

DEPARTMENT OF CHEMISTRY

FACULTY OF NATURAL SCIENCES



JAMIA MILLIA ISLAMIA

(A Central University)

B.Sc. (Subsidiary) CHEMISTRY
Effective from Academic Year 2022-2023

Syllabus of Courses Offered

Core courses

COURSE OUTLINE

Course Outline					
Semester	Paper/ Practical	Paper No	Paper code	Paper Title	Total Credits
Semester-I	Theory (Core)	I-S	CHS-101	General Chemistry-I	03
	Practical (Core)		CHS-101L	General Chemistry Practical-I	01
Semester-II	Theory (Core)	II-S	CHS-203	Physical Chemistry-I	03
	Practical (Core)		CHS-203L	Physical Chemistry Practical -I	01
Semester-III	Theory (Core)	III-S	CHS-302	Organic Chemistry-I	03
	Practical (Core)		CHS-302L	Organic Chemistry Practical-I	01
Semester-IV	Theory (Core)	IV-S	CHS-401	Inorganic Chemistry-I	03
	Practical (Core)		CHS-401L	Inorganic Chemistry Practical-I	01
Semester-V	Theory (Core)	V-S	CHS-503	Physical Chemistry-II	03
	Practical (Core)		CHS-503L	Physical Chemistry Practical -II	01
Semester-VI	Theory (Core)	VI-S	CHS-602	Organic Chemistry-II	03
	Practical (Core)		CHS-602L	Organic Chemistry Practical-II	01
Total Credits					24

Paper code – 1st letter for semester, 2nd and 3rd for subject as mentioned below:-
 01-Inorganic Chemistry, 02-Organic Chemistry, 03-Physical Chemistry,
 04-Elective, 05-Ability Enhancement

SEMESTER-I

Paper/ Practical	Paper No	Paper code	Paper Title	Total Credits
Theory (Core)	I-S	CHS-101	General Chemistry -I	03
Practical (Core)		CHS-101L	General Chemistry Practical-I	01
TOTAL CREDITS				04

SEMESTER-II

Theory (Core)	II-S	CHS-203	Physical Chemistry-I	03
Practical (Core)		CHS-203L	Physical Chemistry Practical-I	01
TOTAL CREDITS				04

SEMESTER-III

Theory (Core)	III-S	CHS-302	Organic Chemistry-I	03
Practical (Core)		CHS-302L	Organic Chemistry Practical-II	01
TOTAL CREDITS				04

SEMESTER-IV

Theory (Core)	IV-S	CHS-401	Inorganic Chemistry-I	03
Practical (Core)		CHS-401L	Inorganic Chemistry Practical-I	01
TOTAL CREDITS				04

SEMESTER-V

Theory (Core)	V-S	CHS-503	Physical Chemistry-II	03
Practical (Core)		CHS-503L	Physical Chemistry Practical-II	01
TOTAL CREDITS				04

SEMESTER-VI

Theory (Core)	VI-S	CHS-602	Organic Chemistry-II	03
Practical (Core)		CHS-602L	Organic Chemistry Practical-II	01
Total Credits				04

CHS-101 Paper No: I-S	General Chemistry-I	Theory (Marks)		Total Credits
		U.E (60)	I.A (40)	03 (100)

Unit I Atomic Structure and Periodic Classification of Elements

Bohr's atomic model, limitations, Idea of elliptical orbits, Schrödinger wave equation, physical significance of ψ and ψ^2 , probability distribution curves, quantum numbers. Modern periodic law, Periodic Table and periodic properties – atomic/ionic radius, ionization energy, electron affinity and electronegativity, scales of electronegativity.

Unit II Chemical Bonding and Molecular Structure

Chemical Bonding Overlapping of orbital, homo and heterodiatomic molecules, types of bonds: ionic, covalent, coordinate, Metallic and hydrogen bonding, Valence bond theory of covalent bonding and its limitations, Hybridization and hybrid orbitals, resonance, Born- Haber cycle and lattice energy.

Unit III Solutions

Types of solutions, normality molarity, molality, mole fraction, Raoult's law, ideal, non-ideal and colloidal solutions, phase rule, phase diagrams of one component systems (water and sulphur); two-component systems: partially miscible liquids, consolute solution temperature UCST and LCST.

Unit IV: Acids and bases

Theories of acids and bases- Arrhenius, Bronsted-Lowry, Lewis, solvent and Lux-Flood, Relative strengths of acids and bases-effect of solvent, polarity and dielectric constants, effect of substituents and steric effects of substituents.

Reference Books

1. Concise Inorganic Chemistry by J. D. Lee.
2. Inorganic Chemistry by Puri and Sharma
3. Principle of Physical Chemistry by Puri, Sharma and Pathania.

CHS-101 L	General Chemistry Practical-I	Practical (Marks)		Total Credits
		U.E (25)	I.A (25)	01 (50)

1. To prepare standard solution of sodium carbonate and determine the percentage of given NaOH and KOH mixture solution (2.5 g/liter) by using HCl solution.
2. To prepare standard solution of potassium dichromate and find out the strength of given potassium dichromate solution using sodium thiosulphate (hypo solution) as an intermediate.
3. To prepare standard solution of potassium permanganate and find out the strength of given potassium permanganate solution using sodium thiosulphate (hypo solution) as an intermediate.
4. To prepare standard solution of copper(II) sulphate and find out the strength of given copper(II) sulphate solution using sodium thiosulphate (hypo solution) as an intermediate.
5. To determine the viscosity of pure liquids and binary mixtures by Ostwald viscometer.
6. Determination of the surface tension of pure liquids and binary mixtures.
7. Determination of partition coefficient of iodine between water and carbon tetrachloride or toluene or chloroform.
8. Determination of partition coefficient of Benzoic acid between water and toluene.

Reference books

1. Practical Chemistry, OP Pandey, DN Bajpai, S. Giri, S. Chand & Company Ltd., 2008.
2. Senior Practical Physical Chemistry by B.D. Khosla, V.C. Garg and Adarsh Khosla – R.Chand & Co. Delhi.

CHS-203 Paper No: II-S	PHYSICAL CHEMISTRY-I	Theory (Marks)		Total Credits
		U.E (60)	I.A (40)	03 (100)

Unit I. Chemical Kinetics

Chemical Kinetics and its Scope, Rate of a Reaction, Rate Laws, Factors Influencing the Rate of Reaction: Concentration, Temperature, Pressure, Catalyst. Rate Constant, Elementary and Complex Reactions, Molecularity, Order of Reactions, Concentration and Temperature Dependence of Rates, Mathematical Characteristics of Simple Chemical Reactions - Zero Order, First Order, Second Order, Pseudo Order, and their Half-life Expressions. Determination of Order of Reaction - Differential Method, Method of Integration, Half-life Method and Isolation Method.

Unit II. Chemical Equilibrium

Reversible and irreversible reactions, Characteristics of chemical equilibrium, Formulation of equilibrium law, equilibrium law for ideal gases, interpretation of ΔG^0 , free energy change in a chemical reaction and spontaneity of reactions, chemical affinity and thermodynamic functions, relation between K_p and K_c and K_x , variation of equilibrium constant with temperature, pressure and concentration, effect of inert gas on reaction equilibrium, Le – Chatelier’s principle.

Unit III. Ionic Equilibria-I

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization. Dissociation constants of weak acids and weak bases. Ionization constant and Ionic product of water. The pH scale, Buffer solutions, Calculations of pH values of buffer mixtures, Derivation of Henderson equation and its applications, buffer capacity and buffer action.

Unit IV. Ionic Equilibria-II

Solubility and solubility product of sparingly soluble salts – Applications of solubility product principle. Common ion effect. Salt hydrolysis, Determination of hydrolysis constant, degree of hydrolysis and pH for different salts. Relation between K_h , K_a and K_b .

Books Recommended:

1. Essentials of Physical Chemistry, B.S. Bahl, G.D.Tuli and ArunBahl, S. Chand & Company Ltd.
2. A Text Book of Physical Chemistry, A.S. Negi and S.C. Anand, New Age International Publishers.
3. Physical Chemistry, G. M. Barrow, International Student Edition, McGraw Hill.
4. Physical Chemistry, P. W. Atkins, & J. de Paula, 10th Ed., Oxford University Press (2014).

CHS-203L	PHYSICAL CHEMISTRY PRACTICAL -I	Practical (Marks)		Total Credits
		U.E (25)	I.A (25)	01 (50)

Chemical Kinetics

- To determine the order of the reaction between thiosulphate and HCl w.r.t.thiosulphate.
- To determine the order of the reaction between thiosulphate and HCl w.r.t. HCl.
- To study the kinetics of the reaction between thiosulphate and HCl at moderate concentration of $[H^+]$ by using initial rate method.
- To determine the order of reaction for acid hydrolysis of methyl acetate at room temperature.
- To determine the kinetics of the hydrolysis of ethyl acetate catalyzed by hydrogen ions at room temperature.
- To study the effect of acid strength on the hydrolysis of an ester.
- To study the kinetics of alkaline hydrolysis of M/40 methyl acetate by providing M/40 HCl and M/40 NaOH.
- To study the kinetics of the saponification of ethyl acetate by integrated rate method.

Ionic Equilibria

- Study the effect on pH of addition of HCl/NaOH to solutions of acetic acid, sodium acetate and their mixtures.
- pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
- Determination of dissociation constant of a weak acid.
- Preparation of buffer solutions of different pH
 - Sodium acetate-acetic acid
 - Ammonium chloride-ammonium hydroxide

Any other experiment carried out in the class.

Reference Books

- O.P. Pandey, D.N. Bajpai & S. Giri, Practical Chemistry, S. Chand & Company Ltd.
- B. D. Khosla, V. C. Garg & A. Gulati, *Senior Practical Physical Chemistry*, S. Chand & Co.: New Delhi (2011).
- C. W. Garland, J.W. Nibler, & D.P. Shoemaker, *Experiments in Physical Chemistry 8th Ed.*; McGraw- Hill: New York (2003).
- R.C. Das and B. Behra, *Experiments in Physical Chemistry*; Tata McGraw Hill.

CHS-302 Paper No: III- S	ORGANIC CHEMISTRY-I	Theory (Marks)		Total Credits
		U.E (60)	I.A (40)	03 (100)

Unit I: Fundamentals of Organic Chemistry

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles. Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values. Aromaticity: Benzenoid and non-benzenoid systems.

Unit II: Stereochemistry

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (up to two carbon atoms). Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; cis-trans nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

Unit III: Phenols

Nomenclature, structure and bonding of phenols, Physical properties and acidic character. Comparative acidic strengths of alcohols and phenols, resonance stabilization of phenoxide ion. Reactions of phenol. Electrophilic aromatic substitution, acylation and carboxylation, mechanism of Fries rearrangement, Claisen rearrangement, Gatterman synthesis, Hauben-Hoesch reaction, Reimer Tiemann reaction.

Unit IV: Ethers and Epoxides

Nomenclature of ethers and methods of their formation, Physical properties. Chemical reactions- Cleavage and autoxidation, Ziesel's method. Synthesis of epoxides. Acids and base catalysed ring opening, reaction of Grignards and organolithium reagents with epoxides.

CHS-302L	ORGANIC CHEMISTRY PRACTICAL -I	Practical (Marks)		Total Credits
		U.E (25)	I.A (25)	01 (50)

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements).
2. Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
3. Separation of mixtures by Chromatography: Measure the R_f value in each case:
 - a. Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography
 - b. Identify and separate the sugars present in the given mixture by paper chromatography.

Books Suggested:

1. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.
2. 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.

CHS-401 PaperNo: IV- S	INORGANIC CHEMISTRY-I	Theory (Marks)		Total
		U.E (60)	I.A (40)	Credits
				03 (100)

Unit I Chemistry of s Block Elements

Hydrogen: Isotopes (separation method not needed), Ortho and para hydrogen, Hydrides and their classification; *Alkali and Alkaline earth metals*: Chemical properties of the metals: reaction with water, air, nitrogen; uses of s-block metals and their compounds, Compounds of s-block metals: oxides, hydroxides, peroxides, superoxides, oxo salts-carbonates, bicarbonates, nitrates; halides and anomalous behavior of Li. Diagonal relationship, solvation and complexes of s-block metals including their applications in biosystems.

Unit II Chemistry of p Block Elements

Study of the following compounds with emphasis on structure, bonding, preparation, properties and uses. Boric acid and borates, boron nitrides, nitrates, acetates, borohydrides (diborane) and graphitic compounds, silanes, Oxides and oxoacids of nitrogen, Phosphorus and chlorine. Peroxo acids of sulphur, interhalogen compounds, polyhalide ions, and pseudohalogens.

Unit III Transition Elements

Electronic structure and position in the periodic table. General properties: variable valency, colour, magnetic properties and catalytic role, important uses of transition metals and their alloys; differences between the first and the other rows, horizontal comparison with Fe, Co, Ni groups; toxicity of Cd and Hg.

Unit IV Coordination Compounds

IUPAC Nomenclature of mononuclear complexes, Types of ligands and chelates Werner's theory of coordination compounds, isomerism (geometrical and optical) in square planar and octahedral complexes. Sidgwick's theory and EAN Principle, Use of coordination compounds in qualitative analysis ($\text{Cu}^{2+}/\text{NH}_3$) and quantitative analysis ($\text{Ni}^{2+}/\text{DMG}$), Hardness of water using EDTA.

Reference Books

1. Lee, J.D. Concise Inorganic Chemistry, ELBS, 1991.
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. Concepts & Models of Inorganic Chemistry 3rd Ed., John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N. & Earnshaw. Chemistry of the Elements, Butterworth-Heinemann. 1997.
4. Cotton, F.A. & Wilkinson, G. Advanced Inorganic Chemistry, Wiley, VCH, 1999.
5. Rodger, G.E., Inorganic and Solid State Chemistry, Cengage Learning India Edition, 2002.
6. Miessler, G. L. & Donald, A. Tarr, Inorganic Chemistry, 4th Ed., Pearson, 2010.

CHS-401L	INORGANIC CHEMISTRY PRACTICAL -I	Practical (Marks)		Total Credits
		U.E (25)	I.A (25)	01 (50)

A. Inorganic Preparations:

- i. Tetraamminecopper(II) sulphate, $[\text{Cu}(\text{NH}_3)_4]\text{SO}_4 \cdot \text{H}_2\text{O}$
- ii. *Cis* and *trans* $\text{K}[\text{Cr}(\text{C}_2\text{O}_4)_2 \cdot (\text{H}_2\text{O})_2]$ Potassium dioxalatodiaquachromate(III)
- iii. Tetraamminecarbonatocobalt(III) ion
- iv. Potassium tris(oxalate) ferrate(III).

B. Gravimetric Analysis:

1. Estimation of nickel(II) using Dimethylglyoxime (DMG).
2. Estimation of copper as CuSCN
3. Estimation of iron as Fe_2O_3 by precipitating iron as $\text{Fe}(\text{OH})_3$.
4. Estimation of Al (III) by precipitating with oxine and weighing as $\text{Al}(\text{oxine})_3$ (aluminiumoxinate).

Reference Books

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

CHS-503 Paper No: V-S	PHYSICAL CHEMISTRY-II	Theory (Marks)		Total Credits
		U.E (60)	I.A (40)	03 (100)

Unit I. Colloidal State

Introduction and Definition of Colloids, Classification of Colloids – Lyophilic and lyophobic colloids. Solids in Liquids (Sols): Preparation of Sols, Optical and Electrical Properties of Sols; electro-kinetic potential, electrophoresis, electro osmosis, Stability of Colloids, Protective Action, Hardy-Schulze Rule, Flocculation value, Gold Number. Liquids in Liquids (Emulsions): Types of Emulsions, Preparation and Properties of Emulsions, Emulsifier. General Applications of Colloids.

Unit II. Solution and Colligative properties

Ideal and non-ideal solutions, methods of expressing concentrations of solutions, activity and activity coefficient. Dilute solution, colligative properties, Raoult's law, relative lowering of vapour pressure, molecular weight determination. Osmosis, Law of osmotic pressure and determination of molecular weight from osmotic pressure. Elevation of boiling point and depression of freezing point. Abnormal molar mass, degree of dissociation and association of solutes.

Unit III. Thermochemistry

Thermochemistry: Heats of reactions: standard states; enthalpy of formation of molecules and ions, Hess's law of heat summation and its applications; calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, effect of temperature (Kirchoff's equations) and pressure on enthalpy of reactions.

Unit IV. Thermodynamics

Intensive and extensive variables; state and path functions; isolated, closed and open systems; zeroth law of thermodynamics. First law: Concept of heat, work, internal energy, enthalpy, Heat capacity and relation between heat capacities at constant volume and pressure, Joule's law, Joule-Thomson Coefficient and inversion temperature. Calculations of q, w, U and H for reversible expansion of ideal gases under isothermal and adiabatic conditions. Second Law: Concept of entropy; different statements of the second law of thermodynamics; molecular and statistical interpretation of entropy. Calculation of entropy change for reversible and irreversible processes. Third Law and concept of residual entropy.

Books Recommended:

1. Essentials of Physical Chemistry, B.S. Bahl, G.D.Tuli and Arun Bahl, S. Chand & Company Ltd
2. An Introduction to Chemical Thermodynamics, R P Rastogi, R R Misra.
3. Physical Chemistry, G. M. Barrow, International Student Edition, McGraw Hill.
4. Physical Chemistry, P. W. Atkins, & J. de Paula, 10th Ed., Oxford University Press (2014).

CHS-503L	PHYSICAL CHEMISTRY PRACTICAL -II	Practical (Marks)		Total Credits
		U.E (25)	I.A (25)	01 (50)

1. Determination of the heat capacity of a calorimeter.
2. Determination of heat capacity of the calorimeter and integral enthalpy (endothermic and exothermic) of solution of salts.
3. To determine the enthalpy of neutralization of a weak acid / weak base versus strong base/ strong acid and determine the enthalpy of ionisation of the weak acid / weak base.
4. To determine the enthalpy of hydration of CuSO_4 .
5. To study of the solubility of benzoic acid in water and determination of ΔH .
6. To determine the enthalpy of solution of solid calcium chloride and calculate the lattice energy of calcium chloride from its enthalpy data using Born Haber Cycle.
7. Verification of Hess's law by utilizing the enthalpy of neutralization of (i) HCl (aq), (ii) $\text{NaOH(s)} + \text{HCl(aq)}$, and (iii) enthalpy of solution of NaOH(s) in water.
8. Determination of basicity of a polyprotic acid by the thermochemical method in terms of the changes of temperatures observed in the graph of temperature versus time for different additions of a base. Also calculate the enthalpy of neutralization of the first step.
9. Determination of the molar mass of the given solute by using Rast method.
10. Any other experiment carried out in the class.

Reference Books

1. O.P. Pandey, D.N. Bajpai & S. Giri, Practical Chemistry, S. Chand & Company Ltd.
2. B. D. Khosla, V. C. Garg & A. Gulati, *Senior Practical Physical Chemistry*, S. Chand & Co.: New Delhi (2011).
3. C. W. Garland, J.W. Nibler, & D.P. Shoemaker, *Experiments in Physical Chemistry 8th Ed.*; McGraw- Hill: New York (2003).
4. R.C. Das and B. Behra, *Experiments in Physical Chemistry*; Tata McGraw Hill.

CHS-602 Paper No: VI-S	ORGANIC CHEMISTRY- II	Theory (Marks)		Total Credits
		U.E (60)	I.A (40)	03 (100)

Unit I: Aliphatic Hydrocarbons

Alkanes: Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation. Alkenes: Preparation: Elimination reactions: Saytzeff's rule cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. KMnO₄) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation. Alkynes: Preparation: Acetylene from CaC₂ and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides.

Unit II: Aromatic hydrocarbons

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure. Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

Unit III: Alkyl and Aryl Halides

Alkyl Halides Types of Nucleophilic Substitution (SN₁, SN₂ and SN_i) reactions. Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution. Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by -OH group) and effect of nitro substituent

Unit IV: Carbohydrates:

Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides.

Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

Books Suggested:

1. Organic Chemistry (Vol. I) - SM Mukherji, SP Singh and RP Kapoor, New Age Publishers, New Delhi.
2. Organic Chemistry, I L Finar, Pearson Education, New Delhi .
3. Organic Chemistry, Solomons and Fryhle, Wiley Student Edition, New Delhi.
4. Organic Chemistry, Morrison and Boyd, Pearson Education, New Delhi.
5. Understanding Organic Chemistry, Brown and Foote, Cengage Learning

CHS-602L	ORGANIC CHEMISTRY PRACTICAL-II	Practical (Marks)		Total Credits
		U.E (25)	I.A (25)	01 (50)

1. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
2. Criteria of Purity: Determination of melting and boiling points.
3. Preparations: Mechanism of various reactions involved to be discussed
4. Recrystallisation, determination of melting point and calculation of quantitative yield to be done.
 - a. Bromination of Phenol/Aniline
 - b. Benzoylation of amines/phenols
 - c. Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone
 - d.