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Item No: 2.7

Rayat Shikshan Sanstha's
KARMAVEER BHAURAO PATIL COLLEGE, VASHI.
NAVI MUMBAI
(AUTONOMOUS COLLEGE)

Sector-15- A, Vashi, Navi Mumbai - 400 703

Syllabus for S.Y.B.Sc. Organic Chemistry

Program: S.Y.B.Sc.

Course: S.Y.B.Sc. Chemistry

(Choice Based Credit, Grading and Semester System with effect from the academic year 2019-2020)

UNIVERSITY OF MUMBAI

Sr. No.	Heading	Particulars
1	**Title of Course**	**S. Y. B. Sc. Chemistry**
2	**Eligibility for Admission**	F. Y. B. Sc. Passed from this university (or with ATKT in any two courses at the F. Y. B. Sc. Level) or equivalent qualification from other universities as may have been allowed by the relevant ordinances of this university
3	**Passing marks**	40%
4	**Ordinances/Regulations**	
5	**(if any)**	
6	**No. of Semesters**	Two
7	**Level**	U.G.
8	**Theory Pattern**	Semester
9	**Practical Pattern**	Annual
10	**Status**	New
11	**To be implemented from Academic year**	2019-2020

Syllabus for Approval
UNIVERSITY OF MUMBAI
Essentials Elements of The Syllabus

1	**Title of Course**	Syllabus for two semester S. Y. B. Sc. course in chemistry
2	**Couse Code**	UGCH301, UGCH302, UGCH303 UGCH401, UGCH402, UGCH403 UGCHP1 to UGCHP3
3	**Preamble**	Attached
4	**Objective**	• To infuse in the learner a spirit of inquiry into the fundamental aspects of the various core areas of Chemistry. • To make the learner proficient in analysing the various observations and chemical phenomena presented to him during the course. • To make the learner capable of solving problems in the various units of this course • To give the learner an opportunity to get hands on experience of the various concepts and processes in the various branches of chemistry • To impart various skills of handling chemicals, reagents, apparatus, instruments and the care and safety aspects involved in such handling • To make the learner capable of analysing and interpreting results of the experiments he conducts or performs
5	**Eligibility**	Pass F. Y. B. Sc.
6	**Fee Structure**	As Per Guidelines issued from the University
7	**No. of Lectures**	9 lectures per week (three lectures per paper)
8	**No. of Practicals**	9 periods per week (three periods per paper)
9	**Duration of Course**	Two Semester

10	**Notional Hours**	72 hours per paper per semester Theory and 36 hours per paper per semester for laboratory sessions
11	**No of students per batch**	120 students per division (20 Students for laboratory sessions)
12	**Selection**	As per merit.
13	**Assessment**	End of semester examination of 60 marks per paper for theory and 50 marks per paper for laboratory sessions
14	**Syllabus Detail**	Attached
15	**Title of the Unit**	As given in the Syllabus text
16	**Title of the Sub-unit**	As given in the syllabus text.
17	**Semester wise Theory**	As prescribed in the syllabus text
18	**Semester wise Practicals**	As prescribed in the syllabus text.
19	**Question Paper Pattern**	As prescribed by the Faculty of Science
20	**Scheme of evaluation of Project**	N.A.
21	**List of suggested reading**	As Attached
22	**List of websites**	As Attached
23	**List of You Tube videos**	As attached
24	**List of MOOCs**	As Attached

REGULATIONS

1. Preamble and objectives of the Course:

In the first two semesters of the six semester graduation program of B. Sc.(Chemistry) the learner was introduced to some basic aspects in the various core branches of chemistry like Physical Chemistry, Organic chemistry and Inorganic chemistry. Concepts about the structure of atom, distribution of electrons, Thermodynamics, Formation of organic compounds and basic ideas in reactivity of molecules in general and organic compounds in particular were introduced to the learner. He was made inquisitive about why and how should atoms combine to give molecules or ions. The non-orbital approach to appreciating the shapes of polyatomic species in general and molecules in particular.

The story of chemistry is taken further in the coming two semesters of the second year of the B. Sc. (Chemistry) Program. However it is also realized that some students opting for the course on Chemistry may not continue with the subject subsequently as such the syllabus is designed to retain the interest of the serious learner of chemistry as well as be helpful to non-chemistry learners. With such students who would want to pursue other branches of science but would want to acquire a basic appreciation and experience of chemistry a separate paper (Paper-III) is designed. This paper along with the laboratory session unit that goes with it deals with the basics of chemical analysis, separating components from a given sample, basic concepts like pH, experimental techniques like Titrimetry, Gravimetry, using instruments to carry out analysis, the various techniques like chromatography, electrophoresis, Instrumentation in general is felt to be of interest to learners of various branches like physics, botany, zoology, and microbiology.

The major objectives of B.Sc. Chemistry course are

- To infuse in the learner a spirit of inquiry into the fundamental aspects of the various core areas of Chemistry.

- To make the learner proficient in analysing the various observations and chemical phenomena presented to him during the course.

- To make the learner capable of solving problems in the various units of this course

- To give the learner an opportunity to get hands on experience of the various concepts and processes in the various branches of chemistry
- To impart various skills of handling chemicals, reagents, apparatus, instruments and the care and safety aspects involved in such handling

- To make the learner capable of analysing and interpreting results of the experiments he conducts or performs

- To make the learner capable of acquiring or pursuing a source of livelihood like jobs in chemical industry
- To arouse the interest to pursue higher levels of learning in chemistry,

2. Condition for Admission

A candidate who has passed the F.Y.B.Sc. of Mumbai University or an examination of some other university accepted by the syndicate as equivalent there to with Chemistry, Physics, Maths, Botany, Zoology or Life Science shall be eligible for admission into S.Y.B.Sc., course in to Chemistry.

3. Duration of the Course: one year

4. Course of study:

Draft copy of the proposed revised syllabus for Choice Based Credit System S.Y.B.Sc. Chemistry To be implemented from the Academic year 2019-2020

For the subject of chemistry there shall be three papers for 45 lectures each comprising of three units of 15 L each.

Semester-III

1. Paper-I	Unit-I Physical Chemistry Unit-II Inorganic Chemistry Unit-III Organic Chemistry.
2. Paper-II	Unit-I Physical Chemistry Unit-II Inorganic Chemistry Unit-III Organic Chemistry.
3. Paper-III	Unit-I Treatment of analytical data and sampling. Unit-II Classical Methods of Analysis. Unit-III Modern Approach to Chemical Industry

Semester-IV

2. Paper-I	Unit-I Physical Chemistry Unit-II Inorganic Chemistry Unit-III Organic Chemistry.
3. Paper-II	Unit-I Physical Chemistry Unit-II Inorganic Chemistry Unit-III Organic Chemistry.
4. Paper-III	Unit-I Basic Concepts in Instrumental methods Unit-II Miscellaneous methods and environmental analysis Unit-III Industrial Chemistry

Choice Based Credit System
S. Y. B. Sc.
Chemistry Syllabus
To be implemented from the Academic year 2019-2020

Course Content
Semester III

Course Code	Unit	Topics	Credits	L/Week
USCH301	I	Chemical Thermodynamics-II, Electrochemistry	2	1
	II	Chemical Bonding		1
	III	Reactions and reactivity of halogenated hydrocarbons, alcohols, phenols and epoxides		1
USCH302	I	Chemical Kinetics-II, Solutions	2	1
	II	Selected topics on p block elements		1
	III	Carbonyl Compounds		1
USCH303	I	Treatment of analytical data and sampling	2	1
	II	Classical Methods of Analysis		1
	III	Basic Approach to Chemical Industry		1
USCHP1		Chemistry Practicals I	1	3
USCHP2		Chemistry Practicals II	1	3
USCHP3		Chemistry Practicals III	1	3

Note: 1. Blue Highlighted Topic / Course has focus on employability/ entrepreneurship/skill development

Semester IV

Course Code	Unit	Topics	Credits	L/Week
USCH401	I	Electrochemistry-II, Phase Equilibria	2	1
	II	Comparative Chemistry of the transition metals & Coordination Chemistry		1
	III	Carboxylic acids and their derivatives		1
USCH402	I	Solid state, Catalysis	2	1
	II	Ions in aqueous medium & Uses and Environmental Chemistry of volatile Oxides and oxo-acids		1
	III	Amines, Diazonium salts, Heterocyclic compounds		1
USCH403	I	Basic Concepts in Instrumental methods	2	1
	II	Miscellaneous methods and environmental		1

		analysis		
	III	Industrial Chemistry		1
USCHP4		Chemistry Practicals I	1	3
USCHP5		Chemistry Practicals II	1	3
USCHP6		Chemistry Practicals III	1	3

Note: 1. Blue Highlighted Topic / Course has focus on employability/ entrepreneurship/skill development
2. Yellow Highlighted Topic / Course is related to professional ethics, gender, human values, Environment & sustainability

Semester III
Paper I

Theory: 45 Lectures

Unit I: Physical Chemistry

1.1 Chemical Thermodynamics-II (8L)

1.1.1 Free Energy Functions: Helmholtz Free Energy, Gibb's Free Energy, Variation of Gibb's free energy with Pressure and Temperature.

1.1.2 Gibbs-Helmholtz equation, van't Hoff reaction isotherm and van't Hoff reaction isochore.(Numericals expected).

1.1.3 Thermodynamics of Open System: Partial Molal Properties, Chemical Potential and its variation with Pressure and Temperature, Gibb's Duhem equation.

1.1.4 Clausius –Clapeyron Equation –Derivation and application in phase Equilibria.

1.2 Electrochemistry: (7L)

1.2.1 Conductivity, equivalent and molar conductivity and their variation with dilution For weak and strong electrolytes.

1.2.2 Kohlrausch law of independent migration of ions.

1.2.3 Applications of conductance measurements: determination of degree of Ionization and ionization constant of weak electrolyte, solubility and solubility product of sparingly soluble salts, ionic product of water. (Numericals expected).

1.2.4 Ostwald dilution law-Derivation, numericals expected.

Unit-II

Chemical Bonding

2.1 Non-Directional Bonding(4L)

2.1.1 Ionic Bond: Conditions for the Formation of Ionic Bond.

2.1.2 Types of Ionic Crystals

2.1.3 Radius Ratio Rules

2.1.4 Lattice Energy, Borne-Lande Equation

2.1.5 Kapustinski Equation

2.1.6 Born-Haber Cycle and its Application

2.2. Directional Bonding: Orbital Approach. (6L)

2.2.1 Covalent Bonding The Valence Bond Theory- Introduction and basic tenets.

2.2.2 Interaction between two hydrogen atoms and the Potential energy diagram of the resultant system.

2.2.3 Corrections applied to the system of two hydrogen atoms- Formation of H_2

2.2.4 Homonuclear diatomic molecules from He_2 to Ne_2

2.2.5 Resonance and the concept of Formal Charge; Rules for Resonance or Canonical structures.

2.2.6 Bonding in Polyatomic Species: The role of Hybridization. Types of hybridization involving d orbitals.dsp^2, sp^3d, sp^3d^2 and sp^3d^3.

2.2.7 Equivalent and Non-Equivalent hybrid orbitals

2.2.8 Contribution of a given atomic orbital to the hybrid orbitals (with reference to sp^3 hybridization as in CH_4, NH_3 and H_2O and series like NH_3, PH_3, AsH_3, BiH_3)

2.3 Molecular Orbital Theory (5L)

2.3.1. Comparing Atomic Orbitals and Molecular Orbitals.

2.3.2. Linear combination of atomic orbitals. to give molecular orbitals LCAO-MO approach for diatomic homonuclear molecules).

2.3.4. Wave mechanical treatment for molecular orbitals (H_2^+ and H_2)

2.3.4 Molecular orbital Theory and Bond Order and magnetic property: with reference to O_2,O_2^+ O_2^-,O_2^{2-}

(Problems and numerical problems expected wherever possible)

Unit III: Organic Chemistry

3.1. Reactions and reactivity of hydrocarbons: [6L]

3.1.1. **Aliphatic Nucleophilic substitution**

Nucleophilic substitution reactions: S_N1, S_N2 and S_Ni mechanisms with stereochemical aspects and examples factors affecting nucleophilic substitution reactions-nature of substrate, solvent, nucleophilic reagent and leaving group. Allylic nucleophilic substitution, Vinylic nucleophilic substitution reactions.

3.1.2. **Aromatic Nucleophilic substitution**

Reactivity of aryl halides towards nucleophilic substitution reactions. Nucleophilic aromatic substitution (S_NAr) addition-elimination mechanism and benzyne mechanism. SN^1 reactions (Sandmeyer reaction)

3.2 Reagents in Organic Synthesis: [6L]

3.2.1 Oxidizing & Reducing reagents [3L]

Oxidizing Agents (Preparation, reaction and application) PDC, PCC, Swern, Jones regent oxidation, Oppenauer oxidation, Reducing Agents (Preparation, reaction and application)

Clemmensen Reduction, Wolff- Kishner Reduction, Birch Reduction, MPV reduction, Barnavont Blanc Reduction

3.2.2 **Organomagnesium and organolithium compounds: [3L]**

Nomenclature, nature, type and reactivity of carbon-metal bond. Preparation using alkyl / aryl halide. Structure, stability and reactions with compounds containing acidic hydrogen, carbonyl compounds, CO_2, cyanides and epoxides.

Semester III
Paper II

Unit I: Physical Chemistry

1.1 Chemical Kinetics-II (7L)

1.1.1 Types of Complex Chemical reactions: Reversible or opposing, consecutive and parallel reactions (No derivations, only examples expected),
Thermal chain reactions: H. and Br. reaction. (only steps involved, no kinetic expression expected).

1.1.2 Effect of temperature on the rate of reaction, Arrhenius equation, Concept of energy of activation (Ea). (Numericals expected).

1.1.3 Theories of reaction rates: Collision theory and activated complex theory of bimolecular reactions. Comparison between the two theories (Qualitative treatment only)

1.2 Solutions: (8 L)

1.2.1 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.

1.2.2 Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids with respect to Phenol-Water , Triethanolamine – Water and Nicotine – Water systems

1.2.4 Nernst distribution law and its applications, solvent extraction.

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Unit-II

2. Selected topics on p block elements (15L)

2.1 Chemistry of Boron compounds

2.1.1 Electronic configuration of elements of Group 13 and trends in their periodic properties.

2.1.1 Electron deficient compounds – BH_3, BF_3, BCl_3 with respect to Lewis acidity and applications.

2.1.2 Preparation of simple boranes like diborane and tetraborane.

2.1.3 Structure and bonding in diborane and tetraborane (2e-3c bonds)

2.1.4 Synthesis and applications of Borax.

2.2 Chemistry of Silicon and Germanium

2.2.1 Electronic configuration of elements of Group 14 and trends in their periodic properties

2.2.1 Silicon compounds: Occurrence , Structure and inertness of SiO_2

2.2.2 Preparation of structure of $SiCl_4$

2.2.3 Occurrence and extraction of Germanium

2.2.4 Preparation of extra pure Silicon and Germanium

2.3 Chemistry of Nitrogen family

2.3.1 Electronic configuration of elements of Group 15 and trends in their periodic properties

2.3.1 Trends in chemical reactivity - Formation of hydrides, halides, oxides with special reference to oxides of nitrogen.

2.3.2 Oxides of nitrogen with respect to preparation and structure of NO, NO_2, N_2O and N_2O_4.

2.3.3 Synthesis of ammonia by Bosch – Haber process.

Unit III: Organic Chemistry

Carbonyl Compounds and their Reactivity: [15L]

3.1 Nomenclature of aliphatic, alicyclic and aromatic carbonyl compounds. Structure, reactivity of aldehydes and ketones and methods of preparation; Oxidation of primary and secondary alcohols using PCC, hydration of alkynes, action of Grignard reagent on esters, Rosenmund reduction, Gattermann – Koch formylation and Friedel Craft acylation of arenes, Riemer-Tiemann Reaction, Vilsmeier Haack reaction

3.2 General mechanism of nucleophilic addition, and acid catalyzed nucleophilic addition reactions.

3.3 Reactions of aldehydes and ketones with $NaHSO_3$, HCN, RMgX, alcohol, amine, phenyl hydrazine, 2,4-Dinitrophenyl hydrazine, $LiAlH_4$ and $NaBH_4$.

3.4 Mechanisms of following reactions: Aldol condensation, Knoevenagel condensation, Claisen-Schmidt and Cannizzaro reaction.

3.5 Keto-enol tautomerism: Mechanism of acid and base catalysed enolization

3.6 Active methylene compounds: Acetylacetone, ethyl acetoacetate diethyl malonate, stabilised enols. Reactions of Acetylacetone and ethyl acetoacetate (alkylation, conversion to ketone, mono- and dicarboxylic acid)

Semester III
Paper III
Basics in analytical Chemistry
Theory: 45 Lectures

Scope/Objectives:

Learners should be able to

1. Select a method of analysis
2. Decide how to identify a sample and prepare it for analysis
3. Select a procedure for analysis
4. Identify sources of possible errors in the results obtained.

(Problems including numericals expected wherever necessary)

Unit I- Treatment of analytical data and sampling (15 L)

1.1. Sampling (06L)

1.1.1 Definition and purpose of Sampling

1.1.2 Types of Sampling,

1.1.3 Sampling of liquids: Homogeneous (Static), Heterogeneous (Static immiscible) and flowing liquids.

1.1.4 Sampling of solids: Sample size, size reduction, Different sampling equipments.

1.1.5 Sampling of gases: Ambient sampling, stack sampling.

1.2. Treatment of Analytical Data (09L)

1.2.1 Types of errors

1.2.2 Precision and Accuracy in Analysis

1.2.3 Corrections for Determinate Errors

1.3 Concept of Confidence limits and confidence interval and its computation using

1.3.1 Population standard deviation

1.3.2 Student's test

1.3.3 Range

1.4 Criterion for rejection of doubtful results

1.4.1 2.5d rule

1.4.2 4.0 d rule

1.4.3 Q-test

1.5 Test of Significance

1.5.1 Null hypothesis

1.5.2 F- Test (Variance Ratio test)

(Numerical problems wherever possible, expected)

References:

1. Instrumental Analysis by Douglas A. Skoog,F. James Holler, Stanley R.Crouch

2. Instrumental methods of analysis by Willard, H.H.; Merritt, L.L. Jr.; Dean, J.A.; Settle,7thEdition

3. Fundamental of Analytical Chemistry by Douglas A. Skoog, West, F. James Holler, S. R. Crouch

4. Modern Analytical Chemistry by David Harvey, McGraw-Hill Higher Education

Unit II- Classical Methods of Analysis (15 L)

Objectives:

The main objectives of this unit is to

- Introduce classical methods of chemical analysis.
- Appreciate the various terms and types of titrimetric analysis.
- Ability to select proper titrimetric method
- Appreciate the usefulness of the gravimetric method of analysis
- Identify a suitable gravimetric method
- Perform the required calculations involved in the analysis by titrimetry as well as gravimetry.

Classical Methods

2.1 Gravimetric analysis (05L)

2.1.1 General Introduction to Gravimetry.

2.1.2 Types of Gravimetric Methods

2.1.3 Precipitation Gravimetry.

2.1.4 Steps involved in gravimetric analysis

2.1.5 Role of Digestion, Filtration, Washing, Drying Ignition of precipitate.

Methods of separation

2.2 Solvent extraction (05 L)

2.2.1 Introduction, Nernst distribution Law, Distribution Ratio, Partition Coefficient.

2.2.2 Single step and multi-step extraction, Percentage extraction for single step and Multistep extraction.

2.2.3 Batch and continuous extraction

(Numericals are expected)

2.3 Chromatography: (05L)

2.3.1. Introduction to Chromatography

2.3.2 Classification of chromatographic methods, Principles, techniques and applications of a) Paper Chromatography and b) Thin layer Chromatography

References:

1) Skoog et al. “Fundamentals of Analytical chemistry" Cengage Learning, Eight Edition, chapter 13, 14 and 15

2) Day and Underwood, “Quantitative analysis" prentice hall 1991,chapter3

3) S.M. Khopkar, “ Basic Concepts of Analytical Chemistry”, IInd Edition NewAge International Publisher

4) Gary D. Christan,” Analytical Chemistry”, VIth Edition, Wiley Students Edition, Chapter No8,9,10

5) Fundamental of Analytical Chemistry by Douglas A. Skoog, West, F. James Holler, S. R. Crouch

6) Modern Analytical Chemistry , David Harvey (page numbers 232-265)

Unit III: Industrial Chemistry I **15 L**

3.1 Basic Approach to Chemical Industry (08)

Introduction, basic requirements of chemical industries, chemical production, raw materials, unit process and unit operations, Quality control, quality assurance, process control, research and development, pollution control, human resource, safety measures, classification of chemical reactions, batch and continuous process, Conversion, selectivity and yield, copy right act, patent act, trade marks

3.2 Fermentation Industry: (07)

Introduction, importance, Basic requirement of fermentation process, Manufacture of industrial alcohol from molasses, fruits, food grains, & ethylene, Manufacturing of wine, beer, whisky, rum from molasses

Ref. 1: Chapter 2 (relevant pages) 2. www.wikipedia.org/wiki/copyright_act_of 1976 3. www.wikipedia.org/wiki/patentact 4. www.wikipedia.org/wiki/trademark

Semester IV
Paper I

Semester IV

Paper I

Unit I: Physical Chemistry

1.1Electrochemistry-II: (8 L)

1.1.1 Electrochemical conventions, Reversible and irreversible cells.

1.1.2 Nernst equation and its importance, Types of electrodes, Standard electrode potential, Electrochemical series (Numericals expected).

1.1.3 Thermodynamics of a reversible cell, calculation of thermodynamic properties: ΔG, ΔH and ΔS from EMF data. (Numericals expected)

1.1.4 Calculation of equilibrium constant from EMF data. (Numericals expected)

1.1.5 pH determination using hydrogen electrode and quinhydrone electrode. (Numericals expected)

1.2 Phase Equilibria: (7L)

1.2.1 Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation.

1.2.2 Phase diagrams of one-component systems (water and sulphur).

1.2.3 Two component systems involving eutectics, congruent and incongruent melting points (lead-silver system).

1.2.4 Three component System –Introduction with diagrammatic representation.

Unit-II

2.1 Comparative Chemistry of the transition metals (8L)

2.1.1 Position in the periodic table; Natural occurrence principal ores and minerals;

2.1.2 Significance of special stability of d^0, d^5 and d^{10} leading to variable oxidation states; Unusual oxidation states and their stabilities in aqueous solutions (with special reference to vanadium, and chromium.)

2.1.3 Origin of color for transition metals and their compounds: such as reflectivity, surface coatings, particle size, packing density for metals and nature of d-orbitals, number of electrons in the d-orbitals, geometry, and ability for charge transfer).

2.1.4 Magnetic properties of transition metal compounds: Origin of magnetism-spin

and orbital motion of electrons; equation for spin only and spin-orbital magnetism in terms of Bohr magnetons (No derivation of relevant equations expected); Reasons for quenching of orbital moments.

2.1.5 Chemistry of Titanium and vanadium: properties of Oxides and chlorides; use in titrimetric analysis

2.1.6 Qualitative tests for transition metal ions: General considerations in devising tests (with reference to Chromium, Manganese, iron, Cobalt Nickel and Copper)

2.2 Coordination Chemistry : (7 L)

2.2.1 Introduction to Chemistry of Coordination Compounds

i. Historical perspectives: Early ideas on coordination compounds

ii. Basic terms and nomenclature.

iii. Types of ligands

iv. Isomerism: Types of Structural Isomerism. Evidence for the formation of coordination compounds.

2.2.2. Theories of coordination compounds

i. Werner's Theory of coordination compounds,

ii. Effective atomic number rule.

2.2.3. Nature of the Metal-Ligand Bond:

i. Valence Bond Theory; Hybridization of the central metal orbitals- sd^3/d^3s $sp^3d^2/d^2sp^3, sp^2d$

ii. Inner and outer orbital complexes of .(suitable examples of Mn(II) Fe(II),Fe(III),Co(II)/Co(III),Ni(II), Cu(II) Zn(II) complexes with ligands like aqua, ammonia CN^- and halides may be used)

iii. Limitations of V.B.T

Unit III: Organic Chemistry

3.1 Carboxylic Acids and their Derivatives: (11 L)

3.1.1. Nomenclature, structure and physical properties, acidity of carboxylic acids, effects of substituents on acid strength of aliphatic and aromatic carboxylic acids.

3.1.2. Preparation of carboxylic acids: oxidation of alcohols and alkyl benzene, carbonation of Grignard and hydrolysis of nitriles.

3.1.3. Reactions: Acidity, salt formation, decarboxylation, Reduction of carboxylic acids with $LiAlH_4$, diborane, Hell- Volhard-Zelinsky reaction,Conversion of carboxylic acid to acid chlorides, esters, amides and acid anhydrides and their relative reactivity.

3.1.4. Mechanism of nucleophilic acyl substitution and acid-catalysed nucleophilic acyl substitution. Interconversion of acid derivatives by nucleophilic acyl substitution.

3.1.5. Mechanism of Claisen condensation and Dieckmann condensation.

3.2. Bio molecules and carbohydrates [4]

Introduction to Biomolecules, types of bio molecules..

Carbohydrates : Definition, classification of carbohydrates – oxidation, reduction osazone formation, ester formation, isomerization, Killiani Fischer synthesis, Ruff degradation, D/L configuration, configuration of D(+) Glucose, Fischer proof and mutarotation, cyclic structure of glucose-Fischer Haworth and chair configuration. Brief account of maltose, sucrose, lactose, cellobiose, polysaccharides - starch, cellobiose.

Semester IV
Paper II

Unit I: Physical Chemistry

1.1.1 Recapitulation of laws of crystallography and types of crystals

1.1.2 Characteristics of simple cubic, face centered cubic and body centered cubic systems, interplanar distance in cubic lattice (only expression for ratio of interplanar distances are expected)

1.1.3 Use of X-rays in the study of crystal structure, Bragg's equation (derivation expected), X-rays diffraction method of studying crystal lattice structure, structure of NaCl and KCl. Determination of Avogadro's number (Numericals expected)

1.2 Catalysis: (8 L)

1.2.1 Types of catalysis, catalytic activity, specificity and selectivity, inhibitors, catalyst poisoning and deactivation

1.2.2 Mechanisms and kinetics of acid-base catalyzed reactions, effect of pH.

1.2.3 Mechanisms and kinetics of enzyme catalyzed reactions (Michaelis-Menten equation)

1.2.4 Effect of particle size and efficiency of nanoparticles as catalyst.

Unit-II

2.0 Ions in aqueous medium

2.1. Acidity of Cations and Basicity of Anions

i. Hydration of Cations; Hydrolysis of Cations predicting degree of hydrolysis of Cations-effect of Charge and Radius.

ii. Latimer Equation. Relationship between pKa, acidity and z^2/r ratios of metal ions graphical Presentation

iii. Classification of cations on the basis of acidity category – Non acidic, Moderately acidic, strongly acidic, very strongly acidic with pKa values range and examples

iv. Hydration of Anions; Effect of Charge and Radius; Hydration of anions-concept, diagram classification on the basis of basicity

2.2. Uses and Environmental Chemistry of volatile Oxides and oxo-acids

i. Physical properties of concentrated oxo-acids like sulfuric, Nitric and Phosphoric acid

ii. Uses and environments aspects of these acids

Unit III: Organic Chemistry

Nitrogen containing compounds and heterocyclic compounds:

3.1 Amines: Nomenclature, effect of substituent on basicity of aliphatic and aromatic amines;

3.1.1. Preparation: Reduction of aromatic nitro compounds using catalytic hydrogenation, chemical reduction using Fe-HCI, Sn-HCl, Zn-acetic acid, reduction of nitriles, ammonolysis of halides, reductive amination , Hofmann bromamide reaction.

3.1.2. Reactions- Salt Formation, N-acylation, N-alkylation, Hofmann's exhaustive methylation (HEM),Hofmann-elimination reaction, reaction with nitrous acid, carbylamine reaction, Electrophilic substitution in aromatic amines: bromination, nitration and sulphonation.

3.2 Diazonium Salts: **(7 Lectures)**

Preparation and their reactions/synthetic application - Sandmeyer reaction, Gattermann reaction, Gomberg reaction, Replacement of diazo group by -H,-OH. Azo coupling with phenols, naphthols and aromatic amines, reduction of diazonium salt to aryl hydrazine and hydroazobenzene.

3.3 Heterocyclic Compounds: (8 Lectures)

3.3.1. Classification, nomenclature, electronic structure, aromaticity in 5-numbered and 6-membered rings containing one heteroatom;

3.3.2. Synthesis of Furan, Pyrrole (Paal-Knorr synthesis, Knorr pyrrole synthesis, and Hantzsch synthesis), Thiophene, Pyridine (Hantzsch synthesis),

3.3.3. Reactivity of furan, pyrrole and thiophene towards electrophilic substitution reactions on the basis of stability of intermediate and of pyridine on the basis of electron distribution.

3.3.4. Reactions of furan, pyrrole and thiophene: halogenation, nitration, sulphonation, Vilsmeier-Haack reaction, Friedel-Crafts reaction. Furan: Diels-Alder reaction, Ring opening. Pyrrole: Acidity and basicity of pyrrole. Comparison of basicity of pyrrole and pyrrolidine. Hydrogenation, ortholithation, Reimer-Tieaman reaction.

References:

1. Morrison, R. T. and Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).2012
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education)
4. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
5. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; Organic Chemistry, Oxford University Press.
6. Graham Solomons, T.W. Organic Chemistry, John Wiley & Sons, Inc.
7. Comprehensive Organic Chemistry- The synthesis and reactions of Organic Compounds, Derek barton ,W. David Ollis.
8. Kalsi, P. S. Textbook of Organic Chemistry 1st Ed., New Age International (P) Ltd. Pub.
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Semester IV

Paper III Basics in Analytical Chemistry -II

Theory: 45 Lectures

Unit I: Basic Concepts in Instrumental methods [15 L]

1.1 Optical methods. (07L)

1.1.1 Statement of Beer's Law and Lambert's Law, Combined Mathematical Expression of Beer -Lambert's Law,

1.1.2 Deviations from Beer-Lambert's Law (Real deviations, Instrumental deviations and Chemical deviations) (Numerical problems based on Beer-Lambert's Law)

1.1.3 Block Diagrams for Single beam Colorimeter, and Spectrophotometer (Construction and working-Details of Components expected)

1.2 Potentiometry: (03L)

1.2.1 Principle.

1.2.2 Role of Reference and indicator electrodes

1.2.3 Applications in Neutralization reactions with reference to the titration of a Strong acid against a Strong Base (using quinhydrone electrode)

1.2.4 Graphical methods for detection of end points

1.3 pH metry: (02L)

1.3.1 Principle, Construction Working of Combined Glass electrode

1.3.2 Construction of titration curve (On the basis of change in pH)

1.4 Conductometry: (03L)

1.4.1 Principle

1.4.2 Conductivity cell and its construction.

1.4.3 Applications in Neutralization Titrimetry with respect to

i. Strong Acid-Strong Base

ii. Strong Acid-Weak Base

iii. Strong Base-weak Acid

References:

1. Instrumental Methods of Chemical Analysis by Gurdeep R. Chatwal , Sham K.Anandpp2.107-2.148
2. Principles of Instrumental Analysis by Skoog, Holler, Nieman, 5th Edition pp143-172.
3. Instrumental Methods of Analysis by Willard, Merritt, Dean, Settle 7th Edition pp118-181.

UNIT-II Miscellaneous methods and environmental analysis 15 L

2.1 Thermal methods (07)

2.1.1 Introduction, Different thermal events, and classification based on different interactions.

2.1.2 Principle, instrumentation and applications of

i) Thermogravimetric Analysis (TGA)

ii) Differential Thermal Analysis (DTA)

2.3 Environmental analysis (08) (Basic relations and formulae are expected)

2.3.1 Soil analysis, important parameters of soil testing namely,

i) Cation exchange capacity (CEC), ii) Organic matter, iii) SAR (Sodium Absorption Ratio), iv) Soil pH v) EC (Electrical Conductivity)

2.3.2 Water analysis,

i) pH ii) Total Dissolved Solids (TDS) iii) Hardness iv) Biological Oxygen Demand (BOD) v) Chemical Oxygen Demand (COD) vi) E. Coli (Escherichia coli)

UNIT-III

Industrial Chemistry II

3.1 Unit Operation -Distillation (7)

3.1.1 Introduction

3.1.2 Fractional distillation

3.1.3 Azeotropic distillation

3.1.4 Vaccum distillation

3.1.5 Extractive distillation

OBJECTIVES:

Petrochemicals and eco-friendly fuels Introduction, occurrence, composition of petroleum, resources, processing of petroleum, other properties Fuels and eco-friendly fuels, use of solar energy etc.

3.2 Petrochemicals and eco-friendly fuels (08)

3.2.1 Introduction, occurrence, composition of petroleum, resources, processing of petroleum, calorific value of fuel, cracking, octane rating (octane number), cetane number, flash point, and petroleum refineries, applications of petrochemicals, synthetic petroleum, lubricating oils & additives

3.2.2 Fuels and eco-friendly fuels: liquid, gaseous fuel (LPG, CNG), fossil fuels, diesel, Bio-diesel, gasoline, aviation fuels. Use of solar energy for power generation.

Chemistry Practicals:

Unit I: Physical Chemistry

1. To verify Ostwald's dilution law for weak acid conductometrically.
2. To determine dissociation constant of weak acid conductometrically.
3. To determine the critical solution temperature (CST) of phenol – Water System.
4. Determination of energy of activation of acid catalyzed hydrolysis of methyl acetate.
5. To investigate the reaction between $K_2S_2O_8$ and KI with equal initial concentrations of the reactants
6. To determine solubility of sparingly soluble salts (anytwo) conductometric
7. To determine standard EMF and the standard free energy change of Daniel cell potentiometrically .
8. To determine the amount of HCl in the given sample potentiometrically.
9. Compare the strengths of HCl and H_2SO_4 by studying kinetics of acid hydrolysis of methyl acetate.

Unit II: Inorganic Chemistry

1.Identification of cations in a given mixture and Analytically separating them

[From a mixture containing not more than two of the following: Pb(II), Ba(II), Ca(II), Sr (II), Cu(II), Mg(II), Zn(II), Fe(II), Fe(III), Ni(II), Co(II) Al(III), Cr(III)] (any four Combinations)

2.Crystallisation of potassium iodate and to estimate its purity before and after the separation.

3.To estimate total hardness of water sample

4.Investigation of the reaction between Copper sulphate and Sodium Hydroxide (Standard EDTA solution to be provided to the learner)

5.Inorganic preparation – Nickel dimethyl glyoxime using microscale method.

6.Complex cation – *Tris* (ethylene diamine) nickel (II) thiosulphate.

7.Complex anion – Sodium Hexanitrocobaltate (III) The aim of this experiment is to understand the preparation of a soluble cation (sodium)and a large anion hexanitrocobaltate(III) and its use to precipitate a large cation (potassium)

8.Inorganic salt – Calcium or magnesium oxalate using precipitation from homogenous solution (PFHS) technique

9. Bruce H. Mahan, University Chemistry, Narosa publishing house pg. 611 to 683.
10. R. Gopalan, Universities Press India Pvt.Ltd. Inorganic Chemistry for Undergraduates.
11. Chemistry of Transition Elements Pg.- 608 – 679 .
12. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3rd edition, Oxford University Press (1999) page 325-446.
13. Ramesh Kapoor and R.S. Chopra, Inorganic Chemistry, R. Chand publishers, New Delhi.
14. CNR Rao edited, University General Chemistry, 513-578.
15. James E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity,
16. Emeleus and Anderson, Modern Aspects of Inorganic Chemistry, page no. 435-463.
17. Cotton and Wilkinson, Advanced Inorganic Chemistry, 3rd. Edition.
18. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt,. Ltd. (2002).
19. Puri, Sharma and Kalia, Milestone publishers, Principles of Inorganic Chemistry, page 416-628.

20. Bruce H. Mahan, University Chemistry, Narosa publishing house.
21. R. Gopalan , Universities Press India Pvt. Ltd. Inorganic Chemistry for Undergraduates.
22. J. D. Lee, 4th Edn., Concise Inorganic Chemistry, ELBS
23. D. F. Shriver and P. W. Atkins, Inorganic chemistry, 3rd edition, Oxford University Press (1999)
24. Ramesh Kapoor and R.S. Chopra, Inorganic Chemistry, R. Chand publishers, New Delhi.
25. CNR Rao edited, University General Chemistry
26. James E. Huheey, Inorganic Chemistry: Principles of Structure and Reactivity,
27. Emeleus and Anderson, Modern Aspects of Inorganic Chemistry
28. Cotton and Wilkinson, Advanced Inorganic Chemistry, 3rd. Edition.
29. Gary Wulfsberg, Inorganic chemistry, Viva Books Pvt,. Ltd. (2002).
30. Puri, Sharma and Kalia, Milestone publishers, Principles of Inorganic Chemistry

Unit III: Organic Chemistry

Short organic preparation and their purification: Use 0.5-1.0g of the organic compound. Purify the product by recrystallization. Report theoretical yield, percentage yield and melting point of the purified product.

A) Preparation of:

1. Cyclohexanone oxime from cyclohexanone.
2. Glucosazone from dextrose or fructose
3. Tribromoaniline from aniline.
4. β-Naphthylbenzoate
5. m-Dinitrobenzene from nitrobenzene
6. Anthracene to anthraquinone
7. Preparation of p-nitroacetalide from acetanilide
8. Preparation of 2-methoxy naphthalene's from β-naphthol

9. Hippuric acid from Glycine (Benzoylation)
10. Benzoquinone from Hydroquinone (Oxidation by KBrO3/K2CrO3) Phthalic anhydride from phthalic acid by sublimation
11. Acetanilide from aniline
12. p-Bromoacetanilide from acetanilide
13 Iodoform from acetone

(Any eight preparations)

B) Qualitative Analysis of bi-functional organic compounds on the basis of

1. **Preliminary examination**
2. **Solubility profile**
3. **Detection of elements C, H, (O), N, S, X.**
4. **Detection of functional groups**
5. **Determination of physical constants (M.P/B.P)**

Solid or liquid Compounds containing not more than two functional groups from among the following classes may be given for analysis to be given: Carboxylic acids, phenol, carbohydrates, aldehydes, ketones, ester, amides, nitro, anilides, amines, alkyl and aryl halides.

Students are expected to write balanced chemical reactions wherever necessary.

(Minimum 6 compounds to be analyzed)

UNIT IV

1. **Introduction to tools of Analytical Chemistry:**
2. Gravimetric estimation of Nickel (II) as Ni-DMG and calculation of % error.

   (The learner is expected to know the role of the various reagents/chemicals used In the estimation, various steps involved. They should write the complete and Balanced chemical reaction for the formation of the $Ni(DMG)_2$ complex.
3. Colorimetric Determination of Copper Ions in given Solution by using calibration curve method and calculation of % error.

   (The learner is expected to learn the relation between concentration and Absorbance, to draw a calibration curve, use the slope of the calibration curve and compare it with the calculated slope. They are also expected to state the error estimate of their results).
4. Determination of buffer capacity of acid buffer and basic buffer.

(The learner is expected to learn the use pH meter, standardization of pH meter, use of Henderson's equation and calculation of buffer capacity)

5. Estimation of Aspirin
6. Gravimetric estimation of barium ions using K_2CrO_4 as precipitant calculation of % error.

(The learner is expected to learn the skills of using the counterpoise technique used in this gravimetric estimation; Using counterpoise method Whatman No.42 for filtration. In such a case no incineration or use of silica crucible is required. They are also expected to state the error estimate of their result

(The learner should draw diagrams and write-ups providing uses of the items mentioned in (a and b Principle, Construction care and Uses of items (c) to (f) in his journal.)

7. **Paper chromatography:** Separation of cations like Fe(III), Ni(II) and Cu(II) in a sample Separation of a solute between two immiscible solvents to determine the distribution ratio and/or extraction efficiency. (Solutes could be as their aqueous solutions and the organic solvent ethyl acetate) Suggested solute for the distribution study: Fe (III) in aqueous solutions.

   (The learner is expected to learn the technique of solvent extraction by using separating funnel, method to estimate the concentrations of the solute distributed in the two immiscible phases, determination of the extraction efficiency)

8. Conductometric titration: Estimation of given acid by conductometric titration with strong base and calculation of % error. (The learner is expected to learn the handling of the conductometer and the conductivity cell, determination of end point by plotting a graph. They are also expected to state the error estimate of their results).
9. Estimation of Fe(II) in the given solution by titrating against $K_2Cr_2O_7$ potentiometrically and calculation of % error. (The learner is expected to learn the handling of the potentiometer, use of Platinum electrode and reference electrode like SCE. They will learn to determine end point by plotting a graph. They are also expected to state the error estimate of their results).

6. Gravimetric estimation of Sulfate as $BaSO_4$ and calculation of % error. (The learner is expected to write a balanced chemical reaction, need for digestion of the precipitate and the skill required to carry out the incineration and to estimate the % error.)

(The learner is expected to write a balanced chemical reaction, need for digestion of the precipitate and the skill required to carry out the incineration and to estimate the % error.)

Reference Books for Practicals:

Analytical Chemistry Practicals

1. D. A. Skoog, D. M. West, F. J. Holler, and S. R. Crouch, Analytical Chemistry: An Introduction, 7th ed., Chapter 15, pp. 345-381.
2. A.I. Vogel. "Textbook of Quantitative Inorganic Analysis," Longman, London (1961).
3. R.V. Dilts. "Analytical Chemistry. Methods of Separation," van Nostrand, N.Y. (1974).
4. Some Experiments for B. Tech in Chemistry & Chemical Technology compiled by Prof. J.B.BARUAH, Mrs. Abhilasha Mohan Baruah and Mr. Parikshit Gogoi

Physical Chemistry Practicals

1. Khosla B.D., Garg V.C. and Gulati A., Senior Practical Physical Chemistry, R. Chand and Co., New Delhi (2011).
2. Garland C. W., Nibler J.W. and Shoemaker D.P., Experiments in Physical Chemistry, 8th Ed., McGraw-Hill, New York (2003).
3. Halpern A.M. and McBane G.C., Experimental Physical Chemistry, 3rd Ed., W.H. Freeman and Co., New York (2003).
4. Athawale V.D. and Mathur P., Experimental Physical Chemistry, New Age International, New Delhi (2001)

Inorganic Chemistry Practicals

31. *Practical Inorganic Chemistry* by G. Marr and B. W. Rockett van Nostrand Reinhold Company (1972)
32. Inorganic Chemistry – Gary Wulfsberg, Viva Book, First Indian Edition 2002
33. Quantitative Analysis – R.A.Day, A.L. Underwood, sixth editio
34. Vogel's Textbook of quantitative chemical analysis – J Mendham, R C Denny, J D Barnes, M Thomas, B Sivasankar

Organic Chemistry Practical

1. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
2. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry: Preparation and Quantitative Analysis, University Press (2000). Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009)
3. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012)
4. 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

5 Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).

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7 Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt.Ltd., New Delhi (2009).

8 Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).

9 Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co., NewYork (1985).

10 K.L.Kapoor A textbook of Physical Chemistry3rd Ed. vol.1,2Macmillan Publishing Co., New Delhi(2001