Shiksha Mandal's

Bajaj College of Science, Wardha

(An Autonomous Institution)

Department of Chemistry

Proposed Syllabus for Four Year B.Sc. Honors with Chemistry as Major

Department Specific Course (DSC) as Major

Semester III course in
Chemistry

Syllabus under Autonomy

(Discussed in BOS Meeting of 10-October-2023 and approved in BOS Meeting of 28-March-2024 to be implemented from Academic Session 2024-25)

Shiksha Mandal's

Bajaj College of Science, Wardha

Syllabus of B.Sc. II Semester III

SUBJECT – CHEMISTRY (Major/ DSC)

UCH230T: (Elements of Organic and Physical Chemistry)

[60 Hrs] **[4 Credits]**

Course Description: -

The purpose of this course is to equip learners with knowledge of some important topics of organic and physical chemistry. The organic chemistry units will cover mainly the structure, preparation methods, and chemical reactions of alkenes, dienes, aromatic hydrocarbons, alkyl and aryl halides. The physical chemistry units are designed to cover core topics like thermodynamics with special focus on entropy and free energy, ionic and phase equilibria.

Course Objectives: -

1. To learn the chemistry of dienes and aromatic hydrocarbons with respect to their structure, methods of preparation and chemical reactions.
2. Develop a deep understanding of aromatic compounds and their significance in organic chemistry, including properties and reactions.
3. To study important organic compounds like alkyl and aryl halides, organometallic compounds, with respective of their synthesis, properties and reactivities.
4. To understand fundamental concepts in organic chemistry like electronic displacements, bond fissions, classification of reagents, reactive intermediates and types of reactions.
5. To understand the important aspects of ionic equilibrium.
6. To reinforce the basics of phase equilibrium and to understand related concepts.

Course Learning Outcomes: -

On completion of this theory course, students will-

1. Gain in-depth knowledge of the structure, preparation methods, and chemical reactions of dienes and aromatic hydrocarbons.
2. Develop a profound understanding of aromatic compounds and their pivotal role in organic chemistry, encompassing their properties and reactions.
3. Master the synthesis, properties, and reactivities of crucial organic compounds, including alkyl and aryl halides, and organometallic compounds, leading to a comprehensive understanding of their significance in the field.
4. Apply second law of thermodynamics to investigate the concepts of entropy, free energy and explain the partial molar properties.
5. Employ the principles of ionic equilibrium to differentiate strong and weak electrolytes, to determine important quantities - degree of dissociation, dissociation constant, degree of hydrolysis, hydrolysis constant and pH.

6. Interpret the phase diagrams of one and two component systems and determine degree of freedom of various systems.

The topics of this course cover mainly the fundamentals of the subject.

Contents: -

Unit I: Alkenes and Dienes **(10 Hrs)**

A. **Alkenes:** Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides, Saytzeff's & Hoffman rule); Stereospecific reductions of alkynes (H_2/Pd, $BaSO_4$ & Na/liq NH_3): Syn and anti-addition of alkene (alk. $KMnO_4$, OsO_4, bromine), Addition of HX with mechanism-both ionic and free radical (Markovnikoff's and anti-Markovnikoff's addition), Ozonolysis, Hydroboration-oxidation, Oxymercuration and demercuration.

B. **Dienes:** Nomenclature and classification of dienes. Methods of formation of 1, 3 - butadiene. Chemical reactions of butadiene - 1, 2 and 1, 4 additions, Diels-Alder reaction.

Unit II: **Aromatic compounds and Aromaticity**: **(10 Hrs)**

Nomenclature of benzene derivatives, structure of benzene, Molecular formula and Kekule structure. Resonance structure, MO picture, Preparation of benzene from phenol and acetylene, Aromaticity: Huckel's rule (ex: benzene, naphthalene, cyclopropenium cation, cyclopentadienyl anion and cycloheptatrienyl cation). Orientation & reactivity activating & deactivating groups (CH_3, OH, NH_2, NO_2, CHO, COOH, Cl etc.), Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation).

Unit III: Alkyl and Aryl Halides **(10 Hrs)**

A. Alkyl Halides: Preparation: from alkenes and alcohols. Reactions: Nucleophilic substitution reactions of alkyl halides (alcohol, ester, nitrile & isonitrile formation, Williamson's ether synthesis), mechanism and stereochemistry of nucleophilic substitution reactions (SN_1 and SN_2), factors affecting SN_1 and SN_2 reactions.

B. Aryl Halides: Chlorobenzene: Preparation by aromatic halogenation and Sandmeyer reaction. Aromatic nucleophilic substitution involving Benzyne Mechanism: KNH_2/NH_3 (or $NaNH_2/NH_3$). Reactivity and Relative strength of C-Halogen bond in alkyl and aryl/ Vinyl halides.

Unit IV: Thermodynamics II **(10 Hrs)**

A. Second law of thermodynamics : Need for second law of thermodynamics, statements of second law of thermodynamics, Carnot's cycle and its efficiency, concept of entropy, entropy as a state function of V & T, P & T, entropy change in phase change for ideal gas, entropy as criteria of spontaneity & equilibrium.

B. Free energy functions: Gibb's free energy (G) & Helmholtz free energy (A) and their properties, variation of Gibb's free energy with T & P, Gibb's – Helmholtz equation & its applications, Spontaneity of reaction in terms of A & G .

Systems of variable composition: Partial molar quantities, chemical potential, van't-Hoff's reaction isotherm.

Unit V: Ionic Equilibria (10 Hrs)

Strong, moderate and weak electrolytes, degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect, Salt hydrolysis - calculation of hydrolysis constant and degree of hydrolysis for salt of strong acid and weak base, weak acid and strong base and Numericals. Buffer solutions – Introduction, Henderson's equations, buffer solution of weak acid and its salt (No derivation), buffer solution of weak base and its salt (No derivation). Numericals.

Unit VI: Phase Equilibrium (10 Hrs)

Phases, components and degrees of freedom of a system, Gibbs Phase Rule no derivation. Phase diagrams of one-component systems (phase diagram of water) and two component systems involving eutectics (phase diagram of lead-silver). Liquid-Liquid mixtures: Ideal liquid mixtures, Raoult's law of ideal solutions, Henry's law, Partial miscible liquids: phenol-water system, trimethylamine-water, nicotine-water system, lower & upper consolute temperature, Nernst distribution law, limitations and applications (association and dissociation - No derivation).

Reference Books:

Organic Chemistry

- Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. *Organic Chemistry,* John Wiley & Sons (2014).
- McMurry, J.E. *Fundamentals of Organic Chemistry,* 7th Ed. Cengage Learning India Edition, 2013.
- Sykes, P. *A Guidebook to Mechanism in Organic Chemistry,* Orient Longman, New
- Delhi (1988).
- Eliel, E.L. *Stereochemistry of Carbon Compounds*, Tata McGraw Hill education, 2000.
- Finar, I.L. *Organic Chemistry* (Vol. I & II), E.L.B.S.
- Morrison, R.T. & Boyd, R.N. *Organic Chemistry*, Pearson, 2010.
- Bahl, A. & Bahl, B.S. *Advanced Organic Chemistry,* S. Chand, 2010.
- P. S. Kalsi *Organic Stereochemistry,* Narosa Publishing House

Physical Chemistry

- S.H. Marron and C.F.Pruton. *Principles of Physical Chemistry*,4th edition
- Samuel Glasstone. *Textbook of Physical Chemistry*,
- Ira Levine, *Physical Chemistry*, 5th Edition, 2002 Tata McGraw Hill Publishing Co. Ltd.
- G.M. Barrow, *Physical Chemistry*, 6th Edition, Tata McGraw Hill Publishing Co. Ltd. New Delhi.
- Atkins, P. W. & Paula, J. de Atkins *Physical Chemistry* 9th Ed.,Oxford UniversityPress2011.

- Puri, Sharma and Pathania. *Principles of Physical Chemistry*,
- Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa 2004.
- Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall 2012.
- McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics* Viva Books Pvt. Ltd.: New Delhi 2004.
- Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S. *Commonly Asked Questions in Thermodynamics.* CRC Press: NY 2011
- http://nsdl.niscair.res.in
- http://ocw.mit.edu

UCH230P: Elements of Practical Chemistry

[60 Hrs] **[2 Credits]**

Course Description: -

The purpose of this course is to inculcate basic practical skills among the learners. They will learn to perform experiments of specific aims with correct techniques. The learners will develop skills to synthesize an organic compound with known methods. They will be able to corelate theory with practical. They will apply the theoretical knowledge to practically prepare buffer solutions of fixed pH and determine important properties of binary mixtures and solutions.

Course Objectives: -

The primary objective of the practical course is to learn to perform experiments those have specific aims with correct techniques.

1. To prepare an organic compound (single step synthesis)
2. To apply the concepts and principles of ionic and phase equilibrium to determine important properties like dissociation constant, critical solution temperature.

Course Outcomes: -

On completion of the practical course students will-

1. Acquire skill in synthetic organic chemistry. This will also help them understand the concepts of atom economy, percent yield which are important for any synthetic process.
2. Apply the concepts and principles of ionic and phase equilibrium to determine important properties like dissociation constant, critical solution temperature.

Organic Chemistry

Organic qualitative analysis with respect to type, preliminary tests, elements, functional group, physical constants of single organic compound involving following steps:

I. Preliminary examination
II. Detection of elements
III. Detection of functional group
IV. Determination of M.P.
V. Preparation of derivative.
VI. Performance of specific test if any

There should be at least one belonging from each type (any four)

a) Benzoic acid, Salicylic acid, Cinnamic acid, Phthalic acid, Succinic acid.
b) β-Naphthol, α-naphthol, Resorcinol.
c) p-Toluidine, α-naphthylamine.
d) Napthalene, Thiourea, Urea, m-Dinitrobenzene, Diphenyl, Glucose, Lactose and Benzamide.

Physical Chemistry

1. To determine pk_a value of given weak acid by pH-metric titration with strong base.

2. To determine the dissociation constant of oxalic acid by pH-metric titration with strong base
3. To prepare buffer solution of different pH and measure their pH
4. To determine the critical solution temperature of two partially miscible liquids(phenol-water systems).
5. To study the critical solution temperature of phenol-water system in presence of 1% NaCl
6. To study the critical solution temperature of phenol-water system in presence of 1% succinic acid
7. To study the distribution of iodine between water and kerosene

Reference Books:-

- Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.
- 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.
- Mann, F. G. & Saunders, B. C. *Practical Organic Chemistry* Orient-Longman, 1960.
- Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi, 2011.
- Yadav J. B., *Advanced Practical Physical Chemistry*, Krishna Prakashan Media (P) Ltd, 2015.
- http://nsdl.niscair.res.in
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Department of Chemistry

Proposed Syllabus for Four Year B.Sc. Honors with Chemistry as Major

Department Specific Course (DSC) as Major

Semester IV course in Chemistry

Syllabus under Autonomy

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Bajaj College of Science, Wardha

Syllabus of B.Sc. II Semester IV

SUBJECT – CHEMISTRY (DSC – Major)

UCH240T: Concise Inorganic and Organic Chemistry

[60 Hrs] **[4 Credits]**

Course Description: -

This course is designed to give learners the knowledge of core topics of inorganic and organic chemistry. The inorganic chemistry units focus on extending the study of periodic table to Lanthanides and Actinides. They will also cover important aspects of molecular orbital theory and coordination compounds. The organic chemistry units will cover mainly the structure, preparation methods, and chemical reactions of alcohols, phenols, aldehydes, ketones, carboxylic acids and their derivatives.

Course Objectives: -

1. To recognize lanthanides and actinides and describe their occurrence, separation, and properties.
2. To impart knowledge about MO theory and its application to illustrate MO energy level diagrams of molecules.
3. To demonstrate coordination compounds, its structure and bonding and isomerism in complexes.
4. To study alcohols and phenols with an aim to provide students with a comprehensive understanding of the properties, reactions, and applications of compounds belonging to these functional groups.
5. To study aldehydes and ketones with a comprehensive understanding of the properties, reactions, and applications of compounds belonging to these functional groups.
6. To study carboxylic acids and their derivatives with special focus on the properties, reactions, and applications of compounds in this functional group, outlining the general goals for the topic.

Course Learning Outcomes: -

On completion of this theory course, students will-

1. Differentiate between lanthanides and actinides and illustrate their separation and properties.
2. Apply MO theory and sketch MO energy level diagrams of molecules.
3. Identify coordination compounds, determine its structure and bonding and types of isomerism in complexes

4. Illustrate alcohols and phenols, including their properties, reactions, and applications.
5. Apply the structural distinctiveness of aldehydes and ketones to demonstrate their properties, reactions, and applications.
6. Compare the properties, reactions, and applications of carboxylic acids and various derivatives of carboxylic acids.

Contents:-

Unit I: Lanthanides and Actinides **(10 Hrs)**

A. **Chemistry of Lanthanides:** Position in periodic table, electronic configuration, Oxidation states, Atomic and ionic radii, Lanthanide contraction and its consequences, Complex forming tendency. Occurrence and separation of lanthanides (ion exchange and solvent extraction).
B. **Chemistry of Actinides:** Position in periodic table, electronic configuration, Oxidation states, Atomic and ionic radii.

Unit II: **MO theory** **(10 Hrs)**

LCAO approximation, wave equation for molecular orbitals. Difference between bonding and anti-bonding MO in terms of energy and electron density distribution curves, order of energy levels in MO. Molecular Orbital diagrams for homonuclear diatomic molecules of elements (with Z = 1 to 9) Concepts of non-bonding MO in HF molecule. Coulson's MO diagram of CO and NO diatomic molecule.

Unit III: Coordination compounds **(10 Hrs)**

A. **Coordination compounds**: Distinction among simple salts, double salts and coordination compounds. Werner's Coordination theory and its experimental verification. Sidgwicks electronic interpretation, EAN rule with examples, Nomenclature of Coordination compounds. Chelates: Classification and their application, Valence Bond Theory of transition metal complexes.
B. **Isomerism in coordination compounds:** Structural isomerism and Stereoisomerism in coordination compounds.

Unit IV: Alcohol & Phenols **(10 Hrs)**

A. **Alcohols:** Classification and nomenclature of primary alcohol.
Dihydric alcohols: Nomenclature, methods of formation of ethylene glycol (from ethylene, epoxide, ethylene dibromide and ethylene diamine). Chemical reactions of vicinal glycols: with carbonyl compounds, dehydration, oxidative cleavage with $Pb(OAc)_4$ and HIO_4 and Pinacol–Pinacolone rearrangement (with mechanism).
Trihydric alcohols: Nomenclature and methods of formation (from hydrolysis of fats and oils, propene and acrolein), chemical reactions of glycerol (with PCl_5, HI, oxidation and dehydration).

B. Phenols

Nomenclature, Preparation of phenols from cumene, chlorobenzene (Dows and Raschig process) and diazonium salts. Physical properties and acidic nature of phenol, Resonance stabilization of phenoxide ion, Reactions of phenols, Electrophilic aromatic substitution, acetylation and carboxylation, Claisen rearrangement, Gatterman reaction, Mechanism of i) Fries Rearrangement, ii) Reimer-Tiemann reaction.

Unit V: Aldehydes and Ketones (10 Hrs)

A. Nomenclature and structure of the carbonyl group, synthesis of aldehydes (from alcohol and acid chloride) and ketones (from alcohol and nitriles). Acidity of alpha hydrogens and formation of enolate, Concept of reactive methylene group, Keto-enol tautomerism inAcetoacetic ester. Oxidation of aldehydes by KMnO4, Tollen's reagent and Fehling solution, Reduction of aldehydes by LiAlH4 and NaBH4.

B. Mechanism of nucleophilic additions to carbonyl group with particular emphasis on benzoin, aldol, Perkin and Knoevenagel condensation. Wittig and Mannich reaction (without mechanism), Baeyer-Villiger oxidation of Ketones, Cannizaro reaction (with mechanism), MPV reaction, Clemmensen and Wolf-Kishner reaction.

Unit VI: Carboxylic Acids & Derivatives (10 Hrs)

A. Carboxylic Acids: Nomenclature, structure, physical properties and acidity of carboxylic acids, effect of substituent's on acid strengths, preparation of carboxylic acids (from G.R., cyanides and acetoacetic ester), Chemical Reactions of carboxylic acids: Hell-Volhard-Zelinsky reaction (with mechanism), reduction with $LiAlH_4$, decarboxylation with mechanism. Unsaturated monocarboxylic acids: (i) Crotonic acid (synthesis from malonic ester and chemical reaction: addition of Br_2 & HX, with NBS) (ii) Cinnamic acid (synthesis by Perkin reaction and chemical reaction: oxidation with $KMnO_4$ and reduction with $LiAlH_4$ & Na-Hg) Dicarboxylic acids: Succinic acid: preparation from malonic & acetoacetic ester. Phthalic acid: synthesis from o-xylene. Effect of heat/dehydrating agents on succinic & phthalic acid.

B. Carboxylic Acid Derivatives: Interconversion of acid derivatives by nucleophilic acyl substitution. Preparation of carboxylic acid derivatives (acetyl chloride-from acetic acid, ethyl acetate-from ethanol & acetyl chloride, acetamide-from acyl chloride and acetic anhydride from acetic acid), Chemical reactions (acetyl chloride: Rosenmund reduction & Friedel-Craft reaction, ethyl acetate: hydrolysis & Claisen condensation, acetamide: reduction with $LiAlH_4$ & Hoffmann reaction and acetic anhydride: acylation of alcohol and amine).

Reference Books:

Inorganic Chemistry

- Lee, J.D. *Concise Inorganic Chemistry*, ELBS, 1991.
- Cotton, F.A., Wilkinson, G. & Gaus, P.L. *Basic Inorganic Chemistry*, 3rd ed., Wiley.

- Douglas, B.E., McDaniel, D.H. & Alexander, J.J. *Concepts and Models in Inorganic Chemistry*, John Wiley & Sons.
- Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson Education India, 2006.
- Puri, Sharma, Kalia. *Principles of Inorganic Chemistry*.

Organic Chemistry

- Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
- McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
- Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988).
- Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
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- Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.
- Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
- Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
- Tadashi Okuyama and Haward Maskill, Oxford organic chemistry, a mechanistic approach (oxford)
- Hashmat Ali, Reaction mechanism in organic chemistry (S-chand publications)
- Gautam Brahmacharini, Organic chemistry through solved problems (Narosa publications)
- Gautam Brahmacharini, Organic name reactions, a united approach (Narosa publications)

UCH240P: Concise Practical Chemistry

[60 Hrs] **[2 Credits]**

Course Description: -

The main objective of this course is to train the learners for qualitative analytical skills. The learners will develop skills to qualitatively analyze given inorganic mixture and organic compound by non-instrumental methods. They will be able to systematically identify the group of radicals and then confirm the presence of certain acidic and basic radicals. They will learn step by step identification of given organic compound and confirm it by preparing a derivative.

Course Objectives:-

The primary objective of the practical course is to learn to perform experiments those have specific aims with correct techniques

1. To learn to detect two acidic radicals of different group and two basic radicals of same groups from given mixture of inorganic salts.
2. To identify the given organic compound.

Course Outcomes:-

On completion of the practical course students will-

1. Execute step by step detection of two acidic radicals of different group and two basic radicals of same group.
2. Demonstrate skill in qualitative organic analysis to identify given organic compound. This skill is of great help in analysis of various samples while working in government, industrial or forensic laboratories.

A. Inorganic Chemistry

Semi micro–Qualitative Analysis

Qualitative analysis of inorganic salt mixture containing two acidic radicals of different groups and two basic radicals of same groups. (At least six mixtures to be analyzed)

B. Organic Chemistry

1. Bromination of phenol.
2. Oxidation: Preparation of Benzoic acid from Benzaldehyde.
3. Nitration: P-nitroacetanilide from Acetanilide.
4. Benzophenone oxime synthesis.

Reference Books:-

- Svehla G. Vogel's Qualitative Inorganic Analysis, Pearson India, 7th Edition, 2002
- Gurdeep Raj, Advanced Practical Inorganic Chemistry, Krishna Prakashan Media (P) Ltd, 2013.
- Mendham, J. *Vogel's Quantitative Chemical Analysis*, Pearson, 2009.

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