Sir P. T. Sarvajanik College of Science

Autonomous

Affiliated to Veer Narmad South Gujarat University, Surat

Re-Accredited 'A+' with CGPA 3.35

SYLLABUS

FOR

SEM V

Programme: B.Sc.

Course: Chemistry

Academic year

2026-27

(NEP-2020)

(To be effective from June, 2026)

B. Sc. SEMESTER V

Major Course - XI

COURSE NAME: Chemistry Paper -XI

COURSE CODE: CHEMJ-S5P11-2CR26 [CREDITS - 02]

Course learning outcome
At the end of this course, students will be able to 1. Analyze and interpret the effect of Jahn–Teller distortions on octahedral complexes and explain bonding with reference to molecular energy level diagrams and magnetic properties of different complexes. 2. Describe and classify various types of metal carbonyls based on their structure, coordination, and electron count, and explain the nature of metal–carbonyl bonding. 3. Interpret structural and spectroscopic data (particularly IR spectra) to correlate bonding and geometry in different metal carbonyl complexes. 4. Describe and explain the rules for the formation of hybrid orbitals and calculate bond angles in sp, sp^2, and sp^3 hybridization using wave functions. 5. Define and classify organometallic compounds based on their bonding and structural features. 6. Describe the structure and bonding in selected organometallic compounds such as Ferrocene, Dibenzene chromium, Zeiss's salt, Dimethyl beryllium, and Tetramethyl lead.

Module 1	**Metal Complexes**	**[15L]**

Learning Objective:

- To familiarize the student with the theories of bonding in transition metal complexes, Jahn-Teller distortion, structure and bonding in metal-carbonyls.

Learning Outcomes:

At the end of this module, the learner will be able to

1. Analyze and interpret the effect of Jahn–Teller distortions on octahedral complexes and explain bonding with reference to molecular energy level diagrams and magnetic properties of different complexes.
2. Describe and classify various types of metal carbonyls based on their structure, coordination, and electron count, and explain the nature of metal–carbonyl bonding.
3. Interpret structural and spectroscopic data (particularly IR spectra) to correlate bonding

and geometry in different metal carbonyl complexes.		
1.1	**Bonding in Transition Metal Complexes** Jahn-Teller Theorem, Distortion in octahedral complexes (tetragonal and square-planar distortion), Ligand Field Theory (LFT) and Molecular Orbital Theory (MOT), σ–bonding in octahedral complxes, Molecular Energy Level diagram and magnetic properties for $[CoF_6]^{3-}$, $[Co(NH_3)_6]^{3-}$, $[FeF_6]^{3-}$, $[Fe(CN)_6]^{3-}$, II-bonding in octahedral complexes	**[8L]**
1.2	**Metal Carbonyls** Definition, Classification, nature of bonding in metal carbonyls, structure and IR spectra in different complexes e.g. $Ni(CO)_4$, $Fe(CO)_5$, $Cr(CO)_6$, $Fe_2(CO)_9$, $Mn_2(CO)_{10}$, $Co_2(CO)_8$	**[7L]**
Module 2	**Hybridization and Organometallic compounds**	**[15L]**
Learning Objective: • To acquaint the students with the principles of hybridization, hybrid orbitals, and with the structure and bonding of different organometallic compounds		
Learning Outcomes: At the end of this module, the learner will be able to 1. Describe and explain the rules for the formation of hybrid orbitals and calculate bond angles in sp, sp^2, and sp^3 hybridization using wave functions. 2. Define and classify organometallic compounds based on their bonding and structural features. 3. Describe the structure and bonding in selected organometallic compounds such as Ferrocene, Dibenzene chromium, Zeiss's salt, Dimethyl beryllium, and Tetramethyl lead.		
2.1	**Hybridization** Introduction, rules for hybridization, Valence state of a molecules, Bond angles, bond strength and coefficient in sp, sp^2, and sp^3 hybrid orbitals using wave function (Full mathematical calculations).	**[8L]**
2.2	**Organometallic compounds** Definition and Classification of organometallic compounds; Structure and bonding in different organometallic compounds e.g.	**[7L]**

	Ferrocene, Dibenzene chromium, Zeiss's salt (Ions), Gaseous dimethyl beryllium, Tetramethyl lead.	

List of Major Textbooks:

1. Concise Inorganic Chemistry by J. D. Lee, 5/E, Oxford University Press, Indian Edition.
2. Basic Inorganic Chemistry by F. A. Cotton and G. Wilkinson, Wiley publication.
3. Inorganic Chemistry by Shriver & Atkins, 4/E, Oxford University Press, Indian Edition.
4. General and Inorganic Chemistry: Volume I by R. P. Sarkar, New Central Book Agency; 3rd Revised edition (1 July 2011), India
5. Inorganic Chemistry: Principles of Structure and Reactivity by J. E. Huheey, E.A. Keiter, R.L. Keiter, Pearson; 4th edition (1997).
6. Inorganic Chemistry by Shriver, Atkins and Langford, Pubs: W H Freeman & Co (1994)
7. Selected topics in inorganic chemistry by Bhal, Tuli and Madan.

e-Resources:

Module 1:

1. http://www.digimat.in/nptel/courses/video/104105085/L15.html
2. http://www.digimat.in/nptel/courses/video/104105085/L16.html
3. http://www.digimat.in/nptel/courses/video/104101091/L49.html
4. Swayam Prabha: https://www.youtube.com/watch?v=etxRR08x7x8

Module 2:

1. NPTEL-NOC: https://www.youtube.com/watch?v=JBtpMlz3Vxo
2. Swayam Prabha: https://www.youtube.com/watch?v=WaLy1hnxBNw
3. NPTEL-HRD: https://www.youtube.com/watch?v=8pqCeN7GoMc
4. Swayam Prabha: https://www.youtube.com/watch?v=ENsH4uI8gwM
5. http://www.digimat.in/nptel/courses/video/104108062/L33.html
6. http://www.digimat.in/nptel/courses/video/104108062/L40.html
7. http://www.digimat.in/nptel/courses/video/104101090/L56.html

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes								
	1	2	3	4	5	6	7	8	9
1.	√		√						
2.	√	√							
3.	√	√							
4.	√	√							
5.	√	√		√					
6.	√	√		√					

B. Sc. SEMESTER V
Major Course - XII

COURSE NAME: Chemistry Paper -XII

COURSE CODE: CHEMJ-S5P12-2CR26 [CREDITS - 02**]**

Course learning outcome
At the end of this course, students will be able to 1. Define key terms such as esterification, hydrolysis, pyrolytic elimination, acid chlorides, anhydrides and amides. 2. Construct detailed reaction mechanisms for esterification, ester hydrolysis, acid chloride, acid anhydride, amide formation, hydrolysis of amides, Cope and Chugaev reaction. 3. Define amino acids, peptides, and proteins & explain the structure of amino acids and how peptide bonds are formed. 4. Describe the principle of the Merrifield method for peptide synthesis and discuss the difference between N-terminal and C-terminal determination techniques. 5. Define alkaloids and state their general characteristics & explain the basis of alkaloid classification with examples. 6. Summarize the structural features of nicotine and papaverine. 7. Apply structural elucidation methods to identify structural components of nicotine and papaverine. 8. Define and list the classification of vitamins and hormones. 9. Describe the structural features and synthesis of pyridoxine, riboflavin, thyroxine, and adrenaline. 10. Apply structural elucidation methods to identify structural components of pyridoxine, riboflavin, thyroxine, or adrenaline.

Module 1	**Reaction mechanism and Polypeptides**	**[15L]**

Learning Objectives:

- To study mechanism of esterification, ester hydrolysis, acid chloride, acid anhydride, formation amide, hydrolysis of amides, Cope and Chugaev reaction.
- To develop students' foundational understanding of amino acids, peptide synthesis, analytical methods for terminal determination, protein structure, and the biochemical significance of protein denaturation and renaturation.

Learning Outcomes:

At the end of this module, the learner will be able to

1. Define key terms such as esterification, hydrolysis, pyrolytic elimination, acid chlorides, anhydrides and amides.
2. Describe the mechanistic pathway for the formation and hydrolysis of ester, amide.
3. Construct detailed reaction mechanisms for esterification, ester hydrolysis, acid chloride, acid anhydride, amide formation, hydrolysis of amides, Cope and Chugaev reaction.
4. Define amino acids, peptides, and proteins &explain the structure of amino acids and how peptide bonds are formed.
5. Describe the principle of the Merrifield method for peptide synthesis and discuss the difference between N-terminal and C-terminal determination techniques.
6. Apply Sanger's or Edman method to determine the N-terminal amino acid in a given peptide sequence.

1.1	**Reaction Mechanism** (a) Mechanism of Esterification and Hydrolysis: $B_{AC}2$, $A_{AC}2$, $A_{AC}1$, $A_{AL}1$ (b) Mechanism of acid chloride and acid anhydride (c) Mechanism of formation and hydrolysis of amides (d) Pyrolytic elimination: Cope and Chugaev reaction	**[10 L]**
1.2	**Polypeptides** Definition & Structures of Amino acid, Synthesis of peptide by Merry Field Method, End group analysis, N-terminal determination, Sanger's method, Edman method, C-terminal determination by generation of amino alcohol and using digestive enzymes. End group analysis, selective hydrolysis of peptides classical levels of protein structure, Protein denaturation / renaturation.	**[5L]**
Module 2	**Alkaloids, Vitamins and Hormones**	**[15L]**

Learning Objectives:

- To equip students with foundational knowledge of alkaloids, including their classification, methods of structural determination, and the ability to apply analytical and synthetic evidence to elucidate the structures of complex alkaloids

such as nicotine and papaverine.

- To provide students with a foundational understanding of vitamins and hormones, their classification, structural determination, and synthesis, focusing on biologically significant compounds such as pyridoxine, riboflavin, thyroxine, and adrenaline.

Learning Outcomes:

At the end of this module, the learner will be able to

1. Define alkaloids and state their general characteristics & explain the basis of alkaloid classification with examples.
2. Summarize the structural features of nicotine and papaverine.
3. Apply structural elucidation methods to identify structural components of nicotine and papaverine.
4. Define and list the classification of vitamins and hormones.
5. Describe the structural features and synthesis of pyridoxine, riboflavin, thyroxine, and adrenaline.
6. Apply structural elucidation methods to identify structural components of pyridoxine, riboflavin, thyroxine, or adrenaline.

2.1	**Alkaloids** The occurrence, Classification, General methods to determine their structure, Analytical and Synthetic evidence to prove the structure of Nicotine and Papavarine.	**[8L]**
2.2	**Vitamins and Hormones:** General Introduction, Classification, Structural determinations and Synthesis of Pyridoxine, Riboflavin, Thyroxine and Adrenaline	**[7L]**

List of Major Textbooks:

1. Mechanism and Structure in organic chemistry-Goulde. S.
2. Reaction mechanism in organic chemistry by Mukhargy & Singh
3. Principles of reaction mechanism in organic chemistry by Dharmaraha & Chawla
4. Organic reaction mechanism by Bansal Tata Mac. Hill
5. Organic Chemistry (Vol I & II) 6thEdn, I. L. Finar.
6. Organic Chemistry by Hendrickson, Cram & Hammond
7. Organic Chemistry by Brown R. F.
8. Organic Chemistry by Solomon W. Graham

9. Principles of Organic Synthesis- R. O. C. Norman
10. Basic Principles of Organic chemistry, by R. Y. Caserio, W. A. Benjamin
11. Synthetic Organic Chemistry by O. P. Agarwal
12. Organic Chemistry by Morrison and Boyd.
13. Chemistry of organic Natural Product Vol. I & II by O. P. Agarwal.
14. Organic reactions & their mechanism by P. S. Kalsi, New age international publishers.

e-Resources:

1. https://share.google/ZbhLiRCGpeNo74xPB
2. https://share.google/nimok9OgSABzDJ4Gi
3. https://share.google/qLGnIWo4IZC3m5c7y
4. https://share.google/EOzKckhv2S9Eubnzt
5. https://ugcmoocs.inflibnet.ac.in/index.php/courses/view_pg/696
6. https://nios.ac.in/media/documents/dmlt/Biochemistry/Lesson-12.pdf

Mapping of CLOs and PSOs

Course Learning Outcomes	**Programme Specific Outcomes**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1.	√	√							
2.	√	√	√						
3.	√								
4.	√	√	√						
5.	√	√							
6.	√	√	√				√	√	
7.	√	√	√				√	√	
8.	√	√	√				√	√	

B. Sc. SEMESTER V

Major Course- XIII

COURSE NAME: Chemistry Paper - XIII

COURSE CODE: CHEMJ-S5P13-2CR26 [CREDITS - 02**]**

Course learning outcome
At the end of this course, students will be able to 1. Apply the principles of Chemical Thermodynamics to open systems, including the use of partial molal properties, and the Gibbs-Duhem equation to analyse the relationship between component potentials. 2. Evaluate and predict the behavior of real gases using the concepts of fugacity, the Lewis fugacity rule, and activity coefficients, and relate these to chemical potential and standard states for different phases. 3. Explain the third law of thermodynamics and the Nernst Heat Theorem (NHT), including their limitations and exceptions. 4. Determine the absolute entropy of gases, liquids, and solids using the Third Law and calculate or explain the concept of residual entropy with suitable examples. 5. Calculate, analyse and solve numerical problems based on above topics of Thermodynamics. 6. Define phase rule. Apply the Gibbs phase rule (P + F = C + 2) to systematically analyze heterogeneous equilibria. 7. Interpret and construct phase diagrams for one-component systems (water and sulfur) and two-component systems (the KI-Water system), identifying key features such as the Eutectic point and the formation of freezing mixtures. 8. Classify and explain advantages of chromatography. 9. Explain principle and instrumentation of GC and HPLC. 10. Describe sampling and detectors used in GC and HPLC. 11. Explain mobile phase, stationary phase and different types of column used in GC and HPLC. 12. Explain temperature programing in GC. 13. Interpret GC and HPLC chromatogram for qualitative and quantitative analysis.

Module 1	**Physical Chemistry I**	**[15 L]**

Learning Objectives:

- To familiarize the students with the fundamental concepts and principles of

chemical thermodynamics and its applications to various systems.

- To equip students with knowledge of phase rule and its applications to analyze heterogeneous equilibria.

Learning Outcomes:

At the end of this module the learner will be able to

1. Apply the principles of Chemical Thermodynamics to open systems, including the use of partial molal properties, and the Gibbs-Duhem equation to analyse the relationship between component potentials.
2. Evaluate and predict the behavior of real gases using the concepts of fugacity, the Lewis fugacity rule, and activity coefficients, and relate these to chemical potential and standard states for different phases.
3. Explain the third law of thermodynamics and the Nernst Heat Theorem (NHT), including their limitations and exceptions.
4. Determine the absolute entropy of gases, liquids, and solids using the Third Law and calculate or explain the concept of residual entropy with suitable examples.
5. Calculate, analyse and solve numerical problems based on above topics of Thermodynamics.
6. Define Phase rule. Apply the Gibbs phase rule (P + F = C + 2) to systematically analyze heterogeneous equilibria.
7. Interpret and construct phase diagrams for one-component systems (water and sulfur) and two-component systems (the KI-Water system), identifying key features such as the Eutectic point and the formation of freezing mixtures.

1.1	**Thermodynamics Of Open System** Concept of partial molal properties, derivation of Gibb's duhem equation for chemical potential, chemical potential in case of a system of ideal gases. variation of chemical potential with temperature, variation of chemical potential with pressure, concept of fugacity, fugacity function, fugacity at low pressures, physical significance of fugacity, graphical method for determination of fugacity, lewis fugacity rule. Activity and activity coefficient (only concept). Standard state, standard state of solid, liquid and gas. Numerical problems.	**[6 L]**

1.2	**The Third Law Of Thermodynamics** The Nernst Heat Theorem (NHT), limitations of NHT, statement of the third law of thermodynamics, consequence of third law of thermodynamics, determination of absolute entropy of gases and liquids and solid, applications of third law of thermodynamics, concept of residual entropy with suitable examples, exceptions to the third law of thermodynamics, numerical problems.	**[5 L]**
1.3	**Phase Rule** Gibbs phase rule, definitions of the terms phase, component, degree of freedom, phase equilibria of one component system(water, sulphur system) phase equilibria of two component system (KI-water system), the eutectic point, freezing mixtures.	**[4 L]**
Module 2	**Separation Techniques**	**[15 L]**

Learning Objectives:

- To study basic principle, concepts and techniques used in gas chromatography (GC) and HPLC chromatography.

Learning Outcomes:

At the end of this module, the learner will be able to

1. Classify and explain advantages of chromatography.
2. Explain principle and instrumentation of GC and HPLC.
3. Describe sampling and detectors used in GC and HPLC.
4. Explain mobile phase, stationary phase and different types of column used in GC and HPLC.
5. Explain temperature programing in GC.
6. Interpret GC and HPLC chromatogram for qualitative and quantitative analysis.

2.1	**Gas Chromatography** Classification of chromatography, principles of GC separation. Components of GC, sample introduction system, columns: packed column capillary column (WCOT, SCOT), carrier gas and its selection stationary phases: solid adsorbents, inert supports (selection criteria, diatomaceous earths) and liquid stationary phases, detectors: FID, TCD AND ECD. Qualitative and quantitative analysis using GC.	**[10 L]**

2.2	**Liquid Chromatography** Limitation of conventional liquid chromatography (no detail method). Technique of HPLC. Elementary idea about technique and layout diagrams of instrument. Components of instrument of HPLC technique, elementary idea of TLC.	**[5 L]**

List of Major Textbooks:

1. Elements of physical chemistry by Glasstone and Lewis
2. Physical chemistry by G.M. Barrow
3. Physical chemistry by W. Moore
4. Physical chemistry by Atkins
5. Physical chemistry by G.K.Vemulapalli
6. Physical chemistry by B.K.Sharma
7. Physical chemistry by Gurdeep raj
8. Physical chemistry by Puri, Pathania, Sharma
9. Essential of Physical chemistry by Bahl and Bahl
10. Physical chemistry by Negi and Anand
11. Physical chemistry by K.L. KapoorVol 1-5.
12. Physical chemistry by Baliga,Dhavale and ZaveriVol 1-3.
13. Physical chemistry by Dr. S. Pahari
14. Physical Chemistry by D.N. Bajpai.
15. Introduction to Instrumental Analysis (1987), R. D. Braun (McGraw-Hill Book Company), NewDelhi.
16. Analytical Chemistry: Principles and Techniques: Larry G. Hargis (Prentice-Hall Internationaledition).
17. Introduction to Modern Liquid Chromatography: L. R. Shyder & J. J. Kirkland (John Wiley & Sons,New York).
18. Handbook of Analytical Chemistry: L. Meites (McGraw-Hill, New York

e-Resources:

1. https://nptel.ac.in/courses/104103112
2. https://nptel.ac.in/courses/104101084
3. https://epgp.inflibnet.ac.in/Home/ViewSubject?catid=13G8VouhmrFfuhs6rkiyTA =p-10, module 10-11
4. https://ebooks.inflibnet.ac.in/esp02/chapter/gas-chromatography-gsc-and-glc-technique-and-sample-preparations/.
5. https://chem.libretexts.org/Bookshelves/Analytical_Chemistry/Physical_Methods_in_Chemistry_and_Nano_Science_(Barron)/03%3A_Principles_of_Ga

s_Chromatography/3.02%3A_High_Performance_Liquid_chromatography
6. https://egyankosh.ac.in/bitstream/123456789/43314/1/Unit-7.pdf
7. https://egyankosh.ac.in/bitstream/123456789/43313/1/Unit-8.pdf
8. https://kvmwai.edu.in/upload/StudyMaterial/Analytical-Chemistry-by-Gary-D_-Christian-Purnendu-K_-Dasgupta-Kevin-A_-Schug-z-lib_org_.pdf
9. https://chem.hbcse.tifr.res.in/wp-content/uploads/2019/10/vogels-textbook-of-quantitative-chemical-analysis-5th-edition.pdf

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1.	√	√	√			√	√	√	
2.	√	√	√			√	√	√	
3.	√	√							
4.	√	√	√						
5.	√	√	√				√		
6.	√	√	√						
7.	√	√	√			√	√	√	
8.	√	√							
9.	√	√							
10.	√	√							
11.	√	√							
12.	√	√							
13.	√	√	√				√	√	

B. Sc. SEMESTER V

Minor Course - IV

COURSE NAME: Chemistry Minor Paper - IV

COURSE CODE: CHEMN-S5P4-2CR26 [CREDITS - 02**]**

Course learning outcome		
At the end of this course, students will be able to 1. Define analytical chemistry and its key terminologies. 2. Discuss the advantages and disadvantages of chemical vs. instrumental analysis. 3. Define key terms such as significant figures, accuracy, precision, mean, standard deviation, and types of errors. 4. Explain the difference between determinate and indeterminate errors and interpret the significance of statistical parameters in data analysis. 5. Solve problems using computation rules for significant figures and calculate various statistical values. 6. Define the composition of natural gas and crude oil. 7. Illustrate the process of crude oil distillation and describe the products obtained at various stages. 8. Explain the significance of each petrochemical generation and describe the principles behind various petroleum conversion processes. 9. Demonstrate how specific conversion processes are used to transform petroleum fractions into first, second, or third generation petrochemicals.		
Module 1	**Introduction to analytical chemistry and Treatment of analytical data**	**[15L]**
Learning Objectives: • To provide students with a foundational understanding of analytical chemistry principles, including the distinction between chemical and instrumental methods, sampling strategies, classification of analytical techniques, and the systematic steps involved in quantitative analysis. • To equip students with the ability to accurately analyze, interpret, and evaluate experimental data by applying statistical tools, error analysis techniques, and standard rules for data treatment in chemical analysis.		
Learning Outcomes:		

At the end of this module, the learner will be able to:

1. Define analytical chemistry and its key terminologies.
2. Discuss the advantages and disadvantages of chemical vs. instrumental analysis.
3. Define key terms such as significant figures, accuracy, precision, mean, standard deviation, and types of errors.
4. Explain the difference between determinate and indeterminate errors and interpret the significance of statistical parameters in data analysis.
5. Solve problems using computation rules for significant figures and calculate various statistical values (mean, standard deviation, variance, etc.).

1.1	**Introduction to analytical chemistry** Chemical and Instrumental Analysis (advantages and disadvantages), Overview of methods used in Quantitative analysis (classification ofclassical and instrumental analysis), Factors affecting the choice of analytical methods (in brief), Step in quantitative analysis (Flow diagram),Analytical methods on the basis of Sample size (in brief), Samplingmethods. Sampling in different physical states.	**[7 L]**
1.2	**Treatment of analytical data** **Significant figures and rules of computation.** Error Definition, Types of errors: Determinates errors, indeterminate errors, constant and proportional errors. Define and explain the followingterms – Accuracy and Precision, mean, median, deviation, averagedeviation, standard deviation, variance, coefficient of variation, relativemean deviation, range, absolute errors, relative errors. (Problems based on above topics).	**[8L]**
Module 2	**Source of Petrochemicals and Classification of Petrochemicals**	**[15L]**

Learning Objectives:

- To enable students to understand the composition and industrial significance of natural gas and crude oil as sources of petrochemicals, including their processing, refining, and the utilization of their derived products.
- To provide students with comprehensive knowledge of the classification of petrochemicals and the chemical conversion processes involved in transforming petroleum products into valuable petrochemical intermediates and final products.

Learning Outcomes:

At the end of this module, the learner will be able to

1. Define the composition of natural gas and crude oil.
2. Explain how natural gas and crude oil serve as feedstocks for the petrochemical industry.
3. Illustrate the process of crude oil distillation and describe the products obtained at various stages.
4. List and define the three generations of petrochemicals and key conversion processes like cracking, reforming, and isomerization.
5. Explain the significance of each petrochemical generation and describe the principles behind various petroleum conversion processes.
6. Demonstrate how specific conversion processes are used to transform petroleum fractions into first, second, or third generation petrochemicals.

2.1	**Source of Petrochemicals** (a) Natural gas: Composition, Natural gas as Petrochemical feed stock. (b) Crude oil: Composition, Distillation and Refining, Utilization of various fractions (oil product)	**[8 L]**
2.2	**Classification of Petrochemicals** First, Second and Third generation petrochemicals. Conversion process: Cracking reforming, Isomerisation, Hydrogenation, Alkylation and Hydrodealkylation, Dehydrocyclisation of petroleum products, Polymerization of gaseous hydrocarbons.	**[7 L]**

List of Major Textbooks:

1. Quantitative Analysis by R. A. Day & A. L. Underwood, 6th ed. Pub. Prentice Hall of India ltd.
2. Vogel's Text Book Inorganic Quantitative Analysis, 6 th ed.
3. Analytical Chemistry (Principles & Technique) by Lary G. Hargis.
4. Fundamental of Analytical Chemistry by Skoog D. A. & West D. M.
5. Holler F. J. Instrumental Methods of Analysis by B. K. Sharma
6. Instrumental analysis by R. D. Braun Mc Graw Hill.

7. Analytical Chemistry by Gary Christian Instrumental methods of chemical analysis
8. Dr. H. Kaur. Pragatiprakashan Meerut.
9. College Analytical Chemistry by Mangaonkar, Teckchandani, Sathe, Ghalsasi, Jain(Himalaya Publication House)
10. Introduction to petrochemicals by SukumarMaiti oxford and IBH pubs co. New Delhi.
11. A text on petrochemicals by Dr. B. K. Bhaskar Rao, Khanna pubs. New Delhi.
12. Chemicals from petroleum by A. L. Wadams (ELBS and John Murray London)
13. Petrochemicals by S. L. Venkateswarn (Colour pubs. Pvt. Ltd. Bombay)
14. Petrochemicals digest by MGK Manon (Asia Publishing house Bombay)

e-Resources:

1. https://share.google/ka3RXT21McNZmUmYi
2. https://nios.ac.in/media/documents/313courseE/L32A.pdf

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1.	√								
2.	√								
3.	√								
4.	√	√	√						
5.	√	√	√				√	√	
6.	√								
7.	√	√							
8.	√								
9.	√	√							

B. Sc. SEMESTER V

Minor Course - V

COURSE NAME: Chemistry Minor Paper -V

COURSE CODE: CHEMN-S5P5-2CR26 [CREDITS - 02**]**

Course learning outcome
At the end of this course, students will be able to 1. Define terms such as potable water**,** tap water**,** mineral water**,** distilled water**,** hard water**,** and soft water**.** 2. Demonstrate the purification techniques like boiling, filtration, chlorination**,** and reverse osmosis are applied in real-life situations. 3. Define chromatography, R_f value, and key terms like mobile phase and stationary phase. 4. Explain the principles of chromatography and the basis of separation of components. 5. Explain the step-by-step production of chemical pulp using the sulphate and sulphite processes, including chemical reactions, raw materials, and equipment used. 6. Demonstrate an understanding of the transformation of pulp into paper through mechanical and chemical treatments. 7. Explain the steps involved in the manufacture of sugar from sugarcane. 8. Illustrate the flow diagram of a typical sugar manufacturing process..

Module 1	**Purification of water and Paper Chromatography**	**[15L]**

Learning Objectives:

- To understand various concepts and methods related to classification, composition, and purification of water for both potable and industrial use, including advanced techniques like desalination.
- To understand, analyse, and apply the principles and techniques of paper chromatography, including its types, classification, and its application in inorganic analysis, with emphasis on R_f value calculation and separation of ions.

Learning Outcomes:

At the end of this module, the learner will be able to:

1. Define terms such as potable water**,** tap water**,** mineral water**,** distilled water**,** hard

water**,** and soft water**.**

2. Demonstrate the purification techniques like boiling, filtration, chlorination**,** and reverse osmosis are applied in real-life situations.
3. Define chromatography, R_f value, and key terms like mobile phase and stationary phase.
4. Explain the principles of chromatography and the basis of separation of components.

1.1	**Purification of water** Classification and composition of water (tap water, mineral water, portable water, distilled water). Different methods of purification of water for potable and industrial purposes, Soft and hard water. Desalination of sea water by reverse osmosis and electro dialysis.	**[7 L]**
1.2	**Paper chromatography** Principles of chromatography, Classification of chromatography according to mobile phase and stationary phase. Types of paper chromatography, one dimensional, two dimensional and radial paper chromatography, Rf value, Use of paper chromatography in inorganic analysis (I, IIA, IIIB, IV, and halides).	**[8L]**
Module 2	**Pulp, Paper and sugar industry**	**[15L]**

Learning Objectives:

- To understand the different types of pulp used in the paper industry and analyze key paper manufacturing operations such as beating, filling, sizing, colouring, and calendaring.
- To learn the overall process of sugar manufacturing from sugarcane.

Learning Outcomes:

At the end of this module, the learner will be able to

1. Explain the step-by-step production of chemical pulp using the sulphate and sulphite processes, including chemical reactions, raw materials, and equipment used.
2. Demonstrate an understanding of the transformation of pulp into paper through mechanical and chemical treatments.
3. Explain the steps involved in the manufacture of sugar from sugarcane.

4. Illustrate the flow diagram of a typical sugar manufacturing process.		
2.1	**Pulp and Paper industry** Type of pulp, manufacture of chemical pulp by sulphate pulp process, sulphite pulp process, manufacture of paper (conversion of pulp into paper, beating process, importance of fillings, sizing, colouring materials in manufacture of paper and calendaring).	**[7 L]**
2.2	**Sugar Industry** Introduction, Manufacture of sugar from sugarcane: Extraction of juice, Purification of juice, Concentration & crystallisation of purified juice, refining of sugar. Manufacturing of Jaggery & Jaggery powder	**[8 L]**

List of Major Textbooks:

1. Environmental Chemistry, By S. K. Banerji. Prentice Hall India Pvt. Ltd.
2. Environmental Chemistry by. A. K. De.
3. Introduction to Chromatography Theory and Practice by V. K. Srivastava and K. K. Srivastava – S. Chand Pub.
4. Vogel's Textbook of Quantitative Chemical Analysis, G.H. Jeffery, J. Bassett, J. Mendham, and R.C. Denney
5. Instrumental Methods of Chemical Analysis
6. Elementary Organic Chemistry (Part-1) A. I. Vogel
7. Quantitative Analysis, 6th Edition by R.A. Day Jr. and A.L. Underwood, Pearson Publication
8. An Introduction to Industrial Chemistry by Peter Wiseman, Applied Science Pub. Ltd. London.
9. Industrial Chemistry by Clerk Ranken; Andesite Press.
10. Industrial Chemistry by B. K. Sharma Goel Pub.
11. Dryden's Outlines of Chemical Technology,M.Gopal Rao & Marshall Sittig (Revised by S.D. Gokhale in newer editions), East-West Press Pvt. Ltd.

e-Resources:

1.https://chem.libretexts.org/Bookshelves/Introductory_Chemistry/Chemistry_for_Changing_Times

2. https://share.google/t6rchTW0d0imvJfx3

3. https://share.google/U1gyUlMmCYnlzYCut
4. https://share.google/bm7dpQhEnWf7dyxJZ

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes								
	1	2	3	4	5	6	7	8	9
1.	√								
2.	√	√							
3.	√								
4.	√								
5.	√	√							
6.	√	√	√						
7.	√								
8.	√	√	√					√	

B. Sc. SEMESTER V

Major Practical Course –IX

COURSE NAME: Chemistry Practical – IX

COURSE CODE: CHEMJ-S5PR9-2CR26 [CREDITS –2**]**

Learning Objective

Learning Objective:

- To equip students with the knowledge of inorganic qualitative analysis

Course Learning Outcome

Learning Outcomes:

At the end of this course, students will be able to

1. Identify systematically the acidic and basic radicals present in an unknown inorganic mixture.
2. Apply classical qualitative analysis techniques to detect up to six radicals in a mixture soluble in water, dilute HCl, or concentrated HCl, including chromate and borate.
3. Demonstrate proficiency in handling reagents, preparing test solutions, and performing confirmatory tests with accuracy and safety.
4. Interpret experimental observations (e.g., precipitates, colour changes, gas evolution) to draw logical conclusions about the presence of specific cations and anions.

INORGANIC QUALITATIVE ANALYSIS

Inorganic Qualitative Analysis:

List of inorganic chemicals used for inorganic qualitative analysis

- **Chloride:** Cu^{+2}, Cd^{+2}, Fe^{+3}, Mn^{+2}, Co^{+2}, Ni^{+2}, Ca^{+2}, Ba^{+2}, Sr^{+2}, Na^{+}, K^{+}, NH_4^{+}
- **Bromide:** Sr^{+2}, Na^{+}, K^{+}, NH_4^{+}
- **Iodide:** K^{+}
- **Nitrite:** Na^{+}, K^{+}
- **Nitrate:** Co^{+2}, Ni^{+2}, Ba^{+2}, Sr^{+2}, Na^{+}, K^{+}, NH_4^{+}
- **Sulphite:** Na^{+}
- **Sulphide:** Zn^{+2}, Sb^{+3}
- **Sulphate:** Cu^{+2}, Cd^{+2}, Al^{+3}, Fe^{+2}, Zn^{+2}, Mn^{+2}, Co^{+2}, Ni^{+2}, Mg^{+2}, Na^{+}, K^{+}, NH_4^{+}
- **Carbonate:** Cu^{+2}, Cd^{+2}, Zn^{+2}, Mn^{+2}, Co^{+2}, Ni^{+2}, Ca^{+2}, Ba^{+2}, Sr^{+2}, Mg^{+2}, Na^{+}, K^{+}, NH_4^{+}

- **Phosphate:** Cu^{+2}, Al^{+3}, Fe^{+3}, Zn^{+2}, Mn^{+2}, Co^{+2}, Ni^{+2}, Ca^{+2}, Ba^{+2}, Sr^{+2}, Mg^{+2}, Na^{+}, K^{+}, NH_4^{+}
- **Borate:** H_3BO_3

Inorganic qualitative analysis of a mixture containing six radicals. The mixture may be soluble in water or dilute HCl or Concentrated HCl including chromate and borate.

List of Major Textbooks:

1. Ghosh, S. Das Sharma, M., Majumdar, D. and Manna, S. Chemistry in Laboratory-B.Sc. – SEM:I-VIII-Hons.Santra Publication Pvt.Ltd.
2. Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012.
3. Ray, B. C. and Das, S. A Textbook on Chemistry Practical by New Central Book Agency 2014.

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1.		√		√	√	√	√	√	
2.		√		√	√	√	√	√	
3.		√		√	√	√	√	√	
4.		√		√	√	√	√	√	

B. Sc. SEMESTER V

Major Practical Course –X

COURSE NAME: Chemistry Practical – X

COURSE CODE: CHEMJ-S5PR10-2CR26 [CREDITS – 2**]**

Learning Objective

Learning Objective:

- To equip students with the knowledge of experimental methods of organic estimations and chromatographic techniques.

Course Learning Outcome

Learning Outcomes:

At the end of this course, students will be able to

1. Explain methods, reagents, principles and chemical reactions underlying organic estimation of specific organic compounds (e.g., ketones, oils, aspirin, formaldehyde, ethyl acetate).
2. Apply the ascending paper chromatography to quantitatively determine the concentration of various organic compounds and separate amino acid mixtures.
3. Analyse the results obtained from estimations and chromatographic separations, interpreting the data to calculate concentrations or identify components.
4. Evaluate the accuracy and reliability of their experimental methods, refining techniques to minimize errors in estimations and separations.

Organic Estimation & Paper Chromatography

A. Organic Estimation

1. Determination of amount of Ketone (Acetone).
2. Determination of saponification value of an oil.
3. Determination of percentage purity of Aspirin.
4. Determination of amount of Formaldehyde in given solution.
5. Determination of amount of Ethyl acetate in the given solution.
6. Determination of amount of Glycine. (weight sample will be given)

B. Chromatography separation of amino acid mixture by ascending paper chromatography.

1. Glycine +leucine
2. Alanine + leucine

3. Glycine + Methionine
List of Major Textbooks: 1. Ghosh, S. Das Sharma, M., Majumdar, D. and Manna, S. Chemistry in Laboratory-B.Sc. – SEM:I-VIII-Hons.Santra Publication Pvt. Ltd. 2. Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012. 3. Ray, B. C. and Das, S. A Textbook On Chemistry Practical by New Central Book Agency 2014.

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1.		√		√	√	√	√	√	
2.		√		√	√	√	√	√	
3.		√		√	√	√	√	√	
4.		√		√	√	√	√	√	

B. Sc. SEMESTER V

Major Practical Course –XI

COURSE NAME: Chemistry Practical – XI

COURSE CODE: CHEMJ-S5PR11-2CR26 [CREDITS – 2**]**

Course Learning Objective

Learning Objective:

- To equip students with the knowledge of practicals related to pH metry, conductometry, potentiometry, chemical kinetics and polarimetry.

Course Learning Outcome

Learning Outcomes:

At the end of this course, students will be able to

1. Demonstrate proficiency in performing practicals related to pH metry, conductometry, potentiometry, chemical kinetics and polarimetry.

PHYSICAL CHEMISTRY PRACTICALS

1. To investigate rate of reaction between $K_2S_2O_8$ and KI, $a = b$.
2. To investigate rate of reaction between $K_2S_2O_8$ and KI, $a \neq b$.
3. To investigate rate of reaction between H_2O_2 and KI, $a = b$.
4. Polarimetry: Determination of angle of rotation of given substance using three different dilutions and determination of concentration of unknown solution. Sugar, Glucose, Tartaric acid.
5. pH metry: To measure pH of different buffer solution and to study the buffer capacity.
6. pH metry: To determine the concentration and amount of Na_2CO_3 and $NaHCO_3$ in given mixture.
7. Conductometry: To estimate the amount of lead present in given solution of lead nitrate by conductometric titration with sodium sulphate.
8. Conductometry: To determine the amount of NaCl in the given solution using $AgNO_3$ solution.
9. Potentiometry: To determine the normality of given HCl solution using 0.5N NaOH.
10. Potentiometry: To determine the solubility and solubility product of sparingly soluble salt AgCl by the titration of $AgNO_3$ and NaCl. Also determine the % purity of NaCl.

List of Major Textbooks:

1. Experimental Physical Chemistry, V. D. Athawale, 2007, New Age International Publishers.
2. Physical Chemistry Experiments, R. Rajalakshmi, 2020, Notion press Publishers.
3. Senior Practical Physical Chemistry, Khosla B. D.; Garg V. C. & Gulati A., R. Chand & Co.:
   New Delhi (2011).
4. Practical Physical Chemistry by J. B. Yadav 2001 Goel Publishing House.

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1.		√		√	√	√	√	√	

B. Sc. SEMESTER V

Minor Practical Course - IV

COURSE NAME: Chemistry Practical Minor- IV

COURSE CODE: CHEMN-S5PR4-2CR26 [CREDITS – 02]

Course learning Objective

Learning Objective:

- To make students understand the analysis of inorganic mixture.

Course Learning Outcome

Learning Outcome:

At the end of this course, students will be able to

1. Interpret the solubility and reactivity of inorganic compounds in various solvents.
2. Apply knowledge of chemical analysis to determine the presence of specific ions in mixtures, ensuring accurate qualitative analysis.

INORGANIC QUALITATIVE ANALYSIS

List of inorganic chemicals used for inorganic qualitative analysis:

CHLORIDES: Cu^{+2}, Cd^{+2}, Fe^{+3}, Mn^{+2}, Co^{+2}, Ni^{+2}, Ca^{+2}, Ba^{+2}, Sr^{+2}, Na^{+}, K^{+}, NH_4^{+}

BROMIDES: Sr^{+2}, Na^{+}, K^{+}, NH_4^{+}

IODIDES: K^{+}

NITRITES: Na^{+}, K^{+}

NITRATES: Pb^{+2}, Co^{+2}, Ni^{+2}, Ba^{+2}, Sr^{+2}, Na^{+}, K^{+}, NH_4^{+}

SULPHITES: Na^{+}

SULPHATES: Cu^{+2}, Cd^{+2}, Fe^{+2}, Al^{+3}, Mn^{+2}, Co^{+2}, Ni^{+2}, Zn^{+2}, Mg^{+2}, Na^{+}, K^{+}, NH_4^{+}

CARBONATES: Cu^{+2}, Zn^{+2}, Mn^{+2}, Co^{+2}, Ni^{+2}, Ca^{+2}, Ba^{+2}, Sr^{+2}, Mg^{+2}, Na^{+}, K^{+}, NH_4^{+}

PHOSPHATES: Cu^{+2}, Al^{+3}, Fe^{+3}, Zn^{+2}, Mn^{+2}, Ni^{+2}, Ca^{+2}, Ba^{+2}, Sr^{+2}, Mg^{+2}, Na^{+}, K^{+}, NH_4^{+}

(**NOTE:** Inorganic qualitative analysis of mixture containing four radicals. The mixture may be soluble in water or dilute hydrochloric acid or concentrated hydrochloric acid excluding Arsenite, Arsenate, Chromates and Borate.)

List of Major Textbooks:

1. Svehala G. and Sivasankar I. B, Vogel's Qualitative Inorganic Analysis, Pearson, India, 2012.

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1.		√		√	√	√	√	√	
2.		√		√	√	√	√	√	

B. Sc. SEMESTER V

Minor Practical Course - V

COURSE NAME: Chemistry Practical Minor – V

COURSE CODE: CHEMN-S5PR5-2CR26 [CREDITS – 02]

Course Learning Objective

Learning Objective:

- To enable students to understand the nature of water-insoluble organic binary mixtures and to develop practical skills in separating and identifying amino acids using ascending paper chromatography techniques.

Course Learning Outcome

Learning outcomes:

At the end of this course, students will be able to

1. Analyze the solid water insoluble organic binary mixture and determine the type present in it.
2. Explain the basis of separation of compounds in paper chromatography and demonstrate it for amino acids.

TYPE OF WATER INSOLUBLE ORGANIC SOLID BINARY MIXTURE & PAPER CHROMATOGRAPHY

1) Binary mixture

Type of water insoluble organic solid binary mixture

2) Paper Chromatography:

Paper chromatography separation of amino acid mixture by ascending paper chromatography

1) Glycine + Methionine
2) Alanine + Methionine
3) Alanine + Valine

List of Major Textbooks:

1. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry, Pearson Education (2009).
2. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. Practical Organic Chemistry, 5th Ed., Pearson (2012).
3. Introduction to Chromatography Theory and Practice by V. K. Srivastava and K. K.

Srivastava - S. Chand Pub.

Mapping of CLOs and PSOs

Course Learning Outcomes	Programme Specific Outcomes								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1.		√		√	√	√	√	√	
2.		√		√	√	√	√	√	