Rayat Shikshan Sanstha's

Yashavantrao Chavan Institute of Science, Satara (Autonomous)

Department of Chemistry

B. Sc. III Revised Syllabus

(Autonomous)

w.e.f. June 2023

1. TITLE : B.Sc. Chemistry
2. YEAR OF IMPLEMENTATION : 2023-2024
3. DURATION : One year
4. **Preamble:** This updated syllabus is prepared for third year undergraduate students. The main objective is 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 their graduation. The units in the syllabus are well defined with scope and the number of lectures. The references are mentioned with relevance.
5. **General Objectives of the Course:**
   a To develop the content of the syllabus according to the UGC norms.
   b To inculcate fundamental principles of chemical sciences in students.
   c To establish the link between theory and laboratory practice by conducting laboratory experiments which help students to improve the understanding of the concepts.
   d To prepare students for academic and industrial sector.
6. PATTERN : Semester
7. MEDIUM OF INSTRUCTION: English
8. COURSE Structure: No. of Papers -04

Semester	Course Category	Code	Course Title	No. of Lectures Per Week	Credits
V	Theory Paper IX	BCT-501	Physical Chemistry	03	02
	Theory Paper X	BCT-502	Inorganic Chemistry	03	02
	Theory Paper -XI	BCT-503	Organic Chemistry	03	02
	Theory Paper –XII (Elective)	BCT-504	Analytical Chemistry	03	02
	Theory Paper –XII (Elective)	BCT-505	Analytical Chemistry		
	Theory Paper –XII (Elective)	BCT-506	Analytical Chemistry		
	Paper SECC: Paper – I	SECCCT 507	Basic Numerical Skills	02	01
	Practical Course Lab-V	BCP-508	Physical and Inorganic Chemistry	10	04
	Practical Course Lab-VI	BCP-509	Organic and Analytical Chemistry	10	04
	Practical SECC: Paper – I	SECCCP 510	Basic Numerical Skills	03	01

Semester	Course Category	Code	Course Title	No. of Lectures Per Week	Credits
VI	Theory Paper XIII	BCT-601	Physical Chemistry	03	02
	Theory Paper XIV	BCT-602	Inorganic Chemistry	03	02
	Theory Paper -XV	BCT-603	Organic Chemistry	03	02
	Theory Paper –XVI (Elective)	BCT-604	Analytical Chemistry	03	02
	Theory Paper –XVI (Elective)	BCT-605	Analytical Chemistry		
	Theory Paper –XVI (Elective)	BCT-606	Analytical Chemistry		
	Paper SECC: Paper – II	SECCCT 607	Entrepreneurship Development in Chemistry	02	01
	Practical Course Lab-VII	BCP-608	Physical and Inorganic Chemistry	10	04
	Practical Course Lab-VIII	BCP-609	Organic and Analytical Chemistry	10	04
	SECCCP Paper – II	SECCCP 610	Entrepreneurship Development in Chemistry	03	01

Structure and Titles of Papers of B. Sc. III Semester V

Paper IX: Physical Chemistry (BCT 501)

Subject	Unit No.	Title	Periods	Credits
Physical Chemistry	I	Elementary Quantum Mechanics	09	2
	II	Spectroscopy	09	
	III	Photochemistry	09	
	IV	Electromotive Force	09	
	V	Polymer Chemistry	09	
Grand Total			**45**	

Paper X: Inorganic Chemistry (BCT 502)

Subject	Unit No.	Title	Periods	Credits
Inorganic Chemistry	I	Metal Ligand Bonding in Transition Metal Complexes.	10	2
	II	Metal Semiconductors and Superconductors.	10	
	III	Organometallic Compounds	09	
	IV	Catalysis	10	
	V	Inter Halogen Compounds.	06	
Grand Total			**45**	

Paper XI: Organic Chemistry (BCT 503)

Subject	Unit No.	Title	Periods	Credits
Organic Chemistry	I	Introduction to Spectroscopy and UV Spectroscopy	11	2
	II	IR Spectroscopy	09	
	III	NMR Spectroscopy	10	
	IV	Mass spectroscopy	09	
	V	Combined Problems based on UV, IR NMR and Mass Spectral data	06	
Grand Total			**45**	

Paper XII: Analytical Chemistry (BCT 504) (Elective Paper -I)

Subject	Unit No.	Title	Periods	Credits
Analytical Chemistry	I	Artificial Intelligence	12	2
	II	Theory of Titrimetric Analysis	10	
	III	Flame Photometry	11	
	IV	Chromatographic Techniques and Applications	12	
Grand Total			**45**	

Paper XII: Analytical Chemistry (BCT 505) (Elective Paper -II)

Subject	Unit No.	Title	Periods	Credits
Analytical Chemistry	I	Artificial Intelligence	12	2
	II	Thermal Methods of Analysis	10	
	III	Green Techniques in Chemistry	11	
	IV	Atomic Absorption Spectroscopy	12	
Grand Total			**45**	

Paper XII: Analytical Chemistry (BCT 506) (Elective Paper -III)

Subject	Unit No.	Title	Periods	Credits
Analytical Chemistry	I	Artificial Intelligence	12	2
	II	Petroleum Industry and Eco - friendly Fuels	12	
	III	Separation Techniques	11	
	IV	Silicate Industries	10	
Grand Total			**45**	

Skill Enhancement Compulsory Course (SECCCT-507)

Subject	Unit No.	Title	Periods	Credits
Basic Numerical Skills	I	Mathematics	10	1
	II	Computer programming	10	
Grand Total			**20**	

Practical Course

Practical	Section I	Section II		Credits
Lab V	Physical Chemistry	Inorganic Chemistry	Seminar	4
Lab VI	Organic Chemistry	Analytical Chemistry	Project	4
Practical	Basic Numerical Skills		Case Study	1

	Rayat Shikshan Sanstha's **Yashavantrao Chavan Institute of Science, Satara** **(Autonomous)** **B. Sc. Part III, Semester V**	
Credits 2	**Paper IX: Physical Chemistry** **Course Code: BCT 501**	**Lectures 45**
	Course Objectives: Students should be able to… 1. Understand the basic concepts in Elementary Quantum Mechanics. 2. Learn fundamentals of various spectroscopic Techniques. 3. Study the photochemical activation and deactivations of molecules. 4. Learn Electromotive force in reversible and irreversible cell and various types of cells 5. Study the basic concepts in polymer chemistry.	
Unit No.	**Title and Syllabus**	**Lectures Allotted**
I	**Elementary Quantum Mechanics:** 1.1 Introduction, Dual nature of matter and energy: de Broglie Hypothesis. 1.2 The Heisenberg's Uncertainty Principle. 1.3 Concept of Operator, Energy Operators (Hamiltonian Operator). 1.4 Derivation of Schrodinger Wave Equation. 1.5 Physical Interpretation of the ψ and Ψ^2. 1.6 Particle in a One-dimensional Box. Concept of Quantum numbers.	**09**
II	**Spectroscopy:** 2.1 Introduction, Electromagnetic Radiation. 2.2 Interaction of radiation with matter, Electromagnetic Spectrum, Energy level diagram. 2.3 Rotational spectra of diatomic molecules: Rigid rotor model; moment of inertia; energy levels of rigid rotor, selection rules; Intensity of spectral lines, determination of bond length; isotope effect, Microwave oven. 2.4 Vibrational spectra of diatomic molecules: Simple Harmonic Oscillator model, Vibrational energies of diatomic molecules, Determination of force constant, overtones. 2.5 Raman spectra: Concept of polarizability, pure rotational and pure Vibrational Raman spectra of diatomic molecules, selection rules. 2.6 Comparative study of IR and Raman spectra, rule of mutual exclusion- CO_2 molecule 2.7 Numerical problems.	**09**

III	**Photochemistry:** 3.1 Introduction, Difference between thermal and photochemical processes. 3.2 Laws of photochemistry: i) Grotthus - Draper aw, ii) Lambert law, iii) Lambert – Beer's law (with derivation), iv) Stark - Einstein law. 3.3 Quantum yield0, Reasons for high and low quantum yield. Factors affecting Quantum yield. 3.4 Photosensitized reactions – Dissociation of H_2, Photosynthesis. Photo dimerization of anthracene, decomposition of HI and HBr. 3.5 Jablonski diagram depicting various processes occurring in the excited state: Qualitative description of fluorescence and phosphorescence. Photo-physical and photochemical processes. Chemi-luminescence, Electroluminescence. 3.6 Numerical problems.	**09**
IV	**Electromotive Force:** 4.1Introduction, Recapitulation of Nernst equation, Reversible and Irreversible cells. 4.2 Electrochemical Cells: i) Chemical cells without transference. ii) Concentration cells with and without transference. 4.3 Liquid – Liquid junction potential: Origin, elimination and determination. 4.4 Applications of emf measurements to determine Solubility and solubility product of sparingly soluble salts (based on concentration cell). 4.5 Introduction, Principle and example of i] Dye sensitized cell ii] Nuclear Fuel cell iii] Lithium ion battery. 4.6 Numerical problems	**09**
V	**Polymer Chemistry:** 5.1 Basic terms: macromolecule, monomer, repeat unit, degree of polymerization. 5.2 Classification of polymers: Classification based on source, structure, thermal response and physical propertiesTypes of polymer. 5.3 Molar masses of polymers: Number average, Weight average, Viscosity average molar mass, Mono dispersity and Polydispersity. 5.4 Method of determining molar masses of polymers: Viscosity method using Ostwald Viscometer. (Derivation expected) 5.5 Applications- conducting polymer, structural adhesives, coatings, Packaging.	**09**

	References: 1. Chandra, A. K. 1994. Introductory Quantum Chemistry: Tata McGraw- Hill. 2.Soni P. L., Dharmrha O. P., Dash U. N. 2011. Text Book of Physical Chemistry: Sultan Chand and Sons. 3. Bahl B. S., Tuli G. D. 1982. Essential of Physical Chemistry: S. Chand. 4. Puri B.R., Sharma, L.R., Pathania M.S. 2020. Principles of Physical Chemistry: Vishal publishing Company. 5. Banwell, C. N. & Mc Cash, E. M. 2006. Fundamentals of Molecular Spectroscopy 4thEd.: Tata McGraw-Hill: New Delhi. 6. Gowariker, V. R. Viswanathan, N. V., Jayadev Sreedhar. 2005. Polymer Science: New Age International (P) Ltd., Publishers.	
	Course Outcomes: After completion of the course students will be able to… 1. Apply operator concept to particle in one dimensional box. 2. Derive energy equations for rotational, vibrational spectra of molecules. 3. Draw and explain photochemical pathways using Jablonski diagram. 4. Apply emf concept to various batteries used in day to day life. 5. Classify polymers used in real life and their application and disadvantages.	

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Credits 2	Paper X: Inorganic Chemistry Course Code: BCT – 502	Lectures 45
	Course Objectives: Students should be able to… 1. Learn Metal ligand bonding in Transition metal complexes. 2. Understand properties of metal, semiconductors, superconductors and their applications. 3. Study the fundamentals of organometallic chemistry. 4. Learn types of catalysis and their industrial applications. 5. Acquire knowledge about inter-halogen compounds.	
Unit No.	**Title and Syllabus**	**Lectures Allotted**
I	**Metal Ligand Bonding in Transition Metal Complexes:** 1.1 Isomerism in complexes with C.N. 4 and 6: Geometrical Isomerism, Optical Isomerism, Structural Isomerism-Ionization Isomerism, Hydrate Isomerism, Coordination Isomerism, Linkage Isomerism and Co-ordination position Isomerism. 1.2 Molecular orbital theory (MOT): Introduction. 1.3 MOT of octahedral complexes with sigma bonding such as $[Ti(H_2O)_6]^{3+}$, $[Ni(NH_3)_6]^{2+}$, $[CoF_6]^{3-}$, $[Co(NH_3)_6]^{3+}$. Merits and demerits of MOT.	**10**
II	**Metals, Semiconductors and Superconductors:** 2.1 Introduction. Properties of metallic solids. 2.2 Theories of bonding in metal. i) Free electron theory. ii) Molecular orbital theory (Band theory). 2.3 Classification of solids as conductor, insulators and semiconductors on the basis of band theory. 2.4 Semiconductors: Types of semiconductors - intrinsic and extrinsic semiconductors. Applications of semiconductors. 2.5 Superconductors: Ceramic superconductors-Preparation and structures of mixed oxide $YBa_2Cu_3O_7$ Applications of superconductors.	**10**
III	**Organometallic Chemistry:** 3.1 Introduction: Definition, Nomenclature of organometallic compounds. 3.2 Synthesis and structural study of alkyl and aryl compounds of Li, Be and Al. 3.3 Mononuclear carbonyl and nature of bonding in simple metal carbonyls.	**09**
IV	**Catalysis:** 4.1 Introduction, Types of catalysis (Homogenous & Heterogeneous). 4.2 Industrial applications of inorganic complex i) Hydrogenation (Wilkinson catalyst) ii) Hydro-formylation iv) Ziggler- Natta polymerization v) Monsanto acetic acid synthesis	**10**

V	**Inter Halogen Compounds:** 5.1 Introduction, Types of inter halogen compounds (AX, AX_3, AX_5, AX_7), Polyhalides 5.2 Basic properties of the halogens, Pseudo halogens and pseudo halides.	**06**
	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.	
	Course Outcomes: After completion of the course students will be able to… 1. Identify and draw different types of isomerism in transition metal complexes. 2. Apply knowledge of semiconductors and superconductors to various fields. 3. Name organometallic compounds and describe the type of bonding in metal carbonyls. 4. Compare properties of halides with inter-halogen compounds.	

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Credits 2	Paper XI: Organic Chemistry Course Code: BCT – 503	Lectures 45
	Course Objectives: students should be able to… 1. Understand the basic principles of spectroscopy. 2. Know the different regions of the spectrum and the type of molecular transitions. 3. Study basic concept of NMR spectroscopy and understand chemical shift. 4. Learn instrumentation of Mass spectrometry. 5. Solve combined problems based on UV, IR, NMR and Mass spectroscopy.	
Unit No.	**Title and Syllabus**	**Lectures Allotted**
I	**A. Introduction to Spectroscopy:** 1.1 Meaning of spectroscopy, 1.2 Nature of electromagnetic radiation: wavelength, frequency, energy, amplitude, wave number and their relationship, Different units of measurement of wavelength and frequency, Different regions of electromagnetic radiations. 1.3 Interaction of radiation with matter: absorption, emission, fluorescence and scattering. 1.4 Types of spectroscopy and advantages of spectroscopic methods. 1.5 Energy types and energy levels of atoms and molecules. **B. UV Spectroscopy:** 1.6 Introduction, Beer - Lamberts law, absorption of UV radiation by organic molecules leading to different excitation, 1.7 Terms used in UV Spectroscopy - Chromophore, Auxochrome, Bathochromic shift, hypsochromic shift, hyperchromic and hypochromic effect, 1.8 Modes of electromagnetic transitions, Effect of conjugation on position of UV band, 1.9 Calculation of λ_{max} by Woodward and Fisher rules for dienes and enones systems, 1.10 Colour and visible spectrum, Applications of UV Spectroscopy	**11**

II	**IR Spectroscopy:** 2.1 Introduction, Principle of IR Spectroscopy, IR Instrumentation, schematic diagram 2.2 Fundamental modes of vibrations types and calculation – Condition for absorption of IR radiations 2.3 Regions of IR Spectrum, fundamental group region, finger print region, 2.4 Hooke's Law for Calculation of vibrational frequency, Factors affecting on IR absorption frequency, 2.5 Characteristic of IR absorption of following functional groups a] Alkanes, alkenes, alkynes b] Alcohol and phenols c] Ethers d] Carbonyl compounds e] Amines f] Nitro compounds g] Aromatic Compounds	**09**
III	**NMR Spectroscopy:** 3.1 Introduction, Principles of PMR Spectroscopy 3.2 NMR - Instrumentation, Schematic diagram, 3.3 Magnetic and nonmagnetic nuclei, Chemical shift- definition, measurement, calculation, Factors affecting Chemical shift 3.4 Shielding & deshielding, Peak Integration 3.5 Merits of TMS as PMR reference compounds 3.6 Coupling Constant, Types of Coupling Constant, Spin-spin splitting $(n + 1)$ rule, Applications	**10**
IV	**Mass Spectroscopy:** 4.1 Introduction, Principle of mass spectroscopy, 4.2 Mass spectrometer - schematic diagram 4.3 Types of ions produced in mass spectrum, 4.4 Fragmentation patterns of- alkanes, alkenes, aromatic hydrocarbons, alcohols, phenols, amines and carbonyl compounds 4.5 McLaffrety rearrangement, Applications	**09**
V	**Combined Problems based on UV, IR NMR Mass Spectral Data:**	**06**

	References: 1. Kalsi P. S. 2002. Spectroscopy of Organic compounds: New Age International Private Limited. 2. Parikh V. M. 1974. Spectroscopy: Wesley Publishing Company. 3. Donald Pavia. 2012. Introduction to Spectroscopy (4th Edition):. Thomson Press (India) Ltd. 4. Gross Jurgen H. 2004. Mass Spectrometry https://link.springer.com/book/10.1007/978-3-319-54398-7 5. Field L. D., Sternhell S. 2012. Organic Structures from Spectra: John Wiley & Sons pvt ltd. 6. Jacobsen N. E. 2016. NMR Data Interpretation Explained: Understanding 1D and 2D NMR, Spectra of Organic Compounds and Natural Products: John Wiley & Sons pvt ltd. 7. Robert M., Silverstein,, Francis X, Webster, 1996. Spectrometric Identification of Organic Compounds: John Wiley & Sons Pvt. Ltd.	
	Course Outcomes: After completion of the course students will be able to… 1. Explain basic principle of spectroscopy and regions of electromagnetic radiation. 2. Calculate the λ_{max} by Woodward and Fisher rules for dienes and enones systems. 3. Calculate chemical shift values of protons of compounds based on spectral data of NMR spectroscopy. 4. Predict molecular ion, fragmentation pattern and different types of ions produced. 5. Predict the structure of organic compound with the help of provided spectral data.	

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Credits 2	Paper XII: Analytical Chemistry (Elective Paper I) Course Code: BCT – 504	Lectures 45
	Course Objectives: Students should be able to… 1. Know the basic idea of Artificial intelligence. 2. Recapitulate the titrimetric analysis and related calculations 3. Understand fundamentals of flame photometry. 4. Study the theory of chromatographic techniques and its application in analytical industries and laboratories	
Unit No.	**Title and Syllabus**	**Lectures Allotted**
I	**Artificial Intelligence:** 1.1 Introduction, fundamentals: classical/symbolic approach to Artificial Intelligence 1.2 Theories and technologies for building complete A.I. systems, Knowledge representation and reasoning, Uncertain and probabilistic reasoning (Bayesian networks, fuzzy sets). 1.3 AI for chemistry, Molecule property prediction, Molecule design, Retrosynthesis, Reaction outcome prediction, Reaction conditions prediction, Chemical reaction optimization, 1.4 AR/VR introduction fundamentals etc.	**12**
II	**Theory of Titrimetric Analysis:** 2.1 Acid - Base Titrations: Introduction. 2.2 Theory of indicators w.r.t. colour change interval and Ostwald's Quinoid theory. 2.3 Neutralization curves and choice of indicators for the following titrations i) Strong acid and strong base. ii) Strong acid and weak base. iii) Strong base and weak acid. 2.4 Complexometric Titration: General account. Types of EDTA titrations. Metalo-chromic indicators w.r.t. Eriochrom Black T.	**10**
III	**Flame Photometry:** 3.1 Introduction, General principles of flame photometry, , 3.2 Instrumentation: Block diagram Burners (Premix and Lundergarph burners), mirror, slits, filters, detector (Photomultiplier tube), 3.3 Effect of solvent in flame photometry, Experimental procedure of analysis (Standard addition and internal standard) 3.4 Interference and Factors that influence the intensity of emitted radiation in a flame photometer 3.5 Application of flame photometry in real sample analysis 3.6 Limitations of flame photometry.	**11**

IV	**Chromatographic Techniques and Its Applications:** 4.1 Introduction, Developments in chromatography, Classification of chromatography 4.2 Column Chromatography: Introduction, types, Principle of adsorption column chromatography, solvent system, stationary phases, Methodology-Column packing, applications of sample, development, detection methods, recovery of components, Applications. 4.3 Ion Exchange Chromatography: Introduction, Principle, Types and properties of ion exchangers, Methodology- Column packing, application of sample, elution, detection/ analysis, Applications. 4.4 Gas Chromatography: Principal, Methodology, Column packing, application of sample, elution, detection/analysis, Applications.	**12**
	References: 1. Vogel A. I. 1966. Text Book of Quantitative Inorganic Analysis: Longman. 2. Chatwal G. R., Anand S. 2011. Instrumentals Methods of Chemical Analysis: Himalaya Publishing House. 3. Khopkar S.M. 2008. Basic Concepts of Analytical Chemistry: New Academic Science. 4. Kaur H. 2012. Instrumental Methods of Chemical Analysis: Pragati Prakashan. 5. Russell S., Norvig P. 2020. Artificial Intelligence: A Modern Approach: Pearson. 6. Nilsson N. J. 1998. Artificial Intelligence: A New Synthesis: Morgan Kaufmann. 7. Akerkar R. Intro. to Artificial Intelligence.	
	Course Outcomes: After completion of the course students will be able to… 1. Understand the basic concept of Artificial Intelligence and role of AI in chemistry. 2. Perform the titrimetric analysis by acid-base titrations and Complexometric titrations. 3. Understand principle, instrumentation and application of flame photometry to alkali and alkaline earth elements. 4. Perform chromatographic separations.	

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Credits 2	Paper XII: Analytical Chemistry (Elective Paper II) Course Code: BCT 505	Lectures 45
	Course Objectives: Students should be able to… 1. Know the basic idea of Artificial intelligence. 2. Study essentials of thermal methods of analysis 4. Understand Principles and techniques of Green Chemistry. 5. Study the theory and instrumentation of Atomic Absorption Spectroscopy	
Unit No.	**Title and Syllabus**	**Lectures Allotted**
I	**Artificial Intelligence:** 1.1 Introduction, fundamentals: classical/symbolic approach to Artificial Intelligence 1.2 Theories and technologies for building complete A.I. systems, Knowledge representation and reasoning, Uncertain and probabilistic reasoning (Bayesian networks, fuzzy sets). 1.3 AI for chemistry, Molecule property prediction, Molecule design, Retrosynthesis, Reaction outcome prediction, Reaction conditions prediction, Chemical reaction optimization, 1.4 AR/VR introduction fundamentals etc.	**12**
II	**Thermal Methods of Analysis (TGA & DTA):** 2.1 Classification of thermal methods. 2.2 Thermogravimetric Analysis, Derivative Thermogravimetric Analysis DTG 2.3 Differential Thermal Analysis DTA 2.4 Interpretation of graphs	**10**
III	**Green Techniques in Chemistry:** 3.1 Introduction; Principles of Green Chemistry 3.2 Green Technology-definition, importance, factors affecting green technology 3.3 Emerging green technologies- Microwave chemistry, Sonochemistry, photochemistry, Electro chemistry, Mechanochemistry 3.4 Green organic Synthesis by use of Zeolites, Natural catalysts and Biocatalysts.	**11**

IV	**Atomic Absorption Spectroscopy:** 4.1 Principles of AAS, Difference between AAS and flame Photometry, Atomic Absorption Process, Sample preparation & calculation, characteristic concentration and detection limits 4.2 Instrumentation of single beam for atomic absorption spectrometer (Source, chopper, nebulizer, monochromator, detector, amplifier), Interference: Spectral and chemical 4.3 Applications of AAS.	**12**
	References: 1.Vogel A. I. 1966. Text Book of Quantitative Inorganic Analysis: Longman. 2. Chatwal G. R., Anand S. 2011. Instrumentals Methods of Chemical Analysis: Himalaya Publishing House. 3. Khopkar S.M. 2008. Basic Concepts of Analytical Chemistry: New Academic Science. 4. Kaur H. 2012. Instrumental Methods of Chemical Analysis: Pragati Prakashan. 5. Ahluwalia V. K., Varma R. S. 2009. Green Solvents for Organic Synthesis: Alpha Science International Ltd. 6. Shrama B. K. 2014. Industrial Chemistry: Krishnan Prakashan. 7. Russell S., Norvig P. 2020. Artificial Intelligence: A Modern Approach: Pearson. 8. Nilsson N. J. 1998. Artificial Intelligence: A New Synthesis: Morgan Kaufmann.	
	Course Outcomes: After completion of the course students will be able to … 1. Explain the basic concept of Artificial Intelligence and its application to chemistry. 2. Differentiate between thermal methods of analysis and interpretation from graphs 3. Apply green chemistry principles to common laboratory techniques. 4. Analyse real samples using Atomic Absorption Spectroscopy.	

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Credits 2	Paper XII: Analytical Chemistry (Elective Paper III) Course Code: BCT 506	Lectures 45
	Course Objectives: Students should be able to … 1. Understand basic concepts on Artificial intelligence. 2. Study the process of petrochemical industry and eco -friendly fuels. 3. Develop the green methodology for Separation techniques. 4. Study the manufacturing process in term of principle, flow chart and working of silicate industries.	
Unit No.	**Title and Syllabus**	**Lectures Allotted**
I	**Artificial Intelligence:** 1.1 Introduction, fundamentals: classical/symbolic approach to Artificial Intelligence 1.2 Theories and technologies for building complete A.I. systems, Knowledge representation and reasoning, Uncertain and probabilistic reasoning (Bayesian networks, fuzzy sets). 1.3 AI for chemistry, Molecule property prediction, Molecule design, Retrosynthesis, Reaction outcome prediction, Reaction conditions prediction, Chemical reaction optimization, 1.4 AR/VR introduction fundamentals etc.	**12**
II	**Petroleum Industry and Eco-friendly Fuels:** **A] Petroleum Industry** 2.1 Introduction, occurrence, composition of petroleum, resources 2.2 Processing of petroleum, calorific value of fuel, cracking, octane rating (octane number), cetane number, flash point, petroleum refineries 2.3 Applications of petrochemicals, synthetic petroleum, lubricating oils & additives. **B] Fuels** 2.4 Fuels and eco-friendly fuels: liquid, gaseous fuel (LPG, CNG), fossil fuels, diesel, bio diesel, gasoline, aviation fuels. 2.5 Use of solar energy for power generation.	**12**
III	**Separation Techniques:** 3.1 Solvent Extraction: Introduction, principle, techniques, factors affecting solvent extraction 3.2 Batch extraction, continuous extraction and counter current extraction. Synergism. 3.3 Application-Determination of Iron (III).	**11**

IV	**Silicate Industries:** 4.1 Ceramics: Important clays and feldspar, ceramic, their types and manufacture. 4.2 High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fibre 4.3 Industrial applications	**10**
	References: 1.Vogel A. I. 1966. Text Book of Quantitative Inorganic Analysis: Longman. 2. Chatwal G. R., Anand S. 2011. Instrumentals Methods of Chemical Analysis: Himalaya Publishing House. 3. Khopkar S.M. 2008. Basic Concepts of Analytical Chemistry: New Academic Science. 4. Kaur H. 2012. Instrumental Methods of Chemical Analysis: Pragati Prakashan. 5. Shrama B. K. 2014. Industrial Chemistry: Krishnan Prakashan. 6. Russell S., Norvig P. 2020. Artificial Intelligence: A Modern Approach: Pearson. 7. Nilsson N. J. 1998. Artificial Intelligence: A New Synthesis: Morgan Kaufmann.	
	Course Outcomes: After completion of the course students will be able to: 1. Explain the basic concept of Artificial Intelligence and its 2. application to chemistry. 3. Illustrate the terminology and processes in petrochemical industry. 4. Perform experiments on separation techniques in laboratory. 5. Explain properties and industrial applications of clay and ceramics.	

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Credits 1	Basic Numerical Skills SECCCT 507, SECC Paper No. I	Lectures 20
	Course Objectives: Students should be able to… 1. Empower the tools of mathematics to solve different chemical problems. 2. Understand the key concepts of computer operation and its importance.	
Unit No.	**Title and Syllabus**	**Lectures Allotted**
I	**Mathematics:** 1.1 Fundamentals, mathematical functions 1.2 Mean, standard deviation, relative error. 1.3 Some Important Units of Measurement 1.4 Accuracy and Precision: 1.5 Determinate Errors 1.6 Indeterminate Errors 1.7 Significant Figures 1.8 Standard Deviation 1.9 Projection of a Result 1.10 Linear Least Squares 1.11 Detection Limits 1.12 Statistics of Sampling 1.13 Numerical integration	**10**
II	**Applications in Computer Programming:** 2.1 Constants, variables, bits, bytes, binary and ASCII formats. 2.2 Arithmetic expressions, hierarchy of operations, inbuilt functions. 2.3 Elements of the BASIC language. BASIC keywords and commands. Logical and relative operators. 2.4 Introduction of Excel, using digital tools to create graphical displays. 2.5 Graphing in excel, grade distribution graph, definition of bar graph, types of bar graph, uses, advantages and disadvantages. 2.6 Difference between bar graph and histogram, steps to draw bar graph, examples, area chart, bar chart, radar chart. 2.7 Use of Spreadsheets in Analytical Chemistry Using Spreadsheets for Plotting Calibration Curves.	**10**

	References: 1. McQuarrie, D. A. 2008. Mathematics for Physical Chemistry: University Science Books. 2. Mortimer, R. 2005. Mathematics for Physical Chemistry 3rd Ed: Elsevier. 3. Steiner, E. 1996. The Chemical Math's Book: Oxford University Press. 4. Yates, P. 2007. Chemical Calculations 2nd Ed.: CRC Press. 5. Harris, D. C. 2007. Quantitative Chemical Analysis 6th Ed.: Freeman Chapt. 3-5. 6. Levie, R. de, 2001. How to Use Excel in Analytical Chemistry and in General Scientific Data Analysis: Cambridge Univ. Press. 7. Noggle, J. H. 1985. Physical Chemistry on a Microcomputer: Little Brown & Co. 8. Venit, S.M. 1996. Programming in BASIC: Problem Solving with Structure and Style: Jaico Publishing House : Delhi.	
	Course Outcomes: After completion of the course students will be able to: 1. Understands the graphical representation and processing. 2. Understands and uses the rules and differentiation and integration in chemical derivations. 3. Understand importance and use of algorithm and flowchart drawing. 4. Learn algorithm writing and flowchart drawing.	

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Credits 4	**Practical Course** **Lab V BCP - 508**	
	Course Objectives: Students should be able to… 1. Study different principles and instrumentation techniques. 2. Learn chemical kinetics of reaction. 3. Determine molecular weight of polymer by viscosity measurement. 4. Gain the knowledge of conductometric acid - base titrations. 5. Study the determination of standard potential and redox potential by potentiometry. 6. Impart the idea of principle of refractometry and its operation.	
Unit No.	**Section I - Physical Chemistry Experiments**	**Lectures Allotted**
	I. Chemical Kinetics: 1.The determine energy of activation of first order reaction (hydrolysis of methyl acetate in presence of 0.5 N HCl/0.5 N H_2SO_4) 2.To determine energy of activation of the reaction between potassium persulphate and potassium iodide (equal concentration). **II. Viscosity:** 3. To determine the average molecular weight of a polymer. **III. Conductometry:** 4. To determine the percentage composition (by weight) of strong acid and weak acid in a given mixture by titrating against strong base conductometrically. 5. To determine the normality of oxalic acid by titrating it with strong alkali conductometrically. **IV. Potentiometry:** 6. To determine the normality of the strong acid by titrating it with strong alkali by potentiometric method. 7. Determination of standard electrode potential of Zn/Zn^{++}, Cu/Cu^{++} 8. Titration of ferrous ammonium sulphate using $K_2Cr_2O_7$ solution and to calculate redox potential of Fe^{++}, Fe^{+++} system. **V. Refractometry:** 9. To determine specific refractivities of pure liquids A and B and of their mixtures and to determine percentage composition of the unknown mixture. 10. To determine the molar refractivities of methyl acetate, ethyl acetate, n- hexane and carbon tetrachloride and calculate the refraction equivalents of C, H and Cl atoms.	

	Course Outcomes: After completion of the experiments students will be able to… 1. Operate, standardise and measure various parameters using laboratory instruments. 2. Calculate rate constant and energy of activation of reaction of first and second order reaction. 3. Measure time of flow of polymer solution and calculate its molecular weight from the data. 4. Determine percentage composition of mixture of solution by conductometry. 5. Calculate standard potential and redox potential by using potentiometric instruments. 6. Evaluate specific and molar refractivity by refractometry.	
Unit No.	**Section - II - Inorganic Chemistry Experiments**	**Lectures Allotted**
	Course Objectives: Students should be able to… 1. Study the principle of gravimetric analysis technique. 2. Learn to prepare various inorganic complexes. 3. Gain knowledge and analytical skill about titrimetric analysis.	
	I. Gravimetric Estimations (G): **G1.** Gravimetric estimation of barium as barium sulphate from the given solution containing barium chloride, ferric chloride and free hydrochloric acid. **G2.** Gravimetric estimation of nickel as bis (dimethyl glyoximato) nickel (II) from the given solution containing nickel sulphate, ferrous ammonium sulphate and free Sulphuric acid. [For the gravimetric experiments, stock solution should be given in the range of 10 to 15 cm^3 and asked to dilute to 100 cm^3 (or the stock solution should be given in the range of 20 to 30 cm^3 and asked to dilute to 250 cm^3). Use 50 cm^3 of this diluted solution for estimation.] **II. Inorganic Preparations (P):** **P_1.** Preparation of sodium cuprous thiosulphate. **P_2.** Preparation of potassium trioxalato ferrate (III). **P_3.** Preparation of potassium trioxalato aluminate (III). **P_4.** Preparation of tris (ethylene diamine) nickel (II) thiosulphate. **P_5.** Preparation of bis (ethylene diamine) copper (II) thiosulphate. **III. Titrimetric Estimations: Percentage Purity** **V_1.** Determination of percentage purity of ferrous ammonium sulphate. **V_2.** Determination of percentage purity of Nickel (II) complexometrically using muroxide indicator.	

	References: 1. Findlay, Alexander. 1973. Practical Physical Chemistry: Prentice Hall Press 2. Khosla, B. D., Garg V. C., Gulati A. 2018. Senior Practical Physical Chemistry: R. Chand and Co. 3. Sivasankar B., Svehla G., 2012. Vogel's Qualitative Chemical Analysis: Pearson Education India. 4. Vogel A. I., 1989. Vogel's Text Book of Quantitative Inorganic Analysis: Longman 5. Palmer W. G. 1954. Experimental Inorganic Chemistry: Cambridge Uni. Press, New York	
	Course Outcomes: After completion of the experiments, students will be able to: 1. Evaluate the amount of Ni and Ba by gravimetric analysis technique. 2. Expertise in skills for inorganic preparations. 3. Determine percentage purity by titrimetric analysis.	

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Credits 04	**Practical Course** **Lab- VI BCP - 509**	
	Course Objectives: Students should be able to… 1. Earn the ability for separation of binary mixture and identifying components. 2. Determine structure of organic compounds by using NMR spectroscopy.	
	Section -I- Organic Chemistry Experiments	
	1. Qualitative Analysis Separation of Binary Mixture and Identification of One Component (At least 08 mixtures) 1) Solid – Solid : 4 mixtures 2) Solid – Liquid : 2 mixtures 3) Liquid – Liquid : 2 mixtures **1) Solid – Solid Mixtures:** One mixture from each the following types should be given : i) Acid+Phenol ii) Acid + Base iii) Acid+Neutral iv) Phenol +Base v) Phenol+Neutral vi) Base +Neutral **2) Solid – Liquid Mixtures:** Mixture of type Neutral + Neutral or Acid + Neutral should be given. **3) Liquid – Liquid Mixtures**: Mixture of type Neutral + Neutral or Base + Neutral should be given. Following compounds should be used for preparation of mixtures **Acids:** Benzoic acid, Phthalic acid, Salicylic acid, Cinnamic acid, Aspirin, Oxalic acid. **Phenols:** α -naphthol, β -naphthol, resorcinol, **Bases:** o-nitroaniline, m-nitroaniline, p-nitroaniline, aniline, o-toluidine and N, N- dimethylaniline, diphenylamine, **Neutrals:** Anthracene, acetanilide, m-dinitrobenzene, chloroform, carbon tetrachloride, acetone, nitrobenzene, ethyl acetate, ethyl benzoate, bromobenzene, urea and thiourea. NB: 1. For Solid - Liquid and Liquid - Liquid mixtures avoid detection of type of mixture. Instead, the weightage is given to detection of nature and separation of mixture. 2. Separation and qualitative analysis of the binary Mixtures should be carried out on microscale using microscale kits. **2. Determination of structure of organic compound from given NMR spectra.** Ethanol, Ethyl acetate, Benzyl alcohol, Propanoic acid, Butaraldehyde, Ethyl benzoate, Isopropyl benzene, Propyl ether, n - pentane, Propene, Diethyl amine, 2- chloro butane etc.	

	Course Outcomes: After completion of the experiments students will be able to… 1. Separate the binary mixture and identify each component by qualitative analysis. 2. Interpret structure of organic compounds by NMR spectra.	
	Section - II Analytical Chemistry Experiments	
	Course Objectives: Students should be able to… 1. Acquire the experimental know-how for volumetric analysis 2. Learn the technique to analyse commercial sample quantitatively. 3.Obtain the necessary skills for instrumentation analysis.	
	Estimation and Preparation (Organic Analytical Section): 1. To determine the amount of acid and amide present in the given mixture of acid and amide. 2. Determination of Molecular weight of monobasic/dibasic acid by volumetric method. 3. To determine the amount of acid and ester present in the given mixture of acid and ester. **Analysis of Commercial Sample (Inorganic Analytical Section):** 4. Determination of percentage of magnesium in the given sample of talcum Powder. 5. Determination of amount of aluminium in the given solution of potash alum. (Standard succinic or oxalic acid solution to be prepared to standardize the given sodium hydroxide solution.) **Colorimetry (Physical Analytical Section):** 6. Determination of copper ions in the given solution by using calibration curve. 7. To estimate Fe^{+3} ions using salicylic acid by colorimetric titration (static method) **pH – Metry:** 8. To determine the dissociation constant of monobasic acid (Acetic acid). **Potentiometry:** 9. To determine the pH values of various mixtures of sodium acetate and acetic acid in aqueous solutions and hence find out the dissociation constant of the acid. 10. To prepare buffer solutions and determine their pH experimentally and theoretically using Henderson's equation.	

	Reference Books: 1. Findlay, Alexander. 1973. Practical Physical Chemistry: Prentice Hall Press 2. Khosla, B. D., Garg V. C., Gulati A. 2018. Senior Practical Physical Chemistry: R. Chand and Co. 3. Sivasankar B., Svehla G., 2012. Vogel's Qualitative Chemical Analysis: Pearson Education India. 4. Vogel A. I., 1989. Vogel's Text Book of Quantitative Inorganic Analysis: Longman 5. Vogel A. I. 2003.Vogel's Textbook of Practical Organic Chemistry: Pearson India. 6. Agarwal O. P. 2014. Advanced Practical Organic Chemistry: Krishna Prakashan Media (P) Ltd.	
	Course Outcome: After completion of the experiments students will be able to: 1. Perform analysis of samples using instrumental techniques. 2. Calculate molecular weight and composition of organic compounds by quantitative analysis. 3. Quantify amount of metal from commercial samples. 4. Estimate amount of metal by colorimetry. 5. Plan the experimental projects and execute them.	

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Credits 01	**Practical SECCCP 510: Basic Numerical Skills**	
	Course Objectives: students should be able to… 1. Learn the interdisciplinary nature of chemistry and to integrate knowledge of mathematics to a wide variety of chemical problems. 2. Study mathematical tools to tackle common problems in physical chemistry, including solving ordinary and partial differential equations, calculating differentials, solving multiple integrals etc. 3. Acquire statistical information for a set of data. 4. Learn the unit conversions and related calculations. 5. Understand computer programs based on numerical methods. 6. Understand the role of computers in simulating chemical processes and analysing data.	
Unit No.	**Title and Syllabus**	**Lectures Allotted**
	1. Find the mean, error, percent deviation and standard deviation for given sets of result (e.g.i to iii) i] The boiling point of a liquid which has a theoretical value of 54^{o}C, was measured by a student four times. Determine mean, for each measurement the error and percent deviation. Observed values are 54.9, 54.4, 54.1, 54.2 ii] The student has measured the % of chlorine in an experiment a total of six times. The values are 18.92, 19.56, 19.75, 18.25, 19.60, and 18.70. Calculate the mean and standard deviation? iii] A student analysing a sample for bromine makes five trials with the following results:36.1, 35.9, 36.5, 35.9, and 36.3. The theoretical value is 36.2. Calculate the mean, error and percent deviation for each trial, the standard deviation 2. Conversion of the given unit into other unit (e.g. i and ii) i] The temperature outside is measured to be 95^{o}F. Given that Fahrenheit and Celsius are linked by the equation: C = 5/9 x (F- 32) and Celsius and Kelvin are linked by the equation: K = C + 273 Calculate the outside temperature in Kelvin. ii] An industrial chemist produces 2.5x10^{5} dm^{3} of fertilizer in a reaction. How much is that in m^{3}? 3. Calculate the pH of weak acid by using quadric equation. Formic acid is a weak acid with a dissociation constant Ka of 1.8 x10^{4}. The Ka relates the concentration of the H^{+} ions denoted [H^{+}] and the amount of acid dissolved denoted N by the equation: Ka = [H^{+}]^{2} / N - [H^{+}] Given that there is 0.1 moles of formic acid dissolved, calculate the pH of the solution.	

	4. Application of numerical methods in finding root of volume (Van der W aal's gas equation e.g. i - ii) i] What is the volume of exactly one mole of oxygen gas at a pressure of 10.00 atm. and a temperature of 300.0 K.? For oxygen *a* is 1.360 liter^2 atm / mol^2 and *b* is 0.003183 liter / mol. Take *R* to be 0.0820578 liter - atm /mol - K. ii] For benzene, *a* = 18.00 liter^2 atm / mol^2 and *b* is 0.1154 liter / mol. Find the volume of 1.400 moles of benzene vapor at 500°C and a pressure of 40.00 atm. 5. Computer programs based on numerical methods for i] Numerical differentiation (e.g., change in pressure for small change in volume of a van der Waals gas, potentiometric titrations). ii] Roots of equations: (e.g. volume of van der Waals gas and comparison with ideal gas, pH of a weak acid). iii] Matrix operations. Application of Gauss-Siedel method in colorimetry. iv] Simple exercises using molecular visualization software. 6. Use the following set of stock prices (in dollars): 10, 7, 20, 12, 5, 15, 9, 18, 4, 12, 8, 14 Find the 10th percentile and the 50th percentile Solutions. 7. Find Population Mean and Sample Standard Deviation for the following data set: 5, 10, 15, 20.	
	References: 1. Levie, R. D. 2001. How to Use Excel in Analytical Chemistry and in General Scientific Data Analysis Cambridge University Press. 2. Noggle, J. H. 1985. Physical Chemistry on a Microcomputer: Little Brown & Co. 3. Venit, S.M. 1996. Programming in BASIC: Problem Solving with Structure and Style: Jaico Publishing House.	
	Course Outcomes: After completion of experiments student will be able to… 1. Apply mathematical formulae to solve problems in physical chemistry. 2. Calculate the mean, median, Standard deviation for any set of data. 3. Use quadric equation to finding pH of weak acid. 4. Apply numerical methods in finding root of volume (Vander waal's gas equation). 5. Solve basic chemistry- related mathematical problems using the Mathematica computer algebra system.	

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Semester VI

Paper XIII: Physical Chemistry (BCT 601)

Subject	Unit No.	Title	Periods	Credits
Physical Chemistry	I	Surface Chemistry	09	2
	II	Thermodynamics	09	
	III	Solid State Chemistry	09	
	IV	Chemical Kinetics	09	
	V	Nanomaterials	09	
Grand Total			**45**	

Paper XIV: Inorganic Chemistry (BCT 602)

Subject	Unit No.	Title	Periods	Credits
Inorganic Chemistry	I	Co- ordination Chemistry	12	2
	II	Nuclear Chemistry	07	
	III	Iron and Steel	10	
	IV	Acids and Bases and Non-aqueous Solvents	08	
	V	Inorganic Polymers	08	
Grand Total			**45**	

Paper XV: Organic Chemistry (BCT 603)

Subject	Unit No.	Title	Periods	Credits
Organic Chemistry	I	Name Reactions	10	2
	II	Reagents in Organic Synthesis	08	
	III	Stereochemistry	06	
	IV	Natural Products	08	
	V	Pharmaceuticals and Heterocyclic Chemistry	13	
Grand Total			**45**	

Paper XVI: Industrial Chemistry (BCT 604)
Elective Paper I

Subject	Unit No.	Title	Periods	Credits
Industrial Chemistry	I	Small Scale Industries	11	2
	II	Sugar Industry	12	
	III	Manufacture of Industrial Heavy Chemicals	12	
	IV	Electroplating	10	
Grand Total			**45**	

Paper XVI: Industrial Chemistry (BCT 605)
Elective Paper II

Subject	Unit No.	Title	Periods	Credits
Industrial Chemistry	I	Small Scale Industries	11	2
	II	Synthetic Polymer	12	
	III	Glass Industry	12	
	IV	Batteries	10	
Grand Total			**45**	

Paper XVI: Industrial Chemistry (BCT 606)
Elective Paper III

Subject	Unit No.	Title	Periods	Credits
Industrial Chemistry	I	Small Scale Industries	11	2
	II	Dairy Chemistry	10	
	III	Soil Chemistry	12	
	IV	Leather Chemistry	12	
Grand Total			**45**	

Skill Enhancement Compulsory Course (SECCCT 607)

Subject	Unit No.	Title	Periods	Credits
Entrepreneurship Development in Chemistry	I	Entrepreneurship, Creativity & Opportunities	06	1
	II	Business Finance & Accounts	05	
	III	Enterprise Management and Modern Trends	05	
	IV	Chemistry Entrepreneurs	04	
Grand Total			**20**	

Practical Course

Practical	Course Code	Section I	Section II		Credits
Lab VII	BCP 608	Physical Chemistry	Inorganic Chemistry	Seminar/Industrial Visit	4
Lab VIII	BCP 609	Organic Chemistry	Industrial Chemistry	Project	4
Practical	SECCCP 610	Entrepreneurship Development in Chemistry		Case Study/ Internship/ Industrial Training	1

Credits 2	Paper XIII: Physical Chemistry Course Code: BCT 601	Lectures 45
	Course Objectives: Students should be able to… 1. Learn basic concept of surface chemistry and its applications in catalysis. 2. Study the concepts of thermodynamics and apply it to physical and chemical systems. 3. Insight into the fascinating area of solid state chemistry and material science. 4. Learn the third order reaction with examples. 5. Learn the preparative skill of nanomaterials.	
Unit No.	**Title and Syllabus**	**Lectures Allotted**
I	**Surface Chemistry:** 1.1 Introduction - Terminologies in surface chemistry - Difference between adsorption and absorption 1.2 Mechanism of adsorption, Factors affecting adsorption. 1.3 Types of adsorption: Physical and Chemical Adsorption. 1.4 Types of adsorption isotherms.: Freundlich adsorption isotherm, Langmuir adsorption isotherm with derivation. 1.5 BET equation and determination of surface area of adsorbent by BET equation. 1.6 Applications of adsorption. 1.7 Application of Adsorption in catalysis: Terms - Mechanism of Catalytic Reaction, Criteria (or) Characteristics for Catalyst 1.8 Types of Catalysis - Homogeneous Catalysis - Heterogeneous Catalysis 1.9 Catalytic Poisoning and Promoters	**09**
II	**Thermodynamics:** 2.1 Introduction, Free energy: Gibbs function (G) and Helmholtz function (A) 2.2 Criteria for thermodynamic equilibrium and spontaneity. 2.3 Relation between ΔG andΔ H : Gibbs Helmholtz equation. 2.4 Thermodynamic derivation of law of mass action, van't – Hoff isotherm and isochore. 2.5 Fugacity and activity concepts. 2.6 Partial molar quantities, Partial molar volume, 2.7 Concept of chemical potential, Gibbs-Duhem equation. 2.8 Numerical problems.	**09**

III	**Solid State Chemistry:** 3.1 Introduction Space lattice, lattice sites, Lattice planes, Unit cell. 3.2 Laws of crystallography: i] Law of constancy of interfacial angles ii] Law of rational indices iii] Law of crystal symmetry. Weiss indices and Miller indices. 3.3 Cubic lattice and types of cubic lattice, planes or faces of a simple cubic system, spacing of lattice planes. 3.4 Diffraction of X - rays, Derivation of Bragg's equation. 3.5 Determination of crystal structure by Bragg's method. 3.6 Determination of crystal structure of NaCl and KCl on the basis of Bragg's equation. 3.7 Debye Scherrer method	**09**
IV	**Chemical Kinetics:** 4.1 Introduction and recapitulation of second order reactions 4.2 Third order reactions – derivation of rate constant, Characteristics of Third-order reactions, Examples of third order reaction. 4.3 Simultaneous reactions such as i. Opposing reaction: (Derivation of rate equation for first order opposed by first order expected) ii. Side reaction iii. Consecutive reactions iv. Chain reaction v. Explosive reaction (Derivation of rate equation and Numerical problems are not expected)	**09**
V	**Nanomaterials:** 5.1 Introduction: Nanomaterial and Nanotechnology. 5.2 Size dependent properties of Nanomaterials - Optical properties and semiconducting properties. 5.3 Approaches for preparation of nanomaterials a. Top-down Approach b. Bottom-up Approach 5.4 Synthesis: Physical Methods, Chemical Method, Sol gel Method 5.5 Characterization of Nanomaterial : Introduction to 1. Scanning Electron Microscopy (SEM) and 2. Transmission Electron Microscopy (TEM) 5.6 Applications of Nanomaterial	**09**

	References: 1. Levine I. 2002. Physical Chemistry, 5th Edition: Tata McGraw Hill Publishing Co. Ltd. 2. Atkins P. W., Paula J. De. 2005. The Elements of Physical Chemistry, 7nd Edition: Oxford University Press Oxford. 3. Puri, B. R., Sharma, L.R., Pathania M.S. 2008. Principles of Physical Chemistry: Vishal publishing Company. 4. Rao Y. V. C. 2003. An Introduction to Thermodynamics: Universities Press. 5. Kulkarni S. 2014. Nanotechnology: Principles and Practices: Springer Nature.	
	Course Outcomes: After completion of the course students will be able to… 1. Recognise applications of surface chemistry in catalysis. 2. Relate free energy, chemical potential in thermodynamic equations 3. Determine of crystal structure of some solids. 4. Derive rate constant equations of third order reaction. 5. Differentiate nanomaterials on the basis of size, properties, synthesis methods and elaborate its applications	

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Credits 2	Paper XIV: Inorganic Chemistry Course Code: BCT 602	Lectures 45
	Course Objectives: Students should be able to… 1. Learn the mechanism of the reactions involved in inorganic complexes of transition metals. 2. Gain knowledge about generation of nuclear power with the help of nuclear reactions and applications of radio isotope. 3. Know the techniques involved in ore dressing and extraction of cast iron from its ore. 4. Study different theories of Acids and bases and learn non aqueous solvents 5. Understand types of homoatomic and heteroatomic inorganic polymers.	
Unit No.	**Title and Syllabus**	**Lectures Allotted**
I	**Coordination Chemistry:** **A] Inorganic Reaction Mechanism** 1.1 Introduction. 1.2 Classification of Mechanism: Association, dissociation, interchange and the rate determining steps, SN^1 and SN^2 reaction for inert and labile complexes, Mechanism of substitution in cobalt (III) octahedral complexes. 1.3 Trans effect and its theories. 1.4 Applications of trans effect in synthesis of Pt (II) complexes. **B] Thermodynamic and Kinetic Aspects of Metal Complexes.** 1.5 Introduction. 1.6 Thermodynamic stability. 1.7 Kinetic Stability. 1.8 Relation between thermodynamic and kinetic stability. 1.9 Stepwise stability constant and factor affecting the stability of complexes. Determination of Stability constant by Job variation, Mole ratio and Slope ratio method.	**12**

II	**Nuclear Chemistry:** 2.1 Nuclear reactions and energetic of nuclear reactions. 2.2 Types of nuclear reactions i] artificial transmutation. ii] Artificial radioactivity. iii] Nuclear fission and its application in Heavy water nuclear reactor. iv] Nuclear fusion. 2.3 Applications of radio - isotopes as tracers: i] Chemical investigation – Esterification. ii] Structural determination – Phosphorus pentachloride. iii] Analytical Chemistry – Isotopic dilution method for determination of volume of blood. iv] Age determination – Dating by C14.	**07**
III	**Iron and Steel:** 3.1 Occurrence, and ores of iron. 3.2 Definition of the Terms - Ore, Mineral, Slag, Flux, Gangue, Matrix, Calcinations, Reduction, Roasting, Smelting and Leaching. 3.3 Extraction of iron by Blast furnace. 3.4 Steel: Definition and types. 3.5 Conversion of cast iron in to steel by i] Bessemer process. ii] L.D. process. 3.6 Heat treatment on steel.	**10**
IV	**Acid Bases and Non-Aqueous Solvents:** 4.1 Introduction to Theories of Acids and bases. 4.2 Arrhenius concept. 4.3 Bronsted - Lowry concept. 4.4 Lewis Concept 4.5 Lux - Flood Concept (definition and examples). 4.5 Hard and Soft Acids and Bases. (HSAB Concept) i] Classification of acids and bases as hard, soft and borderline. ii] Pearson's HSAB concept. iii] Acid –Base strength and hardness - softness. iv] Application and limitations of HSAB principle. **Chemistry of Non aqueous Solvents** 4.6 Introduction. 4.7 definition and characteristics of solvents. 4.8 Classification of solvents. 4.9 Physical properties and Acid base reactions in Liquid Ammonia (NH_3) and liquid Sulphur Dioxide (SO_2).	**08**

V	**Inorganic Polymers:** 5.1 Introduction. 5.2 Basic concept and definition. 5.3 Classification of polymers - Organic and Inorganic polymers. 5.4 Comparison between organic and inorganic polymers. 5.5 Polymer back bone. 5.6 Homoatomic polymer containing – i] Phosphorus. ii] Fluorocarbons. 5.7 Heteroatomic polymers i] Silicones ii] Phosphonitrilic compounds.	**08**
	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. Kettle S. F. A. 1995. Co-ordination Compounds: Springer. 5. Arnikar. H. J. 2011. Essentials of Nuclear Chemistry: New Age International Pvt. Ltd. 6. Puri, Sharma and Kalia. 2020. Principles of Inorganic Chemistry: Vishal Publishing Co. 7. Mehrotra R. C., Sing A. Organometallic Chemistry: Wiley Eastern Ltd. New Delhi.	
	Course Outcomes: After completion of course students will be able to: 1. Explain inorganic reaction mechanism and thermodynamics and kinetic stability of inert and labile complexes. 2. Describe theory behind nuclear reactions and applications of radioactive isotopes in everyday life. 3. Elucidate extraction process of metal and ore preparation 5. Differentiate between Lewis acids and bases. 6. Clarify different types of inorganic polymers	

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Credits 2	**Paper XV: Organic Chemistry** **Course Code: BCT 603**	**Lectures 45**
	Course Objectives: Students should be able to… 1. Understand the mechanism of name reactions. 2. Gain knowledge about preparation and applications of reagents in organic synthesis. 3. Study the conformational analysis, stereoselective and stereospecific reactions. 4. Learn structure determination of natural products. 5. Know the steps in synthesis of pharmaceuticals compounds and reactions of heterocyclic compounds.	
Unit No.	**Title and Syllabus**	**Lectures Allotted**
I	**Name Reactions: Statement, General Reaction, Mechanism and Synthetic applications:** 1. Diels - Alder reaction 2. Oppenauer Oxidation 3. Meerwein – Pondorff - Verley reduction 4. Schmidt rearrangement 5. Hofmann rearrangement 6. Wittig reaction 7. Wagner - Meerwein rearrangement 8. Favorskii rearrangement 9. Michael reaction 10. Dieckmann's reaction or condensation 11. Benzilic acid rearrangement 12. Benzidine rearrangement 13.Problem based on above reactions.	**10**
II	**Reagents in Organic Synthesis-Preparation and Applications of following reagents:** 1. Lithium aluminium hydride $LiAlH_4$, Osmium tetraoxide (OsO_4), Dicyclohexyl Carbodiimide (DCC) 2. Raney Nickel 3. 2,3 - Dichloro - 5,6 - dicyano – 1, 4 - benzoquinone (DDQ) 4. Polyphosphoric acid (PPA) 5. Diazomethane 6. Ceric Ammonium Nitrate (CAN) 7. N-Bromo succinamide (NBS) 8. Selenium dioxide (SeO_2) 9. Sodium borohydride ($NaBH_4$)	**08**

III	**Stereochemistry:** 3.1 Introduction, Baeyer's strain theory. Theory of strainless rings. 3.2 Conformation and stability of cyclohexane and monosubstituted cyclohexanes: cyclohexanol, bromocyclohexane and methyl cyclohexane. 3.3 Locking of conformation in t-butyl cyclohexane. 3.4 Conformation and stability of disubstituted methyl cyclohexanes (1,2, 1,3, 1,4 disubstituted)	**06**
IV	**Natural Products:** **A] Terpenoids:** 4.1 Introduction, Occurrence, Isolation, General Characteristic, Classification. 4.2 General Methods for structure determinations. 1. Isoprene rule. 2. Analytical evidences and synthesis of Citral. **B] Alkaloids:** 4.3 Introduction, Occurrence, Isolation, Classification, Properties. 4.4 General Methods for structure. 4.5 Analytical evidences and synthesis of Ephedrine.	**08**

V	**Pharmaceuticals and Heterocyclic Chemistry:** **A] Pharmaceuticals:** 5.1 Introduction, Classification, Qualities of ideal drug. 5.2 Synthesis and Uses: Ethambutal, Phenobarbitone, Isoniazide, Benzocaine, Chloramphenicol, Paludrine. Sulpha Drugs. **B] Heterocyclic Chemistry:** 5.3 Introduction, Classification, 1) Pyrrole - method of synthesis, aromatic character, molecular orbital structure, resonance, reactivity, electrophilic substitution with mechanism, chemical reaction - reduction Nitration, sulphonation , Halogenation , friedal craft reaction, coupling reaction, 2) Pyridine. Methods of synthesis. i] From acetylene and hydrogen cyanide ii] From piperidine. Physical properties. Chemical reactions i] Basic character ii] Electrophilic substitution (Nitration, sulphonation & bromination) reactions.Nucleophilic substitution–General mechanism. Reactions with sodamide, sodium hydroxide and n-Butyl lithium. 3) Indole : Synthesis – Fischer Indole Synthesis. Physical properties. Chemical reactions : Electrophilic substitution reactions Nitration, bromination, Friedel Craft's acylation, diazo coupling, Mannich reaction, oxidation and reduction. 4) Quinoline: Synthesis- Skraup'synthesis, Physical properties. Reactions of quinoline :i] Electrophilic substitution reactions– Nitration and sulphonation ii) Nucleophilic substitution reactions– Reactions with sodamide, alkylation and arylation. iii] Reduction.	**13**
	References: 1. Eliel. 2001. Stereochemistry of Carbon Chemistry: McGraw Hill Education 2. Burger. 2021. Medical Chemistry (Eight Edition): Wiley 3. Jain, M. K. 1978. Principles of Organic Chemistry: S. Nagin. 4. Finar I. L. 2002. Organic Chemistry (sixth edition): Pearson Education India. 5. Tewari, K. S., Mehrotra, S. N., Vishnoi N. K. Vikas. 2017. A Text Book of Organic Chemistry (Fourth Edition): Vikas Publishing. 6. Bahl A. and Bahl B. S. 2016. A Text Book of Organic Chemistry: S. Chand Publication. 7. Bansal, R. K. 2005. Heterocyclic Chemistry Synthesis, Reactions and Mechanism -Stereochemistry Conformation and Mechanism: New Age International.	

	Course Outcomes: After completion of the course students will be able to: 1. Outline the mechanism of name reactions. 2. Illustrate the preparation of reagents and applications in their project work. 3. Sketch the conformational analysis of cyclohexane. 4. Report general methods of structure determination of terpenoids, alkaloids 5. Express the qualities of ideal drugs, synthesis of pharmaceuticals. 6.Summarize synthesis and chemical reactions of five and six membered heterocyclic compounds.	

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Credits 2	Paper XVI: Industrial Chemistry Course Code: BCT 604 (Elective Paper – I)	Lectures 45
	Course Objectives: Students should be able to… 1. Recognize aspects of small scale industries. 2. List the steps in manufacturing of sugar. 3. Review different manufacturing processes of industrial chemicals. 4. Get basic idea of electroplating and identify its applications	
Unit No.	**Title and Syllabus**	**Lectures Allotted**
I	**Small Scale Industries:** 1.1 Introduction and aspects of small scale industries 1.2 safety matches, Agarbatties, naphthalene balls, Wax candles, Shoe polishes, gum paste, fountain pen ink, plaster of Paris, silicon carbide crucibles	**11**
II	**Sugar Industry:** 2.1 Introduction Manufacture of cane sugar in India : Extraction of juice, Clarification, Concentration, crystallization, centrifugation and other details of industrial process 2.2 By products of sugar industry Manufacture of Ethyl Alcohol from Molasses: Introduction, Preparation of wash, Fermentation and Distillation. 2.3 Flow sheets diagram for sugar preparation from Beet root	**12**
III	**Manufacture of Industrial Heavy Chemicals:** Introduction, 3.1 Manufacture of Ammonia by Haber's process; (NH_3) :i] Physico – chemical principles, ii] Plant and process. 3.2 Manufacture of Sulphuric acid by Contact process; (H_2SO_4): i] Physico - chemical principles, ii] Plant and process. 3.3 Manufacture of Nitric acid by Ostwald's (Ammonia oxidation process);(HNO_3): i] Physico - chemical principles, ii] Plant and process. 3.4 Manufacture of Sodium carbonate (Washing soda) by Solvay process. (Na_2CO_3): i] Physico - chemical principles, ii] Plant and process.	**12**
IV	**Electroplating:** 4.1 Electrolysis, Faraday's laws, Cathode current efficiency 4.2 Basic principles of electroplating, cleaning of articles; 4.3Factors affecting electroplating, process & applications 4.4 Electroplating of Nickel and Chromium; Anodizing.	**10**

	References: 1. Sharma B. K. 2014. Industrial Chemistry: Krishnan Prakashan. 2. Austin G. T. 2017. Shreve's Chemical Process Industries: McGraw Hill Education. 3. Das R. K. 1967. Industrial Chemistry: Asia Publishing House. 4. Vaidya, V. G. Sahasrabuddhe K.R. 1979. Introduction to Agronomy and Soil, Water Management: Continental Prakashan.	
	Course Outcomes: After completion of the course students will be able to: 1. Outline basic concepts of small scale industries. 2. Recall process of manufacture of cane sugar the by-products of sugar industry 3. Compile physico-chemical principles of production of ammonia, sulfuric acid, nitric acid and sodium carbonate. 4. Demonstrate basic concept of electroplating. 5. Design electroplating plant for industries.	

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Credits 2	Paper XVI: Industrial Chemistry Course Code: BCT 605 (Elective Paper – II)	Lectures 45
	Course Objectives: Students should be able to… 1. Recognize aspects of small scale industries. 2. Define terminologies in polymer chemistry and formulate their synthesis. 3. Arrange flow chart for manufacturing of glass and classify types of glass 4. Acquire information about components, characteristics, different types and working of batteries	
Unit No.	**Title and Syllabus**	**Lectures Allotted**
I	**Small Scale Industries:** 1.1 Introduction and aspects of small scale industries 1.2 safety matches, Agarbatties, naphthalene balls, Wax candles, Shoe polishes, gum paste, fountain pen ink, plaster of Paris, silicon carbide crucibles	**11**
II	**Synthetic Polymer and Application:** 2.1 Introduction, Classification: Based on origin; Based on composition - organic, inorganic polymers; Based on method of preparation; Based on general physical properties; Based on structure. Addition 2.2 Polymerization: Free radicaladdition and ionic addition polymerization, Zigler Nata polymerization 2.3 Method of preparation and applications of some organic polymers: Polyethylene, polystyrene, polyvinyl chloride, Phenol-formaldehyde resin 2.4 Conducting organic polymers: Synthesis and properties of Polyaniline, polypyrrol, Applications of conducting organic polymers.	**12**
III	**Glass Industry:** 3.1 Glassy state and its properties, classification (silicate and non-silicate glasses). 3.2 Manufacture, processing, Composition, properties and applications of the following types of glasses: i] Soda lime glass, ii] lead glass, iii] armored glass, iv] safety glass, v] borosilicate glass, vi) fluorosilicate, vii) coloured glass, viii) photosensitive glass.	**12**

IV	**Batteries:** 4.1 Primary and secondary batteries 4.2 battery components and their role, 4.3 Characteristics of Battery 4.4 Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. 4.5 Fuel cells, Solar cell and polymer cell. 4.6 Advances in battery technology	**10**
	References: 1. Sharma B. K. 2014. Industrial Chemistry: Krishnan Prakashan. 2. Austin G. T. 2017. Shreve's Chemical Process Industries: McGraw Hill Education. 3. Das R. K. 1967. Industrial Chemistry: Asia Publishing House. 4. Vaidya, V. G. Sahasrabuddhe K.R. 1979. Introduction to Agronomy and Soil, Water Management: Continental Prakashan.	
	Course Outcomes: After completion of the course students will be able to: 1. Outline basic idea for small scale industries and list preparation methods of small scale products. 2. Categorise polymers and revise polymerization processes. 3. Restate the process of manufacturing of glasses and list compositions and properties of various glasses. 4. Compile different types of batteries, their working process and uses.	

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Credits 2	Paper XVI: Industrial Chemistry Course Code: BCT 606 (Elective Paper – III)	Lectures 45
	Course Objectives: Students should be able to… 1. Recognize aspects of small scale industries. 2. Identify the importance of dairy chemistry 3. To make student familiar with soil chemistry including properties, fertility, colloids of soil. 5. Learn regarding leather manufacture, leather processing.	
Unit No.	**Title and Syllabus**	**Lectures Allotted**
I	**Small Scale Industries:** 1.1 Introduction and aspects of small scale industries 1.2 safety matches, Agarbatties, naphthalene balls, Wax candles, Shoe polishes, gum paste, fountain pen ink, plaster of Paris, silicon carbide crucibles	**11**
II	**Dairy Chemistry:** 2.1 Definition and structure of milk, factors affecting composition of milk 2.2 Nomenclature and classification of milk proteins, Casein, carbohydrates, vitamins, and minerals 2.3 Isolation, fractionation and chemical composition, physico chemical properties of casein 2.4 Whey proteins: Preparation of total whey proteins:	**10**
III	**Soil Chemistry:** 3.1 Chemical (elemental) composition of the earth's crust and soils 3.2 Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics 3.3 Soil colloids: inorganic and organic colloids - origin of charge, concept of point of zero-charge (PZC) and its dependence on variable-charge soil components, surface charge characteristics of soils; diffuse double layer theories of soil colloids, zeta potential, stability, coagulation/ flocculation and peptization of soil colloids; electrometric properties of soil colloids; sorption properties of soil colloids; soil organic matter - fractionation of soil organic matter and different fractions, clay-organic interactions.	**12**

IV	**Leather Chemistry:** 4.1 Principles of pre tannage 4.2 Curing: - Definition; necessity; principles and different state of cured hides and skins 4.3 Soaking: -Physico-Chemical explanation of wetting; objectives and different controls in soaking operation 4.4 Liming:- Chemistry of unhairing; unhairing by different methods; objectives of liming; effects of liming on collagen; controls in liming operation to achieve different physical properties of leather 4.5 Deliming and Drenching: - Objectives, principles and controls of deliming and drenching 4.6 Bating: - Chemistry of Proteolytic enzymes used for bating; necessity of bating; its preparation and controls for desired properties of leather 4.7 Pickling: - Acid binding capacity of collagen; use of organic acids or salts in pickling; its necessity and controls; concept of Depickling. 4.8 Degreasing: - Objectives and necessity of degreasing; different degreasing systems and method.	**12**
	References: 1. Sharma B. K. 2014. Industrial Chemistry: Krishnan Prakashan. 2. Austin G. T. 2017. Shreve's Chemical Process Industries: McGraw Hill Education. 3. Das R. K. 1967. Industrial Chemistry: Asia Publishing House. 4. Vaidya, V. G. Sahasrabuddhe K.R. 1979. Introduction to Agronomy and Soil, Water Management: Continental Prakashan.	
	Course Outcomes: After completion of the course students will be able to: 1. Outline basic idea for small scale industries and list preparation methods of small scale products. 2. Analyse composition and quality of milk and dairy products. 3. Identify the soil profile, properties and quality of soil. 4. Manufacture good quality leather.	

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Credits 1	Entrepreneurship Development in Chemistry SECCCT 607: SECC Paper II	Lectures 20
	Course Objectives: Students should be able to… 1. Learn Entrepreneurship education focuses on the development of skills. 2. Motivate for entrepreneurial career and to make them capable of and exploiting successfully opportunities for enterprises. 3. Know how to start their own enterprise and approach various institutions for finance. 4. Learn Management education, is focused on the best way to operate existing hierarchies.	
Unit No.	**Title and Syllabus**	**Lectures Allotted**
I	**Entrepreneurship, Creativity & Opportunities:** 1.1 Concept, Classification & Characteristics of Entrepreneur 1.2 Creativity and Risk taking, Risk Situation, Types of risk & risk takers 1.3 Business Reforms, Process of Liberalization, Reform Policies, Impact of Liberalization, Emerging high growth areas, Business Idea Methods and techniques to generate business idea, Transforming Ideas into opportunities transformation involves, Assessment of idea & Feasibility of opportunity SWOT Analysis Information and Support Systems. 1.4 Information needed and Their Sources: Information related to project, Information related to support system, Information related to procedures and formalities 1.5 Support Systems Small Scale Business Planning, Requirements, Govt. & Institutional Agencies, Formalities Statutory Requirements and Agencies 1.6 Market Assessment Marketing: Concept and Importance Market Identification, Survey Key components Market Assessment.	**06**

II	**Business Finance & Accounts:** 2.1 Business Finance: Cost of Project Sources of Finance Assessment of working capital Product costing Profitability Break Even Analysis 2.2 Financial Ratios and Sign if Unit license Business Account: Accounting Principles, Methodology Book Keeping Financial Statements Concept of Audit. 2.3 Business Plan: Business plan steps involved from concept to commissioning, Activity Recourses, Time, Cost. 2.4 Project Report: Meaning and Importance, Components of project report/profile (Give list), Project Appraisal: 1] Meaning and definition. 2] Technical Economic feasibility. 3] Cost benefit Analysis.	**05**
III	**Enterprise Management and Modern Trends:** 3.1 Enterprise Management: Essential roles of Entrepreneur in managing enterprise. 3.2 Product Cycle: Concept and importance Probable Causes of Sickness. 3.3 Quality Assurance: Importance of Quality, Importance of testing E Commerce: Concept and Process.	**05**
IV	**Chemistry Entrepreneur:** 4.1 Current challenges and opportunities for the chemistry –using industries 4.2 Assess your self are you an entrepreneur? 4.3 Prepare project report for Chemistry and study its feasibility.	**04**
	References: 1. Pandey G. N. 1994. A Complete Guide to Successful Entrepreneurship: Vikas. 2. Alpana Trehan. 2011. Entrepreneurship: Wiley India.	
	Course Outcomes: After completion of the course students will be able to: 1. Establish skills of entrepreneur in customer development and customer validation. 2. Apply knowledge in utilizing design thinking and process tools to evaluate in real - world problems and projects. 3. Link the resources, secure customers, stakeholders, and team members through networks. 4. Create presentations and business plans that articulate and apply financial, operational, organizational, market. 5. Identify entrepreneurship opportunities in chemical industries.	

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Credits 04	Practical Lab VII: BCP 608	
	Course Objective: Students should be able to… 1. Recall the knowledge of chemical kinetics of the reactions. 2. Revise the adsorption phenomenon. 3. Know handling and working of Conductometer. 4. Demonstrate the synthesis of nano particles and theoretical models of compounds. 5. Learn the thermodynamic study of various systems.	
Unit No.	**Section I: Physical Chemistry Experiments**	**Lectures Allotted**
	I. Chemical Kinetics: 1.To determine energy of activation of the reaction between potassium persulphate and potassium iodide (Unequal concentration). 2. To study the effect of addition of electrolyte (KCl) on the reaction between $K_2S_2O_8$ and KI (Equal concentrations). **II. Adsorption:** 3. To investigate the adsorption of oxalic acid by activated charcoal and test the validity of Freundlich & Langmuir isotherms. **III. Conductometry**: 4. To study the effect of substituent on dissociation constant of weak acid with respect to acetic acid and monochloroacetic acid (cell constant to be given). 5. To determine rate constant of hydrolysis of ethyl acetate by NaOH conductometrically. **IV. Nano-Particles Synthesis:** 6. Synthesis of Fe- nanoparticles by sol gel method. **VI: Solid State Chemistry:** 7. Preparation of theoretical models. **VII: Thermodynamics:** 8. To determine partial molar volume of ethanol water mixture at a given composition.	
	Course Outcomes: After completion of experiments students will be able to : 1. Determine rate of reactions by using chemical kinetics. 2. Recognize the adsorption phenomenon by titration method. 3. Compare calculations of dissociation constant by using various instrumental techniques. 4. Synthesize various nano-particles by physico-chemical processes. 5. Create models of various the solids using theoretical calculations.	
	Section II: Inorganic Chemistry Experiments	

	Course Objective: Students should be able to… 1. Analyse different steps of gravimetric estimations. 2. Learn to prepare various inorganic complexes. 3. Gain knowledge and analytical skill about titrimetric analysis.	
	I. Gravimetric Estimations (G): **G_1.** Gravimetric estimation of iron as ferric oxide from the given solution Containing ferrous ammonium sulphate, copper sulphate and free sulphuric acid. **G_2.** Gravimetric estimation of barium as barium chromate from the given solution containing barium chloride, ferric chloride and free hydrochloride acid. [For the gravimetric experiments, stock solution should be given in the range of 10 to 15 cm^3 and asked to dilute to 100 cm^3 (or the stock solution should be given in the range of 20 to 30 cm^3 and asked to dilute to 250 cm^3). Use 50 cm^3 of this diluted solution for estimation.] **II. Inorganic Preparations (P):** **P_1.** Preparation of ammonium diamine tetrathiocynato chromate (III) (Reineck's salt). **P_2.** Preparation of hexammine nickel (II) chloride. **P_3.** Preparation of tris (thiourea) cuprous sulphate. **P_4.** Preparation of potassium diaquo bis oxalatocuprate (II). **P_5.** Preparation of chromium acetato dihydrate. **III. Titrimetric Estimations: A] Percentage Purity** **V_1.** Determination of percentage purity of potassium trioxalato aluminate (III). **V_2.** Determination of percentage purity of potassium trioxalato ferrate (III).	
	Course Outcomes: After completion of experiments, students will be able to: 1. Estimate Fe and Ba quantitatively by gravimetry. 2. Conduct the preparations of various inorganic complex molecules. 3. Determine quantitative analysis by using gravimetric analysis. 4. Enhance titrimetric skill.	
	References: 1. Findlay, Alexander. 1973. Practical Physical Chemistry: Prentice Hall Press 2. Khosla, B. D., Garg V. C., Gulati A. 2018. Senior Practical Physical Chemistry: R. Chand and Co. 3. Sivasankar B., Svehla G., 2012. Vogel's Qualitative Chemical Analysis: Pearson Education India. 4. Vogel A. I., 1989. Vogel's Text Book of Quantitative Inorganic Analysis: Longman 5. Palmer W. G. 1954. Experimental Inorganic Chemistry: Cambridge Uni. Press, New York.	

Credits 04	Practical Lab VIII: BCP 609	
	Course Objectives: Students should be able to… 1. Study qualitative and quantitative analysis of organic compounds. 2. Study the preparation of organic compounds by green chemistry. 3. Learn isolation techniques of chemical compounds from natural sources.	
Unit No.	**Section I: Organic Chemistry Experiments**	**Lectures Allotted**
	I] Quantitative Analysis: Organic Estimations: 1. Estimation of sucrose. 2. Estimation of Phenol by bromate –bromide solution. **II] Organic Preparations:** 1. Radical coupling reaction - Preparation of 1, 1, 2 bis-2naphthol. 2. Diels Alder reaction- Reaction between Furan and Maleic acid. and reaction between anthracene and maleic anhydride 3. Benzil-Benzilic acid rearrangement reaction. 4. Oxidation reaction– Preparation of Methyl phenyl sulfone. 5. Preparation of Picric acid from phenol **III) Extraction of Natural Products:** i) Caffeine from Tea leaves ii) Isolation of clove oils from cloves iii) Isolation of citral from lemon grass oil iv) Extraction of Caffeine from waste tea powder. **IV] Any other suitable experiments as per requirement**	
	Course Outcomes: After completion of experiments students will be able to: 1. Estimate organic compounds by qualitative and quantitative approach. 2. Prepare the organic compounds. 3. Isolate and extract natural ingredients from real life samples. 4. Apply green chemistry approach in experiments.	
	Section II: Industrial Chemistry Experiments	
	Course Objectives: Students should be able to… 1. Acquire the experimental techniques of volumetric analysis. 2. Learn the technique to analyse commercial sample quantitatively. 3. Get the idea of chromatographic separation technique using ion exchange resins. 3. Obtain the necessary skills for instrumentation analysis.	

	Organic Industrial Section: 1. Estimation of unsaturation–to estimate the percentage purity of given olefin compound by brominating method. 2. Saponification value of oil. 3. Estimation of Nitro group 4. Estimation of alkali content in Antacid using HCl. **Inorganic Industrial Section:** **Ion exchange Method** 5. Determination of amount of sodium present in the given solution of common salt using cation exchange resin (By Acid Base titration). 6. Determination of amount of magnesium in the given solution containing (Mg^{2+} and Zn^{2+}) using anion exchange resin and standard solution of EDTA. 7. Determination of amount of zinc in the given solution containing (Mg^{2+} and Zn^{2+}) using anion exchange resin and standard solution of EDTA. **Physical Industrial Section:** 8. Estimation of vitamin -C in the given solution by titrating with ceric ammonium sulphate 9. To determine amount of sulphate in water sample turbidimetrically. 10. Estimation of acetic acid in vinegar by using Quinhydrone electrode potentiometrically.	
	Course Outcomes: After completion of experiments students will be able to: 1. Estimate organic function groups qualitatively and quantitatively. 2. Separate inorganic cations and anions by chromatographic method. 3. Handle various instruments for analysing real life and commercial samples.	
	Reference Books: 1. Findlay, Alexander. 1973. Practical Physical Chemistry: Prentice Hall Press 2. Khosla, B. D., Garg V. C., Gulati A. 2018. Senior Practical Physical Chemistry: R. Chand and Co. 3. Sivasankar B., Svehla G., 2012. Vogel's Qualitative Chemical Analysis: Pearson Education India. 4. Vogel A. I., 1989. Vogel's Text Book of Quantitative Inorganic Analysis: Longman. 5. Vogel A. I. 2003.Vogel's Textbook of Practical Organic Chemistry: Pearson India. 6. Agarwal O. P. 2014. Advanced Practical Organic Chemistry: Krishna Prakashan Media (P) Ltd.	

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Credits 01	Practical SECCCP 610 Entrepreneurship Development in Chemistry	
	Course Objectives: Students should be able to… 1. Visit to a chemical industry. 2. Demonstrate the ability to accomplish innovation. 3. Value ethical and socially responsible actions.	
Unit No.	**Title and Syllabus**	**Lectures Allotted**
	15 Days Internship Program and Report Writing: Visit to Chemical industry Internship Report writing Presentation	
	Course Outcomes: After completing the internship students will be able to: 1. List the major technology related industries. 2. Identify the skills required for the entrepreneurs. 3. Critically evaluate the qualities of entrepreneurs through site visits and interactions with business mentors.	

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Evaluation Pattern

Semester	Course Category	Code	Course Title	Marks
V	Theory Paper IX	BCT-501	Physical Chemistry	30
	Theory Paper X	BCT-502	Inorganic Chemistry	30
	Theory Paper -XI	BCT-503	Organic Chemistry	30
	Theory Paper –XII (Elective)	BCT-504	Analytical Chemistry	30
	Theory Paper –XII (Elective)	BCT-505	Analytical Chemistry	
	Theory Paper –XII (Elective)	BCT-506	Analytical Chemistry	
	Paper SECC: Paper – I	SECCCT 507	Basic Numerical Skills	20
	Practical Course: Lab-V	BCP-508	Physical and Inorganic Chemistry	50
	Practical Course: Lab-VI	BCP-509	Organic and Analytical Chemistry	50
	Practical SECC: Paper – I	SECCCP 510	Basic Numerical Skills	30
Internal Semester Examination (ISE-I, ISE-II) will be conducted for 10 marks for each paper. **Mid Semester Examination** will be conducted for 25 marks for each paper.				

Semester	Course Category	Code	Course Title	Marks
VI	Theory Paper XIII	BCT-601	Physical Chemistry	30
	Theory Paper XIV	BCT-602	Inorganic Chemistry	30
	Theory Paper -XV	BCT-603	Organic Chemistry	30
	Theory Paper –XVI (Elective)	BCT-604	Analytical Chemistry	30
	Theory Paper –XVI (Elective)	BCT-605	Analytical Chemistry	
	Theory Paper –XVI (Elective)	BCT-606	Analytical Chemistry	
	Paper SECC: Paper – II	SECCCT 607	Entrepreneurship Development in Chemistry	20
	Practical Course: Lab-VII	BCP-608	Physical and Inorganic Chemistry	50
	Practical Course: Lab-VIII	BCP-609	Organic and Analytical Chemistry	50
	Practical SECCC: Paper – II	SECCCP 610	Entrepreneurship Development in Chemistry	30
Internal Semester Examination (ISE-I, ISE-II) will be conducted for 10 marks for each paper. **Mid Semester Examination** will be conducted for 25 marks for each paper.				