# Syllabus

# for

# B.Sc. I and II semester (Chemistry)

# (~~Revised~~ Curriculum)

# 2024-25 onwards

**Prepared by**
**BoS (UG & PG) in Chemistry**
**Tumkur University, Tumakuru**

## Curriculum

**Name of the Degree Program: B.Sc.**

**Subject/BoS: Chemistry**

**Discipline Core: Chemistry, Total Credits: 36 (for students not opting deep specialization)**

**Year of implementation: 2024-25**

**Course structure for first and second semesters**

| Semester | L | P | T | Total credits |
|---|---|---|---|---|
| | 4h / week | 4h / week | - | |
| 1 | 4 credits | 2 credits | - | 6 |
| 2 | 4 credits | 2 credits | - | 6 |

**Examination structure for first and second semesters**

| Semester | Paper title | Semester end exam | | IA Marks | Total Marks |
|---|---|---|---|---|---|
| | | Duration | Marks | | |
| 1 | Chemistry – 1 | 3h | 80 | 20 (Average of two Tests 10 M + Average of Two Assignments 10M) | 100 |
| 1 | Chemistry Practicals– 1 | 3h | 40 | 10 (One Test 5 M+ One Assignment 5M) | 50 |
| 2 | Chemistry - 2 | 3h | 80 | 20 (Average of two Tests 10 M+ Average of Two Assignments 10M) | 100 |
| 2 | Chemistry Practicals– 2 | 3h | 40 | 10 (One Test 5M+ One Assignment 5M) | 50 |

## First Semester

## Chemistry-1 60h

**Course objectives**

1. Understand and Apply Quantum Mechanical Concepts
2. Analyze and Interpret Atomic Structure and Electron Configurations
3. Analyze Periodic Trends and Chemical Behavior
4. Compare and Contrast Elemental Properties
5. Understand Organic Chemistry Fundamentals and Bonding
6. Analyze Reactivity and Reaction Mechanisms
7. Quantify and Interpret Gas and Liquid Properties
8. Apply Theoretical Principles to Solutions

**Course outcomes**

1. Apply Quantum Mechanical Models to Solve Problems
2. Analyze and Explain Atomic and Electronic Structures
3. Apply Periodic Trends to Predict Chemical Properties
4. Apply Organic Chemistry Principles to Reactions
5. Evaluate and Explain Organic Chemistry Concepts
6. Calculate and Analyze Properties of Gases and Liquids
7. Solve Problems Related to Solutions and Their Properties

**Unit-I** **15h**

**Atomic Structure - 1**

Bohr's theory of hydrogen atom: assumptions and limitations, expressions for radius and energy of hydrogen atom and hydrogen atom like ions $He^{+}$, $Li^{2+}$ (no derivations), explanation of atomic spectra of hydrogen atom (occurrence of different series in the spectrum), numerical problems on the calculation of wave numbers of spectral lines.

**Wave Mechanics**

Need for a new approach to atomic structure, de Broglie hypothesis (statement and equation), Heisenberg's uncertainty principle (statement and equation) and its significance, numerical problems on de Broglie equation and Heisenberg's uncertainty principle. Concept of orbits and orbitals. Time-independent Schrödinger's wave equation (cartesian coordinate only, no derivation)–one-dimensional and three-dimensional equations, significance of Schrödinger's wave equation.

**Wave Functions**: Characteristics of well-behaved wave functions (few simple examples should be discussed), significance of $\psi$ and $\psi^2$ (or $\psi\psi^*$) (probabilistic approach), normalized and orthogonal wave functions, normalization condition. Quantum numbers and their significance. Time-independent

Schrodinger wave equation for the hydrogen atom and its solution ($R$, $\theta$ and $\varphi$ equations in cartesian and polar coordinates; only expressions, no derivations). Radial and angular wave functions for hydrogen atom, spherical harmonics. Radial and angular distribution curves: Shapes of $s$, $p$, $d$ and $f$ orbitals, radial distribution functions (probability diagrams) for 1s, 2s, 2p, 3s, 3p and 3d orbitals (only graphical representation), radial and angular nodes, nodal planes.

Rules for filling up of electrons in various orbitals: Hund's rule of maximum multiplicity, Pauli's exclusion principle, Aufbau principle (n+l rule), variation of orbital energy with atomic number, stability of half-filled and completely filled orbitals, concept of exchange energy, anomalous electronic configurations (Cr and Cu). Electronic configuration of elements (up to Z =30).

**UNIT II** **15 h**

**Periodic table and periodicity**

**Review of the modern periodic table** (with respect to the classification of elements based on outer electronic configuration).

**Periodicity in *s* and *p*-block elements**, trends in the periodic properties. Applications in predicting and explaining chemical behaviour with respect to a) electronic configuration b) effective nuclear charge, shielding or screening effect, Slater rules, variation of effective nuclear charge in periodic table, c) Atomic radii–the concept of various radii–ionic radii, covalent radii, van der Waal radii with examples; variation of the atomic radii across the period and down the groups, d) ionization enthalpy, successive ionization enthalpies and factors affecting ionization enthalpy, e) Electron affinity of atoms–definition, illustration, variation of the values along the periodic table and explanation of the trends, f) electronegativity (E.N)–the concept of electronegativity and its difference from electron affinity; Ionic characters of bonds and the E.N. difference, other E.N. scales–the Mulliken, Allred–Rochow scales (problems). Applications of electronegativity.

**Diagonal relationship** -definition, reason, diagonal relationship between Lithium and Magnesium, beryllium and aluminium.

Comparative study of elements of alkali and alkaline earth metals.Trends in the chemistry of the compounds of groups 13 to 17 (hydrides, carbides, oxides, and halides) are to be discussed (qualitative only).

**Unit-III** **15h**

**Basics of Organic Chemistry**

Introduction to organic chemistry, catenation, classification and IUPAC nomenclature of some important

organic compounds. Chemical bonding, formation of covalent bond, hybridization- formation and structure of ethane, ethene and ethyne. Localized and delocalized, conjugation and cross conjugation with suitable example.

**Factors affecting reactivity of organic compounds (electronic effects) :** Inductive effect – definition, +I and –I effect with suitable examples. Resonance effect–definition, +R and –R effect with suitable examples. Electrometric effect– definition with examples. Hyperconjugation – definition, ethyl carbocation and propene as examples (propene is more stable than ethene).

**Bond cleavage**–homolysis and heterolysis with examples. **Reactive intermediates:** Carbocations, carbanions, carbon free radicals and carbenes- Generation, structure, stability and reactivity. Types of reagents – electrophiles and nucleophiles with examples.

**Types of organic reactions**–Substitution (Electrophilic and nucleophilic), addition, elimination, and rearrangement (inter and intramolecular) reactions, explanation with examples.

**Chemistry of saturated Aliphatic Hydrocarbons**

**Alkanes**: Introduction, natural sources, preparation – by catalytic hydrogenation of alkenes and alkynes, Wurtz reaction, Kolbe's electrolysis, Grignard reagents, Wurtz-Fittig reaction for alkyl arenes. Free radical substitutions–chlorination of methane and propane with mechanism. Conformational analysis of alkanes: ethane, butane and cyclohexane.

**Unit-IV** **15h**

**Gaseous state** **7h**

**Introduction**. Maxwell-Distribution of molecular velocities-equation only, explanation of important features of the Maxwell's distribution curves of molecular velocities, effect of temperature on distribution of molecular velocities. Types of molecular velocities-most probable velocity, average velocity and root mean square velocity-derivation of expressions from Maxwell-Boltzmann distribution equation, relationships among them, Numerical problems in SI units.

**Real gases**- a review of van der Waal's equation of state, critical constants of a real gas Tc, Pc and Vc-definition and significance, derivation of expression for critical constants from van der Waal's equation, critical compressibility factor, Numerical problems on the calculation of Tc, Pc, Vc and van der Waal's constants a and b, Andrew's isotherm on carbon dioxide and explanation of the curves (no experimental details). Law of corresponding states-statement, explanation, reduced equation of states. Liquefaction of gases-Joule-Thompson effect-definition, explanation, Joule-Thompson coefficient, Inversion temperature (definition, significance, no derivation), application to the liquification of air and hydrogen (Linde's

process in detail).

**Liquid state** **4h**

**Surface Tension:** Definition and explanation, its SI unit, effect of temperature and solute on surface tension, significance of surface tension (mention any two), determination of surface tension using stalagmometer. Surface active agents-definition and examples.

**Viscosity:** Definition and explanation, coefficient of viscosity, SI unit, Determination of viscosity of a liquid using Ostwald viscometer. Effect of temperature, size, weight, shape of molecules and intermolecular forces (qualitative discussion only).

**Solutions-1** **4h**

**Completely miscible liquids**: Ideal and non-ideal solutions, Thermodynamics of ideal solutions- Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes. Numerical problems on Raoult's law (vapour pressure calculation).

**Recommended Books/References:**


1. Concise Inorganic Chemistry: J. D. Lee, Wiley, 4th edition (2021).
2. Fundamentals Concepts of Inorganic Chemistry, Vols. 1 and 2, Asim K. Das, CBS Publishers and Distributors, 2nd edition (2013).
3. Basic Inorganic Chemistry, F. A. Cotton, G. Wilkinson, P. L. Gaus, Wiley. India, 3rd edition (1995).
4. Inorganic Chemistry, Catherine E. Housecroft, A.G. Sharpe, Pearson Prentice Hall, 2nd edition (2005).
5. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
7. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
8. Text book of Organic chemistry - Jagdamba Singh, vol. I and II.
9. Advanced Organic Chemistry - Reactions, Mechanism and Structure, Jerry March, John Wiley (2008).
10. Advanced Organic Chemistry, F A Carey and R J Sundberg Plenum, (1990).
11. A Guide Book to Mechanism in Organic Chemistry, Peter Sykes, Longman, (2000).
12. Atkin's Physical Chemistry, Peter Atkins, Julio De Paula, Oxford University Press, 8th edition (2006).
13. Elements of Physical Chemistry, Samuel Glasstone, David Lewis, Palgrave Macmillan, 2nd edition (1963).
14. A Text book of Physical Chemistry, A. S. Negi, S. C. Anand, New Age International Publishers (2007).
15. Principles of Physical Chemistry, Puri, Sharma, Pathania, Vishal Publishing Co., 47th edition (2020).
16. A Text Book of Physical Chemistry P. L. Soni, O. P. Dharmarha and, U. N. Dash, Sultan Chand and Sons (2016).
17. Advanced Physical Chemistry, Gurdeep Raj, Krishna Prakashan Media Publishers (2020).

## Chemistry practicals-1 4h/week

**Course objectives**

1. To learn basic laboratory practices and basic practical concepts
2. To understand the principle and to learn the skill of estimation by volumetric titrations
3. To learn basic purification techniques
4. To learn determination of density, viscosity and surface tension of liquids as well as mixtures.

**Course outcomes**

1. Apply basic laboratory practices and use basic concepts every day in laboratory
2. Quantitative estimation of the given compound by volumetric titrations
3. Apply preliminary purification techniques such as distillation, recrystallization etc.
4. Determination of surface tension and viscosity of liquids and estimation of composition of mixture.

**Basic concepts: Demonstration of laboratory practices** [safety, glassware/chemicals handling, chemical nature understanding, chemical/glassware waste management, error analysis], calibration of laboratory glassware [pipettes and burettes].

**Practical concept** of Molarity, Molality, Normality, Weight %. Preparation of standard solutions, normal solutions, and dilution of stock solutions (0.1M) to different concentrations.

**Note: Minimum eight experiments to be performed giving equal weightages to Part-A and Part-B.**

**Part -A**

1. Estimation of oxalic acid using potassium permanganate solution.
2. Estimation of Fe (II) ions by titrating it with $K_2Cr_2O_7$ using an internal indicator.
3. Estimation of Mohr's salt (FAS) by titrating with $KMnO_4$.
4. Estimation of sodium carbonate and sodium hydrogen carbonate (sodium bicarbonate) present in a mixture by double indicator method.

**Part -B**

1. Purification of organic solids by recrystallization (from water and alcohol) and determination of melting point.
2. Purification of organic liquids by distillation and determination of boiling point.
3. Determination of density and surface tension of a liquid using a stalagmometer (Ethyl acetate, toluene, chlorobenzene or any other non-hazardous liquids).
4. Study of the variation of surface tension of a detergent solution with concentration.
5. Determination of density and viscosity of a liquid using an Ostwald's viscometer (Ethyl acetate, toluene, chlorobenzene or any other non-hazardous liquids).

6. Study of the variation of viscosity of sucrose solution with concentration.
7. Determination of the composition of liquid mixture by viscometry method (toluene and alcohol or any other pair of non-hazardous miscible pair of liquids).

**Recommended Books/References:**

1. Vogel's text book of Practical Organic Chemistry, B. S. Furniss, A. J. Hannaford, P. W. G. Smith, A. R. Tatehell, Prentice Hall, 5th edition (1989).
2. Elementary Practical Organic Chemistry-Part-III: Quantitative Organic Analysis, Arthur I, Vogel, Pearson India (2011).
3. Laboratory manual of Organic Chemistry, B. B. Dey and M. V. Sitaraman, Laboratory manual of Organic Chemistry, B. B. Dey, M. V. Sitaraman, T. R. Govindachari, Allied Publishers, New Delhi (1996).
4. Practical Organic Chemistry, F. G. Mann, B.C. Saunders, Pearson Education Limited, 4th edition (2011).
5. Practical Volumetric Analysis, A. C. Peter, McPherson, Royal Society of Chemistry, Cambridge, UK (2015).
6. L. Rakesh Sharma, Practical Inorganic Chemistry (for undergraduate students), Evincepub publishing, 1st edition (2021).
7. Practical physical chemistry by B. Viswanathan and P.S. Raghavan, Viva publishers.
8. Advanced practical physical chemistry by J.B.Yadav, Krishna's Educational publishers.

number of bond pairs, number of lone pairs and predicting the shapes of the molecules and ions by taking $BeCl_2$, $BCl_3$, $NO_3^-$, $SO_2$, $NH_3$, $NH_4^+$, $PF_5$, $H_2O$, $SF_4$, $ClF_3$, $SF_6$, $XeF_4$, $BrF_5$ and $I_3^-$ as examples.

Concept of hybridization with suitable examples of linear, trigonal planar, tetrahedral, trigonal bipyramidal and octahedral arrangements (Eg. $BeCl_2$, $BF_3$, $CCl_4$, $PCl_5$, $SF_6$).

Concept of resonance and resonating structures in various inorganic compounds; CO, $CO_2$, $CO_3^{2-}$, $SO_2$, $SO_4^{2-}$, $NO_3^-$.

**Unit-II** **15h**

**Chemistry of unsaturated Aliphatic Hydrocarbons**

**Alkenes and alkynes**: Formation by elimination reactions: Alcohols, 1,2-dihalides and tetra-halides. Saytzeff and Hofmann eliminations. Addition reactions- Hydrogenation, hydration, epoxidation of alkenes (each with examples) Addition of HBr to alkenes- Addition of HBr to propene (Markonikoff's and anti-Markonikoff's rules with examples). Ozonolysis- mechanism of ozonolysis of propene, Significance.

**Aromatic Hydrocarbons**

Introduction and characteristics of aromatic hydrocarbons. Concept of resonance, aromaticity,

Huckel rule-explanation with examples. Aromatic character of arenes. (benzene and benzenoids).

Preparation of,

1. Benzene (a) from acetylene (b) by decarboxylation of benzoic acid
2. Naphthalene (a) from phenyl-1-butene (b) from α-tetralone

Reactions with mechanisms (by taking benzene as an example): Electrophilic substitution – nitration, halogenation (chlorination), sulphonation, Friedel-Craft's alkylation and acylation. Polycyclic arenes as carcinogens–definition of carcinogen, name and structure of benzo[a]anthracene and benzo[a]pyrene.

**Alkyl and Aryl halides**

**Alkyl Halides:** Preparation – from alkenes (addition of HCl and HBr) and alcohols (using $PCl_5$ and $SOCl_2$). Nucleophilic substitution reactions–definition with examples (hydrolysis, and nitro formation Williamson's ether synthesis). Mechanisms of $S_N^1$ & $S_N^2$ reactions, Stereochemistry and factors effecting $S_N^1$ and $S_N^2$ reactions. Elimination reaction with example.

**Aryl Halides**: Preparation of chloro, bromo and iodo-benzene from phenol, preparation of chlorobenzene by Sandmeyer reaction. Reactions of chlorobenzene – aromatic nucleophilic substitution (replacement of –Cl by –OH group), effect of activating group (Eg. $-NO_2$) on aromatic nucleophilic substitution of chlorobenzene.

**Unit-III** **15h**

**Compounds containing Oxygen-1**

**Alcohols:** Preparation of 1°, 2° and 3° alcohols using Grignard reagents, ester hydrolysis, reduction of aldehydes, ketones, and carboxylic acid. Reactions – with sodium, and HCl (Lucas test), esterification, oxidation (alkaline $KMnO_4$, acidified $K_2Cr_2O_7$ and con. $HNO_3$). Test for alcohols (Lucas test and Victor Meyer test). Oppeneauer oxidation, oxidation of 1,2-diols using $HIO_4$, mechanism of Pinacol-Pinacolone rearrangement. Chemistry of methanol poisoning and harmful effects of ethanol on the human body.

**Phenols**: Preparation – of phenol from cumene hydroperoxide and diazonium salts. Reactions – Electrophilic substitution – nitration, bromination and sulphonation. Reimer-Tiemann Reaction (with mechanism), Schotten – Baumann Reaction. Uses of phenol – preparation and applications of phenolphthalein, reason for the change in colour of phenolphthalein with pH.

**Ethers**: Nomenclature, isomerism, preparation by Williamson's ether synthesis. Reactions of ethers – cleavage by acids, Claisen rearrangement with mechanism.

**Aldehydes and Ketones:** *Introduction, preparation of aldehydes* – Rosenmund reduction, Etard's reaction. Preparation of ketones from nitriles and Grignard reagents. Reactions of formaldehyde, acetaldehyde, benzaldehyde and acetone: Nucleophilic addition – addition of water, HCN, alcohol; Condensation reactions – hydroxylamine, hydrazine, phenylhydrazine and 2,4-DNP; Oxidation with $KMnO_4$, Tollen's reagent and Fehling's solution. Reduction – Wolf Kishner, MPV reaction, mechanism of Clemmenson reaction and Cannizaro's reaction. Knoevenagel and Perkin reaction.

**Unit-IV** **15h**

**Ionic equilibria** **11h**

Electrolytes-Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization. ionization constant. Ionic product of water. Ionization of weak acids and weak bases-degree of dissociation, dissociation constant, Ostwald's dilution law (derivation). pH, pOH and pH scale. Common ion effect-definition and applications. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for four types of salts. Buffer solutions- definition, types and preparation, pH of buffer- Henderson's equation (derivation), buffer action, applications. Solubility and solubility product of sparingly soluble salts (AB and $AB_2$ type salts)– applications of solubility product. (Numerical problems for all concepts).

**BLUE PRINT OF QUESTION PAPERS FOR EXAMINATION AND EVALUATION**

## *CORE PAPERS (I-II Semester B. Sc)*

### *Theory*

| DURATION: 3 HOURS | THE QUESTION PAPER SHALL CONSIST OF TWO PARTS: PART A AND PART B | MAXIMUM MARKS: 80 |
|---|---|---|
| **Part A** | Answer any 10 out of 12 questions [Q1 to Q12]<br>**(three questions from each unit)** | 10 ×2 =20 |
| **Part B** | Answer any 6 out of 8 questions [Q13 to Q20]<br>**(two questions from each unit)** | 6 × 10 =60 |
| i) Equal weightage of marks shall be given to all the units in Part A and Part B.<br>ii) In part B, each main question shall have only three sub-divisions (a), (b) and (c) with (4+3+3) marks respectively. | | |

### *Practical*

| **Duration: 3 Hours** | **Max. Marks: 40** |
|---|---|
| **Performance** | **30 marks**<br>(20 marks for major experiment and 10 marks for minor experiment; One from part-A and one from part-B) |
| **Viva** | **5 marks** |
| **Record** | **5 marks**<br>(minimum 8 experiments to be recorded) |

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