

DRAFT SYLLABUS UNDER AUTONOMY

CHEMISTRY

SEMESTER I

COURSE : S.CHE.1.01

BASIC CHEMISTRY I

[45 LECTURES]

LEARNING OBJECTIVES :

1. To understand the behaviour of fluids and study the physical phenomena involved.
2. To understand and explain the structures of organic functional groups and simple organic compounds in terms of various electronic effects.
3. To account for physical properties and chemical reactivity of organic compounds on basis of structure and geometry
4. To correctly name an organic compound using IUPAC nomenclature, and to accurately represent the structure of an organic compound given its IUPAC name
5. To understand the periodicity of properties of elements
6. To understand and apply Slater's and Fajan's rules, and solve numerical problems based on these concepts
7. To understand the basic concepts involved in qualitative analysis
8. To apply theoretical concepts in order to solve numerical problems.

Unit I ;

[15 Lectures]

1.1 : Study of Fluids

(15 Leecs.)

- 1.1.1: Gases : Introduction, ideality, and kinetic theory of gases (only postulates), gas laws, Maxwell's distribution of velocities (graph and qualitative discussion). Real gases, compressibility factor, Boyle temp, van der Waal's equation of state, critical phenomena, super-critical fluids, liquefaction of gases based on Joule-Thompson effect (numerical problems expected).
- 1.1.2: Liquids : introduction, study of viscosity, and its determination using Ostwald's viscometer, study of surface tension and its determination using stalagmometer, basic principles of polarimetry and refractometry, determination of refractive index using Abbe's refractometer.

Unit II :

[15 Lectures]

2.1 : Bonding and Structure of Organic Compounds

(8 Lecs.)

- 2.1.1 : Hybridization : sp^3 , sp^2 , sp hybridization of carbon and nitrogen ; sp^3 and sp^2 hybridization of oxygen in organic compounds. Structure of common functional groups: C=O, $C\equiv N$, $C\equiv C$, C=N, C=C.
- 2.1.2 : Overlap of atomic orbitals to form sigma and pi bonds, shapes of organic molecules.
- 2.1.3 : Electronic effects in organic molecules : Polarization or inductive effect – nature, polarity of covalent bond, dipole moment and its effect on properties of molecules such as m.p. / b.p., solubility; Polarizability effect; Delocalized bonds - Resonance, drawing of resonance structures of different conjugated systems, resonance energy and stability of conjugated systems; Hyperconjugation.
- 2.1.4 : Bonds weaker than a covalent bond; Hydrogen bond - nature, effect of hydrogen bonding on m.p./ b.p., solubility in water, van der Waal's forces.
- 2.1.5: Geometry and electronic structure of common functional groups in order to understand their reactivity.

2.2. Nomenclature of organic compounds

(7 Lecs.)

- 2.2.1: Functional groups and types of organic compounds, basic rules of IUPAC Nomenclature.
- 2.2.2: Nomenclature of mono and bi- functional compounds, on the basis of priority order, of the following classes of compounds : alkanes, alkenes, alkynes, haloalkanes, alcohols, ethers, aldehydes, ketones, carboxylic acids, carboxylic acid derivatives (acid halides, esters, anhydrides, amides), nitro compounds, nitriles and amines, including their cyclic analogues.
- 2.2.3: Nomenclature of aromatic compounds : mono-, di-, and poly-substituted benzenes, with not more than two functional groups.

UNIT III

[15 lectures]

3.1: Periodic Table and Periodicity of Properties:(with respect to s and p block elements)

(8 Lecs.)

- 3.1.1 : Long form of periodic table, atomic and ionic radii, ionization of atoms (formation of cations and anions), oxidation states .
- 3.1.2: Effective nuclear charge and its calculation using Slater's rules;
- 3.1.3: Electronegativity and its determination by Pauling's and Mulliken's methods (numerical problems expected)
- 3.1.4: Polarizability (Fajan's rules),

3.2 Introduction to Qualitative Analysis

(7 Lecs.)

3.2.1: Types of qualitative analysis.

3.2.2: Solubility product

3.2.3: Factors affecting precipitation equilibria (solubility products) in qualitative analysis (numerical problems expected) : common ion effect, pH, complexation, diverse ion effect, oxidation states. (Examples to illustrate these factors may be selected from the schemes for qualitative analysis in laboratory work.)

C.I.A. Mid-Semester Test, Quiz

Students who miss the quiz will have to appear for a Viva.

SEMESTER I

COURSE : S.CHE.1.02

BASIC CHEMISTRY II

[45 LECTURES]

LEARNING OBJECTIVES:

1. To understand the basics of chemical calculations and stoichiometry
2. To study mechanisms of organic reactions involving different reaction intermediates
3. Basic study of alkanes with respect to origin, refining, stability, physical and chemical properties
4. To understand and elucidate the basis of bond formation in molecules
5. To apply theoretical concepts in order to solve numerical problems

UNIT I

[15 Lectures]

1.1: Introduction to Quantitative Analysis :

(11 Lecs.)

1.1. 1: Methods of expressing concentration of solutions - molarity, normality, molality, mole fraction, formality, dilution of solutions, inter-conversion between different concentration units, concept of milliequivalents, millimoles, ppm and ppb.

1.1.2 : Gravimetric and Volumetric analysis : use of digital balance, calibration of glassware : pipette, burette, and volumetric flask. Primary and secondary standards. Preparation of standard solutions, calculation of concentration of commercial samples of acids and bases like HCl, H₂SO₄, acetic acid and ammonia.

1.2: Presentation of experimental data : (4 Lecs.)

1.2.1: Significant figures, concept rules and examples, graphical representation of experimental data equation of straight line, slope and intercept and their significance with the relevant examples. Use of computers in chemical calculations.

UNIT II [15 Lectures]

2.1 Mechanism of Organic Reactions : (9 Lecs.)

2.1.1 Bond breaking processes : Representation of electronic movement by curved arrows. Homolytic and heterolytic fission,

2.1.2 : Formation, structure and stability of carbocations, carbanions and carbon radicals.

2.1.3 :Types of reagents : Electrophiles and nucleophiles, acids and bases, Lowry - Bronsted and Lewis concept, carbon acids, classification of reactions on the basis of mechanisms.

2.1.4 : Study of mechanisms : S_N1 and S_N2 reactions - effect of structure of substrate, leaving group, solvent, nucleophile, Aldol reaction, base catalyzed and simple and crossed aldol reactions of aldehydes and ketones,

2.2 Alkanes and cycloalkanes (6 Lecs.)

2.2.1 Introduction : applications of alkanes and cycloalkanes : general formula, lack of reactivity in alkanes, concept of angle strain, stability and reactivity of cycloalkanes up to 6 carbon atoms,

2.2.2.: Sources : Petroleum oil - Composition , refining, cracking - thermal and hydrothermal, reformation; Natural gas - importance of methane.

2.2.3 : Physical properties : m.p. , b.p., solubility

2.2.4 : Chemical properties : Combustion - alkanes as fuels, heat of combustion, octane number concept, anti-knocking agents, isomerisation, free radical halogenation – mechanism, thermodynamics, factors affecting product distribution, reactivity-selectivity principle

UNIT III [15 lectures]

3.1 Chemical Bonding and molecular structure : (15 Lecs.)

3.1.1: Ionic Bond: Formation of ionic bond, lattice energy, solvation energy, Born – Haber cycle and Kapustinski's equation. (numerical problems expected).

3.1.2: Covalent Bond : Lewis electron dot structures : Single and multiple bonding , co-ordinate bonding,

- 3.1.3: VSEPR concept : Shapes of chemical species on the basis of VSEPR theory [e.g. NH_3 , ClF_3 , BrF_5 , ICl_2^{-2} , TeF_5^{-1} , phosphorus trihalides]
- 3.1.4: Valence Bond Theory : sigma and pi bonding ; theory of hybridization with respect to equivalence of contributing atomic orbitals in the following examples: CH_4 , NH_3 , and H_2O ; Energetics of hybridization ; Types of hybridization: sp, sp^2 , sp^3 , with illustrations like BeCl_2 , BF_3 , SiCl_4 .

C.I.A. Mid-Semester test, Quiz

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SEMESTER II

COURSE : S.CHE.2.01

BASIC CHEMISTRY III

[45 LECTURES]

LEARNING OBJECTIVES :

1. To familiarize the student with different types of chemical reactions
2. To understand photochemistry with respect to certain laws
3. To introduce the students to environmental chemistry
4. To apply theoretical concepts in order to solve numerical problems
5. To understand the concept of isomerism, and represent the structure of organic compounds
6. To study preparation and properties of unsaturated hydrocarbons
7. To understand mechanisms of certain reactions and predict the outcome of an organic reaction given the identities of reactants.
8. To understand the various terms, rules and phenomena involved in co-ordination chemistry
9. To understand the periodic trends in periodic properties of group 13 elements
10. To apply theoretical concepts in order to solve numerical problems

UNIT I

[15 Lectures]

1.1: Chemical Kinetics

(10 Lecs.)

- 1.1.1: Rate of Reaction: Definition of rate constant, measurement of reaction rates, order and molecularity, integrated rate equations for zero, first and second order reactions (second order reactions with equal and unequal initial concentration to be considered), kinetic characteristics of first and second order reactions, pseudo first order reactions.
- 1.1.2 : Methods of determining order of reaction: by a) integration method b) graphical method c) equi-fraction method d) Ostwald's isolation method.

1.1.3 : Effect of temperature on rate of reaction, temperature coefficient, Arrhenius equation.

1.2 : Photochemistry (5 Lecs.)

1.2.1 : Laws of Photochemistry, photon yield (quantum yield) and its determination, primary and secondary reactions, reasons for high and low quantum yields.

1.2.2: Study of photochemical reactions: i) reaction between hydrogen and chlorine, ii) dissociation of hydrogen iodide

1.2.2 : Photosensitizers and photosensitized reactions, photochemical smog, ozone depletion, green house effect, concept of flash photolysis.

UNIT II [15 Lectures]

2.1 Stereochemistry of organic compounds (8 Lecs.)

2.1.1 Isomerism : Types of isomerism ; Structural isomerism (chain , position and functional) and stereoisomerism.

2.1.2 Chirality : Configuration, chirality and enantiomers, stereogenic / chiral centre, asymmetric carbon atom, representation of configuration by flying wedge formula and projection formulae - Fisher, Newman and Sawhorse.

2.1.3 Stereochemistry of carbon compounds with one and two similar and dissimilar asymmetric carbon atoms, enantiomers, diastereomers and racemic mixtures and their properties; threo, erythro and meso isomers.

2.1.4 Diastereomerism : (Geometrical isomerism) due to restricted rotation around carbon – carbon double bond.

2.1.5 Conformations : Conformations of ethane, difference between conformation and configuration.

2.2 Alkenes , Cyclo-alkenes Alkynes (7 Lecs.)

2.2.1 Introduction : Concept of elements of unsaturation, applications of alkenes, cycloalkenes and alkynes.

2.2.2 Preparation of alkenes & cycloalkenes (up to 6 carbons) : Dehydration of alcohols, dehydrohalogenation of haloalkanes. E1 and E2 mechanisms, Saytseff's rule and Hoffman rule

2.2.3 Reactions of Alkenes: Cycloalkenes (up to 6 carbons); Hydrogenation, epoxidation, permanganate oxidation, ozonolysis, halogenation, addition of HX – Markovnikov and anti- Markovnikov addition with mechanism, hydroboration – oxidation , Diels – Alder reaction.

2.2.4 Preparation of alkynes : dehydrohalogenation of vicinal dihalides and haloalkenes; from metal carbides.

2.2.5 Reactions of alkynes : Hydration, addition of HX , selective hydrogenation to cis and trans alkenes, acidity of terminal alkynes, preparation of metal acetylides and their alkylation.

UNIT III

[15 Lectures]

3.1 Chemistry of Co-ordination Compounds

(7 Lecs.)

- 3.1.1 Distinction between double salts and co-ordination compounds
- 3.1.2 Effective atomic number rule
- 3.1.3 IUPAC nomenclature
- 3.1.4 Terms involved in co-ordination chemistry
- 3.1.5 Experimental evidences of co-ordinate bond formation
- 3.1.6 Werner's theory of co-ordination compounds
- 3.1.7 Applications of co-ordination compounds

3.2 Comparative Chemistry of group 13 elements

(8 Lecs.)

- 3.2.1 Trends in metallic character, oxidation states, melting and boiling points, inert pair effect
- 3.2.2 Structures of electron deficient compounds with respect to boron hydrides.
- 3.2.3 Chemistry of aluminium compounds: halides, oxides and alkyls.

C.I.A. Mid-Semester test, Quiz

Students who miss the quiz will have to appear for a Viva.

SEMESTER II

COURSE : S.CHE.2.02

BASIC CHEMISTRY IV

[45 LECTURES]

LEARNING OBJECTIVES:

1. To study and understand the tenets of thermodynamics pertaining to the first and second law of thermodynamics
2. To understand and be able to elucidate the difference between molecular and atomic spectra, and understand various types of spectroscopy
3. To understand concept of aromaticity, non-aromaticity and anti aromaticity as applied to benzenoid and non-benzenoid carbocycles
4. To study the reactivity of various aliphatic organic compounds and their interconversions in 5 – 6 steps
5. To understand the role and significance of metal ions like Na, K, Fe and Cu in biological systems
6. To introduce the basic concepts of environmental chemistry and create awareness about pollution and conservation of the environment
7. To understand the trends in periodic properties of group 14 elements
8. To study the chemistry of Silicon

9. To apply theoretical concepts in order to solve numerical problems

UNIT I

[15 Lectures]

1.1 Thermodynamics

(12 Lects.)

- 1.1.1 First Law of thermodynamics, internal energy, enthalpy, isothermal and adiabatic processes, P-V-T relation for adiabatic process.
- 1.1.2 Second Law of thermodynamics, need for the law, Carnot cycle, mechanical efficiency,
- 1.1.3 Concept of entropy, physical significance of entropy, entropy changes accompanying change of state and transition,
- 1.1.4 Helmholtz's and Gibbs Free energy, relation between them, criteria of spontaneity

1.2 Introduction to Molecular Spectroscopy

(3 Lects.)

- 1.2.1 Nature of electromagnetic radiation, interaction of EMR with matter: absorption, emission, fluorescence and scattering
- 1.2.2 Energy types and energy levels for atoms and molecules
- 1.2.3 Types of spectroscopy: quantization of energy, regions of electromagnetic spectrum, and different types of spectroscopy
- 1.2.4 General applications of different spectroscopic techniques (qualitative discussion: only introduction)

UNIT II

[15 Lectures]

2.1 Aromaticity and aromatic hydrocarbons

(4 Lects.)

- 2.1.1 Aromaticity : characteristic properties of aromatic compounds, Huckel's rule, aromaticity and anti-aromaticity, resonance energy
- 2.1.2 Aromatic hydrocarbons : a) benzenoid hydrocarbons: benzene, naphthalene, anthracene , phenanthrene , b) non- benzenoid ions : cyclopropenium , cyclopentadienide, cycloheptatrienium cation
- 2.1.3 Anti- aromatic hydrocarbons : cyclobutadiene, structure of cyclooctatetraene.

2.2 Reactions of aliphatic organic compounds and their inter-conversions (11 Lects.)

- 2.2.1. Reactions of alkyl halides with : aqueous alkali; alcoholic alkali (dehydrohalogenation); potassium cyanide, conversion of alkyl cyanide further to primary amine and carboxylic acid; ammonia; silver salt of carboxylic acid; sodium alkoxide; formation of Grignard reagent; Wurtz reaction.
- 2.2.2. Reaction of alcohols with : sodium metal; HX; PCl_3 , PCl_5 , SOCl_2 ; dehydration; oxidation of primary , secondary and tertiary alcohols.
- 2.2.3. Reactions of aldehydes and ketones :

- a) Addition to carbonyl compounds: i) HCN ii) Grignard reagent;
 - b) Condensation reaction with hydroxylamine;
 - c) Aldol condensation
 - d) Reduction of aldehydes and ketones: i) catalytic reduction; ii) Clemmensen reduction iii) reduction with LiAlH_4 and NaBH_4 iv) Wolff - Kishner reduction
 - e) Haloform reaction
- 2.2.4. Reaction of acids esters and amines :
- a) Acids : Formation of salt, anhydride, amide, acid halide, ester and alkanes.
 - b) Esters: Hydrolysis of esters with acids and alkalis; reaction of esters with Grignard's reagent,
 - c)Amides: Hydrolysis of amides, reduction of amides, Hoffman – bromamide reaction
- 2.2.5. Reaction of amines:
- a) Formation of amines from nitro-alkanes, oximes,
 - b) Acetylation of amines with acetic anhydride and acetyl chloride.
 - c) Action of nitrous acid on primary / secondary / tertiary amines.
 - d) Methylation of primary / secondary / tertiary amines yielding quaternary ammonium salts, Hoffman elimination.

Note : Each reaction should be studied with respect to compounds with up to 6 carbon atoms. Based on these and the reactions of alkanes, alkenes and alkynes, multi-step synthesis of compounds having one functional group are expected, the number of carbon atoms in each being not more than six. No mechanisms are expected.

UNIT III

[15 lectures]

3.1 Basic bio-inorganic chemistry: (2 Lecs.)

3.1.1 Introduction, essential and non-essential elements in biological systems , role of metal ions such as Na, K, Fe and Cu in biological systems.

3.2 Environmental chemistry : (6 Lecs.)

3.2.1 Study of various gaseous pollutants, such as oxides of nitrogen, carbon and sulphur with respect to sources of emissions, fate, health hazards, and control measures.

3.3. Comparative chemistry of Group 14 elements : (7 Lecs.)

3.3.1 Trends in metallic character, oxidation state, melting and boiling points, inert pair effect,

3.3.2 Catenation and allotropy with special reference to carbon (to include study of fullerenes and carbon nano-tubes)

3.3.3. Chemistry of Silicon with special reference to methods of purifications, zone refining and single crystal method,

3.3.4 Introduction to silicones with reference to methods of preparation and their uses

C.I.A. Mid-Semester test, Quiz
Students who miss the quiz will have to appear for a Viva.

REFERENCES:

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2. Physical Chemistry, Ira Levine, 5th Edition, 2002 Tata McGraw Hill Publishing Co. Ltd.[Chapter 4 , 14]
3. Physical Chemistry, G.M. Barrow, 6th Edition, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
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5. University Chemistry, Bruce Mahan
6. Textbook of Physical Chemistry, Sharma and Puri
7. Schaum Outline Series: College Chemistry
8. Schaum Outline Series: Physical Chemistry
9. Organic Chemistry, R.T. Morrison and R.N. Boyd, 6th Edition, Pearson Education.
10. Organic Chemistry, T.W.G. Solomon and C.B. Fryhle, 8th Edition, John Wiley & Sons, 2004.
11. A guide to mechanism in Organic Chemistry, 6th Edition, Peter Sykes, Pearson Education.
12. Fundamentals of Organic Chemistry, G. Marc Loudon, 4th Edition, Oxford University Press, 2006.
13. Organic Chemistry, John McMurry
14. Organic Chemistry, L.G. Wade Jr. and M.S. Singh, 6th Edition, 2008.
15. Organic Chemistry, Paula Y. Bruice, Pearson Education, 2008.
16. Organic Chemistry, J.G. Smith, 2nd Edition, Special Indian Edition, Tata McGraw Hill.
17. F.A.Cotton,G.Wilkinson and P.L.Gauss, Basic Inorganic Chemistry, 3rd Edition, J.Wiley and Sons, Inc.(1995)
18. J.D.Lee,Concise Inorganic Chemistry,5th Edition, Oxford University press,
19. Environmental Chemistry, A.K. De, Wiley Eastern Ltd., New Delhi, 1989
20. Fundamental concepts of Environmental Chemistry, G.S.Sodhi
21. Advanced Inorganic Chemistry, Bahl, Anand, and Tuli, Vol. 1 and 2

PRACTICALS:

LEARNING OBJECTIVES:

1. To enable the development of analytical skills in organic and inorganic qualitative analysis
2. To acquire quantitative skills and perform estimations of different types
3. To purify organic compounds in quantitative manner
4. To study kinetics of a first order reaction
5. To determine different physical properties of liquids such as viscosity, surface tension and refractive index

SEMESTER I

COURSE : S.CHE.1.PR

PRACTICAL 1.

Volumetric Analysis
Organic Spotting
Physical Chemistry Experiments

PRACTICAL 2.

Qualitative Analysis
Organic Purification
Gravimetric Analysis

SEMESTER II

COURSE : S.CHE.2.PR

PRACTICAL 1.

Volumetric Analysis
Organic Spotting
Physical Chemistry Experiments

PRACTICAL 2.

Qualitative Analysis
Organic Purification
Gravimetric Analysis

(1) PHYSICAL CHEMISTRY EXPERMENTS:

1. Study of acid catalyzed hydrolysis of methyl acetate – rate constant to be evaluated graphically and from calculations.

2. To determine the relative strength of HCl and H₂SO₄ by hydrolysis of methyl acetate method.
3. To determine strength of commercial sample of HCl and acetic acid. (standard solution of succinic acid to be prepared, NaOH solution to be supplied)
4. Ostwald's Viscometer to determine viscosity of given liquid.
5. To determine refractive index of the given liquid using Abbe's refractometer.

(2) INORGANIC :

I Gravimetric Analysis : To study the effect of heat on the mixture of:

- a) NH₄Cl + BaSO₄
 - b) Na₂CO₃ + NaHCO₃
- and calculate the percentage composition of the mixture

II Volumetric Analysis :

a) Determination of number of electrons required in a chemical reaction between potassium oxalate and potassium permanganate in acidic medium titrimetrically. (solution of potassium oxalate to be prepared by students)

b) Estimation of a mixture of oxalic acid and potassium oxalate by titration with standard NaOH and KMnO₄.

c) Determination of strength of a mixture of Na₂CO₃ and NaHCO₃ by titration with standard acid solution using phenolphthaleine and methyl orange as indicators

d) Estimation of Mg by titration with EDTA using Eriochrome Black T indicator.

III Inorganic Semi-Micro Qualitative Analysis: of a sample containing four anions and probable cations from those given below : Cl⁻, Br⁻, I⁻, CO₃²⁻, S²⁻, SO₃²⁻, SO₄²⁻, NO₂⁻, NO₃⁻, CrO₄²⁻, PO₄³⁻, BO₃³⁻ ;

Preliminary dry tests to indicate probable cations, preparation of solution and wet tests for confirmation of the presence of 4 anions (complexities of anions to be included). Minimum 6 mixtures should be analyzed.

(3) ORGANIC :

A) Purification of solid compounds by crystallization from water.

Percentage yield of the purified compound is to be determined. Quality and quantity of the crystallized compound to be given credit. Quantity of compound to be given : about 1 gm. (minimum 6 compounds to be given for purification)

B) Determination of melting point and boiling point of pure compounds.
(minimum 6 compounds)

C) Organic Spotting:

Characterization of organic compounds (by micro-scale techniques).

An organic compound containing only one functional group is to be characterized and identified.

Analysis to include the following tests: preliminary observations, solubility profile, elemental analysis, functional group identification, m.p. / b.p.

Type of compounds : carboxylic acids, phenols, aldehydes and ketones, alcohols, esters, amines, amides, aromatic nitro compounds, hydrocarbons, halogenated hydrocarbons. (at least one compound from each type)

Quantity of compounds to be given: about 1 gm / 2 ml.

Minimum 12 compounds should be analyzed during the course.

NOTE : Theory behind all the experiments is expected during the viva / written test

REQUIREMENTS FOR JOURNAL CERTIFICATION:

The Chemistry journal will be certified only if the student has minimum 75 % attendance at Chemistry practicals, and performs 2/3 of the experiments in **each practical category** as specified by the Department