SOPHIA COLLEGE FOR WOMEN (AUTONOMOUS)
AFFILIATED TO UNIVERSITY OF MUMBAI

Syllabus for FYBSc
Course: CHEMISTRY
With effect from the academic year 2019-20

Syllabus for Approval

Sr No	Heading	Particulars
1	Title of course	FYBSc Chemistry
2	Passing marks	40%
3	Ordinance/Regulation (if any)	
4	No. of Semester	Two
5	Level	UG
6	Pattern	Semester
7	To be implemented from Academic year	2019-20

Date:

BOS Chairperson
Dr I A Mendes

Convener
Dr Santosh Haram

FACULTY: Science

COURSE: B.Sc

SEMESTER I

Course Code	Unit	Topic	Credits	L/week
SBSCHE101	I	1.1Chemical thermodynamics 1.2 Chemical calculations	2	6
	II	2.1 Atomic structure 2.2 Periodic table and periodicity		
	III	3.1 Classification and Nomenclature of organic compounds 3.2 Bonding and structure of organic compounds 3.3 Fundamentals of otganic reaction mechanisms		
SBSCHE102	I	1.1 Chemical kinetics 1.2 Liquid State	2	6
	II	2.1 History of science 2.2 Comparative chemistry of main group elements		
	III	3.1 Stereoisomerism 3.2 Representation of stereoisomers 3.3 Nomenclature, relative and absolute configuration		
SBSCHEP1	PRACTICAL COURSE		2	6

SEMESTER II

Course Code	Unit	Topic	Credits	L/week
SBSCHE201	I	1.1 Gaseous state 1.2 Chemical equilibria and thermodynamic parameters. 1.3 Catalysis	2	6
	II	2.1 Concept of qualitative analysis 2.2 Acid base theory		
	III	3.1 Carbon carbon sigma bond 3.2 Carbon carbon pi bond		
SBSCHE202	I	1.1 Ionic equilibria 1.2 Molecular spectroscopy	2	6
	II	2.1 Chemical bond and reactivity 2.2 Oxidation reduction chemistry		
	III	3.1 Stereochemistry of cycloalkanes and conformational analysis 3.2 Aromatic hydrocarbons 3.3 Electrophilic aromatic substitution		
SBSCHEP2	PRACTICAL COURSE		2	6

Semester I
Paper I Course Code SBSCHE101

Learning objectives

- **To understand the fundamental concepts of thermodynamics and relationship among thermodynamic parameters.**
- **To understand the calculations involved in preparation of solutions of different concentrations.**
- **To clarify the basics of atomic structure using quantum mechanics: shapes of orbital**
- **To understand the special features of the quantum mechanical model of an atom and to define an atomic orbital in terms of its quantum numbers**
- **To correlate the chemical properties of elements with their position in the periodic table**
- **To understand the method of naming organic compounds systematically.**
- **To understand the bonding and geometry of different organic compounds**
- **To understand the fundamental concepts of organic chemistry and its effect on acidity, basicity, reactivity of organic compounds.**

Learning outcomes:The learner will be able to

- **derive relationship between different thermodynamic variables and solve numericals based on data given**
- **calculate amounts of solutes required for preparation of different solutions.**
- **explain the concepts of nodes and the shapes of the orbital with correct signs of wave functions.**
- **explain experimental observables by using the quantum mechanical model studied**
- **capable of discerning the chemical properties of elements based on parameters with predictable trends across periods and groups in periodic table**
- **identify the various functional groups and name them using IUPAC nomenclature**
- **predict the acidity, basicity and reactivity of organic compounds.**

Unit-I-Physical Chemistry

1.1 Chemical Thermodynamics: (10L)

Thermodynamic terms: System, surrounding, boundaries, open, closed and isolated system, intensive and extensive properties, state functions and path functions, zeroth law of thermodynamics

First law of thermodynamics: concept of heat (q), work (w), internal energy (U), statement of first law, enthalpy, relation between heat capacities, sign conventions, calculations of heat (q), work (w), internal energy (U), and enthalpy (H) (Numericals expected)

Thermochemistry: Heats of reactions, standard states, enthalpy of formation of molecules, enthalpy of combustion and its applications, calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data, Kirchhoff's equation (intergrated form) (Numericals expected)

1.2 Chemical Calculations: (5L)

Expressing concentration of solutions: Normality, molality, molarity, formality, mole fractions, weight ratio, volume ratio, weight to volume ratio, ppm, ppb, millimoles, milliequivalents (Numericals expected)

Unit II-Inorganic Chemistry

2.1 Atomic structure: (10L)

a) Historical perspectives of the atomic structure: Rutherford's Atomic Model, Bohr's theory, its limitations and the atomic spectrum of hydrogen atoms. Structure of hydrogen atom.
b) Hydrogenic system
1. Postulates of quantum mechanics
2. Atomic orbitals
i) Hydrogenic energy levels
ii) Shells, subshells and orbitals
iii) Electron spin
iv) Radial components of orbitals
v) Radial distribution function
vi) Angular shapes of orbitals.
3. Many Electron system
i) Penetration and shielding
ii) Effective nuclear charge
4. Aufbau principle
(Qualitative treatment only; it is expected that the learner knows the mathematical statements and understands their physical significance after completing this topic. No derivations of the mathematical equations required)

2.2 Periodic Table and periodicity: (5L)
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, Mulliken and Alred Rochow electronegativities (Numericals expected, wherever applicable.)

Unit III-Organic Chemistry

3.1 Classification and Nomenclature of Organic Compounds: (5L)
Review of basic rules of IUPAC nomenclature. 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; including their cyclic analogues.
3.2 Bonding and Structure of organic compounds: (4L)
3.2.1.Hybridization: hybridization of carbon,nitrogen and oxygen (sp^3, sp^2 sp)in the following compounds.(alcohol, ether, aldehyde, ketone, carboxylic acid, ester, amine, imine, amide and cyanide)
3.2.2Overlap of atomic orbitals: Overlaps of atomic orbitals to form sigma and pi bonds, shapes of organic molecules.
3.2.3Shapes of molecules: Influence of hybridization on bond properties (as applicable to ethane, ethene, ethyne)
3.3 Fundamentals of organic reaction mechanism: (6L)
3.3.1Introduction: Lewis structure, Formal Charge ,types of arrows, homolytic and heterolytic fission with suitable examples. Electrophiles and Nucleophiles; Nucleophilicity and basicity;

3.3.2.Reactive intermediates: carbocation, carbanions and free radicals
types ,structure, shape and their relative stability (primary, secondary, tertiary, allyl, benzyl)

3.3.3.Electronic Effects: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications; Dipole moment; Organic acids including carbon acids and bases; their relative strengths.

Paper II Course Code SBSCHE102

Learning outcomes

- **To understand the fundamental concepts of chemical kinetics.**
- **To recognise different properties of liquid states and instruments for their measurement.**
- **To understand the properties of main group elements**
- **To understand the terminology, nomenclature and basic concepts related to stereochemistry.**
- **To acquaint with the various projections used and conformational analysis of organic molecules**
- **To understand the method of assigning configuration to chiral compounds with and without a stereogenic centre**

Learning objectives: Learner will be able to

- **interpret data obtained from various kinetic reactions and identify order of reaction**
- **calculate the values of various properties exhibited by liquids from experimental data**
- **write and compare properties of main group elements.**
- **distinguish between the different types of stereoisomers.**
- **assign configuration to compounds and correlate between the structure and configuration of stereoisomers and the chemical and biological properties**

Unit I Physical Chemistry

1.1 Chemical Kinetics: (8L)

Rate of reaction, rate constant, measurement of reaction rates, order and molecularity of reaction, integrated rate equation of first and second order reactions (with equal initial concentration of reactants) (Numericals expected)

Determination of order of reaction by (a) Integration method (b) Graphical method (c) Ostwald's isolation method (d) Half time method (Numericals expected)

1.2 Liquid State: (7L)

Surface tension: Introduction, methods of determination of surface tension by drop number method (Numericals expected)

Viscosity: Introduction, coefficient of viscosity, relative viscosity, specific viscosity, reduced viscosity, determination of viscosity by Ostwald's viscometer (Numericals expected)

Refractive index: Introduction, specific refraction, molar refraction and polarizability, determination of refractive index by Abbe's refractometer (Numericals expected)

Liquid crystals: Introduction, classification and structure of thermotropic phases (Nematic, smectic and cholesteric phases), applications of liquid crystals

Unit-II-Inorganic Chemistry

2.1 History of Science: (2L)

Development of science over the 19th and 20th century, Nobel prizes in chemistry.

2.2 Comparative Chemistry of Main Group Elements: (13L)

Metallic and non-metallic nature, oxidation states, electronegativity, anomalous behaviour of second period elements, allotropy, catenation, diagonal relationship. Comparative chemistry of carbides, nitrides, oxides and hydrides of group I and group II elements. Oxides of carbon, oxides and oxyacids of sulphur and nitrogen with respect to environmental aspects.

Unit III-Organic Chemistry

3. Stereochemistry I: (15L)

3.1Stereoisomerism: Chirality versus stereogenicity,classification of stereisomers Definition:enantiomers diasteremers asymmetric carbon

3.2Representation of stereoisomers: Flying-wedge model, Fischer Projection, Newman and Sawhorse Projection formulae (of erythro, threo isomers of tartaric acid and 2,3 dichlorobutane) and their interconversions

3.3Nomenclature relative and absolute configuration: D/L and R/S designations. Optical activity vs chirality: compounds with one chiral centre Optical activity, Specific Rotation, racemic mixture and resolution (methods of resolution not expected).

Molecules with two, similar and dissimilar chiral-centres, Distereoisomers, meso structures, Geometrical isomerism in alkene and cycloalkanes: cis–trans and syn-anti isomerism E/Z notations with C.I.P rules.Conformation analysis of alkanes (ethane), relative stability with energy diagram

Semester II
Paper I Course Code SBSCHE201

Learning objectives

- **To understand different laws applicable to gases**
- **To understand various concepts of chemical equilibrium and Le Chatelier's principle**
- **To introduce to catalysis and different types of catalyst**
- **To apply the concept of the solubility product and pH of the medium on precipitation of ionic compounds**
- **To study different acid-base theories**
- **To learn various methods of preparation of hydrocarbons**
- **To understand the mechanism of reactions of hydrocarbons.**

Learning outcomes:Learner will be able to

- **solve numericals based on gas laws**
- **apply Le Chatelier's principle and identify different parameters required for optimization of chemical reaction**
- **understand the experimental observations in the laboratory in semi-micro analysis with the concept of solubility product**
- **compare the different acid-base theories**
- **identify different types of catalyst and explain the mechanism of action**
- **write various preparative methods and predict the mechanisms of hydrocarbon**

Unit-I-Physical Chemistry

1.1 Gaseous State: (8L)

Ideal gas laws, kinetic theory of gases, Maxwell-Boltzmann's distribution of velocities (qualitative discussion), ideal gases, real gases, compressibility factor, Boyle's temperature (Numericals expected)
Deviation from ideal gas laws, reasons for deviation from ideal gas laws, Van der Waals equation of state (Numericals expected), Joule-Thomson effect: qualitative discussion and experimentation,inversion temperature.

1.2 Chemical Equilibria and Thermodynamic Parameters: (5L)

Reversible and irreversible reactions, law of mass action, dynamic equilibria, equilibrium constant K_c and K_p, relationship between K_c and K_p, Le Chatelier's principle with special reference to Habers process, factors affecting chemical equilibrium (Numericals expected)

1.3Catalysis: (2L)

General characteristics of catalytic reactions, types of catalysis, effects of catalysis, principle of chemical and adsorption theory of catalysis(Derivation not expected)

Unit II-Inorganic Chemistry

2.1 Concept of Qualitative Analysis: (8L)

a) 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).

b) Precipitation equilibria, effect of common ions (Numericals expected), diverse 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, Usanovich concept, Solvent – Solute concept of acids and bases, Hard
and Soft acids and bases. Applications of HSAB
Applications of acid base chemistry in understanding organic reactions like Friedel Craft's (acylation/alkylation) reaction

Unit III- Organic Chemistry

3. Chemistry of Aliphatic Hydrocarbons

3.1 Carbon-Carbon sigma bonds: (3L)

Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

3.2 Carbon-Carbon pi-bonds: (12L)

3.2.1Formation of alkenes and alkynes by elimination reactions: Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.

3.2.2.Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition).
Oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, reduction(catalytic and chemical), syn and anti-hydroxylation (oxidation). 1, 2-and 1, 4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylicbromination using N-bromosuccinimide. (propene,1-butene,toluene,ethylbenzene) (No Mechanism expected)

3..2.3Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes. (No mechanism expected)

Paper II Course Code SBSCHE202

Learning objectives

- **To understand concept of ionic equilibria, pH and buffers**
- **To understand basic terms in spectroscopy and laws of visible spectroscopy**
- **To learn different types of chemical bonds and factors affecting their reactivity**
- **To study redox chemistry with respect to electrochemical reactions**
- **To understand the stereochemistry of cycloalkanes and aromatic hydrocarbons and their relative stability**
- **To understand the criteria of aromaticity**
- **To understand mechanism of reactions of aromatic hydrocarbons**

Learning outcomes:Learner will be able to

- **calculate equilibrium constants and pH of aqueous solution and buffer**
- **identify and compare different types of spectroscopy and solve numericals based on Beer Lambert's law**
- **explain the bonding and factors affecting chemical bonds in inorganic molecules**
- **predict the outcome of redox reactions based on the electrochemical series**
- **explain the stereochemistry of cycloalkanes and predict the strain experienced by the compound.**
- **classify the organic compounds as aromatic and antiaromatic compounds**
- **predict the mechanisms for aromatic compounds**

Unit-I Physical Chemistry

1.1. Ionic Equilibria (9L)

Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water, ionization of weak acids and bases, pH scale, common ion effect, dissociation constants of mono-, di- and triprotic acid (derivation for monoprotic acid only)

Buffers: Introduction, types of buffers, derivation of Henderson equation for acidic and basic buffers, buffer action, buffer capacity (Numericals expected)

1.2 Molecular Spectroscopy: (6L)

Electromagnetic radiation, electromagnetic spectrum, Planck's equation (Numericals expected) interaction of electromagnetic radiation with matter: Absorption, emission, scattering, fluorescence,electronic, vibrational and rotational transitions Basic terms: Radiant power, absorbance, transmittance, monochromatic light, polychromatic light, Absorptivity. Statement of Beer's Law ,Lambert's Law, Combined mathematical expression of Beer-Lambert's Law, Validity of Beer- Lambert's Law, Deviation from Beer-Lambert's Law. (Numericals expected)

Unit II- Inorganic Chemistry

2.1: Chemical Bond and Reactivity: (7L)

Types of chemical bonds, comparison between ionic and covalent bonds, polarizability (Fajan's Rule), shapes of molecules, Lewis dot structure, Sidgwick, Powell Theory, basic VSEPR theory for AB_n type molecules with and without lone pair of electrons, isoelectronic principles, applications and limitations of VSEPR theory.

2.2: Oxidation Reduction Chemistry: (8L)

Definition of Oxidation, Reduction and Redox reactions (with reference to addition or removal of H_2 or O_2 and electronic concept) oxidizing and reducing reagents. Oxidation number and rules for assigning oxidation number (Numericals expected).
Balancing redox equations using ion electron method and oxidation number method. (Numericals expected)

Unit III Organic Chemistry

3.1 Stereochemistry II:Cycloalkanes and Conformational analysis (5 L)
Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy.
3.2Aromatic Hydrocarbons: (10L)
Criteria for aromaticity including Hückel's rule, anti-aromaticity, aromatic character of arenes, cyclic carbocations/carbanions (examples using C1-C7 atoms) and heterocyclic compounds (examples with one hetero atom-O,N, S).
Resonance energy, characteristics of aromatics compounds,
3.3Electrophilic aromatic substitution-general mechanism halogenation, nitration, sulphonation and Friedel-Craft alkylation/acylation.
Directing effects of substituents in mono substituted benzene.

Suggested Textbooks
Unit I:Physical Chemistry
Physical chemistry by McQuarrie (ISBN no.1891389505)
Further Reading
Physical Chemistry by Peter Atkins, Julio de Paula and James Keeler (ISBN; 9780198769866)

Unit II : Inorganic
Concise Inorganic Chemistry by J.D.Lee(ISBN 13:978-8126575547)
Further reading:
Inorganic Chemistry by D F Shriver and Peter Atkins

Unit III: Organic Chemistry
Organic Chemistry by Graham Solomons, Craig Fryhle(ISBN;9814-12-613-6)
Further reading
Organic Chemistry by Jonathan, Clayden,Greeves Warren (ISBN:13) oxford-198503466
Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.

CHEMISTRY PRACTICALS

Semester I
Course Code: SBSCHEP1

Learning Objectives:

- **To prepare standard solutions for volumetric analysis**
- **To learn to carry out chemical kinetics in the laboratory**
- **To introduce volumetric and gravimetric methods of analysis**
- **To understand steps in characterization of organic compounds**

Learning Outcomes :
The learner will be able to

- **prepare standard solutions of exact normality**
- **perform chemical kinetics and predict order of reaction from the data**
- **carry out analysis using volumetric and gravimetric methods**
- **characterize organic compounds**

Unit I: Physical Chemistry

1. To prepare 0.1 N succinic acid and standardize the NaOH of two different concentrations.
2. To determine enthalpy of dissolution of salt (like KNO_3)
3. To determine the rate constant for the hydrolysis of ester using HCl as catalyst.
4. To determine the rate constant for the saponification reaction between ethyl acetate and NaOH

Unit II: Inorganic Chemistry

.1. Commercial analysis of
   a) Mineral acid
   b) Organic acid
2. Titration using double indicator: analysis of solution of Na_2CO_3 and $NaHCO_3$.
3. Gravimetric analysis
   a) To determine the percentage purity of sample of $BaSO_4$ containing NH_4Cl
   b) To determine the percentage purity of ZnO containing $ZnCO_3$.

Unit III: Organic Chemistry
Characterization of organic compound containing C, H, (O), N, S, X elements.
(minimum 8 compounds)

Semester II

Course Code: SBSCHEP2

Learning Objectives:

- **To learn the use of pH meter and colorimeter**
- **To learn the standardisation of commercial samples of acids and bases**
- **To carry out qualitative analysis of inorganic salts**
- **To study the use of chromatography as a tool of separation and identification**
- **To learn to recrystallise organic solids**

Learning Outcomes : Learner will be able to

- **use pH meter and colorimeter for analysis of compounds**
- **successfully standardize commercial samples of acids and bases**
- **analyze and identify ions of mixture of inorganic salts**
- **carry out TLC of mixture of organic compounds**
- **be able to purify organic solids by using suitable recrystallization solvents**

Unit I:Physical Chemistry

1. To determine dissociation constant of weak acid (Ka) using Henderson's equation and the method of incomplete titration pH metrically.
2. To verify Beer-Lambert's law, using the KMnO4 solution by colorimetric method.
3. To standardize commercial sample of HCl using borax and to write material safety data of the chemicals involved.
4. To standardize commercial samples of NaOH using Potassium Hydrogen Phthalate and to write material safety data of the chemicals involved.

Unit II: Inorganic Chemistry

1. Qualitative analysis: (at least 4 mixtures to be analyzed)

Semi-micro inorganic qualitative analysis of a sample containing two cations and two anions.

Cations (from amongst):

Pb^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Cu^{2+}, Fe^{2+}, Ni^{2+}, Mn^{2+} ,Mg^{2+}, Al^{3+} ,Cr^{3+}, K^{+},NH^{4+}

Anions (From amongst):

CO_3^{2-}, S^{2-} ,SO_3^{2-},NO_2^{-}, NO_3^{-}, Cl^{-}, Br^{-}, I^{-}, SO_4^{2-}, PO_4^{3-}

(Scheme of analysis to include sulphide scheme)

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. Purification of any three organic compounds by recrystallization selecting suitable solvent.
   a) Solvent for recrystallization.
   b) Mass and the melting points of purified compound.
2. Chromatography

Separation of a mixture of o-and p-nitrophenols by thin layer chromatography (TLC)

Reference books

Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, 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

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