SOPHIA COLLEGE FOR WOMEN (AUTONOMOUS)

Affiliated to the University of Mumbai

Programme: Sciences

Chemistry (Major/Minor)

Syllabus for the Academic Year 2023-2024

based on the National Education Policy 2020

SOPHIA COLLEGE (AUTONOMOUS)

DEPARTMENT OF CHEMISTRY

COURSE DETAILS FOR MAJOR/MINOR:

	SEMESTER 1		SEMESTER 2
TITLE	**Fundamentals of Chemistry -1**		**Fundamentals of Chemistry -2**
TYPE OF COURSE - DSC	**Major/Minor**		**Major/Minor**
CREDITS	**4**		**4**

Preamble:

Programme: BSc Chemistry

Chemistry - a vibrant and ever growing science that encompasses every aspect of our lives. The fascinating study of matter and its applications is vital in areas like drug designing, material science, nanotechnology and most importantly, 'green chemistry', areas that are beneficial to both humanity and the environment. Bachelor's degree in Chemistry is the culmination of in-depth knowledge of Inorganic, Organic and Physical chemistry, Analytical chemistry and specialized courses such as Pharmaceutical Chemistry, spectroscopy, Nanoscience, Forensic Science, Cosmeticology, Food chemistry, Dairy Chemistry, Environmental chemistry and so on.

The learning objectives are designed to provide a focused outcome based syllabus with an agenda to structure the teaching learning experiences in a more student centric manner. This programme helps learners in building a solid foundation for higher studies in Chemistry. The hands-on experience the students gain in Practical enable them to apply theoretical knowledge acquired to solve problems in everyday life, think critically and innovatively. The syllabus is designed so that the student starts from the basic concepts of chemistry and will gradually move towards the advanced level. They are given opportunities to improve their creativity, scientific writing and communication skills through assignments and other co-curricular activities in all the semesters. The credit courses on "Positive Health in Women" and "Innovation in Natural dyeing and Entrepreneurship Skills" offered by the department further enhances their life skills and helps them evolve as entrepreneurs.

Students completing this programme will be equipped with knowledge of the concepts of Chemistry, interpret data and present their findings to both the scientific community and laymen. Completion of this programme will also enable the learners to join teaching professions, conducting research in Industry and Government run research labs.

PROGRAMME OBJECTIVES

PO1	The students are expected to understand the basic concepts in chemistry and be aware of the recent development in the subject area.
PO2	To inculcate critical thinking and scientific attitude in the students.
PO3	The students should be able to apply the theoretical knowledge and practical skills acquired to solve the real world problems and environmental issues.

PROGRAMME SPECIFIC OUTCOMES

PSO1	**Core competency:** The chemistry graduates are expected to gain the theoretical and practical knowledge of the basic concepts in chemistry.
PSO2	**Skill development:** They would acquire necessary skills and training to pursue higher studies in the field of chemistry and to be an entrepreneur.
PSO3	**Responsible citizens:** The students will get trained to adopt and practice sustainable techniques for their personal growth and to address societal and environmental problems.

SOPHIA COLLEGE (AUTONOMOUS)

Programme: Sciences **Chemistry Major/ Minor**	**Semester – 1**
Course Title: Fundamentals of Chemistry-1	**Course Code: SCHE111MJ/MN**

COURSE OBJECTIVES:

1. To understand the fundamental concepts of thermodynamics and relationship among thermodynamic parameters.
2. To understand the fundamental concepts of chemical kinetics.
3. To clarify the basics of atomic structure and understand the shapes of orbital and assigning quantum numbers.
4. To correlate the chemical properties of elements with their position in the periodic table.
5. To understand the fundamental concepts of organic chemistry and its effect on acidity, basicity, reactivity of organic compounds.

COURSE OUTCOMES:

The learner will be able to :

1. Derive relationship between different thermodynamic variables and solve numericals based on data given.
2. Interpret data obtained from various kinetic reactions and identify order of reaction.
3. Explain the shapes of atomic orbital and assign quantum number.
4. Capable of discerning the chemical properties of elements based on parameters with predictable trends across periods and groups in periodic table.
5. Predict the acidity, basicity and reactivity of organic compounds.

Lectures per week (1 Lecture is 60 minutes)		**3**	
Total number of Hours in a Semester		**45**	
Credits		**3**	
Evaluation System	**Summative Assessment**	**2 Hours**	**50 marks**
	Continuous Assessment	**--**	**50 marks**

UNIT 1 Physical Chemistry	**1.1 Chemical Thermodynamics (10 L)**	1.1.1 Thermodynamic terms: System, surrounding, boundaries, open, closed and isolated system, intensive and extensive properties, state functions and path functions, types of processes. 1.1.2 Zeroth law of thermodynamics 1.1.3 Concept of heat and work. 1.1.4 First law of thermodynamics: Internal energy (U) and enthalpy(H). Statement and mathematical relation. Sign conventions, calculations of heat (q), work (w), internal energy (U), and enthalpy (H) 1.1.5 Relation between heat capacities (Cp And Cv), Kirchoff equation. 1.1.6 Second law of thermodynamics: Heat engines, mechanical efficiency 1.1.7 Concept of entropy: Relation between enthalpy and entropy for reversible and irreversible processes, physical significance of entropy, entropy changes for fusion, vaporisation and transition. (Numericals expected wherever applicable)	15 hours
	1.2 Chemical Kinetics (5 L)	1.2.1 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 wherever applicable) 1.2.2 Determination of order of reaction by (a) Integration method (b) Graphical method (c) Ostwald's isolation method (d) Half time method 1.2.3 Arrhenius equation: Effect of temperature on reaction rate. Energy of activation. (Numericals expected wherever applicable)	
	2.1 Atomic structure (5 L)	2.1.1 Historical perspectives of the atomic structure: i)Rutherford's Atomic Model, ii)Bohr's theory and its limitations iii)The atomic spectrum of hydrogen atoms. Structure of hydrogen atom.	15 hours

UNIT 2 Inorganic Chemistry		iv) De Broglie's relation and Heisenberg Uncertainty Principle v) Need for a new approach to atomic structure 2.1.2 Quantum Numbers 2.1.3 Many Electron system i) Penetration and shielding ii) Effective nuclear charge ii)Aufbau principle	
	2.2 Periodic Table and periodicity (5L)	2.2.1 Long form of Periodic Table; Classification for elements as main group, transition and inner transition elements. 2.2.2 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 electronegativity) (Numericals expected wherever applicable.)	
	2.3 Concept of Qualitative Analysis (5 L)	2.3.1 Types of qualitative analysis. Concept of wet and dry test in inorganic analysis. 2.3.2 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). 2.3.3 Precipitation equilibria, effect of common ions, diverse ions, oxidation states, buffer action, complexing agents on precipitation of ionic compounds. (Balanced chemical equations) (Numericals expected wherever applicable.)	
	3.1Classification and Nomenclature of Organic Compounds (5L)	3.1.1 Review of basic rules of IUPAC nomenclature. 3.1.2 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	15 hours

UNIT 3 Organic Chemistry		acid derivatives (acid halides, esters, anhydrides, amides), nitro compounds, nitriles and amines; including their cyclic analogues. 3.2.3 Shapes of molecules: Influence of hybridization on bond properties (as applicable to ethane, ethene, ethyne)	
	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) 3.2.2 Overlap of atomic orbitals: Overlaps of atomic orbitals to form sigma and pi bonds, shapes of organic molecules.	
	3.3Fundamentals of organic reaction mechanism (6L)	3.3.1 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.	

PRACTICAL **Course Title: Fundamentals of Chemistry-1**	**Course Code:** **SCHE111MJP/MNP**

COURSE OUTCOMES:

The learner will be able:

1. Calibrate glassware.
2. Prepare standard solutions of exact normality.
3. Perform chemical kinetics and predict order of reaction from the data.

4. Carry out analysis using volumetric methods. 5. Detect anions in the given inorganic mixture.			
Lectures per week (1 Lecture is 120 minutes)		**1**	
Total number of Hours in a Semester		**30**	
Credits		**1**	
Evaluation System	**Summative Assessment**	**2 Hours**	**50 marks**
	Continuous Assessment	**--**	

1.	**Principles of Chemical Calculations:** Expressing concentration of solutions: Normality, molarity, mole fractions, % composition (weight ratio, volume ratio, weight to volume ratio), ppm. (Numericals to be solved)
2.	**Calibration of glassware:** Burette, pipettes, standard flasks.
3.	**Volumetric Analysis:** 3.1 To prepare 0.1 N succinic acid and standardize the NaOH of two different concentrations. 3.2. To standardize commercial sample of HCl using borax and to write material safety data of the chemicals involved 3.3 To standardize commercial samples of NaOH using Potassium Hydrogen Phthalate and to write material safety data of the chemicals involved.
4.	**ThermoChemistry:** To determine enthalpy of dissolution of salt (like KNO_3, $CaCl_2$)
5.	**Chemical Kinetics:**To determine the rate constant for the hydrolysis of ester using HCl as catalyst.
6.	**Semi-micro inorganic qualitative analysis of a sample containing two anions.**(From amongst): CO_3^{2-}, S^{2--} ,SO_3^{2-}, NO_3^{-1-}, Cl^{-1--}, Br^{-1--}, I^{-1--}, SO_4^{2-} [4 mixtures]

ASSESSMENT DETAILS:

Continuous Assessment (CA): 50 marks

- 2 activities of 25 marks each
- An additional 25 mark activity will be held ONLY for those who missed any one or both of the 2 activities, due to valid reasons.

Summative Assessment (SA): 50 marks

- All units of the syllabus will be covered in SA and will be given equal weightage.
- An additional SA will be held for those who are absent, due to valid reasons, for the main/regular SA.

There is a single head of passing; a student must get 40 marks out of 100 marks to clear the course but under the condition that the learner has attended atleast one CA activities and SA. Student who fails will have to give an ATKT exam of 100 marks.

Practical Examination

- A 50 marks practical examination will be conducted at the end of the semester.
- Practical is a separate head of passing. The learner will have to get 20 out of 50 to pass the examination.

REFERENCES:

FOR THEORY

1. Physical chemistry by McQuarrie (ISBN no.1891389505)
2. Physical Chemistry by Peter Atkins, Julio de Paula and James Keeler (ISBN; 9780198769866)
3. Concise Inorganic Chemistry by J.D.Lee(ISBN 13:978-8126575547)
4. Inorganic Chemistry by D F Shriver and Peter Atkins
5. Organic Chemistry by Graham Solomons, Craig Fryhle(ISBN;9814-12-613-6)
6. Organic Chemistry by Jonathan, Clayden,Greeves Warren (ISBN:13) oxford-198503466
7. Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013

FOR PRACTICALS

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
2. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G.,
3. Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996

SOPHIA COLLEGE (AUTONOMOUS)

Programme: Sciences **Chemistry Major/ Minor**		**Semester – 2**	
Course Title: Fundamentals of Chemistry-2		**Course Code: SCHE122MJ/MN**	

COURSE OBJECTIVES:

1. To understand different laws applicable to gases.
2. To understand various concepts of chemical equilibrium and Le Chatelier's principle.
3. To understand concept of ionic equilibria, pH and buffers.
4. To understand the fundamental concepts of chemical bonding and reactivity.
5. To understand the stereochemistry and distinguish between the stereoisomers of the organic molecules.

COURSE OUTCOMES:

The learner will be able to:

1. Solve numericals based on gas laws.
2. Apply Le Chatelier's principle and identify different parameters required for optimization of chemical reaction.
3. Calculate equilibrium constants and pH of aqueous solution and buffer.
4. Interpret the shapes and structure of molecules on the basis of Sidwig Powell and VSEPR theories.
5. Identify and differentiate between the enantiomers, diastereoisomers, stereoisomers and geometrical isomers.

Lectures per week (1 Lecture is 60 minutes)		**3**	
Total number of Hours in a Semester		**45**	
Credits		**3**	
Evaluation System	**Summative Assessment**	**2 Hours**	**50 marks**
	Continuous Assessment	**--**	**50 marks**

UNIT 1 Physical Chemistry	**1.1 Ionic Equilibria (5L)**	1.1.1 Electrolytes (Strong, moderate and weak), degree of ionization,ionization constant, factors affecting degree of ionization and ionic product of water, dissociation constants of mono-, di- and triprotic acid (derivation for monoprotic acid only) 1.1.2 Buffers: pH scale, types of buffers, derivation of Henderson equation for acidic and basic buffers, buffer action, buffer capacity (Numericals expected wherever applicable)	15 hours
	1.2 Gaseous State (5L)	**1.2 Gaseous State: (5 L)** 1.2.1 Ideal gas laws, kinetic theory of gases, Maxwell-Boltzmann's distribution of velocities (qualitative discussion), ideal gases versus real gases, compressibility factor, Boyle's temperature 1.2.2 Deviation from ideal gas laws, reasons for deviation from ideal gas laws, Van der Waals' equation of state 1.2.3 Joule-Thomson effect: qualitative discussion and experimentation, inversion temperature. (Numericals expected wherever applicable)	
	1.3 Chemical Equilibria (5L)	1.3.1 Reversible and irreversible reactions, law of mass action, dynamic equilibria, equilibrium constant K_c and K_p, relationship between K_c and K_p, 1.3.2 Le Chatelier's principle, factors affecting chemical equilibrium (examples and special reference to Haber's process) 1.3.3 Catalysis: Effect on chemical equilibrium, types of catalysis (homogenous and heterogenous), mechanism of catalysis (adsorption theory). (Numericals expected wherever applicable)	
	2.1: Chemical Bond and Reactivity (8 L)	2.1.1 Types of chemical bonds, comparison between ionic and covalent bonds, polarizability (Fajan's Rule), shapes of molecules, Lewis dot structure, Sidgwick, Powell Theory 2.1.2 Introduction to VBT, VSEPR theory for AB_n type molecules with and without lone pair of electrons,	15 hours

		isoelectronic principle, applications and limitations of VSEPR theory	
UNIT 2 Inorganic Chemistry	**2.2 Comparative Chemistry of Main Group Elements: (7 L)**	2.2.1 Metallic and non-metallic nature, oxidation states, electronegativity, anomalous behaviour of second period lements, allotropy, catenation, diagonal relationship. 2.2.2 Comparative chemistry of carbides, nitrides, oxides and hydrides of group I and group II elements	
UNIT 3 Organic Chemistry	**3.1 Stereochemistry I (12 L)**	3.1.1 Symmetry elements, Asymmetric carbon. Classification of stereoisomers: enantiomers & diastereomers, chirality versus stereogenicity. 3.1.2 Representation 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. 3.1.3 Geometrical isomerism in alkene and cycloalkanes: cis–trans and syn-anti molecules 3.1.4 Nomenclature-relative and absolute configuration: D/L and R/S designations. with two(similar and dissimilar) chiral-centres, Diastereoisomers, meso structures, isomerism E/Z notations (as per C.I.P rules wherever applicable) 3.1.5 Conformation analysis of alkanes (ethane), relative stability with energy diagram 3.1.6 Optical activity, Specific Rotation, racemic mixture and resolution (methods of resolution not expected).	15 hours
	3.2 Introduction to aromaticity: (3 L)	3.2.1 Criteria for aromaticity (Hückel's rule), anti-aromaticity, aromatic character of arenes, cyclic carbocations /carbanions (examples using C3-C7 atoms) and heterocyclic compounds (examples with one hetero atom-O,N, S).	

SOPHIA COLLEGE (AUTONOMOUS)

Programme: Sciences **Chemistry Major/ Minor**	**Semester – 2**
PRACTICAL: **Fundamentals of Chemistry-2**	**Course Code: SCHE122MJP/MNP**

COURSE OUTCOMES:

The learner will be able to :

1. Analyse and identify cations from a given mixture of inorganic salts using semi micro techniques.
2. Analyse and quantify the given compound by redox titration and gravimetric analysis.

Lectures per week (1 Lecture is 60 minutes)		**2**	
Total number of Hours in a Semester		**30**	
Credits		**1**	
Evaluation System	**Summative Assessment**	**2 Hours**	**50 marks**
	Continuous Assessment	**--**	

1.	**Semi-micro inorganic qualitative analysis of a sample containing two cations** (From amongst): Pb^{2+}, Ba^{2+}, Ca^{2+}, Sr^{2+}, Cu^{2+}, Fe^{2+}, Ni^{2+},Zn^{2+},Mg^{2+}, Al^{3+} , K^{+},NH_4^{+} (Scheme of analysis to include sulphide scheme)[6 mixtures]
2.	**Concept 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. Rules for assigning oxidation number (Numericals to be solved). Balancing redox equations using the oxidation number method.
3.	**Redox Titrations** 3.1 To determine the amount of iron (II) present in a given sample by titration against a standard aqueous potassium dichromate 3.2 To calculate the concentration of KMnO4 present in a given sample by titration against oxalic acid.

4.	**Gravimetric analysis:** 4.1 To determine the percentage of sample of $BaSO_4$ containing NH_4Cl 4.2 To determine the percentage purity of ZnO containing $ZnCO_3$. 4.3 To determine the percentage of water of crystallization for hydrated crystalline salts ($CuSO_4$, $ZnSO_4$)
5.	**pH metry** 5.1 Preparation and determination of pH for a buffer. 5.2 To determine dissociation constant of weak acid (Ka) using Henderson's equation (using the method of incomplete titration pH metrically)

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- Practical is a separate head of passing. The learner will have to get 20 out of 50 to pass the examination.

REFERENCES:

FOR THEORY

Physical Chemistry
Physical Chemistry a Molecular Approach by McQuarrie Donald A. (second edition)
Further Reading
Physical Chemistry by Peter Atkins, Julio de Paula and James Keeler (eleventh edition)

Inorganic Chemistry
Concise Inorganic Chemistry by J.D.Lee (fifth edition)
Further reading:
Inorganic Chemistry by D F Shriver and Peter Atkins (fifth edition)

Organic Chemistry
Organic Chemistry by Graham Solomons, Craig Fryhle
Further reading
Organic Chemistry by Jonathan, Clayden,Greeves Warren
Organic Chemistry Mc Murry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013

FOR PRACTICALS

1. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
2. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G.,
3. Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996