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Item No. _____

UNIVERSITY OF MUMBAI

Program : B.Sc.

Course : Chemistry
Syllabus for Semester: I & II

(Choice Based and Credit System with effect from the Academic year 2022-23)

Cover Page

AC_____
Item No. _____

UNIVERSITY OF MUMBAI

Syllabus for Approval

	Course	
2	Eligibility for Admission	**12th Science of all recognized Board**
3	Passing Marks	40%
4	Ordinances / Regulations (If any)	
5	No. of Semesters	Two
6	Level	UG
7	Pattern	Semester
8	Status	Revised
9	To be implemented from Academic Year	From Academic Year: 2022-2023

Date: Signature:

Dr Vishwanath Patil
Chairman BoS

Dr. Anuradha Majumdar
Dean, Science and Technology

Draft of the proposed syllabus for CBCS

F. Y. B. Sc. Chemistry

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

Semester-I

1. Paper-I / II (General Chemistry) Unit-I will be for Physical Chemistry
2. Paper-I / II Unit-II will be for Inorganic Chemistry
3. Paper- I / II Unit-III will be for Organic Chemistry.

Semester-II

1. Paper-I /II (General Chemistry) Unit-I will be for Physical Chemistry
2. Paper-I / II Unit-II will be for Inorganic Chemistry
3. Paper-I / II Unit-III will be for Organic Chemistry

Choice Based Credit System F.Y.B.Sc. Chemistry
Syllabus To be implemented from the
Academic year 2022-2023

SEMESTER I

Course Code	Unit	Topic	Credits	L/per week
USCH101	I	Chemical Thermodynamics	2	1
		Chemical calculations		
	II	Atomic structure		1
		Periodic Table and periodicity		
	III	Basics of Organic Chemistry:		1
		Bonding and Structure of organic compounds		
		Fundamentals of organic reaction Mechanism		
USCH102	I	Chemical Kinetics	2	1
		Liquid States		
	II	Comparative Chemistry of Main Group elements		1
	III	Stereochemistry I		1
USCHP1	Chemistry Practical		2	6

SEMESTER II

Course Code	Unit	Topic	Credits	L/per week
USCH201	I	Gaseous State	2	1
		Electrochemistry – I		
		Chemical Equilibria and Thermodynamic Parameters		
	II	Concept of Qualitative Analysis		1
		Acid Base Theories		
	III	Chemistry of Aliphatic Hydrocarbons		1
USCH202	I	Ionic Equilibria	2	1
		Photochemistry Molecular Spectroscopy		
	II	Chemical Bond and Reactivity		1
		Oxidation Reduction Chemistry		
	III	Stereochemistry II		1
		Aromatic Hydrocarbons		
USCHP2	Chemistry Practical		2	6

Programme Outcomes
BSc Chemistry

The student graduating with the Degree B.Sc Chemistry should be able to acquire;

i) Core competency: Students will acquire core competency in the subject Chemistry, and in allied subject areas.

ii) A systematic and coherent understanding of the fundamental concepts in Physical chemistry, Organic Chemistry, Inorganic Chemistry, Analytical Chemistry, and all other related allied chemistry subjects.

iii) Students will be able to use the evidence-based comparative chemistry approach to explain chemical synthesis and analysis.

iv) Students will be able to characterize, identify and separate components of organic or inorganic origin and will also be able to analyze them by making use of the modern instrumental methods learned.

v) Students will be able to understand the basic principle of equipment and instruments used in the chemistry laboratory.

vi) Students will be able to demonstrate the experimental techniques and methods of their area of specialization in Chemistry

vii) The course curriculum also includes components that can be helpful to graduate students to develop critical thinking ability by way of solving problems/numerical using basic chemistry knowledge and concepts.

viii) Appreciate the central role of chemistry in our society and use this as a basis for ethical behavior in issues facing chemists including an understanding of safe handling of chemicals, environmental issues, and key issues facing our society in terms of energy, health, and medicine.

ix) Lifelong learner: The course curriculum is designed to inculcate a habit of learning continuously through the use of advanced ICT techniques and other available techniques/books/journals for personal academic growth as well as for increasing employability opportunity.

SEMESTER I
Paper I
UNIT I

1.1	**Chemical Thermodynamics (10 L)** **Thermodynamic terms;** System, surrounding, boundaries, types of system, Intensive and Extensive properties, State functions and path functions, Thermodynamic processes. **First law of thermodynamics:** Concept of heat (q), work (w), internal energy (U), enthalpy, heat capacity, relation between heat capacities, sign conventions, calculations of heat, work, internal energy and enthalpy (H). **Thermochemistry:** Heat of reactions, standard states, enthalpy of formation of molecules, enthalpy of combustion and its applications, calculations of bond energy, bond dissociation energy and resonance energy from thermochemical data, Kirchhoff's equation (Numerical problems expected wherever necessary)
1.2	**Chemical Calculations: (5L)** Methods of expressing concentration of solutions: Normality, Molarity, Formality, Mole fractions, Weight ratio, Volume ratio, Weight to volume ratio, ppm, ppb, millimoles, milliequivalents, Preparation of solutions. (Numerical problems expected wherever necessary)
	UNIT II
2.1	**Atomic structure: (8 L)**
	Historical perspectives of the atomic structure; J. J. Thomson Model, Rutherford's Atomic Model- alpha particle scattering experiment, Bohr's theory, its limitations and atomic spectrum of hydrogen atom. Structure of hydrogen atom. **Hydrogenic atoms:** 1. Simple principles of quantum mechanics 2. Atomic orbitals i) Hydrogenic energy levels ii) Shells, subshells and orbitals iii) Electron spin iv) Radial shapes of orbitals v) Angular shapes of orbitals. Aufbau principle, Hund's rule of maximum multiplicity and Pauli exclusion principle
2.2	**Periodic Table and periodicity: (7 L)** **Long form of Periodic Table;** Classification for elements as main group, transition and inner transition elements. **Periodicity in the following properties:** Atomic and ionic size, electron gain enthalpy, ionization enthalpy, effective nuclear charge (Slater's rule), electronegativity, Pauling and Mulliken methods. (Numerical problems expected, wherever applicable.)
	Unit III
3	**Basics of Organic Chemistry**
3.1	**Classification and Nomenclature of Organic Compounds: (5L)** **Nomenclature of mono and bi-functional aliphatic 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 and their cyclic analogues.
3.2	**Bonding and Structure of organic compounds: (4L)** **Hybridization**: sp3, sp2, sp hybridization of carbon and nitrogen; sp3 and sp2 hybridizations of oxygen in Organic compounds (alcohol, ether, aldehyde, ketone, carboxylic acid, ester, cyanide, amine and amide) **Overlap of atomic orbitals:** Overlaps of atomic orbitals to form sigma and pi bonds, shapes of organic molecules. **Shapes of molecules;** Influence of hybridization on bond properties (as applicable to ethane, ethene, ethyne).
3.3	**Fundamentals of organic reaction mechanism: (6L)** **Electronic Effects:** Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications. Dipole moment**;** Organic acids and bases; their relative strengths. **Basic terms & concepts**: : Homolytic and Heterolytic fission with suitable examples. Electrophiles and Nucleophiles; Nucleophilicity and basicity, Electrophilicity and acidity. **Types (primary, secondary, tertiary, allyl, benzyl), shape and their relative stability of the following reactive intermediates**: i. Carbocations ii. Carbanions and iii. Free radicals **Introduction to types of organic reactions:** Addition, Elimination and Substitution reaction. (With one example of each)
	Semester- I **Paper – II** **Unit – I**
1.1	**Chemical Kinetics: (8L)** Rate of reaction, rate constant, measurement of reaction rates, order and molecularity of reaction, Integrated rate equation of first order and Second order reactions (with equal initial concentration of reactants) Determination of order of reaction by a) Integration method b) Graphical method c) Ostwald's isolation method d) Half time method, Effect of temperature on the rate of reaction, Concept of activation energy and its calculation from Arrhenius equation (derivation not expected). (Numerical problems expected wherever necessary).
1.2	**Liquid State: (7L)** **Surface tension:** Introduction, methods of determination of surface tension by drop number method **Viscosity:** Introduction, coefficient of viscosity, relative viscosity, specific viscosity, reduced viscosity, determination of viscosity by Ostwald viscometer **Refractive index**: Introduction, molar refraction and polarizability, determination of refractive index by Abbe's refractometer. **Liquid crystals**: Introduction, Classification and structure of thermotropic phases (Nematic, Smectic and Cholesteric phases), applications of liquid crystals. (Numerical problems expected wherever necessary).
	Unit II
2	**Comparative chemistry of Main Group Elements: (15L)**

	Metallic and non-metallic nature, oxidation states, electronegativity, anomalous behavior of second period elements, allotropy, catenation, diagonal relationship. Comparative chemistry of oxides and hydroxides of group I and group II elements. Some important compounds- **$NaHCO_3$, Na_2CO_3, CaO, $CaCO_3$**; oxides of carbon, oxides of Sulphur and Nitrogen with respect to environmental aspects like greenhouse effect, photochemical smog and acid rain.
	Unit III
3	**Stereochemistry I: (15L)** Projection formulae: Flying Wedge projection, Fischer Projection, Newman and Sawhorse Projection formulae (of erythro, threo isomers of tartaric acid and 2,3 -dichlorobutane) and their interconversions; **Geometrical isomerism in alkene and cycloalkanes**: cis–trans and syn-anti isomerism E/Z notations with C.I.P rules. **Optical Isomerism:** Optical Activity, Specific Rotation, Chirality/Asymmetry, Enantiomers, Molecules with two similar and dissimilar chiral-centres, Diastereoisomers, meso structures, racemic mixture and resolution (methods of resolution not expected). **Relative and absolute configuration**: D/L and R/S designations. **Conformational analysis of alkanes** (ethane, propane and n-butane); Relative stability with energy diagrams

Semester II
Paper I
Unit I

1.1	**Gaseous State (6L)** Kinetic theory of gases, Maxwell-Boltzmann's distribution of velocities (Qualitative discussion), Ideal gas laws, Deviation from ideal gas laws, Ideal and real gases, Reasons for deviation from ideal gas laws, Compressibility factor, Boyle's temperature, van der Waals equation of state, Critical phenomena, Relation between critical constants and van der Waals constants. (Numerical problems expected wherever necessary)
1.2	**Electrochemistry - I (4 L)** Conductance, specific conductance, equivalent conductance, molar conductance, Variation of molar conductance with concentration of strong and weak electrolyte. Reversible electrodes, Electrode potential, standard electrode potential, Galvanic cells, Conventions to represent the galvanic cells, Concept of emf of cell. (Numerical problems expected wherever necessary)
1.3	**Chemical Equilibria and Thermodynamic Parameters (5L)** Second law of thermodynamics, concept of entropy, Physical significance of entropy, Concept of free energy, Helmholtz and Gibbs free energy, Variation of free energy with temperature and pressure, Spontaneity and Physical significance of free energy. Re Reversible and irreversible reactions, equilibrium constants (Kc and Kp), relationship between Kc and Kp. Thermodynamic derivation of equilibrium constant (Numerical problems expected wherever necessary)
	Unit II

2	**Concept of Qualitative Analysis: (8 L)**
2.1	Testing of Gaseous Evolutes, Role of Papers impregnated with Reagents in qualitative analysis (with reference to papers impregnated with starch iodide, potassium dichromate, lead acetate, dimethylglyoxime and oxine reagents).
	Precipitation equilibria, Formation of precipitates like AgCl, AgBr, AgI and $BaSO_4$ effect of common ions, uncommon ions, oxidation states, buffer action, complexing agents on precipitation of ionic compounds. (Balanced chemical equations)
2.2	**Acid Base Theories: (7L)**
	Arrhenius, Lowry- Bronsted, Lewis, Solvent – Solute concept of acids and bases, Usanovich concept, Hard and Soft acids and bases, Applications of HSAB.
	Unit III
3	**Chemistry of Aliphatic Hydrocarbons**
3.1	**Carbon - Carbon sigma bonds: (3L)** Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig reaction, free radical substitutions: Halogenation - relative reactivity and selectivity
3.2	**Carbon - Carbon pi bonds (12L):** **Formation of alkenes and alkynes by elimination reactions**: Mechanism of E1, E2, E1cb reaction. Saytzeff and Hofmann eliminations **Reactions of alkenes**: Electrophilic additions with mechanisms (Markownikoff / Anti Markownikoff addition), Mechanism of oxymercuration - demercuration, hydroboration - oxidation, ozonolysis, reduction (catalytic and chemical), syn- and anti-dihydroxylation (oxidation), 1, 2- and 1, 4-addition reactions in conjugated dienes, Diels-Alder reaction. **Reaction of alkynes**: Acidity, Electrophilic and Nucleophilic additions with mechanisms. Hydration to form carbonyl compounds, Alkylation of terminal alkynes
	Semester II **Paper II** **Unit I**
1.1	**Ionic Equilibria: (7L)** Strong and weak electrolytes, degree of ionization, factors affecting degree of ionization, Ionization constant and ionic product of water, Ionization of weak acids and bases, Dissociation constants of mono-, di-, and tri-protic acids. pH scale, Buffer solutions, types of buffers, Derivation of Henderson equation for acidic and basic buffers, Buffer action, buffer capacity (Numerical problems expected, wherever necessary)
1.2	**Photochemistry (4L)** Laws of photochemistry, Quantum yield or efficiency, experimental determination of quantum yield, Reasons for low and high quantum yield, Primary and secondary processes. Photochemical reactions (with suitable examples), Photosensitizers and photosensitized reactions, Fluorescence, Phosphorescence and Chemiluminescence. (Numerical problems expected, wherever necessary)
1.3	**Molecular Spectroscopy: (4L)** Electromagnetic radiation, electromagnetic spectrum, Planck's equation, Interaction of electromagnetic radiation with matter; Absorption, Emission, Scattering, Electronic, Vibrational and Rotational transitions, Beer-Lamberts law.

	(Numerical problems expected, wherever necessary)
	Unit II
2.1	**Chemical Bond and Reactivity: (10 L)** Types of chemical bond, comparison between ionic and covalent bonds, polarizability (Fajan's Rule), shapes of molecules, Lewis dot structure, Sidgwick Powell Theory, basic VSEPR theory for ABn type molecules with and without lone pair of electrons, isoelectronic principles, applications and limitations of VSEPR theory.
2.2	**Oxidation Reduction Chemistry: (5L)** Reduction potentials, **Redox potentials: half reactions**; balancing redox equations. **Applications of redox chemistry**; Redox reagents in Volumetric analysis; a) I_2 b) $KMnO_4$
	Unit III
3.1	**Stereochemistry II: (5L)** **Cycloalkanes and Conformational Analysis: (5L)** Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformational analysis of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagram.
3.2	**Aromatic Hydrocarbons: (10L)** **Aromaticity:** Hückel's rule, anti-aromaticity, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. **Electrophilic aromatic substitution:** halogenation, nitration, sulphonation and Friedel-Crafts alkylation/acylation with their mechanism, Directing effects of the groups

Reference Books:

Unit – I

1) Concise Graduate Chemistry – I, II, III & IV, University Text Book of Chemistry, University of Mumbai.
2)
3) Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 10th Ed., Oxford University Press (2014).
4) Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
5) Keith J. Laidler & John H. Meiser, Physical Chemistry, 2nd Ed. (2004)
6) Puri B. R., Sharma L. R. & Pathania M. S. Principles of Physical Chemistry, Vishal Publishing Company, 2008
7) Ball, D. W. Physical Chemistry Thomson Press, India (2007).
8) Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
9) Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).

10) McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics* Viva Books Pvt. Ltd.: New Delhi (2004).
11) Levine, I .N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill (2010).

Unit II

1. Concise Graduate Chemistry – I, II, III & IV, University Text Book of Chemistry, University of Mumbai.
2. Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
3. Douglas, B.E. and McDaniel, D.H. Concepts & Models of Inorganic Chemistry, Oxford, 1970
4. Atkins, P.W. & Paula, J. Physical Chemistry, 10th Ed., Oxford University Press, 2014. Day, M.C. and Selbin, J. Theoretical Inorganic Chemistry, ACS Publications, 1962.
5. Rodger, G.E. Inorganic and Solid State Chemistry, Cengage Learning India

Unit III

1. Concise Graduate Chemistry – I, II, III & IV, University Text Book of Chemistry, University of Mumbai.
2. Morrison, R. T. and Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt Ltd. (Pearson Education).2012
3. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt Ltd. (Pearson Education).
4. Finar, I. L. Organic Chemistry (Volume 2: Stereochemistry and the Chemistry of Natural Products), Dorling Kindersley (India) Pvt Ltd. (Pearson Education).
5. Eliel, E. L. and Wilen, S. H. Stereochemistry of Organic Compounds, Wiley: London, 1994
6. Kalsi, P. S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
7. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013
8. Paula Y Bruice, Organic Chemistry, 7th Ed, Pearson education, Asia.2014
9. Graham Solomon, Fryhle, Dnyder, Organic Chemistry, Wiley publication. 12 th Ed,2016
10. Bahl and Bahl, Advanced Organic chemistry by S. Chand publication.2010
11. Peter Sykes. Guidebook to the mechanism in Organic chemistry ,6th edition
12. D. Nasipuri. Stereochemistry of Organic Compounds, Principles and Applications, Second Edition

Chemistry lab.
Semester – I

Unit – I: Physical Chemistry

1) To prepare 0.1 N succinic acid and standardize the NaOH solution of different concentrations.
2) To determine the rate constant for the hydrolysis of ester using HCl as catalyst.
3) To determine enthalpy of dissolution of salt (KNO_3)
4) Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature (Any two solutions).

Unit II: Inorganic Chemistry

1) Commercial analysis of (any two)
   a) Mineral acid
   b) Organic acid
   c) Salt of weak acid and strong base.
2) Titration using double indicator: analysis of solution of Na_2CO_3 and $NaHCO_3$
3) Gravimetric analysis
   a) To determine the percent purity of sample of $BaSO_4$ containing NH_4Cl
   b) To determine the percent purity of ZnO containing $ZnCO_3$.

Unit III Organic Chemistry

1. Purification of organic compounds by recrystallization selecting suitable solvent (minimum 2 organic compounds to be given)
   (Learners are expected to report a) Solvent for recrystallization. b) Percentage Yield and the melting points of the purified compound.)

2. Basic principles of Organic compound characterization (minimum 4 Solid organic compounds) (Learners should perform Preliminary Tests, Solubility Test, obtain melting point and recrystallize the compound with given solvent)

Minimum 80 percent of practical must be completed in each term

Chemistry lab:
Semester - II

Unit – I: Physical Chemistry

1) To determine the amount of strong acid in the given solution by titrating against strong base conductometrically.
2) To determine the dissociation constant of weak acid (Ka) using Henderson's equation and the method of incomplete titration pH metrically.
3) To verify Beer-Lamberts law using $KMnO_4$ solution by colorimetric method.
4) To standardize commercial sample of HCl using borax and to write material safety data of the chemicals involved.

Unit II Inorganic Chemistry

1) **Qualitative analysis: (5 mixtures to be analyzed)**
   Semi-micro inorganic qualitative analysis of a sample containing two cations and two anions (from amongst):

   Cations (from amongst): Pb^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Cu^{2+}, Cd^{2+}, Fe^{2+}, Ni^{2+}, Mn^{2+}, Mg^{2+}, Al^{3+}, Cr^{3+}, K^+, NH_4^+

   Anions (from amongst): CO_{32}^-, S^{2-}, SO^{2-}, NO_2^-, NO_3^-, Cl^-, Br^-, I^-, SO_{42}^-, PO_4
   (Scheme of analysis should avoid use of sulphide ion in any form for precipitation/ separation of cations.)

2) **Redox Titration:** To determine the percentage of copper (II) present in a given sample by titration against a standard aqueous solution of sodium thiosulfate (iodometry titration)

Unit III Organic Chemistry

1) **Characterization of organic compounds** containing C, H, (O), N, S, X elements (6 solid/liquid Organic compounds)
(Preliminary Tests, Solubility/Miscibility Test, Detection of Elements, Detection of Functional group and determination of Physical constant)
Minimum 80 percent of practicals must be completed in each term

Reference Books

Unit I: Physical Chemistry

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

Unit II: Inorganic Chemistry

1) Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry, University of Mumbai.
2) Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.

Unit III: Organic Chemistry

1) Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry, University of Mumbai.
2) 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.