Karmaveer Bhaurao Patil University, Satara

Syllabus for

B. Sc. I Chemistry

Under

Faculty of Science and Technology

(As per NEP 2020)

With effect from Academic Year 2024-2025

1. **Title:**B.Sc. Chemistry

2. **Year of Implementation:**2024-2025

3. Preamble: This syllabus is prepared for first year undergraduate students. At this level, to develop their interest towards chemistry as basic science and also to prepare them for the academic and industrial exposure simultaneously. Introduction of instrumental techniques with the regular chemistry exercises will help to enhance analytical thinking of the students. The interdisciplinary approach with vigor and depth is compatible to the syllabi of other universities, at the same time is not rigid for the students at first year of their graduation. The units in the syllabus are well defined with scope and the number of lectures. The references are mentioned with relevance.

4. General Objectives of the Course:

1. To develop the content of the syllabus according to the UGC norms.
2. To inculcate fundamental principles of chemical sciences in students.
3. To establish the link between theory and laboratory practice by conducting laboratory experiments which help students to improve the understanding of the concepts.
4. To enhance student's sense of enthusiasm for chemistry and to involve them in an intellectually stimulating experience of learning in a supportive environment.

5. Duration: One year

6. Pattern: Semester

7. Medium of Instruction: English

8. Structure of Course:

Level	Sem	Course I		Course II		Course III		OE / IKS/ VEC			Total
								OE	IKS	VEC	
		T	P	T	P	T	P				
4.5	I	4	2	4	2	4	2	2	2	-	22
	II	4	2	4	2	4	2	2	-	2	22

Subject	Sem	Name of Major Papers	Open Elective Course (OE)	Indian Knowledge System (IKS) and Value Education Course (VEC)
Chemistry (Level 4.5)	I	1) BCT 111: Physical Chemistry 2) BCT 112: Inorganic Chemistry BCP 113-Practical I	BCTOE-1	BCT IKS-1 (Generic)
	II	3) BCT 121: Organic Chemistry 4) BCT 122: Analytical Chemistry BCP 123-Practical II	BCTOE- 2	BCTVEC-1 Democracy, Election and Indian Constitution

Semester	Theory Course Credits 4		Practical Course (Semester Wise) Credits 2
I	Course Code: BCT-111 Course I- Physical Chemistry	Course Code: BCT-112 Course II- Inorganic Chemistry	Course Code: BCP 113: Lab I
II	Course Code: BCT-121 Course III- Organic Chemistry	Course Code: BCT-122 Course IV- Analytical Chemistry	Course Code: BCP 123: Lab II

Structure and Titles of Major Course

Semester I

Course I : Physical Chemistry (BCT 111)

Subject	Unit No.	Title	Hrs.	Credits
Physical Chemistry	I	Chemical Thermodynamics	**08**	**2**
	II	Chemical Equilibria	**08**	
	III	Chemical Kinetics	**08**	
	IV	Kinetic Theory of Gases	**06**	
Grand Total			**30**	

Course II: Inorganic Chemistry (BCT 112)

Subject	UnitNo.	Title	Hrs.	Credits
Inorganic Chemistry	I	Quantum Chemistry and Atomic Structure	**08**	**2**
	II	Ionic Bonding	**08**	
	III	Covalent Bonding	**08**	
	IV	Molecular Orbital Theory (MOT)	**06**	
Grand Total			**30**	

Semester II

Course III: Organic Chemistry (BCT-121)

Subject	UnitNo.	Title	Hrs.	Credits
Organic Chemistry	I	Reactive Intermediates	**08**	**2**
	II	Stereochemistry	**08**	
	III	Chemistry of Aliphatic Hydrocarbon	**08**	
	IV	Chemistry of Aromatic Hydrocarbons	**06**	
Grand Total			**30**	

Course IV: Analytical Chemistry (BCT122)

Subject	UnitNo.	Title	Hrs.	Credits
Analytical Chemistry	I	Introduction to Physico-chemical Principles	**08**	**2**
	II	Purification and Separation Methods	**08**	
	III	Introduction to Chromatography	**08**	
	IV	Theory of Titrimetric Analysis	**06**	
Grand Total			**30**	

	B. Sc. Part I, Semester I	
Credits 2	**Course I: Physical Chemistry** **Course Code: BCT 111**	**No. of Hrs. 30**
	Course Objectives: Students should be able to… 1. Understand the basic concepts in thermodynamics. 2. Learn principle behind the chemical equilibrium. 3. Recall the knowledge of rates of chemical reactions. 4. Study the properties of ideal and non-ideal gases.	
Unit No.	**Title and Syllabus**	**Hrs. Allotted**
I	**Chemical Thermodynamics:** 1.1 Introduction, Basic Terms 1.2 Spontaneous and non-spontaneous process with examples, Statement of Second law of Thermodynamics, Carnot's cycle, its efficiency, Carnot's Theorem (Heat engine) 1.3 Concept of entropy, physical significance of entropy. Entropy as a function of volume and temperature, pressure and temperature, entropy of mixing of gases, entropy change accompanying phase transition 1.4 Third law of thermodynamics 1.5 Numerical problems	**08**
II	**Chemical Equilibria:** 2.1 Concept of free energy, Free energy change in chemical reaction 2.2 Thermodynamic derivation of law of chemical equilibrium 2.3 Distinction between ΔG and ΔG^0, Le Chatelier's principle, conditions for maximum yield in industrial processes like manufacture of ammonia and sulphuric acid 2.4 Relationship between K_p, K_c and K_x for reactions involving ideal gases	**08**
III	**Chemical Kinetics:** 3.1 Introduction, Rate of reaction, Definition and units of rate constant, Factors affecting rate of reaction(nature of reactant, concentration, pressure, temperature and catalyst) 3.2 Order and Molecularity of reaction, Zero order reaction, First order reaction, Characteristics, Examples 3.3 Pseudo-unimolecular reactions, Examples 3.4 Second order reaction:Derivation of rate constant for equal and unequal concentration of thereactants, Characteristics, Examples 3.5 Determination of order of reaction by i) integration method ii) graphical method iii) Half-life method	**08**
IV	**Kinetic Theory of Gases:** 4.1Postulates of Kinetic Theory of Gases 4.2 Ideal and Non ideal gases, Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation 4.3 Van der Waals equation of state for real gases. Explanation of real gas behavior by Van der Waal's equation, Boyle temperature (derivation not required)	**06**

	4.4 Critical Phenomena: PV-isotherms of real gases (Andrew's isotherms), Continuity of state, Critical constants and their calculation from Van der Waals equation 4.5 Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation), Numerical Problems	
	Course Outcomes: After completion of the course students will be able to… 1. Relate the laws of thermodynamics with real life examples. 2. Derive relationship between various equilibrium constants. 3. Illustrate and derive the rate constant of various reactions. 4. Differentiate between ideal and non-ideal behavior of gases.	
	References: 1. PuriB.R., Sharma,L.R., PathaniaM.S. 2020. Principles of Physical Chemistry: Vishal Publishing Company. 2. Soni P. L., Dharmrha O. P., Dash U. N. 2011. Text Book of Physical Chemistry: Sultan Chand and Sons. 3. Bahl Arun, Bahl B. S., Tuli G. D. 2020. Essential of Physical Chemistry: S. Chand. and Company Ltd. 4. Rao, C. N. R. 2009. University General Chemistry -An Introduction to Chemical Science: New Delhi, Macmillan.	

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Credits 2	Course II: Inorganic Chemistry Course Code: BCT – 112	No. of Hrs. 30
	Course Objectives: Students should be able to… 1. Learn basic principles and theories of atomic structure. 2. Recall the concept of bonding in ionic compounds. 3. Acquire the knowledge of theories of covalent compounds. 4. Recite the information of bonding in homo and hetero diatomic molecules.	
Unit No.	**Title and Syllabus**	**Hrs. Allotted**
I	**Introduction to Quantum Chemistry & Atomic Structure:** 1.1 Black Body radiation, Photoelectric effect, Compton Effect 1.2 Plank's theory, De-Broglie's relationship 1.3 Bohr's theory of hydrogen atom, Hydrogen spectrum 1.4 Wave theory, Heisenberg's uncertainty principal 1.5 Atomic orbitals & Quantum numbers 1.6 Pauli's exclusion principle, Hund's multiplicity rule, Aufbau principle, Electronic configuration of elements.	**08**
II	**Ionic Bonding:** 2.1 Definition, General Characteristics of ionic bonding, Formation of ionic bonds 2.2 Energetics of ionic bond formation statement of Born-Lande equation for calculation of lattice energy 2.3 Born– Haber cycle & it's applications 2.4 Fajan's rules, Radius ratio, Radius ratio effects & calculation of radius ratio for octahedral geometry 2.5 Structure of NaCl, Rutile (TiO_2)	**08**
III	**Covalent Bonding:** 3.1 VBT approach 3.2Valence shell electron pair repulsion theory (VSEPR) 3.3VSEPR approach, assumptions, examples and limitations	**08**
IV	**Molecular Orbital Theory (MOT):** 4.1Introduction to LCAO method 4.2 Formation of bonding, anti-bonding & non-bonding molecular orbitals 4.3 Conditions for successful overlaps 4.4 Types of overlaps, Energy level sequence for molecular orbitals when n = 1 & n = 2 4.5 Bond order & it's significance, Molecular orbital diagrams for– a. Homo nuclear diatomic molecules – He_2, B_2, N_2, O_2, O_2^+ b. Hetero nuclear diatomic molecules – CO, NO, NO^+ 4.6 Comparison between VBT &MOT	**06**

	Course Outcomes: After completion of the course students will be able to… 1. Draw electronic configuration of each element on the basis of fundamental principles. 2. Elucidate the structures of ionic compounds. 3. Describe the various theories related to covalent bonding in inorganic compounds. 4. Compare between the theories like VBT and MOT.	
	References: 1. Puri, Sharma & Kalia. 2020. Principles of Inorganic Chemistry: Vishal Publishing Co. 2. Chanda Manas. 2019. Atomic Structure and Chemical Bonding: International Publishing House Pvt. Ltd. 3. Prasad, R. K. 2009. Quantum Chemistry: New Age Science. 4. Huheey James, Keiter Allen, Keiter Richard, Medhi Okhil. 2014. Inorganic Chemistry, Principles of Structure and Reactivity: Pearson Education. 5. Madan, R. D. 1987. Modern Inorganic Chemistry: S. Chand Ltd. 6. Lee J. D. 2008. Concise Inorganic Chemistry 5th Edition: Wiley India Pvt. Ltd.	

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Credits 2	Practical Course Major Lab I BCP - 113	No. of Hrs. 60
	Course Objectives: Students should be able to… 1. Study the enthalpy of neutralization. 2. Learn the preparation of buffer solutions. 3. Study the rate of first order and second order reactions. 4. Gain the knowledge of equivalent weight determination by hydrogen displacement method.	
	Section I - Physical Chemistry Experiments	
	1. Determination of Enthalpy of neutralization of hydrochloric acid with sodium hydroxide. 2. Determination of heat of ionization of weak acid by using polythene bottle. 3. Preparation of Buffer solutions. I) Sodium Acetate –Acetic Acid and Ammonium chloride – Ammonium hydroxide II) Measurement of pH of buffer solution & comparison of values with theoretical values 4. Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos & soaps using pH meter. 5. Chemical Kinetics: To study the hydrolysis of methyl acetate. 6. Chemical Kinetics: To investigate the reaction between $K_2S_2O_8$ and KI with equal initial concentration of reactants. (Plotting of graph). 7. Equivalent weight: To determine equivalent weight of metal (Mg) by hydrogen displacement method using Eudiometer.	
	Course Outcomes: After completion of the experiments students will be able to… 1. Determine the enthalpy of neutralization. 2. Measure the pH of aerated drinks and buffer solutions. 3. Calculate rate constant of first order and second order reaction. 4. Calculate the equivalent weight of metal Mg.	
	Section II - Inorganic Chemistry Experiments	
	Course Objectives: Students should be able to… 1. Study the principle of gravimetric analysis. 2. Gain knowledge and analytical skills of titrimetric analysis.	
	8. Quantitative Analysis: Gravimetric Analysis (volatilization gravimetric analysis) Binary Mixture 1) $NH_4Cl + BaSO_4$ 2) $ZnO + ZnCO_3$ 9. Volumetric Analysis: 1. Preparation of standard 0.1 N $KMnO_4$ solution and determine the strength of given oxalic acid solution. 2. Determine quantity of Fe (II) ions from the given solutions by titrating with 0.1 N $K_2Cr_2O_7$ solutions by using internal indicator. 3. Estimation of amount of Acetic acid from the given vinegar sample by titrimetric method.	

	10. Preparation of $CuSO_4$ from $CuCl_2$.	
	Course Outcomes: After completion of the experiments students will be able to… 1. Determine the weight of inorganic components by gravimetric analysis. 2. Get expertise in quantitative estimation using titrimetric method.	
	References: 1. Sindhu, P. S. 2006.Practical in Physical Chemistry A Modern Approach: Macmillan Publication. 2. Khosla, B. D., Garg V. C., Gulati A. 2018. Senior Practical Physical Chemistry: R. Chand and Co. 3. Athawale V. D., Mathur P. 2001. Experimental Physical Chemistry: New Age International Private Ltd. 4. Findlay Alexander. 2015. Experimental Physical Chemistry-Scholar's Choice Edition: Creative Media Partners, LLC. 5. Vogel Arthur. 1989. Vogel's Text Book of Quantitative Analysis: Longman. 6. Vogel Arthur, Bassett John. 1980. A Text Book of Quantitative Inorganic Analysis Including Elementary Instrumentation Analysis: Longman Sc and Tech.	

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B. Sc. Part I, Semester II		
Credits 2	**Course III: Organic Chemistry Course Code: BCT 121**	**No. of Hrs. 30**
	Course Objectives: Students should be able to… 1. Learn the various reactive intermediates formed in chemical reactions. 2. Study the different stereoisomerism phenomenon. 3. Recall the knowledge of aliphatic hydrocarbons. 4. Define the principles of aromaticity.	
Unit No.	**Title and Syllabus**	**Hrs. Allotted**
I	**Reactive Intermediates:** 1.1 Introduction, Characteristics of reactive intermediates 1.2 Carbocation-Structure, stability, preparation methods and chemical reactions 1.3 Carbanion- Structure, stability, preparation methods and chemical reactions 1.4Carbon free radical-Structure, stability, preparation methods and chemical reactions 1.5 Carbene- Structure, stability, preparation methods and chemical reactions 1.6 Nitrene- Structure, stability, preparation methods and chemical reactions 1.7 Arynes- Structure, stability, preparation methods and chemical Reactions	**08**
II	**Stereochemistry:** 2.1 Introduction, types of stereoisomerism 2.2 Elements of Symmetry, Chiral and achiral compounds 2.3 Optical isomerism in tartaric acid, 2,3-dihydoxy butanoic acid, enantiomerism and diastereomerism 2.4 Gometrical isomerism: Geometrical isomerism in aldoxime & ketomixes, configuration of aldoximes & ketoximes 2.5 Nomenclature of stereoisomerisms DL, CIP rules: R/S, E and Z (cis trans), erythro and threo	**08**
III	**phatic Hydrocarbons:** 3.1 Introduction, Classification of aliphatic hydrocarbons 3.2 Alkanes: preparation methods and chemical reactions 3.3 Alkenes: Preparation methods and chemical reactions 3.4 Alkynes: Preparation methods and chemical reactions	**08**

IV	**Chemistry of Aromatic Hydrocarbons:** 4.1 Introduction to homocyclic and polycyclic aromatic hydrocarbons: benzene, naphthalene, anthracene 4.2 Meaning of important terms; aromatic, non aromatic, anti aromatic compounds 4.3 Huckel's rules and its applications 4.4 Aromatic electrophilic substitution reactions, effect of substitution Groups, General mechanism of electrophilic substitution reactions 4.5 Aromatic nucleophilic substitution (addition –elimination), orientation, activating & deactivating groups	**06**
	Course Outcomes: After completion of the course students will be able to… 1. Identify the structure and stability of various reactive intermediates. 2. Prepare 3D-models ie. stereoisomers of organic molecules. 3. Differentiate between saturated and unsaturated hydrocarbons. 4. Classify the organic compounds as aromatic, anti-aromatic and non-aromatic.	
	References: 1. Morrison Robert, Boyd Robert. 1998. Organic Chemistry: Prentice Hall. 2. Sykes Peter. 2003. A Guidebook to Mechanism in Organic Chemistry: Pearson Education. 3. Mukharji S. M., Singh S. P., Kapoor R. P., Dass R. 2017. Organic Chemistry-As per UGC Syllabus: New Age International Publishers. 4. Eliel Ernest, Welen Samual. 1994. Stereochemistry of Carbon Compounds: Wiley India Ed^{n}. 5. Kalsi P. S. 2017. Stereochemistry: Conformation & Mechanism: New Age International Publishers. 6. Bansal Raj. 2016. A Text books of Organic Chemistry: New Age International Publishers. 7. Ahluwalia V. K., Parashar Rakesh. 2010. Organic Reaction Mechanism: Narosa Publishing House.	

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Credits 2	Course IV:Analytical Chemistry Course Code: BCT 122	No. of Hrs. 30
	Course Objectives: Students should be able to… 1.Define physico-chemical principles of analytical chemistry. 2.Gain knowledge of separation techniques of solids and liquids. 3. Know the technical idea of separation of components from their mixtures by chromatography. 4. Remember the theories behind titrimetric analysis.	
Unit No.	**Title and Syllabus**	**Hrs. Allotted**
I	**Introduction to Physico-chemical Principles:** 1.1 Strong and weak electrolytes 1.2 Degree of Ionization, Factors affecting degree of ionization, Ionization constant and ionic product of water. Ionization of weak acids & bases, Common Ion effect 1.3 pH scale, Buffers, types of buffer 1.4 Solubility & solubility product of sparingly soluble salt 1.5 Numerical problems	**08**
II	**Purification and Separation Methods:** 2.1 Distillation techniques, Distillation of liquid mixtures 2.2 Types of columns and packing, Condensers, Vacuum distillation, Spinning-band distillation, Steam distillation, Keigelrohr distillation, Isopiestic or isothermal distillation 2.3 Recrystallization Techniques 2.4 Filtration, Choice of solvents, Petroleum ethers, Mixed solvents 2.5 Sublimation	**08**
III	**Introduction to Chromatography:** 3.1 Introduction, Basic Principle of Chromatography, Basic terms 3.2 Classification of Chromatography, Paper Chromatography-Principle, Methodology-types of papers and treatment, sample loading, choice of solvent, development-ascending, descending, circular, location of spots, determination of R_f value, Applications, Advantages and disadvantages 3.3 Thin layer chromatography; Principle, Solvent system, stationary phases, preparation of TLC plate, Detecting reagents, methodology-sample loading, development, detection of spot, R_f value, Applications, Advantages and disadvantages 3.4 Comparison of Paper Chromatography and TLC	**08**

IV	**Theory of Titrimetric Analysis:** 4.1 Definition of Terms: Titrand, Titrant, Equivalence Point, titration, indicator 4.2 Theory of Acid-Base Titration 4.3 Theory of Acid-Base Indicators 4.4 Titration of Strong Acid-Strong Base, Strong Acid-Weak Base, Weak Acid-Weak base with titration curves, Choice of Indicators	**06**
	Course Outcomes: After completion of the course students will be able to… 1. Explainthe physico-chemical principles of basic chemical analysis. 2. Purify the solid and liquid compounds by separation techniques. 3. Differentiate between chromatographic techniques. 4. Describe the terms involved in titrimetric analysis and sketch the titration curves.	
	References: 1. Dahm Donald, Nelson Eric. 2012. Calculation in Chemistry: W. W. Norton & Company. 2. Rao C. N. R. 2015. University General Chemistry -An Introduction to Chemical Science: Laxmi Publications. 3. Soni P., Dharmarha O., Dash U. 2011. Text book of Physical Chemistry: Sultan Chand and Son. 4. Bassett J., Denney R. C., Jeffary G. H., Medha J., 1994. Vogels Textbook of Quantitative Inorganic Analysis: Longman Higher Education. 5. Chatwal Gurdeep, Anand Shyam. 2016. Instrumentation Methods of Chemical Analysis: Himalaya Publishing House. 6. Sharma B. K. 2000. Industrial Chemistry: Goel Publishing Housing.	

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Credits 2	Practical Course Major Lab II BCP - 123	No. of Hrs. 60
	Course Objectives: Students should be able to… 1. Study the volumetric estimation of compound quantitatively. 2. Determine the functional groups of molecules by qualitative analysis. 3. Gain the knowledge of preparation of derivatives of organic compounds.	
	Section I - Organic Chemistry Experiments	
	1. Volumetric Analysis: Estimation of Aspirin. 2. Estimation of Acetamide/Aniline. 3. Organic Qualitative analysis of organic compounds like Benzoic acid, alpha naphthol, aniline, acetone, ethyl acetate, acetanilde, urea, thiourea. 4. Preparations of derivatives of organic compounds i) Nitration ii) Oximes of aldehydes & ketones iii) 2,4-dinitropherylhydrazone of aldehydes & ketones iv) Picrate v) Oxalate	
	Course Outcomes: After completion of the experiments students will be able to… 1. Quantify the organic compounds using volumetric estimation. 2. Identify organic compounds using qualitative analysis. 3. Prepare the derivatives of organic compounds.	
	Section II –Analytical Chemistry Experiments	
	Course Objectives: Students should be able to… 1. Study the principles of chromatographic separation of elements from binary mixture. 2. Learn the purification techniques of solid and liquid compounds.	
	5. Separation and identification of cation by paper chromatographic technique from the following mixtures i) Ni^{2+} + Cu^{2+}, ii) Ni^{2+} + Co^{2+},iii) Cu^{2+} +Co^{2+} 6. Identify & separate mixture of amino acids / sugar by paper chromatography. 7. Purification of compounds by crystallization using suitable solvents (Any two). 8. Purification of compounds by sublimation (Any two). 9. Purification of compounds by distillation (Any two).	
	Course Outcomes: After completion of the experiments, students will be able to: 1. Isolate and identify the metal ions from the inorganic binary mixture. 2. Recrystallize the impure compounds to pure one. 3. Distillate volatile organic solvents. 4. Purify the solid compounds by sublimation.	

	References: 1. Vogel Arthur. 1989. Vogel's Text Book of Quantitative Analysis: Longman. 2. Vogel Arthur, Bassett John. 1980. A Text Book of Quantitative Inorganic Analysis Including Elementary Instrumentation Analysis: Longman Sc and Tech. 3. Pandey O. P., Bajpay D. N., Giri S. 2010. Practical Chemistry: For B. Sc. I, II and III Year Students of AllIndiaUniversities: S Chand. 4.VenkateswaranV. 2012. Basic Principles of Practical Chemistry: Sultan Chand and Sons.	

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