Rayat Shikshan Sanstha's

Yashavantrao Chavan Institute of Science, Satara

(Autonomous)

(Lead College, Karmaveer Bhaurao Patil University, Satara)

Department of Chemistry

B. Sc. I Syllabus

(As per NEP 2020)

w.e.f. June 2023

1. Title: B. Sc. Chemistry

2. Year of Implementation: 2023-2024

3. Preamble: This updated 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	Subject -1 Major				Subject -2 Minor		Subject -3 GE/OE		VSEC		AEC, VEC, IKS			CC	Total
		DSC		DSE						VSC	SEC	AEC	VEC	IKS		
		T	P	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	Name of Minor Papers	Open Elective Programs For Others (Chemistry for Everyday Life)	Indian Knowledge System (IKS)	Co-curricular (CC)	Skill Enhancement Course (SEC)	Value Education Course (VEC)
Chemistry (Level 4.5)	I	1) BCT 111: Physical Chemistry	1) BCT 114: Mathematics for Chemist	1) BCT 117: Molecules of Life	IKS 101: Indian Textiles	CC 102: NCC/NSS/ Sports/ Cultural		
		2) BCT 112: Inorganic Chemistry	2) BCT 115: Chemistry of Periodic Table	2) BCT 118: Domestic Chemicals				
		BCP 113	BCP 116	BCP 119				
	II	3) BCT 121: Organic Chemistry	3) BCT 124: Fundamental Organic Chemistry	3) BCT 127: Chemistry in Cosmetics			SEC 103: Laboratory Safety Measurements	VEC 104: Digital Technological Solutions for Society
		4) BCT 122: Analytical Chemistry	4) BCT 125: Basic Analytical Chemistry	4) BCT 128: Chemistry For Health				
		BCP 123	BCP 126	BCP 129				

Semester	Theory Course (Major) 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	Unit No.	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	Unit No.	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 (BCT 122)

Subject	Unit No.	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 the reactants, 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:** 4.1 Postulates 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) 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	**06**
	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. Puri B.R., Sharma, L.R., Pathania M.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 3.2 Valence shell electron pair repulsion theory (VSEPR) 3.3 VSEPR approach, assumptions, examples and limitations	**08**
IV	**Molecular Orbital Theory (MOT):** 4.1 Introduction 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 1.4 Carbon 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	**Chemistry of Aliphatic 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. Explain the 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 All India Universities: S Chand. 4. Venkateswaran V. 2012. Basic Principles of Practical Chemistry: Sultan Chand and Sons.	

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Semester	Theory Course (Minor) Credits 4		Practical Course (Semester Wise) Credits 2
I	Course Code: BCT-114 Course I- Mathematics for Chemist	Course Code: BCT-115 Course II- Chemistry of Periodic Table	Course Code: BCP 116: Lab I
II	Course Code: BCT-124 Course III- Fundamental Organic Chemistry	Course Code: BCT-125 Course IV- Basic Analytical Chemistry	Course Code: BCP 126: Lab II

Structure and Titles of Minor Course

Semester I

Course I : Mathematics for Chemist (BCT 114)

Subject	Unit No.	Title	Hrs.	Credits
Mathematics for Chemist	I	Units and Conversions	**08**	**2**
	II	Concentration Units	**08**	
	III	Chemical Mathematics	**08**	
	IV	Calculations Based on Chemical Equations	**06**	
Grand Total			**30**	

Course II: Chemistry of Periodic Table (BCT 115)

Subject	Unit No.	Title	Hrs.	Credits
Chemistry of Periodic Table	I	Introduction to Periodic Table	**08**	**2**
	II	Orbital Hybridization	**08**	
	III	Chemistry of Metals	**08**	
	IV	Chemistry of Non-metals	**06**	
Grand Total			**30**	

Semester II

Course III: Fundamental Organic Chemistry (BCT-124)

Subject	Unit No.	Title	Hrs.	Credits
Fundamental Organic Chemistry	I	Fundamentals of Organic Reaction Mechanism	**08**	**2**
	II	Alcohols, Phenols and Ethers	**08**	
	III	Aldehydes, Ketones and Carboxylic Acids	**08**	
	IV	Cycloalkanes, Cycloalkenes and Alkadienes	**06**	
Grand Total			**30**	

Course IV: Basic Analytical Chemistry (BCT 125)

Subject	Unit No.	Title	Hrs.	Credits
Basic Analytical Chemistry	I	Scope and Importance of Analytical Chemistry	**08**	**2**
	II	Laboratory Reagents	**08**	
	III	Laboratory Equipments and Their Uses	**08**	
	IV	Analytical Approaches	**06**	
Grand Total			**30**	

	B. Sc. Part I, Semester I	
Credits 2	**Course I: Mathematics for Chemist** **Course Code: BCT 114**	**No. of Hrs. 30**
	Course Objectives: Students should be able to… 1. Understand the basic units used in Chemistry. 2. Learn the various concentration units. 3. Study the use of mathematical concepts required for Chemistry. 4. Acquire the knowledge of chemical calculations and balancing equations.	
Unit No.	**Title and Syllabus**	**Hrs. Allotted**
I	**Units and Conversions:** 1.1 Introduction, General Requirements 1.2 SI Units 1.3 CGS Unit 1.4 Conversions-Rounding procedure and practice 1.5 Conversion Factors	**08**
II	**Concentration Units:** 2.1 Solute and Solvent, Polar, Non-polar, Protic, Aprotic, Aqueous, Non-Aqueous solvents, Acidic, Basic, Amphiprotic, Neutral solvents, Acidity of base, Basicity of acid 2.2 Methods of expressing the concentration of solutions on volume and weight basis-Normality, Morality, Molality, Formality, Mole Fraction 2.3 Numerical Problems involving preparations of standard solutions, dilution of solutions 2.4 Percent composition, part per million (ppm), part per billion (ppb), parts per trillion (ppt) calculations	**08**
III	**Chemical Mathematics:** 3.1 Functions and variables 3.2 Derivative -Rules of differentiation, examples, problems related to chemistry 3.3 Integration-Rules of integration, problems related to chemistry 3.4 Graph: Plotting graphs of linear, exponential and logarithmic functions and their characteristics	**08**

IV	**Calculations Based on Chemical Equations:** 4.1 Mole concept-Determination of molecular weight by gram molecular volume relationship, problems based on mole concept 4.2 Oxidation reduction-Definition and related terms 4.3 Balancing of redox reactions using oxidation number method and ion electron method	**06**
	Course Outcomes: After completion of the course students will be able to… 1. Explain the units and conversions. 2. Solve the numerical based on concentration units. 3. Draw the graphs and illustrate the derivations based on mathematical rules. 4. Apply their understandings to balance chemical equations and related calculations.	
	References: 1. Puri B.R., Sharma, L.R., Pathania M.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: Chemistry of Periodic Table Course Code: BCT-115	No. of Hrs. 30
	Course Objectives: Students should be able to… 1. Recall the Periodic table and different trends. 2. Understand shapes of orbital's, there overlapping and different hybridizations and their applications. 3. Study the fundamentals of metals, metal cluster, there locations and applications. 4. Study the fundamentals of non metals, isomorphism and applications.	
Unit No.	**Title and Syllabus**	**Hrs. Allotted**
I	**Introduction to Periodic Table:** 1.1 Introduction 1.2 Mendeleevs Periodic law and Periodic table 1.3 Modern periodic law and periodic table 1.4 Advantages of modern periodic table 1.5 Division s, p, d and f block elements and general electronic configuration 1.6 Physical properties: valency, atomic radii, ionic radii, ionization energy, electron affinity and electro negativity	**08**
II	**Orbital Hybridization:** 2.1 Introduction 2.2 Shapes of orbitals and orbital overlapping 2.3 Sigma and pi bond formation 2.4 Types of hybridization 2.5 Examples of sp, sp^2, sp^3, sp^3d, sp^3d^2 and sp^3d^3 hybridization	**08**
III	**Chemistry of Metals:** 3.1 Introduction: Definition and position in different groups 3.2 Study of metals and general electronic configuration 3.3 Properties of metals: a) Physical properties b) Chemical Properties 3.4 Metal Clusters 3.5 Uses of metals	**08**
IV	**Chemistry of Non-Metals:** 4.1 Introduction: Definition and position in different groups 4.2 Study of non metals and general electronic configuration 4.3 Properties of non metals: a) Physical properties b) Chemical Properties 4.4 Isomorphism	**06**

	4.5 Uses of non metals	
	Course Outcomes: After completion of the course students will be able to… 1. Identify different elements and their position in periodic table. 2. Apply knowledge of metals and non-metals in various fields. 3. Name metal cluster, their shapes and applications. 4. Identify different isomorphs and their applications.	
	References: 1. Lee J. D. 2008. Concise Inorganic Chemistry 5th Edition: Wiley India Pvt. Ltd. 2. Shriver, D. F., Atkins, P. W., Langford C. H. 1994. Inorganic Chemistry: W. H. Freeman. 3. Cotton F. A., Wilkinson G., Murillo C. A., Bochmann M. 1999. Advanced Inorganic Chemistry: Wiley. 4. Manku G. S. 1982. Theoretical Principles of Inorganic Chemistry: McGraw Hill Education. 5. Mehrotra R. C., Sing A. Organometallic Chemistry: Wiley Eastern Ltd. New Delhi.	

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Credits 2	Practical Course Minor Lab I BCP - 116	No. of Hrs. 60
	Course Objectives: Students should be able to… 1. Study the preparation and standardization of different solutions. 2. Learn the preparation solutions for trace analysis. 3. Gain the knowledge of plotting graph from given data	
	Section I – Physical Chemistry Experiments	
	1. Measurement of pH of water samples from different resources. 2. Preparation and standardization of solution. 2.1. Oxalic acid/Hydrochloric acid 2.2 Sodium Hydroxide 2.3 Potassium dichromate. 2.4 Sodium carbonate. 3. Preparation of solutions for trace analysis. 3.1 ppm 3.2 ppb 3.3 ppt 4. Plotting of graph from given data.	
	Course Outcomes: After completion of the experiments students will be able to… 1. Measure the pH of different water samples. 2. Prepare and standardize different solutions. 3. Plot the graph from given data.	
	Section - II - Inorganic Chemistry Experiments	
	Course Objectives: Students should be able to… 1. Study the preparation of different inorganic complexes. 2. Gain knowledge and analytical skills of complexometric titration.	
	5. Preparation of Mohrs salt 6. Identification of halides in given sample qualitatively. 7. Identification of basic radicals (Spot test). 8. Preparation of Hexa-amine cobalt (III) chloride. 9. Complexometric titration of given sample.	
	Course Outcomes: After completion of the experiments students will be able to… 1. Prepare different inorganic complexes. 2. Get expertise in quantitative estimation using titrimetry.	

	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. I, Sem II		
Credits 2	**Course III: Fundamental Organic Chemistry** **Course Code: BCT-124**	**No. of Hrs. 30**
	Course Objectives: Students should be able to… 1. Learn the fundamentals of Organic Reaction Mechanism. 2. Study the concepts of Alcohols, Phenols and ethers. 3. Recall the knowledge of aldehydes, ketones and carboxylic acids. 4. Understand concept of Cycloalkane, cycloalkene and alkadiene.	
Unit No.	**Title and Syllabus**	**Hrs. Allotted**
I	**Fundamentals of Organic Reaction Mechanism:** 1.1 Introduction, curved arrow notation 1.2 Cleavage of bonds: homolytic and heterolytic fission 1.3 Reagents, their types such as nucleophiles and electrophiles 1.4 Electronic Effects: Inductive effect, Resonance Effect, electromeric effect, hyperconjugation effect 1.5 Types of organic reactions: Substitution reaction, addition reaction, elimination reaction, rearrangement reactions.	**08**
II	**Alcohols, Phenols and Ethers:** 2.1 Classification 2.2 Nomenclature 2.3 Structures of Functional Groups: 2.4 Alcohols and Phenols: Preparations 2.5 Some commercially Important Alcohols 2.6 Ethers: Preparations, 2.7 Physical and Chemical Properties and uses of ethers	**08**
III	**Aldehydes, Ketones and Carboxylic Acids:** 3.1 Nomenclature and structure of Carbonyl groups 3.2 Preparation of aldehydes and ketones 3.3 Physical, Chemical Properties and uses 3.4 Nomenclature and structure of Carboxylic groups 3.5 Preparation of carboxylic Acids 3.6 Physical, Chemical Properties and uses	**08**
IV	**Cycloalkanes, Cycloalkenes and Alkadienes:** 4.1 Cycloalkanes- Introduction, Methods of formation, Chemical properties 4.2 Cycloalkenes -Introduction, Methods of formation, Chemical properties 4.3 Alkadienes- Introduction, Classification, Methods of formation, Chemical Properties	**06**
	Course Outcomes: After completion of the course students will be able to…	

	1. Apply the fundamental principles of organic chemistry to reaction mechanism. 2. Explain the preparations and uses of alcohols, phenols and ethes. 3. Describe preparations and uses of aldehydes, ketones and carboxylic acids. 4. Differentiate between the properties of cycloalkanes, cycloalkenes and alkadienes.	
	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 Publisher. 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: Basic Analytical Chemistry** **Course Code: BCT 125**	No. of Hrs. 30
	Course Objectives: Students should be able to… 1. Understand the basic concepts in analytical chemistry. 2. Get familiar with the basic laboratory reagents and their uses. 3. Learn the safety symbols and proper use of equipments. 4. Gain the knowledge of analytical approaches required for chemical analysis.	
Unit No.	**Title and Syllabus**	**Hrs. Allotted**
I	**Scope and Importance of Analytical Chemistry:** 1.1 Introduction-Scope and importance of Analytical Chemistry 1.2 Chemical Analysis-Qualitative and Quantitative, Major, Minor, Trace constituents 1.3 Steps in Chemical Analysis 1.4 Uses of Chemical Analysis	**08**
II	**Laboratory Reagents:** 2.1 Classification of reagents according to their action-Acids, Bases, Salts, Complexing Agents, Oxidizing Reducing Agents, Precipitating Agents, Chelating Agents 2.2 Primary and Secondary Standards-Definitions, Characteristics, Uses 2.3 Introduction to terms: Bulk chemicals and Fine chemicals 2.4 Chemicals and their grades	**08**
III	**Laboratory Equipments and Their Uses:** 3.1 Introduction-Laboratory safety 3.2 Laboratory Symbols 3.3 Analytical Balance 3.4 Glasswares and their uses	**08**
IV	**Analytical Approaches:** 4.1 Types of errors 4.2 precision & accuracy 4.3 absolute and relative uncertainty 4.4 Significant figures; significant figures in Arithmatics 4.5 Addition, subtraction, multiplication and division. Mean and standard Deviation	**06**
	Course Outcomes: After completion of the course students will be able to… 1. Classify the qualitative and quantitative analysis. 2. Identify the various reagents as per their action. 3. Conduct the experiments using proper set of apparatus. 4. Identify and calculate errors in chemical analysis.	

	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 Minor Lab II BCP - 126	No. of Hrs. 60
	Course Objectives: Students should be able to… 1. Study the different elements in organic compound qualitatively. 2. Determine the functional groups of molecules by qualitative analysis. 3. Gain the knowledge of preparation of organic compounds.	
	Section I - Organic Chemistry Experiments	
	1.Detection of Nitrogen from given samples by Lassaignes test: 1.1 Urea 1.2 Aniline 1.3 Thiourea 1.4 Acetanilide 2.Preparation of p-nitroacetanilide from acetanilide. 3.Identification of functional group from given organic compounds. 3.1 Benzoic acid 3.2 2-naphthol 3.3Aniline 3.4 Ethyl acetate 3.5 Ethyl methyl ketone	
	Course Outcomes: After completion of the experiments students will be able to… 1. Identify organic compounds using qualitative analysis. 2. Prepare different organic compounds.	
	Section - II - Analytical Chemistry Experiments	
	Course Objectives: Students should be able to… 1. Study the qualitative determination of acids, bases and adulteration of milk. 2. Learn the calibration techniques of glasswares.	

	4. Identification of acids and bases from given solution **(**HCl, H_2SO_4, CH_3COOH etc.) 4.1 p^H indicator 4.2 P^H metry **5. Adulteration of milk for qualitative determination for presence of:** 5.1 Detergent 5.2 Starch 5.4 Glucose 5.5 Urea **6. Calibration of laboratory glasswares** 6.1 Beakers 6.2 Measuring cylinders 6.3 Volumetric Flasks	
	Course Outcomes: After completion of the experiments, students will be able to: 1. Identify the acids and bases from unknown samples. 2. Recognize the adulteration of milk. 3. Calibrate the laboratory glasswares.	
	References: 1. Pandey O. P., Bajpay D. N., Giri S. 2010. Practical Chemistry: For B. Sc. I, II and III Year Students of All India Universities: S Chand. 2. Venkateswaran V. 2012. Basic Principles of Practical Chemistry: Sultan Chand and Sons. 3. Vogel Arthur. 1989. Vogel's Text Book of Quantitative Analysis: Longman. 4. Vogel Arthur, Bassett John. 1980. A Text Book of Quantitative Inorganic Analysis Including Elementary Instrumentation Analysis: Longman Sc and Tech. 5. Aparnathi K. D., Shaikh A. I., Patel S. I. 2020. Qualitative Tests for Detection of Common Adulterants in Milk: Director of Research Anand Agricultural University Anand-388110. 6. Verma N. K.,Vermani B. K.,Verma N., Comprehensive Practical Chemistry: Laxmi Publication (P) LTD.	

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Rayat Shikshan Sanstha's

Yashavantrao Chavan Institute of Science, Satara (Autonomous)

(Lead College, Karmaveer Bhaurao Patil University, Satara)

Syllabus to be introduced from June 2023

B. Sc. I, Sem II

Value Education Course (VEC)

Chemistry (Major)

Credits 02	**BCT-VEC-I: Role of Values and Ethics in Chemical Science**	No. of hours per unit
	Course Objectives: The students should be able to… 1. Understand the universal human values. 2. Learn the importance of ethics related with Chemistry. 3. Know the importance of gender equity. 4. Gain the knowledge of cultural heritage in Chemistry.	
Unit No.	**Title and Syllabus**	**Hours Allotted**
I	**Universal Human Values:** 1.1 Introduction to value education and need 1.2 Science related to UHV – harmony in the human being. 1.3 Cases of Chemistry according to ethical topics, codes and regulations 1.4 Metaethics of Chemistry, publication of chemical research and justice	**07**
II	**Ethical Conduct and Ethical Reasoning in Chemistry:** 2.1 The importance of ethics in Chemistry. 2.2 Historical perspectives on scientific ethics. 2.3 Ethical codes and guidelines in Chemistry. 2.4 Recognizing ethical issues in Chemistry. 2.5 Ethical Reasoning, case studies and decision-making models. 2.6 Promoting ethical conduct in Chemistry.	**08**
III	**Importance of Gender Equity in Chemistry:** 3.1 Concept of gender, gender divide and gender equity. 3.2 Gender participation status in Chemistry field. 3.3 Significance of gender equity in the development of Chemistry. 3.4 Case studies highlighting the direct and indirect achievements of females in Chemistry. 3.5 Emerging trends and best practices for achieving gender equity in Chemistry.	**08**

IV	**Importance of Culture and Heritage in the Development of Chemistry:** 4.1 Concept of culture and heritage, Integration of Chemistry with culture and heritage. 4.2 The role of Chemistry with cultural heritage in sustainable development. 4.3 Conservation of cultural heritage as an integral part of Chemistry. 4.4 Applications of cultural and inherited knowledge in present day scenario of Chemistry. 4.5 Cases of Chemistry according to the cultural History.	**07**
	Course Outcomes: After completion of the course students will be able to… 1. Explain the universal human values. 2. Discuss concepts related to ethical values and ethical reasoning. 3. Recognize the importance of gender equity in academics. 4. Compare and analyze the importance of culture and heritage in development of Chemistry.	
	References: 1. Robinson, J.P., Dando, M., & Pearson, G.S. (2007). "Ethical Issues in Research Involving Chemical and Biological Warfare Agents." Science and Engineering Ethics, 13 (4), 569-580. **2.** Rappert, B., & Jefferson, C. (2006). "The Development of the Dual Use Concept in the Life Sciences and Its Influence on International Policy." Science and Public Policy, 33(6), 475-486. 3. Hoffmann, R. (1997). "Ethical Dilemmas in Chemical Sciences: A Few Personal Reflections." Science and Engineering Ethics, 3(2), 199-208. **4.** Corgne, S., et al. (2018). "Responsible Research and Innovation in Industry and Laboratories: A Case Study for Nanomaterials." Journal of Nanoparticle Research, 20 (11), 294	

Credits 2	B. Sc. Part I, Sem-I Indian Knowledge System	No. of Hrs. 30
	IKS 101: Indian Textiles	
	Course Objectives: Students should be able to… 1. Understand the history, challenges, opportunities in textile industries. 2. Recognize Cotton Cultivation in India. 3. Get knowledge about textile industrial process and products. 4. Know about economics of textile.	
Unit No.	**Title and Syllabus**	**Hrs. Allotted**
I	**Introduction to Textile:** 1.1 History of the Indian textile industry 1.2 Current State of the Indian Textile Industry: 1.3 Challenges faced by the Textile Industry: 1.4 Opportunities for Growth in the Indian Textile Industry 1.5 Future Prospects of the Indian Textile Industry	**08**
II	**Cotton Cultivation in India:** 2.1 Conditions required for Cotton cultivation 2.2 Largest cotton-producing country 2.3 Major cotton-producing states in India 2.4 Indian Cotton vs American Cotton 2.5 Per hectare output of Cotton	**08**
III	**Indian Textiles: Nature & Making:** 3.1 The Fabric of India 3.2 Nature and Making 3.3 Silk skeins 3.4 Dye 3.5 Indigo dyeing 3.6 Ikat sari 3.7 Print sari 3.8 Weaving	**08**
IV	**Economics of Textile industries in India:** 4.1 Textile exporting countries worldwide 4.2 Trends & Products 4.3 Industries & Markets 4.4 Consumer & Brands 4.5 Politics & Society 4.6 Effect of textile on GDP.	**06**
	Course Outcomes: After completion of the course students will be able to…	

	1. Describe history of textile industries. 2. Explain the cotton cultivation. 3. Summarize general process and different products of textile industries. 4. Exploit the economics of textile industries.	
	References: 1. https://www.indianculture.gov.in/textiles-and-fabrics-of-india 2. https://www.iiad.edu.in/the-circle/textile-industry-in-india/ 3. introduction of indian textile industry - Search (bing.com) 4. https://www.statista.com/topics/10855/textile-industry-in-india/#topicOverview	

	B. Sc. Part I, Semester II **Skill Enhancement Course**	
Credit 1	**SEC 103: Laboratory Safety Measurements**	**No. of Hrs. 15**
	Course Objectives: Students should be able to… 1. Learn basics of laboratory safety. 2. Understand the various concentration units. 3. Study the concepts of mathematics used in Chemistry. 4. Acquire the knowledge of chemical calculations.	
Unit No.	**Title and Syllabus**	**Hrs. Allotted**
I	**Laboratory Safety:** 1.1 Introduction 1.2 Signs and symbols used in a laboratory 1.3 Types of Chemicals 1.4 Handling and storage of chemicals in a laboratory 1.5 Laboratory Hazards 1.6 Laboratory safety precautions 1.7 First Aid Practice in Laboratory 1.8 Material Safety Data Sheet (MSDS)	**08**
II	**Laboratory Management:** 2.1 Code of Ethics of a laboratory professional 2.2 Role of communication in laboratory 2.3 Organization of a Laboratory 2.4 Handling Hazardous Laboratory Waste 2.5 Laboratory safety inspection 2.6 Chemical security 2.7 Laboratory waste management	**07**
	Course Outcomes: After completion of the course students will be able to… 1. Follow the safety precautions while handling hazardous chemicals. 2. Prevent the causes and cases of accidents.	
	References: 1. Najat, R. Sood R. 2013. Manual of Laboratory Safety: JPB Publication. 2. Hill, R. H., Finster D. C. 2010. Laboratory Safety for Chemistry Students: John Wiley & Sons, Inc.: Hoboken, NJ. 3. Hizal, G. Acar, M. 2018. General Chemistry Laboratory, Safety Booklet.	

Credits 1	Laboratory Safety Measurements Practical Course Code: SEC 103	Hrs 15
	Course Objectives: Students should be able to… 1. Learn signs and symbols used in laboratory. 2. Study the safe handling of chemicals.	
	Experiments	
	1. Demonstration of signs and symbols used in laboratory: Common laboratory signs and symbols collected are distributed for identification and is recorded in the practical log 2. Safety equipment and laboratory apparatus 3. Handling of chemicals 4. Measurements: Length, temp, mass, volume 5. Metric - metric conversions: ml into L, gm into mg 6. Preparation of different types of laboratory request forms 7. Prepare a lay out plan of a multi room laboratory 8. Preparation of models of stock registers- consumables, Non-Consumable 9. Assessment activities	
	Course Outcomes: After completion of the course students will be able to… 1. Recognize the signs and symbols used on laboratory reagents. 2. Prepare laboratory request forms and layout plans. 3. Assess risks of hazards and minimize hazards.	
	References: 1. R. H. Hill, D. C Finster, Laboratory Safety for Chemistry Students; John Wiley & Sons, Inc.: Hoboken, NJ, 2010 2. http://www.luc.edu/environmentalservices/safety_information.shtml 3. http://www.ilpi.com/safety/ 4. http://www.chem.uky.edu/resources/stockroom/waste.html 5. http://www.uttyler.edu/safety/labwastemanual.pdf 6. http://www.cdc.gov/niosh/npg/ 7. http://avogadro.chem.iastate.edu/MSDS/	