

As Per NEP 2020

University of Mumbai



Syllabus of Minor Vertical 2 (Scheme – II)

Faculty of Science

Board of Studies in Chemistry

UG First Year Programme

Semester

II

Title of Paper

Credits 4

I) Basics in Physical, Inorganic and
Organic Chemistry I

2

II) Chemistry Practical 1

2

From the Academic Year

2025-2026

Syllabus
B.Sc. (Chemistry)
SEMESTER I

Course Name : Basics in Physical, Inorganic and Organic Chemistry I

Sr.No.	Heading	Particulars
1	Description the Course:	This program is designed to provide a basic understanding of Chemistry. The B.Sc (Chemistry) is framed to equip students with a basic theoretical foundation, practical skills, and critical thinking abilities necessary to address the challenges and opportunities in the diverse fields of the subject. There is continuous evaluation of students based on quizzes, class tests and assignments. Emphasis is given to conceptual understanding of theoretical concepts followed by inclusion of the same in practicals. B.Sc. (Chemistry) programme offers two majors, one minor, VSCs, SECs, IKS, AECs, OEs VEC and CC. After successful completion of the first year B.Sc. programme the learner will be awarded a UG Certificate in Chemistry.
2	Vertical:	Major
3	Type:	Theory and Practical
4	Credits:	Credits per Semester Theory: 2 Credits (1 Credit = 15 Hours for Theory) Practicals: 2 Credits (1 Credit = 30 Hours for Practical)
5	Hours Allotted:	Hours per Semester Theory: 30 Hrs. Practicals: 60 Hrs.
6	Marks Allotted:	Marks per Semester Theory: 50 Marks Practicals: 50 Marks
7	Course Objectives (CO):	
	CO 1.	To understand the basic concept of viscosity, preparation of solutions, kinetics, rate laws and determination of orders of reactions.
	CO 2.	To understand basic concepts of electrochemistry, thermodynamics and surface tension
	CO 3.	To comprehend the history of atomic structure, periodicity and properties of elements.
	CO 4.	To distinguish the qualitative methods for identification of inorganic compounds; types of chemical bonds in molecule/ compounds and theories.
	CO 5.	To develop critical thinking about different types of organic compounds and about stereochemical approach of organic compounds
	CO 6.	To develop understanding in organic reaction mechanisms, bonding and structure of organic compounds.
8	Course Outcomes (OC):	
	OC 1.	The learner will be able to learn concepts related to state of matter and different methods of concentration expressions and rate laws

	OC 2.	The learner will be able to acquire the knowledge related to electrochemistry, thermodynamics and surface tension
	OC 3.	The learner will be able to classify the elements on the basis of theory learnt and will understand the historical perspective of atomic structure.
	OC 4.	The learner will be able to identify different methods of qualitative analysis and various theories of chemical bonds.
	OC 5.	The learner will be able to identify the organic compounds on the basis of nomenclature and stereochemistry
	OC 6.	The learner will be able to exemplify different organic reaction mechanisms and hybridization involved in organic compounds.

9	Modules
----------	----------------

Semester	Paper	Module	Description	Credits
I	Paper I Basics in Physical, Inorganic and Organic Chemistry I	I	Physical Chemistry 1.1 Liquid State 1.2 Chemical Calculations 1.3 Chemical Kinetics	02
		II	Inorganic Chemistry 2.1 Atomic Structure 2.2 Periodic Table and Periodicity	
		III	Organic Chemistry 3.1 Classification and Nomenclature of Organic Compounds 3.2 Stereochemistry	
	Chemistry Practical 1		Practical Component	02

Basics in Physical, Inorganic and Organic Chemistry I

Module I	Physical Chemistry (10L)
1.1	Liquid State - I: (2L) Viscosity: Introduction, coefficient of viscosity, relative viscosity, specific viscosity, reduced viscosity, determination of viscosity by Ostwald viscometer
1.2	Chemical Calculations: (2L) Methods of expressing concentration of solutions: Normality, Molarity, Molality, Mole fractions, ppm, ppb. Preparation of solutions (Dilution). (Numerical problems expected wherever necessary)
1.3	Chemical Kinetics: (6L) 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 (Numerical problems expected wherever necessary).
Module II	Inorganic Chemistry (10L)
2.1	Atomic Structure: (3L) Historical perspectives of the atomic structure; J.J. Thomson Model, Rutherford's Atomic Model- alpha particle scattering experiment, Bohr's theory, Aufbau principle, Hund's rule of maximum multiplicity and Pauli exclusion principle

2.2	Periodic Table and Periodicity: (2L) Long form of Periodic Table: Classification for elements as main group, transition and inner transition elements. Periodicity in the Following Properties (5L) 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.)
Module III	Organic Chemistry (10L)
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.
3.2	Stereochemistry: (5L) Projection formulae: Flying Wedge projection, Fischer Projection, Newman and Sawhorse Projection formulae (erythro, threo isomers of tartaric acid and 2,3 - dichlorobutane) and their interconversions; Geometrical isomerism in alkene: cis-trans and syn-anti isomerism R/S nomenclature, E/Z notations with C.I.P rules. Conformational analysis of alkanes (ethane, and n-butane); Relative stability with energy profile diagrams

Chemistry Practical 1

Physical Chemistry

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

Inorganic Chemistry

1) Volumetric analysis

- a) To determine the strength of commercial acid sample (HCl).
- b) To estimate the content of Na_2CO_3 and NaHCO_3 in the given sample using double indicator.

2) 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 .

Organic Chemistry

- 1) Purification of organic compounds by recrystallization selecting suitable solvent (minimum 2 Organic compounds to be given)
(Students are expected to report a) Solvent for recrystallization. b) Percentage Yield and the melting points of the purified compound.)
- 2) Basic principles involved in characterization of Organic compound (minimum 4 Solid Organic compounds)
(Students should perform Preliminary Tests, Solubility Test, obtain melting point and recrystallize the compound with given solvent)

Syllabus of Minor	
Board of Studies in Chemistry	
UG First Year Programme	
Semester	II
Title of Paper	Credits 6
Paper I: Basics in Physical and Inorganic Chemistry II	2
Paper II: Basics in Organic and Inorganic Chemistry II	2
Practical: Chemistry Practical 2	2
From the Academic Year	2024-2025

Semester II	Paper I: Basics in Physical and Inorganic Chemistry II	I	Physical Chemistry 1.1. Gaseous State 1.2. Electrochemistry - I	02
		II	Physical Chemistry 2.1 Chemical Thermodynamics 2.2 Chemical Equilibria	
		III	Inorganic Chemistry 3.1 Periodicity 3.2 Concept of Qualitative Analysis	
	Paper II: Basics in Organic and Inorganic Chemistry II	I	Organic Chemistry 1.1. Fundamentals of Organic Reaction Mechanism 1.2. Chemistry of Aliphatic Hydrocarbons	02
		II	Organic Chemistry 2.1 Stereochemistry II 2.2 Aromatic Hydrocarbons	
		III	Inorganic Chemistry 3.1 Comparative Chemistry of Main Group Elements 3.2 Chemical Bond and Reactivity	
	Chemistry Practical 2		Practical Component	02

Syllabus Minor B.Sc. (Chemistry)

SEMESTER II

Paper I: Basics in Physical and Inorganic Chemistry II

Unit I	Physical Chemistry
1.1	Gaseous State (5L) 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 (5L) 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)
Unit II	Physical Chemistry
2.1	Chemical Thermodynamics (5L) 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), Second law of thermodynamics, concept of entropy, Physical significance of entropy. (Numerical problems expected wherever necessary)
2.2	Chemical Equilibria (5L) Concept of free energy, Helmholtz and Gibbs free energy, Variation of free energy with temperature and pressure, Spontaneity and Physical significance of free energy. Reversible and irreversible reactions, equilibrium constants (K_c and K_p), relationship between K_c and K_p . Thermodynamic derivation of equilibrium constant (Numerical problems expected wherever necessary)
Unit III	Inorganic Chemistry
3.1	Periodicity in the Following Properties (4L) 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.)
3.2	Concept of Qualitative Analysis: (6L) 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.

Paper II: Basics in Organic and Inorganic Chemistry II

Unit I	Organic Chemistry
1.1	Fundamentals of Organic Reaction Mechanism: (5L) Basic terms & concepts: Homolytic and Heterolytic fission with curly arrows with suitable examples. Electrophiles and Nucleophiles. 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)
1.2	Chemistry of Aliphatic Hydrocarbons a. Carbon - Carbon sigma bonds: (1L) Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig reaction b. Carbon - Carbon pi bonds (4L): Formation of alkenes and alkynes by elimination reactions: Mechanism of E1, E2, Saytzeff and Hofmann eliminations Reactions of alkenes: Electrophilic additions with mechanisms (Markownikoff / Anti Markownikoff addition), Ozonolysis, reduction (catalytic and chemical), syn- and anti-dihydroxylation (oxidation) Reaction of alkynes: Acidity, Electrophilic and Nucleophilic additions with mechanisms.
Unit II	Organic Chemistry
2.1	Stereochemistry II: (5L) Cycloalkanes and Conformational Analysis 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.
2.2	Aromatic Hydrocarbons: (5L) Aromaticity: Hückel's rule, anti-aromaticity, aromatic character of arenes and cyclic carbocations/carbanions with suitable examples. Electrophilic Aromatic Substitution: Halogenation, Nitration, Sulphonation and Friedel-Crafts alkylation/acylation with their mechanism, Directing effects of the groups.
Unit III	Inorganic Chemistry
3.1	Comparative Chemistry of Main Group Elements (4L) Metallic and non-metallic nature, oxidation states, electronegativity, anomalous behavior of second period elements, allotropy, catenation, diagonal relationship.
3.2	Chemical Bond and Reactivity: (6 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 AB_n type molecules with and without lone pair of electrons, applications and limitations of VSEPR theory.

Semester II Practical

Chemistry Practical 2

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 (K_a) using Henderson's equation and the method of incomplete titration pH metrically.
- 3) To determine enthalpy of dissolution of salt (KNO_3)
- 4) To standardize commercial sample of HCl using borax and to write material safety data of the chemicals involved.

Inorganic Chemistry

Qualitative analysis of simple salts: (3 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+} , Mg^{2+} , K^+ , NH_4^+

Anions (from amongst): CO_3^{2-} , SO_4^{2-} , NO_2^- , NO_3^- , Cl^- , Br^- , I^- , SO_4^{2-} , PO_4^{3-}

(Scheme of analysis should avoid use of sulphide ion in any form for precipitation/ separation of cations.)

Below are the representative mixture combinations, besides these any other combination will also be taken.

Probable mixture combination:

- 1) $MgSO_4 + KCl$
- 2) $CaCl_2 + KNO_3$
- 3) $CaCO_3 + Mg(NO_3)_2$
- 4) $BaSO_4 + NH_4Cl$

Paper II

Organic Chemistry

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)

Inorganic Chemistry

Qualitative analysis of complex salts (3 mixtures to be analyzed)

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

Anions (from amongst): CO_3^{2-} , SO_4^{2-} , NO_2^- , NO_3^- , Cl^- , Br^- , I^- , SO_4^{2-} , PO_4^{3-}

(Scheme of analysis should avoid use of sulphide ion in any form for precipitation/ separation of cations.)

Below are the representative mixture combinations, besides these any other combination will also be taken.

Probable mixture combination:

- 1) $MnSO_4 / MnCl_2 + NH_4Cl$
- 2) $PbSO_4 / PbCl_2 + KCl / KNO_3$
- 3) $Cu(NO_3)_2 / CuSO_4 + ZnCl_2 / Zn(NO_3)_2$
- 4) $NiSO_4 / NiCl_2 + CrCl_2 + CrSO_4$

10. Reference Books:

Physical Chemistry

- 1) Concise Graduate Chemistry – I, II, III & IV, University Text Book of Chemistry, University of Mumbai.
- 2) Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 10th Ed., Oxford University Press (2014).
- 3) Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
- 4) Keith J. Laidler & John H. Meiser, Physical Chemistry, 2nd Ed. (2004)
- 5) Puri B. R., Sharma L. R. & Pathania M. S. Principles of Physical Chemistry, Vishal Publishing Company, 2008
- 6) Ball, D. W. Physical Chemistry Thomson Press, India (2007).
- 7) Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
- 8) Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.*, Prentice-Hall (2012).
- 9) McQuarrie, D. A. & Simon, J. D. *Molecular Thermodynamics* Viva Books Pvt. Ltd.: New Delhi (2004).
- 10) Levine, I. N. *Physical Chemistry* 6th Ed., Tata Mc Graw Hill (2010).
- 11) Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry, University of Mumbai.
- 12) Athawale, V. D. & Mathur, P. *Experimental Physical Chemistry* New Age International: New Delhi (2001).
- 13) Khosla, B. D.; Garg, V. C. & Gulati, A. *Senior Practical Physical Chemistry*, R. Chand & Co.: New Delhi (2011).
- 14) Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. *Experiments in Physical Chemistry 8th Ed.*; McGraw-Hill: New York (2003).
- 15) Halpern, A. M. & McBane, G. C. *Experimental Physical Chemistry 3rd Ed.*; W.H. Freeman & Co.: New York (2003).

Inorganic Chemistry

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
6. Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry, University of Mumbai.
7. Mendham, J., A. I. Vogel's *Quantitative Chemical Analysis 6th Ed.*, Pearson, 2009.
8. Advanced Inorganic Chemistry, 17th Edition, by Satyaprakash, G.D.Tuli and R. D. Madan, 2022.

Organic Chemistry

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, Snyder, 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
13. Organic Chemistry: A problem solving approach by Lakshmi Ravishankar and Gomathi Shridhar, Narosa Publisher, 2023.
14. Laboratory Experiments in Chemistry I & II, University Practical Book of Chemistry, University of Mumbai.
15. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
16. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
17. 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.

**QUESTION PAPER PATTERN
(External and Internal)**

Evaluation Pattern for Minor Theory Course

Minor: 4 credits

Semester I

Theory/Practical	Credits	No. of Hours	Marks
Theory: M3-1: Basics in Physical, Inorganic and Organic Chemistry I	2	30	50
Practical: M3CHP1: Chemistry Practical 1	2	60	50

Semester II

Minor: 6 credits

Theory/Practical	Credits	No. of Hours	Marks
Theory: Paper I: Basics in Physical and Inorganic Chemistry II	2	30	50
Theory: Paper II: Basics in Organic and Inorganic Chemistry II	2	30	50
Practical: Chemistry Practical 2	2	60	50

Evaluation Pattern for semester I and II:

Theory Paper

Internal Continuous Assessment: 40% (20 Marks)	Semester End Examination: 60% (30 Marks)	Duration for End semester examination
Continuous Evaluation through: Quizzes, Class Tests, Presentations, Projects, Role Plays, Creative Writing, Assignments, etc.	As per paper pattern	1 hr.

Paper Pattern for 30 Marks:

Semester End Theory Examination:

1. Duration - These examinations shall be of **one hour** duration.
2. Theory question paper pattern:
 - a. There shall be **03** questions each of **10 marks** on each unit
 - b. All questions shall be compulsory with internal choice within the questions.

Question	Option	Marks	Questions Based on
Q.1	A) Objective questions 4 out of 6	04	Module I
	B) Subjective questions 2 out of 3	06	
Q.2	A) Objective questions 4 out of 6	04	Module II
	B) Subjective questions 2 out of 3	06	
Q.3	A) Objective questions 4 out of 6	04	Module III
	B) Subjective questions 2 out of 3	06	
Total		30	

Evaluation Pattern for Minor Practical Course

Internal Continuous Assessment: 40% (20 Marks)	Semester End Examination: 60% (30 Marks)	Duration for End Semester Examination:
Viva / Assignments / Objective Question Tests (15 Marks), Overall Performance (5 Marks) = 20 Marks	One experiment (25 marks for experiment and 5 Marks for Journal = 30 Marks)	3 hr.

PRACTICAL BOOK/JOURNAL

The students are required to perform 75% of the Practical for the journal to be duly certified. The students are required to present a duly certified journal for appearing at the practical examination, failing which they will not be allowed to appear for the examination.

Sd/-
Sign of
Dr. Sunil Patil
Coordinator,
Board of Studies in
Chemistry

Sd/-
Sign of
Dr. Madhav R. Rajwade
Offg. Associate Dean
Faculty of Science &
Technology

Sd/-
Sign of
Prof. Shivram S. Garje
Offg. Dean
Faculty of Science &
Technology