyclohexane, ethyl methyl ketone, cyclohexanone, acetylacetone, anisole, crotonaldehyde, mesityl oxide,etc.

12 Hours

(ii) Identification of a pure organic compound

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

Liquid Compounds: acetone, aniline and nitrobenzene *18 Hours*

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. A.K. Manna, Practical Organic Chemistry, Books & Allied (P) Ltd.

Ghosh, Das Sharma, Majumdar, Manna, Chemistry in Laboratory, Santra Publication (P) Ltd.

MULTIDISCIPLINARY (for other than Chemistry Major students)

Paper code: CHEM103-I

Paper title: Chemistry for Household Importance Credits 3

Theory

1. Food chemistry: Food additive, food flavor, adulterant, preservative, artificial sweeteners *8 Hours*
2. Drugs and pharmaceuticals: Structure and function, antipyretic and analgesic drugs – aspirin, paracetamol, ibuprofen *8 Hours*
3. Vitamins: Vitamin C and B_{12} *2 Hours*
4. Antibiotics: Penicillin, sulphaguanidine, chloramphenicol *4 Hours*
5. Glass and ceramics: Definition and manufacture of glasses, optical and colour glasses, communication fibre *6 Hours*
6. Surface chemistry: Soaps and detergents *2 Hours*
7. Chemistry of fuels: Conventional and non-conventional energy sources, classification of fuels, calorific values of fuels like kerosene, coal, coal gas, petrol, liquefied petroleum gas, octane number, biogas *15 Hours*

Reference Books:

1. Thapar, Food Chemistry, Pacific Book International
2. Gayatri Baidya, Textbook of Food Chemistry, Book Rivers
3. Mandal, S.K., Pharmaceutical Chemistry and Production: An Introductory Textbook Rebeca Ghanta; Bentham Science Publishers 2022, ISBN: 978-1-68108-890-7
4. Sengupta,S.,Application Oriented Chemistry Books Syndicate Pvt. Ltd., 2000

SKILL ENHANCEMENT COURSE

Paper code: CHEM105-1

Paper title: Drugs and pharmaceuticals

Theory Credits 3

Drug discovery, design and development,synthesis of the representative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (aspirin, paracetamol, ilbuprofen), antibiotics (penicillin, chloramphenicol), antibacterial and antifungal agents (sulphonamides, sulphanethoxazol, sulphacetamide, trimethoprim); antiviral agents (acyclovir), central nervous system agents (phenobarbital, diazepam), cardiovascular (glyceryl trinitrate), antilaprosy (dapsone), HIV-AIDS related drugs(AZT-Zidovudine)

45 Hours

Reference Books:

1. Patrick, G. L. Introduction to Medicinal Chemistry, Oxford University Press, UK, 2013.

2. Singh, H. & Kapoor, V.K. Medicinal and Pharmaceutical Chemistry, Vallabh Prakashan, Pitampura, New Delhi, 2012.

3. Foye, W.O., Lemke, T.L. & William, D.A.: Principles of Medicinal Chemistry, 4th ed., B.I. Waverly Pvt. Ltd. New Delhi.

4. El-Mansi, E.M.T., Bryce, C.F.A., Ddemain, A.L., Allman, A.R., Fermentatias Microbiology and Biotechnology, 2nd Ed. Taylor & Francis.

5. Prescott & Dunn’s Industrial Microbiology, 2004, CBS Publisher.

Semester-II

Chemistry MAJOR

Paper code: CHEM201-1

Paper title: Basic Chemistry-II Credits 3+1

Theory Credits 3

1. Chemical bonding-II

Molecular orbital (MO) 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, 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 – stoichiometric and non-stoichiometric

Weak chemical forces: van der Waals forces, ion-dipole forces, dipole-dipole interactions, induced dipole interactions, instantaneous dipole-induced dipole interactions, repulsive forces, intermolecular forces

Hydrogen bonding: theories of hydrogen bonding, valence bond treatment, receptor-guest interactions, halogen bonds, effects of chemical force, melting and boiling points

8 Hours

2. Redox Reactions and Precipitation Reactions

Balancing of redox reactions: ion-electron method, elementary idea on standard redox potentials- Nernst equation (without derivation), influence of complex formation, precipitation and pH, formal potential

Redox titrations: feasibility, 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 *4 Hours*

3. Stereochemistry-I

Bonding geometries and representation of carbon compounds: tetrahedral nature of carbon and concept of asymmetry: Fischer, sawhorse, flying-wedge and Newman projection formulae and their inter translations

Chirality and symmetry: 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, epimers, stereogenicity,

chirotopicity and pseudoasymmetry, chiral centres and number of stereoisomerism, systems involving 1/2/3-chiral centre(s)- AA, AB, ABA and ABC types

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- C=C, conjugated diene, triene, C=N and N=N systems, combination of R/S- and E/Z-isomerisms

Optical activity 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 Hours*

4. General Treatment of Reaction Mechanism

Free energy profiles: one-, two- 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 (k_H /k_D), principle of microscopic reversibility

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 Hours*

5. Substitution and Elimination Reactions

Nucleophilic substitution reactions: substitution at sp3 centre- mechanisms (with evidence), relative rates, stereochemical features, S_N^1, S_N^2, $S_N^{2'}$, $S_N^{1'}$ (allylic rearrangement) and S_N^i, effects of solvent, substrate structure, leaving group and nucleophiles (including ambident nucleophiles, cyanide & nitrite), electrofuges and nucleofuges, substitutions involving NGP, role of crown ethers and phase transfer catalysts [systems: alkyl halides, allyl halides, benzyl halides, alcohols, ethers, epoxides]

Elimination reactions: E_1, E_2, E_1cB 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 Hours*

6. Thermodynamics-II

Second Law: its need and statement, concept of heat reservoirs and heat engines, Carnot cycle, physical concept of entropy, Carnot engine and refrigerator, Kelvin – Planck and Clausius statements and their equivalence in 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 variations (with T, P and V), criteria of spontaneity and equilibrium

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. *6 Hours*

7. Chemical Kinetics-I

Rate law, order and molecularity: Introduction of rate law, extent of reaction, rate constants, order, forms of rate equations of first-, second- and n-th 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 with all steps of first order)

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. *6 Hours*

8. Introduction to Spectroscopy

Introduction, origin of spectra, spectral regions -UV, IR, Microwave, Radiofrequency, X-ray etc (general idea), fundamental laws of spectroscopy and selection rules (with elementary idea), Lambert-Beer’s law and its validity *3 Hours*

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.

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. Mingos, D.M.P., Essential trends in inorganic chemistry. Oxford University Press (1998).

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13. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
14. Pathak & Saha, Organic Chemistry (Volume-1), Books and Allied (P) Ltd.
15. Rajaram, J. Chemical Thermodynamics: Classical, Statistical and Irreversible, Pearson.
16. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd., (Pearson Education).
17. Morrison, R. T. Study guide to organic Chemistry, Pearson.
18. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford University Press.
19. Castellan, G. W. Physical Chemistry, Narosa Publishing House.
20. Maron, S. &Prutton, Principles of Physical Chemistry, Collier Macmillan Ltd.
21. Laidler, K. J. Chemical Kinetics, Pearson.
22. Glasstone, S. & Lewis, G.N. Elements of Physical Chemistry.
23. Rakshit, P.C., Physical Chemistry, Sarat Book House.
24. Rastogi, R. P. & Misra, R.R. An Introduction to Chemical Thermodynamics, Vikas.
25. Sharma, K. K. & Sharma, L. K., A Textbook of Physical Chemistry, Vikas Publishing House.
26. Nasipuri, D.Stereochemistry of Organic Compounds, New Age International (P) Ltd.
27. Sengupta,S. Basic Stereochemistry of Organic Molecules, Oxford University Press
28. Manna, A.K. Organic Molecular Spectroscopy, Books and Allied (P) Ltd.
29. Bajpai, D. N., Advanced Physical Chemistry, S. Chand Publication.
30. Engel, T. & Reid, P. Physical Chemistry, Pearson.
31 Levine, I. N. Physical Chemistry, Tata McGraw-Hill.
32. Ball, D. W. Physical Chemistry, Thomson Press.
33. Chatterjee Hrishikesh, Physical Chemistry (Volume-1), Platinum Publisher
34. Kapoor, K.L., Textbook of Physical Chemistry (Volume 1 and Volume-2), McGraw Hill Education
35. Ghoshal, A. Numerical problems & short questions on Physical Chemistry, Books and Allied (P) Ltd.

Practical Credit 1

1. Determination of the rate constant of hydrolysis of ethylacetate in the presence of an equal quantity of sodium hydroxide
2. Study of kinetics of acid-catalyzed hydrolysis of methyl acetate
3. Study of kinetics of decomposition of H_2O_2 by KI
4. Verification of Beer's law with $KMnO_4$ and $K_2Cr_2O_7$ solutions *30 Hours*

Reference Books:

1. Bhattacharyya, R. C, A Manual of Practical Chemistry.

2. Nad, Mahapatra, Ghosal, An Advance course in Practical Chemistry, New Central Book Agency (P) Ltd.

3. K. S. Mukherjee, Textbook on Practical Chemistry, New Central Book Agency (P) Ltd.

4. Ghosh, Das Sharma, Majumdar, Manna, Chemistry in Laboratory, santra Publication (P) Ltd.

5. Poddar and Ghosh, Degree Practical Chemistry, Book Syndicate (P) Ltd.

Chemistry MINOR

Paper code: CHEM202-I

Paper title: General Chemistry-II Credits 3+1

Theory Credits 3

1. Thermodynamics-II

Statement of the second law of thermodynamics, concept of heat reservoirs and heat engines, Carnot cycle, physical concept of entropy, Carnot engine, refrigerator and efficiency, entropy change of systems and surroundings for various processes and transformations, auxiliary state functions (G and A) and criteria for spontaneity and equilibrium

7 Hours

2. Chemical Kinetics

Introduction of rate law, order and molecularity, extent of reaction, rate constants, rates of first-, second- and n-th order reactions and their integrated forms (with derivation), pseudo first order reactions, determination of order of a reaction- half-life and differential method, opposing reactions, consecutive reactions and parallel reactions (elementary idea)

Theories of reaction rate: Temperature dependence on reaction rate, Arrhenius equation, energy of activation, Collision theory, Lindemann theory of unimolecular reaction, outline of Transition State theory (classical treatment) *8 Hours*

3. Fundamentals of Organic Chemistry

Electronic displacement phenomena- inductive effect, resonance and hyperconjugation, cleavage of bonds- homolytic and heterolytic, structures of organic molecules on the basis of VBT, nucleophiles, electrophiles, reactive intermediates- carbocations, carbanions and free radicals.

6 Hours

4. Stereochemistry

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- nomenclatures, CIP rules: R/S (upto 2 chiral carbon atoms) and E/Z nomenclatures.

6 Hours

5. Nucleophilic Substitution and Elimination Reactions

Nucleophilic substitutions- S_N1, S_N2 and $S_Ni$reactions, eliminations- E_1 and E_2 reactions (elementary mechanistic aspects), Saytzeff and Hofmann eliminations, elimination vs. substitution *6 Hours*

6. Chemical Bonding and Molecular Structure

Ionic Bonding: general characteristics, energy considerations, lattice energy and solvation energy and their importance for stability and solubility of ionic compounds, statement of Born-Landé equation for lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability, Fajans' rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character

Covalent bonding: Valence Bond (VB) theory 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

Molecular orbital (MO) theory approach -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 the idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and NO+, comparison of VB and MO approaches *12 Hours*

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.

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. Mingos, D.M.P., Essential trends in inorganic chemistry. Oxford University Press (1998).

9. Burgess, J., Ions in solution: basic principles of chemical interactions. Ellis Horwood (1999).

10. Clayden, J., Greeves, N. & Warren, S. Organic Chemistry, Second edition, Oxford University Press, 2012.

11. Smith, J. G. Organic Chemistry, Tata McGraw-Hill Publishing Company Limited.

12. Morrison, R. N. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

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

14. Morrison, R. T. Study guide to organic Chemistry, Pearson.

15. Pathak & Saha, Organic Chemistry (Volume-1), Books and Allied (P) Ltd.

16. Castellan, G. W. Physical Chemistry, Narosa Publishing House.

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18. Maron, S. &Prutton, Principles of Physical Chemistry, Collier Macmillan Ltd.

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31. Atkins, P. W. & Paula, J. de Atkins' Physical Chemistry, Oxford University Press.

Practical Credit 1

1. Determination of the rate constant of hydrolysis of ethylacetate in the presence of an equal quantity of sodium hydroxide

2. Study of kinetics of acid-catalyzed hydrolysis of methyl acetate

3. Verification of Beer's law with $KMnO_4$ and $K_2Cr_2O_7$ solutions

4. Estimation of Mohr's salt by titrating with $KMnO_4$/ $K_2Cr_2O_7$

5. Estimation of sodium carbonate and sodium hydrogen carbonate in a mixture *30 Hours*

Reference Books:

1. Bhattacharyya, R. C, A Manual of Practical Chemistry.

2. Nad, Mahapatra, Ghosal, An Advance course in Practical Chemistry, New Central Book Agency (P) Ltd.

3. K. S. Mukherjee, Textbook on Practical Chemistry, New Central Book Agency (P) Ltd.
4. Ghosh, Das Sharma, Majumdar, Manna, Chemistry in Laboratory, santra Publication (P) Ltd.
5. Poddar and Ghosh, Degree Practical Chemistry, Book Syndicate (P) Ltd.

MULTIDISCIPLINARY (for other than Chemistry Major students)

Paper code: CHEM203-1

Paper title: Chemistry of Dyes, Pigments, Cosmetics and Perfumes Credits 3

Theory

Definition and classification, structures and theories of coloration, preparation, properties and uses of dyes like phenolphthalein, methyl orange, malachite green, alizarin, indigo, different types of pigments like chlorophyll, carotenoids, anthocyanins, flavonoids (elemental idea)

Preparation and uses of the following: hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours

Essential oils and their importance in cosmetic industries with reference to eugenol, geraniol, sandalwood oil, eucalyptus, rose-oil, 2-phenyl ethyl alcohol, jasmone, civetone, muscone

45 Hours

Reference Books:

1. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd., (Pearson Education).
2. Bahl and Bahl, A Text book of Organic Chemistry, S. Chand publication
3. StocchiE.: Industrial Chemistry, Vol -I, Ellis Horwood Ltd. UK.
4. Jain, P.C.&Jain,M:.Engineering Chemistry, Dhanpat Rai & Sons, Delhi.
5. Sharma, B.K. & Gaur, H. Industrial Chemistry, Goel Publishing House, Meerut (1996).

SKILL ENHANCEMENT COURSE

Paper title: CHEM205-1

Paper code: Basic Analytical Chemistry Credits 3

Theory

1. **General principle**

Introduction to analytical chemistry and its interdisciplinary nature, concept of sampling, importance of accuracy, precision and sources of error in analytical measurements, presentation of experimental data and results, role of significant figures *8 Hours*

3. **Analysis of soil**

Composition of soil, concept of pH and pH measurement, complexometric titrations, chelation, chelating agents, use of indicators *6 Hours*

3. Analysis of water

Definition of pure water, contaminants (different types), water sampling methods, water purification methods *6 Hours*

4. Analysis of food products

Nutritional value of a food, idea about food processing and food preservations, and adulteration

6 Hours

5. **Chromatography**

Definition, general introduction on principles of chromatography, paper chromatography, TLC etc., column chomatography, ion-exchange chromatography, etc., determination of ion exchange capacity of anion /cation exchange resin *10 Hours*

6. Analysis of cosmetics

Major and minor constituents of cosmetics and their functions, analysis of deodorants and antiperspirants, Al, Zn, boric acid, chloride, sulphate *9 Hours*

Reference Books:

1. Willard, H.H., Merritt, L.L., Dean, J. &Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.

2. Skoog, D.A., Holler, F.J. & Crouch, S. Principles of Instrumental Analysis, Cengage Learning India Edition, 2007.

3. Skoog, D.A.; West, D.M. & Holler, F.J. Analytical Chemistry: An Introduction sixth Ed., Saunders College Publishing, Fort Worth, Philadelphia (1994).

4. Harris, D. C. Quantitative Chemical Analysis, 9th ed. Macmillan Education, 2016.

5. Dean, J. A. Analytical Chemistry Handbook, McGraw Hill, 2004.

6. Day, R. A. & Underwood, A. L. Quantitative Analysis, Prentice Hall of India, 1992.

7. Freifelder, D.M. Physical Biochemistry 2nd Ed., W.H. Freeman & Co., N.Y. USA (1982).

8. Cooper, T.G. The Tools of Biochemistry, John Wiley & Sons, N.Y. USA. 16 (1977).

9. Vogel, A. I. Vogel's Qualitative Inorganic Analysis 7th Ed., Prentice Hall, 1996.

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

11. Robinson, J.W. Undergraduate Instrumental Analysis 5th Ed., Marcel Dekker, Inc., New York (1995).

12. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.