

Warana University, Warananagar



Syllabus for Bachelor of Science Part-II

(B.Sc. II)

Chemistry (Major) (NEP-2.0)

To be implemented from June, 2026 onwards

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Preamble:

Title: B.Sc. II Chemistry, Warana University, Warananagar — Revised Syllabus as per NEP-2.0.

Faculty: Faculty of Science and Technology.

Year of Implementation: From June 2025 (as stated in the source document's preliminary information — see note at the end regarding a year discrepancy with the cover page).

The B.Sc. II Course (Chemistry) (Level 5.0) will be of Two Semesters (Semester III and Semester IV).

Pattern of Examination: The examinations will be conducted semester-wise for Theory and Practical.

Fee Structure: As per Warana University guidelines.

General Objectives of the Course:

Objectives of a Bachelor of Science (B.Sc.) in Chemistry Programme include:

- Understand the fundamental principles, laws, concepts and formulas of Chemistry.
- Develop problem-solving skills of students.
- Gain practical experience by hands-on experience with instruments and develop laboratory skills.
- Learn about advanced Chemistry and its applications for higher studies.
- Learn to apply conceptual knowledge to practical work.
- Learn to interpret chemical and physical phenomena through experimental evidence.
- Learn to analyze and interpret data accurately through scientific reasoning and experimental hypothesis testing.

Programme Outcomes (POs) – B.Sc.:

PO-1: Students will gain fundamental knowledge of Chemistry which will help them for PG studies and Research.

PO-2: Students will be able to know good laboratory practices and lab safety.

PO-3: Students will become proficient in analyzing the various observations and chemical phenomena presented to them during the course.

PO-4: Students will be able to apply the fundamental knowledge to address the cross-cutting issues such as sustainable development.

PO-5: Students will be able to solve various problems by identifying the essential parts of a problem, formulate a strategy for solving the problem, apply appropriate techniques to arrive at a solution, test the precision and accuracy of the solution and interpret the results.

PO-6: Students will be able to communicate effectively, i.e. being able to articulate, comprehend and write effective reports, make effective presentations and documentation, and be capable of expressing the subject through technical writing as well as through oral presentation.

Programme Specific Outcomes (PSOs) – B.Sc. Chemistry:

PSO-1: Students will be able to explain fundamental concepts of Inorganic, Physical, Organic and Analytical Chemistry.

PSO-2: Students will be able to identify chemical formulae and solve numerical problems.

PSO-3: Students will be able to use modern chemical tools, models, charts and equipment.

PSO-4: Students will be able to prepare and qualify for competitive examinations.

PSO-5: Students will understand good laboratory practices and safety.

PSO-6: Students will develop research-oriented skills.

Eligibility for Admission to B.Sc. Part II (Level 5.0):

1. The students passing or ATKT the B.Sc. Part-I (or Undergraduate Certificate in Science) shall be allowed to enter upon the B.Sc. Part-II (or Undergraduate Diploma in Science). OR
2. An Examination of any other Statutory University or an Examining Body recognized as equivalent thereto. OR
3. Completed a 3-year diploma course with subjects allied/related to the subject at B.Sc. Part I. OR
4. Completed the first year of B.E./B.Tech. with subjects allied/related to the subject at B.Sc. Part I.

Duration:

The B.Sc. II Course (Chemistry) (Level 5.0) will be of Two Semesters (Semester III and Semester IV).

Medium of Instruction:

The medium of instruction shall be English.

Scheme of Teaching and Examination:

Structure of course: Given in the Framework Chart below.

- Each theory course paper constitutes 4–5 units, requires 30 hours of teaching lectures, and there shall be two lectures per theory (2 Cr) course per week.
- B.Sc. II Chemistry Course will be of 44 Credits (1100 marks).
- Examination of each theory course shall be of 50 marks (30 university examination + 20 internal assessment). University examination of 40 marks — wait, see note — (1.5 hours' duration) will be conducted at the end of each semester. Internal assessment of 10 marks will be done before the semester examination during each semester.
- Examination of a practical course shall be of 50 marks per semester.
- Pattern, nature, and marking scheme for theory and practical examination for Major, Specific, SEC and VSC courses are included in the syllabus.
- Question papers will be set in view of the entire syllabus and preferably cover each unit of the syllabus. Weightage should be provided to each unit as per the hours allotted for teaching.

Note: The source document states the theory-course total as "50 marks (30 university + 20 internal)" in one sentence, but the same passage also describes the university exam as "40 marks" and internal assessment as "10 marks" — these two statements conflict with each other and with the Standard of Passing table below (30 + 20 = 50). Reproduced here exactly as in the source; please confirm the correct split at your end.

Standard of Passing:

The standard of passing shall be as per the following table:

	Semester End Exam	Internal Assessment	Course Exam (Total)
Maximum Marks	30	20	50
Minimum Marks required for passing	12	8	20

1. There shall be a separate head of passing for the semester-end examination and the internal examination.
2. A minimum of 18 marks out of 50 is required for passing the practical examination of each course.
3. Passing criteria for Co-Curricular Activities (CC) and Community Engagement Programme (CEP) shall be as per University guidelines.

Nature of Question Paper and Scheme of Marking (brief): Theory question paper — Maximum marks 30, Total number of questions 3, all compulsory. Question 1 is MCQ type (6 marks). Question 2 is a long-answer question carrying 12 marks. Question 3 is a short-answer question carrying 12 marks. (Full pattern is provided in the Scheme of Examination section at the end of this document.)

Bachelor of Science Credit Framework - B.Sc. II Chemistry:**Semester III**

Major	Minor	IDC/MDC/OE	VSC	SEC	AEC	CC	Credits
PCH-301 Paper-V Physical Chemistry (2 Cr)	PCHMN-301 Paper-V Applied Physical Chemistry (2 Cr)	CHOEPR-301 Food Chemistry Practical (2 Cr)	PRCHVSC-301 VSC Practical Paper-I (2 Cr)	CHSECPR-301 Practical Skills in Chemistry Paper-I (2 Cr)	AEC I (2 Cr) (English)	CC-I (2 Cr)	—
ACH-302 Paper-VI Analytical Chemistry (2 Cr)	ACHMN-302 Paper-VI Applied Analytical Chemistry (2 Cr)						
PRCH-303 Practical Paper-III (2 Cr)	PRCHMN-303 Practical Paper-III (2 Cr)						
Credits: 4(T)+2(P)=6	4(T)+2(P)=6	2(P)=2	2(P)=2	2(P)=2	2(T)=2	2	22

Semester IV

Major	Minor	IDC/MDC/OE	SEC	AEC	VEC	CEP	Credits
ICH-401 Paper-VII Inorganic Chemistry (2 Cr)	ICHMN-401 Paper-VII Fundamentals of Inorganic Chemistry (2 Cr)	CHOEPR-401 Chemistry in Everyday Life (2 Cr)	CHSECPR-401 Practical Skills in Chemistry Paper-II (2 Cr)	AEC-II (2 Cr) (English)	VEC-II (2 Cr) (Environmental Studies)	CHCEP-401 Community Engagement Programme in Chemistry (2 Cr)	—
OCH-402 Paper-VIII Organic Chemistry (2 Cr)	OCHMN-402 Paper-VIII Applied Organic Chemistry (2 Cr)						
PRCH-403 Practical Paper-IV (2 Cr)	PRCHMN-403 Practical Paper-IV (2 Cr)						
Credits: 4(T)+2(P)=6	4(T)+2(P)=6	2(P)=2	2(P)=2	2(T)=2	2(T)=2	2	22

Total Credits (Sem III + IV): 44. Degree/Cumulative credits (UG Diploma): 88.

Exit Option: 4 credits — NSQF / Internship / Skill courses.

Course Code / Structure Tables:

Structure of B.Sc. II Chemistry (Major)

Note: the source document's numbering skips 'Sr. No. 5' (jumps from 4 to 6). Reproduced exactly as in the source.

Sr. No.	Semester	Course Code	Title of Paper
1	III	BWU0325MML207C01	PCH-301, Paper-V, Physical Chemistry (2 credits, 30 Hours)
2	III	BWU0325MML207C02	ACH-302, Paper-VI, Analytical Chemistry (2 credits, 30 Hours)
3	III	BWU0325MMP207C03	PRCH-303, Chemistry Practical Paper-III (2 credits, 60 Hours)
4	III	BWU0325VSP207C01	PRCHVSC-301, Vocational Skill Course – Practical Paper-I (2 credits, 60 Hours)
6	IV	BWU0325MML207D01	ICH-401, Paper-VII, Inorganic Chemistry (2 credits, 30 Hours)
7	IV	BWU0325MML207D02	OCH-402, Paper-VIII, Organic Chemistry (2 credits, 30 Hours)
8	IV	BWU0325MMP207D03	PRCH-403, Chemistry Practical Paper-IV (2 credits, 60 Hours)
9	IV	BWU0325CEP207D01	CHCEP-401, Community Engagement Programme in Chemistry (2 Credits, 60 Hours)

Structure of B.Sc. II Chemistry (Major Specific) -Vocational Skill Course in Chemistry

Sr. No.	Semester	Course Code	Title of Paper
1	III	BWU0325VSP207C01	PRCHVSC-301, Vocational Skill Course in Chemistry – Practical Paper-I (2 credits, 60 Hours)

Note: this table's course code (BSU0325VSP207C01) differs from the code shown for the same paper in the Major structure table above (BWU0325VSP207C01) — a BWU/BSU prefix mismatch in the source. Please confirm the correct code.

Structure of B.Sc. II - Community Engagement Programme in Chemistry

Sr. No.	Semester	Course Code	Title of Paper
1	IV	BWU0325CEP207D01	CHCEP-401, Community Engagement Programme in Chemistry (2 credits, 60 Hours)

Note: this table's course code (BSU0325CEP207D01) differs from the code shown for the same paper in the Major structure table above (BWU0325CEP207D01) — a BWU/BSU prefix mismatch in the source.

Structure of B.Sc. II Chemistry (Minor)

Sr. No.	Semester	Course Code	Title of Paper
1	III	BWU0325MIL207C01	PCHMN-301, Paper-V, Applied Physical Chemistry (2 credits, 30 Hours)
2	III	BWU0325MIL207C02	ACHMN-302, Paper-VI, Applied Analytical Chemistry (2 credits,

Sr. No.	Semester	Course Code	Title of Paper
			30 Hours)
3	III	BWU0325MIP207C03	PRCHMN-303, Chemistry Practical Paper-III (2 credits, 60 Hours)
4	IV	BWU0325MIL207D01	ICHMN-401, Paper-VII, Fundamentals of Inorganic Chemistry (2 credits, 30 Hours)
5	IV	BWU0325MIL207D02	OCHMN-402, Paper-VIII, Applied Organic Chemistry (2 credits, 30 Hours)
6	IV	BWU0325MIP207D03	PRCHMN-403, Chemistry Practical Paper-IV (2 credits, 60 Hours)

Structure of B.Sc. II - Skill Enhancement Courses in Chemistry

Sr. No.	Semester	Course Code	Title of Paper
1	III	BWU0325SEP207C01	CHSECPR-301, Practical Skills in Chemistry – Practical Paper-I (2 credits, 60 Hours)
2	IV	BWU0325SEP207D01	CHSECPR-401, Practical Skills in Chemistry – Practical Paper-II (2 credits, 60 Hours)

Open Elective Courses in Chemistry (for B.A. II and B.Com. II)

Sr. No.	Semester	Course Code	Title of Paper
1	III	BWU0325OEP207C01	CHOEPR-301, Food Chemistry – Practical Paper-III (2 credits, 60 Hours)
2	IV	BWU0325OEP207D01	CHOEPR-401, Chemistry in Everyday Life – Practical Paper-IV (2 credits, 60 Hours)

Note: the individual course-page headers for these two papers show different course codes (BSU0325OEP207C03 for CHOEPR-301 and BSU0325OEP207D04 for CHOEPR-401) than this structure table. Reproduced exactly as in the source; please confirm the correct codes.

Syllabus

Semester - III

Chemistry (Major):

PCH-301 -Paper V: Physical Chemistry

Course Code: PCH-301 | Credits: 2 | Hours: 30 | Marks: 50

Course Outcomes:

After successful completion of this course, the students will be able to:

Electrolytic Conductivity	Learning and coherent understanding of conductivity and transport number of aqueous solutions with different applications. Experimental determination of transport number and numerical problems.
Thermodynamics	Knowledge and coherent understanding of basic concepts in thermodynamics and the concept of Entropy will be gained by the student.
Chemical Kinetics	Learning and understanding the knowledge about basic concepts in kinetics and third order reactions with characteristics, suitable examples and methods for determination of order of reactions and numerical problems.
States of Matter	Learning and coherent understanding of the behavior of gases, ideal gas as a model system and its extension to real gases. The dependence of physical state on P, V and T. Liquid crystals are essential in common and research devices, hence introduced with suitable examples.
Surface Chemistry	Learning and understanding of the theoretical basis of the adsorption phenomenon, dynamic nature of surface, and its applications.

Syllabus

Module 1: Electrolytic Conductivity (6 Lecture Periods)

Sub-topic	Content
Content	Introduction, Migration of ions. Hittorf's rule, Transference number, determination of transport number by moving boundary method, factors affecting transport number: nature of electrolyte, concentration, temperature, complex formation and degree of hydration. Kohlrausch law of independent migration of ions and its applications such as relations between ionic conductance, ionic mobility and transport number, determination of equivalent conductance at infinite dilution of weak electrolytes, determination of degree of ionization of weak electrolyte. Conductometric titrations (only acid-base titrations). Advantages of conductometric titrations. Numerical problems.

Module 2: Thermodynamics (6 Lecture Periods)

Sub-topic	Content
Content	Introduction, Concept of Entropy: Definition, mathematical expression, unit. Physical significance of Entropy. Entropy changes for reversible and irreversible processes in isolated systems. Entropy changes for an ideal gas as a function of V & T and as a function of P & T. Entropy change in mixing of gases. Entropy change in phase transformations. Third law of thermodynamics, standard entropy, application of the third law of thermodynamics in determination of absolute entropy, Entropy changes in chemical reactions. Numerical problems.

Module 3: Chemical Kinetics (4 Lecture Periods)

Sub-topic	Content
Content	Introduction. Third order reactions: derivation of rate constant considering reaction with equal initial concentration, characteristics, and examples of third order reaction. Determination of order of reaction by: i) Integration method, ii) Graphical method and iii) Half-life method. Effect of temperature on rate of reaction, Arrhenius equation. Concept of energy of activation. Numerical problems.

Module 4: States of Matter (8 Lecture Periods)

Sub-topic	Content
Content	Introduction, States of matter and their properties. A) Gaseous state: Postulates of Kinetic Theory of Gases. Ideal and Non-ideal gases, deviation of real gases from ideal behavior, compressibility factor, causes of deviation. Van der Waals equation of state for real gases. Explanation of real gas behavior by Van der Waals' equation, Boyle temperature (derivation not required). Critical Phenomena: PV-isotherms of real gases (Andrews' isotherms), continuity of state, critical constants and their calculation from Van der Waals equation. B) Liquid state: Liquid crystals: difference between liquid crystal, solid and liquid. Classification, structure of nematic, smectic and cholesteric liquid crystal. Numerical Problems.

Module 5: Surface Chemistry (6 Lecture Periods)

Sub-topic	Content
Content	Introduction, Adsorption as a surface phenomenon, definition of adsorption, adsorbent, adsorbate. Characteristics of adsorption. Factors affecting adsorption, types of adsorption, distinction between physical and chemical adsorption. Adsorption isotherms: Freundlich adsorption isotherm, Langmuir adsorption isotherm. Applications of adsorption.

References:

1. Barrow, G.M. Physical Chemistry, Tata McGraw-Hill (2007).
2. Castellan G.W. Physical Chemistry, 4th Ed., Narosa (2004).

3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt Ltd: New Delhi (2009).
4. Mahan, B.H. University Chemistry, 3rd Ed., Narosa (1998).
5. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).
6. Elements of Physical Chemistry, S. Glasstone, D. Lewis (2010).
7. Principles of Physical Chemistry, Marron and Prutton (2007).
8. Elements of Physical Chemistry, P.W. Atkins (2017–18).
9. Essentials of Physical Chemistry, Bahl and Tuli, S. Chand (2010).
10. Physical Chemistry, Danials and Alberty (2016).
11. University General Chemistry, C.N.R. Rao (2016).
12. Principles of Physical Chemistry, Puri, Sharma and Pathania, 47th Edition, Vishal Publishing Co., Daryaganj, Delhi 110002 (2017–18).
13. Physical Chemistry, A.J. Mee (2015).
14. Advanced Physical Chemistry, Gurudeep Raj (2017–18).
15. Physical Chemistry, R.A. Alberty (2017–18).
16. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).

ACH-302 - Paper VI: Analytical Chemistry**Course Code: ACH-302 | Credits: 2 | Hours: 30 | Marks: 50****Course Outcomes:**

After successful completion of this course, the students will be able to:

Gravimetric Analysis	Learning and understanding of basic concepts in gravimetric analysis.
Colorimetry and Spectrophotometry	Understanding, working and applications of optical methods as an analytical tool.
Soap and Detergents	Knowledge about the chemical nature and cleansing action of soap.
Chromatographic Techniques, IPR	Learning and coherent understanding of column and ion exchange chromatography, copyrights and trademarks.
Corrosion	Learning and understanding the knowledge about basic concepts in corrosion and the mechanism of corrosion.

Syllabus**Module 1: Gravimetric Analysis (6 Lecture Periods)**

Sub-topic	Content
Content	Introduction. Gravimetric analysis by precipitation: nucleation, crystal growth, digestion/ageing, filtration, drying, ignition, weighing. Optimum conditions for good precipitation. Physical nature of precipitate. Purity of precipitate: co-precipitation, post-precipitation. Organic precipitates and their applications.

Module 2: Colorimetry and Spectrophotometry (6 Lecture Periods)

Sub-topic	Content
Content	Theory of colorimetry and spectrophotometry. Lambert-Beer's law, deviation from Beer's law. Terms used in colorimetry and spectrophotometry. Classification of methods of 'colour' measurement or comparison. Photoelectric colorimeter method — single beam photo-electric colorimeter. Spectrophotometer method — single beam direct reading spectrophotometer. Determination of unknown concentration by using concentration-absorbance plot. Applications of colorimetry and spectrophotometry.

Module 3: Soaps and Detergents (6 Lecture Periods)

Sub-topic	Content
Content	Introduction. Soaps — raw materials, types of soaps, cleansing action of soap, manufacture of soap — boiled or hot process. Detergents — raw materials, types of

Sub-topic	Content
	detergents: anionic, cationic and amphoteric, preparation of Teepol and Deriphat. Comparisons between soaps and detergents.

Module 4: Chromatographic Techniques and IPR (7 Lecture Periods)

Sub-topic	Content
Content	Introduction to chromatography, classification. Column chromatography: introduction, types, principle of adsorption column chromatography, solvent system, stationary phases. Methodology — column packing, application of sample, development, detection methods, recovery of components. Applications. Ion exchange chromatography: introduction, principle, types and properties of ion exchangers. Methodology — column packing, application of sample, elution, detection/analysis. Applications. IPR: introduction to Copyright. Introduction to Trademark.

Module 5: Corrosion (5 Lecture Periods)

Sub-topic	Content
Content	Introduction to corrosion. Electrochemical theory of corrosion. Factors affecting corrosion — i. position of metals in the electrochemical series on the basis of standard reduction potential, ii. purity of metal, iii. effect of moisture, iv. effect of oxygen (differential aeration principle), v. hydrogen overvoltage. Methods of protection of metals from corrosion — alloy formation, making metal cathodic, controlling external conditions, coating — galvanising, tinning, electroplating, metal cladding, organic coating.

References:

1. Principles of Physical Chemistry by Puri, Sharma and Pathania, Vishal Publishing Company, Jalandhar.
2. Vogel's Textbook of Quantitative Chemical Analysis, 5th Edition, Longman Scientific & Technical Ltd., UK.
3. Modern Analytical Chemistry by David Harvey, McGraw-Hill International Edition, 2000.
4. Industrial Chemistry by B.K. Sharma, Goel Publishing House, 16th edition, 2011.
5. Advanced Inorganic Chemistry, Vol. 1, by Gurudeep Raj, Krishna Prakashan Media Ltd, Goel Publication, Meerut.
6. Analytical Chemistry by B.K. Sharma, Krishna Prakashan Media Ltd, Meerut, 3rd Edition, 2011.
7. Chemical Process Industries by Shreve and Brink.
8. Industrial Chemistry by Loutfy Madkor and Helen Njenga.
9. Intellectual Property — A Primer for Academia by Prof. Rupinder Tewari & Ms. Mamta Bhardwaj, Publication Bureau, Panjab University, Chandigarh.

10. Elementary Principles of Chemical Processes by Richard Felder and Ronald Rousseau, John Wiley and Sons.
11. Essentials of Physical Chemistry by Bahl B.S., Tuli G.D. and Bahl Arun, S. Chand and Company Ltd., New Delhi.
12. Analytical Chemistry, H. Kaur, Pragati Prakashan, Meerut.
13. Analytical Chemistry, Alka Gupta, Pragati Prakashan, Meerut.
14. Instrumental Methods of Chemical Analysis — Chatwal & Anand.

PRCH-303 - Chemistry Practical Paper-III

Course Code: PRCH-303 | Credits: 2 | Hours: 60 | Marks: 50

Practical

A) Physical Chemistry — Perform any 8 of the following

1. To study the hydrolysis of methyl acetate in presence of HCl and H₂SO₄ and to determine the relative strength of acids.
2. To study the reaction between Potassium persulphate and Potassium iodide in solution with unequal concentration of the reactants.
3. To study the effect of acid strength on hydrolysis of an ester by using 0.5M HCl and 0.25M HCl.
4. Determination of the adsorption coefficient of acetic acid-charcoal system.
5. To determine the percentage composition of a given liquid mixture by viscosity method (density data to be given).
6. To determine the degree of dissociation and dissociation constant of acetic acid at various dilutions and to verify Ostwald's dilution law conductometrically.
7. To determine the normality of the given strong acid by titrating it against the strong alkali conductometrically.
8. To determine the specific rotation and unknown concentration of sugar solution by Polarimeter.
9. To determine the specific and molar refractions of benzene, toluene and xylene by Abbe's Refractometer and to determine the refraction of CH₂ group (methylene group) (densities should be determined by students).

B) Analytical Chemistry — Perform any 8 of the following

1. Fertilizer analysis: to determine the percentage of nitrogen in the given sample of a nitrogenous fertilizer (ammonium sulphate).
2. Analysis of synthetic/commercial sample: to estimate magnesium from talcum powder.
3. Determination of alkali content from an antacid tablet using HCl solution.
4. Estimation of calcium from chalk: to estimate the amount of calcium from chalk by titrimetric method (by redox titration using KMnO₄ solution).
5. Determination of total hardness of water using 0.01M EDTA solution (students should standardize the given EDTA solution by preparing 0.01M CaCl₂ solution using CaCO₃ salt).
6. Determination of alkalinity of water titrimetrically using 0.02N H₂SO₄ using methyl orange and phenolphthalein indicator.
7. Estimation of acetone.
8. Estimation of Vitamin C from a given tablet.
9. Estimation of phenol by bromination method.

References:

1. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.

2. Khosla, B.D.; Garg, V.C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co: New Delhi (2011).
3. Findlay's Practical Physical Chemistry (Longman), 2015.
4. Practical Physical Chemistry: Gurtu (S. Chand), 2014.
5. Systematic Experimental Physical Chemistry: Rajbhoj, Chandekar (Anjali Publication), 2016.
6. Advanced Practical Chemistry by J. Singh, L.D.S. Yadav, R.K.P. Singh, I.R. Siddiqui et al., Pragati Prakashan.
7. Vogel's Textbook of Qualitative Inorganic Analysis by A.I. Vogel, 3rd and 6th edition.
8. Practical Organic Chemistry by A.I. Vogel.
9. Handbook of Organic Qualitative Analysis by H.T. Clarke.
10. Practical Organic Chemistry by F.G. Mann and B.C. Saunders. Low-priced Textbook, ELBS, Longman.

Chemistry (Minor)**PCHMN-301 - Paper V: Applied Physical Chemistry****Course Code: PCHMN-301 | Credits: 2 | Hours: 30 | Marks: 50****Course Outcomes:**

After successful completion of this course, the students will be able to:

Colloidal State	Learning and understanding the knowledge of colloidal state, understanding of colloidal system, different types of colloidal system, preparation, properties, stability of different colloidal system, general applications of colloids.
Entropy	Knowledge and coherent understanding of basic concepts in thermodynamics and Entropy as a state function will be gained by the student.
Surface Phenomena	Learning and understanding of the theoretical basis of the adsorption phenomenon, dynamic nature of surface and its applications.
Chemical Kinetics	Learning and understanding the knowledge about basic concepts in reaction kinetics and third order reaction with characteristics, suitable examples, and methods for determination of order of reactions.

Syllabus**Module 1: Colloidal State (7 Lecture Periods)**

Sub-topic	Content
Content	Introduction: definition of colloids, colloidal state of matter, true solution, colloidal solution and suspension, dispersed phase and dispersion medium, types of colloidal systems. Solids in liquids (sols): preparation, purification, properties and stability. Liquids in liquids (emulsions): types and preparations. Liquids in solids (gels): types and preparations. General applications of colloids.

Module 2: Entropy (8 Lecture Periods)

Sub-topic	Content
Content	Introduction, Entropy: definition, mathematical expression, unit. Physical significance of Entropy. Entropy changes for reversible and irreversible processes in isolated systems. Entropy changes for an ideal gas as a function of V & T and as a function of P & T. Entropy change in mixing of gases. Entropy change in phase transformations. Statement of the third law of thermodynamics and standard entropy. Numerical problems.

Module 3: Surface Phenomena (7 Lecture Periods)

Sub-topic	Content
Content	Introduction, Adsorption as a surface phenomenon, definition of adsorption, adsorbent, adsorbate. Characteristics of adsorption. Factors affecting adsorption, types of

Sub-topic	Content
	adsorption, distinction between physical and chemical adsorption. Adsorption isotherms: Freundlich adsorption isotherm. Applications of adsorption.

Module 4: Chemical Kinetics (8 Lecture Periods)

Sub-topic	Content
Content	Introduction. Third order reactions: detailed derivation of rate constant considering reaction with equal initial concentration, characteristics, and examples of third order reaction. Determination of order of reaction by: i. Integration method, ii. Graphical method and iii. Half-life method. Effect of temperature on rate of reaction, Arrhenius equation. Concept of energy of activation.

References:

1. Barrow, G.M. Physical Chemistry, Tata McGraw-Hill (2007).
2. Castellan G.W. Physical Chemistry, 4th Ed., Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt Ltd: New Delhi (2009).
4. Mahan, B.H. University Chemistry, 3rd Ed., Narosa (1998).
5. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).
6. Elements of Physical Chemistry, S. Glasstone, D. Lewis (2010).
7. Principles of Physical Chemistry, Marron and Prutton (2007).
8. Elements of Physical Chemistry, P.W. Atkins (2017–18).
9. Essentials of Physical Chemistry, Bahl and Tuli, S. Chand (2010).
10. Physical Chemistry, Danials and Alberty (2016).
11. University General Chemistry, C.N.R. Rao (2016).
12. Principles of Physical Chemistry, Puri, Sharma and Pathania, 47th Edition, Vishal Publishing Co., Daryaganj, Delhi 110002 (2017–18).
13. Physical Chemistry, A.J. Mee (2015).
14. Advanced Physical Chemistry, Gurudeep Raj (2017–18).
15. Physical Chemistry, R.A. Alberty (2017–18).
16. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).

ACHMN-302 - Paper VI: Applied Analytical Chemistry**Course Code: ACHMN-302 | Credits: 2 | Hours: 30 | Marks: 50****Course Outcomes:**

After successful completion of this course, the students will be able to:

Cleansing Agents: Soaps and Detergents	Knowledge about the chemical nature and cleansing action of soap and detergents.
Optical Methods of Analysis	Understanding, working and applications of optical methods as an analytical tool.
Electroplating	Learning and understanding the knowledge about basic concepts in electroplating.
Column and Ion Exchange Chromatography	Learning and coherent understanding of column and ion exchange chromatography.

Syllabus**Module 1: Cleansing Agents - Soaps and Detergents (8 Lecture Periods)**

Sub-topic	Content
Content	Introduction. Soaps — raw materials, types of soaps, cleansing action of soap, manufacture of soap — boiled or hot process. Detergents — raw materials, types of detergents: anionic, cationic and amphoteric, preparation of Teepol and Deriphath. Comparisons between soaps and detergents.

Module 2: Optical Methods of Analysis (8 Lecture Periods)

Sub-topic	Content
Content	Theory of colorimetry and spectrophotometry. Lambert-Beer's law, deviation from Beer's law. Terms used in colorimetry and spectrophotometry. Photoelectric colorimeter method — single beam photo-electric colorimeter. Determination of unknown concentration by using concentration-absorbance plot. Applications of UV-visible spectrophotometry.

Module 3: Electroplating (7 Lecture Periods)

Sub-topic	Content
Content	Electrolysis. Faraday's laws. Cathode current efficiency. Basic principles of electroplating. Cleaning of articles. Electroplating of chromium. Anodising.

Module 4: Column and Ion Exchange Chromatography (7 Lecture Periods)

Sub-topic	Content
Content	Introduction to chromatography, classification. Column chromatography: introduction, types, principle of adsorption column chromatography, solvent system, stationary phases. Methodology — column packing,

Sub-topic	Content
	application of sample, development, detection methods, recovery of components. Applications. Ion exchange chromatography: introduction, principle, types and properties of ion exchangers. Methodology — column packing, application of sample, elution, detection/analysis. Applications.

References:

1. Principles of Physical Chemistry by Puri, Sharma and Pathania, Vishal Publishing Company, Jalandhar.
2. Vogel's Textbook of Quantitative Chemical Analysis, 5th Edition, Longman Scientific & Technical Ltd., UK.
3. Modern Analytical Chemistry by David Harvey, McGraw-Hill International Edition, 2000.
4. Industrial Chemistry by B.K. Sharma, Goel Publishing House, 16th edition, 2011.
5. Advanced Inorganic Chemistry, Vol. 1, by Gurudeep Raj, Krishna Prakashan Media Ltd, Goel Publication, Meerut.
6. Analytical Chemistry by B.K. Sharma, Krishna Prakashan Media Ltd, Meerut, 3rd Edition, 2011.
7. Chemical Process Industries by Shreve and Brink.
8. Industrial Chemistry by Loutfy Madkor and Helen Njenga.
9. Intellectual Property — A Primer for Academia by Prof. Rupinder Tewari & Ms. Mamta Bhardwaj, Publication Bureau, Panjab University, Chandigarh.
10. Elementary Principles of Chemical Processes by Richard Felder and Ronald Rousseau, John Wiley and Sons.
11. Essentials of Physical Chemistry by Bahl B.S., Tuli G.D. and Bahl Arun, S. Chand and Company Ltd., New Delhi.
12. Analytical Chemistry, H. Kaur, Pragati Prakashan, Meerut.
13. Analytical Chemistry, Alka Gupta, Pragati Prakashan, Meerut.
14. Instrumental Methods of Chemical Analysis — Chatwal & Anand.

PRCHMN-303 - Chemistry Practical Paper-III

Course Code: PRCHMN-303 | Credits: 2 | Hours: 60 | Marks: 50

Practical

A) Applied Physical Chemistry - Perform any 8 of the following

1. To study the hydrolysis of methyl acetate in presence of HCl and H₂SO₄ and to determine the relative strength of acids.
2. To study the reaction between Potassium persulphate and Potassium iodide in solution with unequal concentration of the reactants.
3. To study the effect of acid strength on hydrolysis of an ester by using 0.5M HCl and 0.25M HCl.
4. Determination of the adsorption coefficient of acetic acid-charcoal system.
5. To determine the percentage composition of a given liquid mixture by viscosity method (density data to be given).
6. To determine the degree of dissociation and dissociation constant of acetic acid at various dilutions and to verify Ostwald's dilution law conductometrically.
7. To determine the normality of the given strong acid by titrating it against the strong alkali conductometrically.
8. To determine the specific rotation and unknown concentration of sugar solution by Polarimeter.
9. To determine the specific and molar refractions of benzene, toluene and xylene by Abbe's Refractometer and to determine the refraction of CH₂ group (methylene group) (densities should be determined by students).

B) Applied Analytical Chemistry - Perform any 8 of the following

1. Fertilizer analysis: to determine the percentage of nitrogen in the given sample of a nitrogenous fertilizer (ammonium sulphate).
2. Analysis of synthetic/commercial sample: to estimate magnesium from talcum powder.
3. Determination of alkali content from an antacid tablet using HCl solution.
4. Estimation of calcium from chalk: to estimate the amount of calcium from chalk by titrimetric method (by redox titration using KMnO₄ solution).
5. Determination of total hardness of water using 0.01M EDTA solution (students should standardize the given EDTA solution by preparing 0.01M CaCl₂ solution using CaCO₃ salt).
6. Determination of alkalinity of water titrimetrically using 0.02N H₂SO₄ using methyl orange and phenolphthalein indicator.
7. Estimation of acetone.
8. Estimation of Vitamin C from a given tablet.
9. Estimation of phenol by bromination method.

References:

1. Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
2. Khosla, B.D.; Garg, V.C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co: New Delhi (2011).
3. Findlay's Practical Physical Chemistry (Longman), 2015.
4. Practical Physical Chemistry: Gurtu (S. Chand), 2014.
5. Systematic Experimental Physical Chemistry: Rajbhoj, Chandekar (Anjali Publication), 2016.
6. Advanced Practical Chemistry by J. Singh, L.D.S. Yadav, R.K.P. Singh, I.R. Siddiqui et al., Pragati Prakashan.
7. Vogel's Textbook of Qualitative Inorganic Analysis by A.I. Vogel, 3rd and 6th edition.
8. Practical Organic Chemistry by A.I. Vogel.
9. Handbook of Organic Qualitative Analysis by H.T. Clarke.
10. Practical Organic Chemistry by F.G. Mann and B.C. Saunders. Low-priced Textbook, ELBS, Longman.

Major Specific / Skill / Open Elective Courses — Semester III

PRCHVSC-301 - Vocational Skill Course in Chemistry, Practical Paper-I

Course Code: PRCHVSC-301 | Credits: 2 | Hours: 60 | Marks: 50

Course Outcomes:

After successful completion of this course, the students will be able to:

CO1	Understand the concepts, principles, theories and practical applications of Chemistry.
CO2	Understand the simple techniques of synthesis and analysis.
CO3	Gain basic knowledge of instruments to be used for analysis.
CO4	Develop analytical skills.

Practicals (Note: an explanation and understanding of theoretical concepts, mechanisms, reactions, and instrumentation are expected.)

1. Preparation of Orange II Azo dye from Sulphanilic acid.
2. Determine the amount of glycine from a given solution.
3. Determination of viscosity coefficient of unknown solvents using Ostwald's Viscometer.
4. Determination of surface tension of soap solution using a stalagmometer.
5. Analysis of vinegar sample using conductivity measurements.
6. Preparation of standard sodium carbonate solution, standardization of HCl solution and determination of sodium carbonate and sodium bicarbonate in the given solution.
7. Determination of C.O.D. in polluted water.
8. Determination of pH of the following biological juices: (i) Milk (ii) Orange Juice (iii) Lime water (iv) Lemon Juice.
9. Identification of aldehydes and ketones using i) Brady's Test ii) Tollen's Test iii) Schiff Test iv) Iodoform Test.
10. Preparation of tetrammine copper(II) sulphate.
11. Gravimetric estimation of aluminium as aluminium oxinate from a solution containing aluminium sulphate or potash alum and free sulphuric acid.
12. To determine the λ_{max} of KMnO_4 solution using a Colorimeter.
13. Determination of sulphate from drinking water using conductivity measurements.
14. Determination of alkali contents from an antacid tablet using conductivity measurements.
15. Determine the density and refractive index of given unknown liquids.
16. Separation of a liquid+liquid binary mixture by using the distillation method.
17. Identify and differentiate the amines using functional group tests.

18. Determination of reducing sugars and non-reducing sugars.

References:

1. Fundamentals of Analytical Chemistry; Skoog, West, Holler and Crouch, 9th edition; Mary Finch (2014).
2. Vogel's Textbook of Quantitative Chemical Analysis; 6th edition, Pearson Education Limited (2007).
3. Industrial Chemistry by B.K. Sharma.
4. Khosla, B.D.; Garg, V.C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co: New Delhi (2011).
5. Findlay's Practical Physical Chemistry (Longman), 2015.
6. Practical Physical Chemistry: Gurtu (S. Chand), 2014.
7. Systematic Experimental Physical Chemistry: Rajbhoj, Chandekar (Anjali Publication), 2016.
8. Advanced Practical Physical Chemistry: J.B. Yadav (Goel Publishing House), 2015.
9. Vogel's Textbook of Quantitative Inorganic Chemistry by A.I. Vogel.
10. Physical Chemistry of Inorganic Qualitative Analysis by Kuricose & Rajaram.
11. Advanced Practical Organic Chemistry by N.K. Vishnoi, Vikas Publishing House Private Limited.

CHSECPR-301 - Practical Skills in Chemistry, Practical Paper-I**Course Code: CHSECPR-301 | Credits: 2 | Hours: 60 | Marks: 50****Course Outcomes:**

After successful completion of this course, the students will be able to:

CO1	Understand the principles of GLP and safety in the laboratory.
CO2	Interpret the safety data sheets to categorize chemicals according to their hazards.
CO3	Enhance their overall knowledge of handling glassware and apparatus used in the laboratory.
CO4	Enhance their overall skills of preparation of various reagents used in the laboratory.

Practicals (Note: an explanation and understanding of theoretical concepts, mechanisms, reactions, and instrumentation are expected.)

1. Identify the Safety symbol on the labels of a pack of chemicals and its meaning.
2. Study precautions in handling hazardous substances like conc. acids, ammonia, organic solvents, etc.
3. Understand the toxicity of the compounds used in the Chemistry laboratory and classification of toxicity: a) MSDS sheets, points in MSDS — find out MSDS sheets of at least hazardous chemicals ($K_2Cr_2O_7$, Benzene, Cadmium Nitrate, sodium metal, etc.); b) prepare charts for laboratory safety rules; c) prepare SOP for laboratory.
4. Demonstrative experiment: use of fire extinguisher.
5. Calibration of volumetric apparatus.
6. Preparation of indicators and their uses in different titrations (phenolphthalein, methyl orange, diphenylamine, starch, Eriochrome Black-T, etc.).
7. Preparation of commonly used lab solutions and reagents (10% NaOH, sat. $NaHCO_3$, 1:1 NH_3 , bromine water, ferric chloride solution, iodine solution, $NaNO_2$ solution, 2,4-DNP, Tollens, Nessler's, Schiff's, Fehling and Benedict reagents, etc.).
8. Preparation of buffer solutions (pH 4 buffer, pH 10 ammoniacal buffer, acetate buffer).
9. Separation of two miscible solvents by distillation.
10. Separation of immiscible solvents by separating funnel.
11. Demonstrative experiment: preparation of H_2S gas using Kipp's Apparatus.

References:

1. Laboratory Safety for Chemistry Students, Second edition, Robert H. Hill, Jr., David C. Finster, John Wiley & Sons.
2. Handbook of Good Laboratory Practice (GLP), UNDP/World Bank/WHO Special Programme for Research and Training in Tropical Diseases (TDR).

3. Solid Waste Management, Principles and Practice, Ramesha Chandrappa, Diganta Bhusan Das, Springer.
4. Production-Integrated Environmental Protection and Waste Management in the Chemical Industry, Claus Christ, WILEY-VCH.
5. Fundamentals of Industrial Safety and Health, Dr. K.U. Mistry, Siddharth Prakashan.
6. Vogel's Qualitative Inorganic Analysis, 7th Edn, by G. Svehla and B. Shivshankar.
7. Hazardous Waste Management Rules – 2016, 1st edition, Ministry of Environment, Forest & Climate Change, Govt. of India.
8. Vogel's Quantitative Chemical Analysis, 6th Edition, by J. Mendham.

CHOEPR-301 - Food Chemistry: Practicals**Course Code: CHOEPR-301 | Credits: 2 | Hours: 60 | Marks: 50****Course Outcomes:**

After successful completion of this course, the students will be able to:

CO1	Understand the various forms and causes of food adulteration, including mixing, substitution, and misbranding.
CO2	Recognize the health risks associated with adulterated food products.
CO3	Interpret experimental data to assess the purity and quality of food samples.
CO4	Understand the ethical implications of food adulteration and the importance of maintaining food integrity.

Practicals (Note: as the students undertaking this course are from Arts and Commerce faculty, an explanation of the theoretical background, mechanism, instrumentation, and reactions is expected.)

1. Detection of Urea in the given three milk samples.
2. Detection of Starch in the given three milk samples.
3. Detection of Hydrogen Peroxide from milk samples.
4. Detection of Sodium Chloride in the given three milk samples.
5. Detection of Nitrate in the given three milk samples.
6. Determination of pH of buffalo and cow milk samples.
7. To measure pH of some acidic food samples such as lassi, lemon juice, vinegar, orange juice, etc.
8. Detection of sugar/dextrose from honey samples.
9. Detection of adulterants in the given three different tea powder samples.
10. Detection of adulterants in oil/vanaspati ghee samples.
11. Detection of Metanil Yellow in the given three turmeric powder samples.
12. Detection of adulterants in the given three chilli powder samples.
13. To observe the effect of heating baking soda and baking powder on a food sample and study their role in baking.
14. To detect the proteins present in the albumin (egg white) of an egg.
15. To detect the fat present in given seeds.
16. To isolate beta-carotene from carrots.

References:

1. Food Safety and Standards Authority of India (FSSAI) — Official Methods for Food Testing (www.fssai.gov.in).
2. Bureau of Indian Standards (BIS) Guidelines for Food Adulteration Testing.
3. World Health Organization (WHO) Guidelines on Food Safety.
4. Food Adulteration Tests — NCERT Science Lab Manual.
5. ICMR Guidelines on Adulteration Testing.
6. Analysis of Foods — H.E. Cox; Chemical Analysis of Foods — H.E. Cox and Pearson.
7. Foods: Facts and Principles, N. Shakuntala Many and S. Swamy, 4th ed., New Age International (1998).
8. Lillian Hoagland Meyer, Food Chemistry, 1st Edn., CBS Publishers & Distributors, New Delhi, 2004.
9. B.A. Fox, A.G. Cameron, E. Arnold, Food Science, Nutrition and Health, 6th Edn., Edward Arnold, London, 1995.
10. H.S. Ramaswamy, M. Marcotte, Food Processing: Principles and Applications, CRC Press, 2005.
11. A.F. Smith, Encyclopedia of Junk Food and Fast Food, Greenwood Publishing Group, 2006.

Semester - IV

Chemistry (Major)

ICH-401 - Paper VII: Inorganic Chemistry

Course Code: ICH-401 | Credits: 2 | Hours: 30 | Marks: 50

Course Outcomes:

After successful completion of this course, the students will be able to:

Co-ordination Chemistry	Explain fundamental concepts and principles of coordination chemistry. Analyze structure, bonding, and properties of coordination compounds. Apply problem-solving skills to interpret chemical behavior and compare theoretical models. Develop a foundation for advanced studies in coordination chemistry.
Chemistry of Elements of 3d Series	Describe the position, electronic configuration, and general characteristics of 3d series elements. Analyze trends in oxidation states, magnetic properties, and color of transition metal ions. Correlate properties of d-block elements with their chemical behavior and applications
Chemical Bonding and Molecular Structure (VBT and MOT)	Explain VBT, VSEPR, and hybridization concepts to predict molecular geometry. Describe principles of molecular orbital theory including bonding, antibonding orbitals, and bond order. Interpret molecular orbital diagrams to analyze stability and properties of molecules.
Inorganic Semi-micro Qualitative Analysis	Explain principles and techniques of qualitative chemical analysis. Apply concepts such as solubility product, common ion effect, and complex formation in separation of ions. Perform and interpret qualitative analysis using redox reactions and spot tests..

Syllabus

Module 1: Co-ordination Chemistry (10 Lecture Periods)

Sub-topic	Content
Content	Introduction to Coordination Chemistry. Formation of coordinate covalent bond in $[\text{NH}_4]^+$ and $\text{BF}_3\text{-NH}_3$. Description of the terms-Ligand, Coordination Number, Effective Atomic Number. Distinguish between double salt and complex salt. Werner's theory-Postulates and application to $\text{CoCl}_3.6\text{NH}_3$, $\text{CoCl}_3.5\text{NH}_3$, $\text{CoCl}_3.4\text{NH}_3$, $\text{CoCl}_3.3\text{NH}_3$. IUPAC nomenclature of coordination compounds. Isomerism in complexes- Isomerism and its types: Stereoisomerism and Structural Isomerism, Geometrical Isomerism in Square Planar and Octahedral complexes w.r.t monodentate ligands. Valence Bond

Sub-topic	Content
	Theory- Introduction, Postulates. Examples of transition metal complexes with respect to C.N.= 4 Examples $[\text{CuCl}_4]^{2-}$ and $[\text{Cu}(\text{CN})_4]^{2-}$ and C.N. = 6 Example $[\text{FeF}_6]^{3-}$ and $[\text{Fe}(\text{CN})_6]^{3-}$. Chelation. Introduction, Conditions for Chelate Formation., Difference between Metal Chelate and Metal Complex., EDTA as Chelating agent- Equation and five Applications.

Module 2: Chemistry of Elements of the 3d Series (6 Lecture Periods)

Sub-topic	Content
Content	Introduction to Transition elements, Position of elements in periodic table, Detailed study of elements of first transition series w.r.t. Electronic structure, Oxidation states., Stability of compounds of in different oxidation states, Nature of Compounds, Magnetic characters, Colour of Compounds w.r.t. d-d transition.

Module 3: Chemical Bonding and Molecular Structure (7 Lecture Periods)

Sub-topic	Content
Content	A) Valence Bond Theory (VBT) VSEPR Theory- Postulates, Prediction of geometry of compounds on the basis of LP-BP interactions. Hybridization: Planar trigonal geometry- BF_3 (sp^2 hybridization) Tetrahedral geometry- SiCl_4 (sp^3 hybridization) Trigonal Bipyramidal geometry- PCl_5 (sp^3d hybridization) B) Molecular Orbital Theory (MOT) LCAO Principle, Formation of bonding and anti-bonding molecular orbitals, Energy level sequence for molecular orbital's when $n=1$ and 2. Bond order and its significance, MO diagrams for homonuclear diatomic molecules, B_2, N_2 and O_2, MO diagrams for heteronuclear diatomic molecules, CO and NO.

Module 4: Inorganic Semi-micro Qualitative Analysis (7 Lecture Periods)

Sub-topic	Content
Content	Theoretical principles involved in qualitative analysis, Applications of solubility product and common ion effect in separation of cations into groups. Applications of complex formation in-Separation of II group in to IIA and IIB sub-groups, Separation of Cl^- , Br^- , I^- , Application of oxidation and reduction in Separation of Cl^- , Br^- , I^- in mixture, Spot test analysis

References:

1. Concise Inorganic Chemistry - Lee, J. D. (2010). *Concise Inorganic Chemistry* (5th ed.). Wiley India.
2. Inorganic Chemistry -Shriver, D. F., & Atkins, P. W. (2010). *Inorganic Chemistry* (5th ed.). Oxford University Press.

3. Inorganic Chemistry: Principles of Structure and Reactivity – Huheey, J. E., Keiter, E. A., & Keiter, R. L. (2006). *Inorganic Chemistry: Principles of Structure and Reactivity* (4th ed.). HarperCollins.
4. Inorganic Chemistry -Housecroft, C. E., & Sharpe, A. G. (2018). *Inorganic Chemistry* (5th ed.). Pearson.
5. Inorganic Chemistry - Miessler, G. L., Fischer, P. J., & Tarr, D. A. (2014). *Inorganic Chemistry* (5th ed.). Pearson.
6. Advanced Inorganic Chemistry -Cotton, F. A., Wilkinson, G., Murillo, C. A., & Bochmann, M. (1999). *Advanced Inorganic Chemistry* (6th ed.). Wiley.
7. Vogel's Textbook of Qualitative Inorganic Analysis - Vogel, A. I. (1989). *Vogel's Textbook of Qualitative Inorganic Analysis* (5th ed.). Longman.
8. Principles of Inorganic Chemistry - Puri, B. R., Sharma, L. R., & Kalia, K. C. (2017). *Principles of Inorganic Chemistry*. Vishal Publishing.
9. Modern Inorganic Chemistry-Madan, R. D. (2012). *Modern Inorganic Chemistry*. S. Chand Publishing.
10. Theoretical Inorganic Chemistry- Day, M. C., & Selbin, J. (1985). *Theoretical Inorganic Chemistry* (2nd ed.). Affiliated East-West Press.
11. Descriptive Inorganic Chemistry- Rayner-Canham, G., & Overton, T. (2010). *Descriptive Inorganic Chemistry* (5th ed.). W. H. Freeman.
12. Basic Concepts of Inorganic Chemistry -Sathyanarayana, D. N. (2013). *Basic Concepts of Inorganic Chemistry*. Universities Press.
13. Basic Inorganic Chemistry-Cotton, F. A., Wilkinson, G., & Gaus, P. L. (1995). *Basic Inorganic Chemistry* (3rd ed.). Wiley.
14. Concise Coordination Chemistry- Ramalingam, S., & Ramgopalan, R. (2001). *Concise Coordination Chemistry*. Vikas Publishing.

OCH-402 - Paper VIII: Organic Chemistry**Course Code: OCH-402 | Credits: 2 | Hours: 30 | Marks: 50****Course Outcomes:**

After successful completion of this course, the students will be able to:

Carboxylic Acids and Their Derivatives	To impart knowledge about the synthesis, reactivity and applications of carboxylic acids.
Amines and Diazonium Salts	Knowledge about classification, preparation and applications of amines and diazonium salts.
Carbohydrates	Understanding the classification, configuration and structure of carbohydrates.
Carbonyl Compounds - Aldehydes and Ketones	Students will be capable of understanding the nomenclature and reactivity of aldehydes and ketones.
Stereochemistry	Students will learn the basic knowledge of conformational analysis of some organic compounds.

Syllabus**Module 1: Carboxylic Acids and Their Derivatives (6 Lecture Periods)**

Sub-topic	Content
Content	Monocarboxylic acid: introduction, methods of formation from alcohols, aldehydes, ketones, nitriles and alkyl benzenes. Haloacids: a) synthesis of haloacids — mono, di, tri-chloroacetic acid by HVZ reaction; b) reactions — substitution reaction of mono-chloroacetic acid by nucleophile OH⁻, I⁻, CN⁻ and NH₃. Hydroxy acids: citric acid — a) methods of formation of citric acid from glycerol; b) chemical reactions: acetylation by acetic anhydride, reduction by HI, action of heat. Dicarboxylic acids: introduction. Method of formation of succinic acid from ethylene dibromide, maleic acid. Chemical reactions: action of heat, action of NaHCO₃, C₂H₅OH in the presence of acid. Method of formation of phthalic acid from o-xylene and naphthalene. Chemical reactions of phthalic acid: action of heat, reaction with soda lime, ammonia. Carboxylic acid derivatives: introduction. Acid halide derivative: acetyl chloride: i) synthesis from acid, by action with PCl₃ and SOCl₂, ii) reaction with water, alcohol (mechanism of esterification is expected) and ammonia. Acid anhydride derivative: synthesis of acetic anhydride by dehydration of acetic acid. Reactions with water, alcohol and ammonia.

Module 2: Amines and Diazonium Salts (5 Lecture Periods)

Sub-topic	Content
Content	Amines: i. introduction, classification and nomenclature. ii. methods of preparation: a. from alkyl halide by ammonolysis, b. by reduction of nitriles or cyanides, c. from unsubstituted amides (Hoffmann degradation), d. by Gabriel synthesis (from phthalamide). iii. reactions: carbylamine reaction, Schotten-Baumann reaction, electrophilic substitution (aniline) — nitration, bromination, sulphonation. Diazonium salt: i. introduction. ii. preparation of benzene diazonium chloride. iii. reactions of benzene diazonium chloride: a. replacement reaction — Sandmeyer's reaction, b. coupling reactions: synthesis of Congo red.

Module 3: Carbohydrates (7 Lecture Periods)

Sub-topic	Content
Content	Introduction. Classification of carbohydrates, reducing and non-reducing sugars. Physical properties of glucose and fructose. Killiani's synthesis of glucose from D-arabinose. Determination of structure of D-glucose: a. open chain structure of D-glucose, b. configuration of D-glucose from D-arabinose, c. ring structure of D-glucose, d. size of ring in D-glucose by methylation method, e. Haworth projection for D-glucose. Cyclic structure of fructose. Structures of disaccharides: a. linkage between monosaccharides, b. open chain and Haworth cyclic structures of sucrose, lactose and maltose. Structures of polysaccharides: a) starch, b) cellulose.

Module 4: Carbonyl Compounds — Aldehydes and Ketones (6 Lecture Periods)

Sub-topic	Content
Content	Introduction, nomenclature of aliphatic and aromatic aldehydes and ketones. Structure and reactivity of carbonyl group. Reactions of carbonyl compounds — mechanism and applications of: i. aldol condensation, ii. Claisen condensation, iii. Perkin's reaction, iv. Cannizzaro's reaction, v. Knoevenagel condensation and vi. Reformatsky reaction.

Module 5: Stereochemistry (6 Lecture Periods)

Sub-topic	Content
Content	Conformational isomerism — introduction. Representation of conformations of ethane by using Saw-Horse, Fischer (dotted line wedge) and Newmann's projection formulae. Conformations and conformational analysis of ethane and n-butane by Newmann's projection formula with the help of energy profile diagrams. Relative stability of cycloalkanes — Baeyer's strain theory and theory of strainless rings. Conformations and stability of cyclohexane. Conformation and stability of methyl cyclohexane.

References:

1. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).

2. Stereochemistry Conformation & Mechanism, 9th Edition, by P.S. Kalasi, Publisher: New Age International, 2017.
3. Stereochemistry of Carbon Compounds by Eliel.
4. Stereochemistry of Organic Compounds by D. Nasipuri.
5. Finar, I.L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Finar, I.L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd.
7. Organic Chemistry, Volume I, II, III by S.M. Mukharjee, S.P. Singh and R.P. Kapoor, Wiley Eastern Limited (New Age International).
8. Advanced Organic Chemistry by B.S. Bahl, Arun Bahl, S. Chand & Company, Ltd.
9. Chemistry by R.L. Madan, S. Chand and Company Ltd.

PRCH-403 - Chemistry Practical Paper-IV**Course Code: PRCH-403 | Credits: 2 | Hours: 60 | Marks: 50****Practical****Course Outcomes:**

After successful completion of this course, the students will be able to:

Gravimetric Analysis	Apply principles of gravimetric analysis for quantitative estimation of metal ions. Perform precipitation, filtration, drying, and weighing techniques accurately. Calculate analytical results with precision and interpret the data.
Inorganic Preparations	Synthesize inorganic compounds using standard laboratory procedures. Explain reaction conditions and stoichiometric calculations involved in synthesis. Evaluate yield and purity of prepared compounds.
Semi-micro Qualitative Analysis	Identify cations and anions in mixtures using systematic qualitative analysis. Apply concepts such as solubility product, complex formation, and redox reactions. Interpret observations and report results logically.
Overall Course Outcome	Develop analytical, experimental, and problem-solving skills in chemistry. Demonstrate safe laboratory practices and proper handling of chemicals. Correlate theoretical concepts with practical applications in inorganic chemistry.

A) Inorganic Chemistry - Gravimetric Analysis (Any two)

1. Gravimetric estimation of iron as Fe_2O_3 from a solution containing Ferrous ammonium sulphate and free sulphuric acid.
2. Gravimetric estimation of barium as BaSO_4 from a solution containing barium chloride and free hydrochloric acid.
3. Gravimetric estimation of nickel as $\text{Ni}(\text{DMG})_2$ from a solution containing $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$ and free sulphuric acid.

Inorganic Preparations (Any Two)

1. Preparation of sodium cuprous thiosulphate.
2. Preparation of tris(ethylenediamine)nickel(II) thiosulphate.
3. Preparation of hexamminenickel(II) chloride.

Semi-micro Qualitative Analysis

Analysis of binary mixtures with non interfering cations and anions

Anions: Cl^- , Br^- , I^- , NO_3^- , CO_3^{2-} , SO_4^{2-} , S^{2-} Cu^{2+} , Cd^{2+} , Al^{3+} , Fe^{3+} , Cr^{3+} , Zn^{2+} , Mn^{2+} , Ni^{2+} , Co^{2+} , Ca^{2+} , Ba^{2+} , Mg^{2+} , NH_4^+ , K^+

Note:-Use of spot tests to be made whenever possible.

References:

1. Vogel's Quantitative Chemical Analysis. (2009). *Vogel's Quantitative Chemical Analysis* (6th ed.). Pearson Education.
2. Vogel's Textbook of Qualitative Inorganic Analysis. (3rd/6th eds.). Longman.
3. Practical Inorganic Chemistry. Palmer, W. G. *Practical Inorganic Chemistry*. Longman.

4. Fundamentals of Analytical Chemistry. (2014). *Fundamentals of Analytical Chemistry* (9th ed.). Cengage Learning.
5. Analytical Chemistry. (2004). *Analytical Chemistry* (6th ed.). Wiley.
6. Physical Chemistry of Inorganic Qualitative Analysis. Kuricose, J. C., & Rajaram, J. *Physical Chemistry of Inorganic Qualitative Analysis*. Tata McGraw-Hill.
7. Practical Manual in Water Analysis. Goyal, S. K., & Trivedi, R. K. *Practical Manual in Water Analysis*. Oxford & IBH Publishing.

B) Organic Chemistry - 1) Organic Qualitative Analysis: Identification of Any Six organic compounds with reactions including chemical type

Acids - Succinic acid, Phthalic acid, Salicylic acid, Aspirin (any 2). Phenols - Alpha-Naphthol, p-nitrophenol (any 1). Bases - o-nitroaniline, p-nitroaniline, Diphenylamine (any 1). Neutrals - Urea, Acetanilide, Carbon tetrachloride, Bromobenzene, Methyl acetate, Nitrobenzene, Naphthalene, Anthracene, Ethyl methyl ketone (any 2). A systematic study of an organic substance involves reactions in the determination of elements and functional group.

2) Organic Preparations (Any two)

1. Preparation of p-nitroacetanilide from Acetanilide.
2. Preparation of Acetanilide from Aniline using anhydrous ZnCl_2 and Zn dust.
3. Preparation of Phthalimide from Phthalic anhydride.
4. Preparation of Benzoic acid from Benzamide.

References:

1. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
2. Vogel's Textbook of Qualitative Inorganic Analysis by A.I. Vogel, 3rd and 6th edition.
3. Vogel's Textbook of Quantitative Inorganic Chemistry by A.I. Vogel.
4. Physical Chemistry of Inorganic Qualitative Analysis by Kuricose & Rajaram.
5. Practical Manual in Water Analysis by Goyal & Trivedi.
6. Practical Organic Chemistry by A.I. Vogel.
7. Handbook of Organic Qualitative Analysis by H.T. Clarke.
8. A Laboratory Handbook of Organic Qualitative Analysis and Separation by V.S. Kulkarni, Dastane Ramchandra & Co.
9. Practical Organic Chemistry by F.G. Mann and B.C. Saunders. Low-priced Text Book. ELBS. Longman.
10. Advanced Practical Organic Chemistry by N.K. Vishnoi, Vikas Publishing House Private Limited.
11. Advanced Practical Chemistry by J. Singh, L.D.S. Yadav, R.K.P. Singh, I.R. Siddiqui et al., Pragati Prakashan.

Chemistry (Minor)

ICHMN-401 - Paper VII: Fundamentals of Inorganic Chemistry

Course Code: ICHMN-401 | Credits: 2 | Hours: 30 | Marks: 50

Course Outcomes:

After successful completion of this course, the students will be able to:

Chemistry of Lanthanide Elements	Explain the electronic configuration and general characteristics of lanthanides. Analyze oxidation states, colour, and spectral properties. Interpret the concept of lanthanide contraction and its consequences. Apply separation techniques and evaluate industrial applications of lanthanides..
Crystal Structure and Defects in Solids	Describe crystal structures of ionic solids and radius ratio concepts. Analyze different types of crystal structures and their geometries. Explain various types of defects in solids and their formation. Evaluate the impact of defects on physical and chemical properties of solids..
Chemistry of Non-Aqueous Solvents	Describe classification and characteristics of solvents. Explain properties and behavior of non-aqueous solvents. Interpret acid-base reactions in non-aqueous media. Apply solvent concepts in chemical systems and processes..
Catalysis	Describe types and classification of catalytic reactions. Explain mechanisms of catalysis using theoretical models. Analyze characteristics and efficiency of catalytic processes. Evaluate industrial applications of catalysis..

Syllabus

Module 1: Chemistry of Lanthanide Elements (10 Lecture Periods)

Sub-topic	Content
Content	Introduction, Occurrence of lanthanides, Properties of lanthanides with respect to: Electronic configuration, Oxidation states, Colour and spectra, Lanthanide contraction, Separation of lanthanides by ion-exchange method, Applications of lanthanides

Module 2: Crystal Structure and Defects in Solids (8 Lecture Periods)

Sub-topic	Content
Content	Introduction to ionic solids, Crystal structures -radius ratio, radius ratio effect on geometry and calculation of r^+/r^- for octahedral geometry. NaCl crystal structure, CsCl crystal structure, ZnS crystal structure. Defects in solids – Introduction, Types of defects in solids, Stoichiometric defects: Schottky defects, Frenkel defects, Non-stoichiometric defects: Metal excess defects, Metal deficiency defects, Consequences of defects in solids

Module 3: Chemistry of Non-Aqueous Solvents (6 Lecture Periods)

Sub-topic	Content
Content	Introduction, Definition and characteristics of solvents, Classification of solvents- Liquid, solid and gaseous solvents, Protic and aprotic solvents, Ionizing and non-ionizing solvents, Aqueous and non-aqueous solvents. Physical properties and acid-base reactions in Liquid NH ₃ and Liquid SO ₂

Module 4: Catalysis (6 Lecture Periods)

Sub-topic	Content
Content	Introduction, Classification of catalytic reactions- Homogeneous catalysis, Heterogeneous catalysis. Types of catalysis, Characteristics of catalytic reactions, Mechanism of catalysis- Intermediate compound formation theory, Adsorption theory. Industrial applications of catalysis

References:

1. Inorganic Chemistry: Principles of Structure and Reactivity. Huheey, J. E., Keiter, E. A., & Keiter, R. L. (1993). *Inorganic Chemistry: Principles of Structure and Reactivity* (4th ed.). HarperCollins College Publishers.
2. Inorganic Chemistry. Shriver, D. F., Weller, M. T., Overton, T. L., Rourke, J. P., & Armstrong, F. A. (2014). *Inorganic Chemistry* (6th ed.). Oxford University Press.
3. Concise Inorganic Chemistry. Lee, J. D. (2010). *Concise Inorganic Chemistry* (5th ed.). Wiley India Pvt. Ltd.
4. Principles of Inorganic Chemistry. Puri, B. R., Sharma, L. R., & Kalia, K. C. (2013). *Principles of Inorganic Chemistry*. Milestone Publishers & Distributors.
5. Advanced Inorganic Chemistry. Satya Prakash, Tuli, G. D., Basu, S. K., & Madan, R. D. (2012). *Advanced Inorganic Chemistry*. S. Chand Publishing.
6. Theoretical Inorganic Chemistry. Day, M. C., & Selbin, J. (1985). *Theoretical Inorganic Chemistry* (2nd ed.). CBS Publishers & Distributors (Indian reprint).
7. Chemistry in Non-Aqueous Solvents. Sisler, H. H. (1961). *Chemistry in Non-Aqueous Solvents*. Reinhold Publishing Corporation / Chapman & Hall (UK ed.).
8. Modern Inorganic Chemistry. Madan, R. D. (2012). *Modern Inorganic Chemistry*. S. Chand Publishing.
9. Basic Inorganic Chemistry. Cotton, F. A., Wilkinson, G., & Gaus, P. L. (1995). *Basic Inorganic Chemistry* (3rd ed.). John Wiley & Sons.
10. Concepts and Models of Inorganic Chemistry. Douglas, B., McDaniel, D., & Alexander, J. (1994). *Concepts and Models of Inorganic Chemistry* (3rd ed.). John Wiley & Sons.
11. Mechanisms of Inorganic Reactions. Basolo, F., & Pearson, R. G. (1967). *Mechanisms of Inorganic Reactions* (2nd ed.). John Wiley & Sons.

OCHMN-402 - Paper VIII: Applied Organic Chemistry**Course Code: OCHMN-402 | Credits: 2 | Hours: 30 | Marks: 50****Course Outcomes:**

After successful completion of this course, the students will be able to:

Biomolecules	Understanding the sources, classification, structure and functions of major biomolecules: amino acids, peptides, and proteins. Students should also be able to understand biological processes like metabolism, energy transformation, and the functions of enzymes.
Chemistry of Carbohydrates	Learning and understanding of classification, configuration, and structures of carbohydrates.
Synthetic Dyes	Students will get knowledge about classification, preparation, structure, and applications of synthetic dyes.
Organic Chemistry in Agriculture	Understanding the chemistry of fertilizers and pesticides for sustainable agriculture. Students get knowledge about chemical structures and the mechanism of action of various fertilizers and pesticides, with their environmental impact.

Syllabus**Module 1: Biomolecules (7 Lecture Periods)**

Sub-topic	Content
Content	Introduction, nomenclature & sources of amino acids. Classification of amino acids: based on polarity, charge. Acid-base properties and zwitterion concept, isoelectric point (pI) and electrophoresis. Ninhydrin test, and Biuret test. Biological functions and importance of amino acids. Synthesis of amino acids (alanine & phenylalanine). Introduction, nomenclature & sources of peptides. Structure and properties of simple peptides. Biological functions and importance of peptides. Introduction, nomenclature & sources of proteins. Biological functions and importance of proteins.

Module 2: Chemistry of Carbohydrates (8 Lecture Periods)

Sub-topic	Content
Content	Introduction to carbohydrates: definition and general formula ($C_nH_{2n}O_n$). Sources, importance, and biological role of carbohydrates. Classification: monosaccharides, disaccharides, oligosaccharides, polysaccharides. Monosaccharides: structure and nomenclature (aldoses & ketoses). Open and cyclic structure of glucose, fructose: D- and L-configuration. Mutarotation of glucose. Disaccharides: properties and Haworth structures of sucrose, lactose, and maltose. Polysaccharides: properties and structures of starch, cellulose.

Module 3: Synthetic Dyes (7 Lecture Periods)

Sub-topic	Content
Content	Introduction to dyes: classification of dyes (based on application). Terms used in dyes (chromophores and auxochromes with examples). Witt's theory of dye. Diazotization of benzene. Synthesis and applications of Methyl Orange and Indigo dye. Dyeing of cotton, silk, wool.

Module 4: Organic Chemistry in Agriculture (8 Lecture Periods)

Sub-topic	Content
Content	Agrochemicals: introduction, definition, and importance. Types of agrochemicals (fertilizers, pesticides, herbicides, insecticides, fungicides, plant growth regulators). Synthesis and applications of Carbaryl and Indol-3-Acetic Acid (IAA). Biopesticides: preparation of neem-based pesticides. Mechanism of action of fertilizers & pesticides. Advantages of agrochemicals. Limitations of agrochemicals.

References:

1. Lehninger Principles of Biochemistry, 6th edition, by David L. Nelson, Michael M. Cox.
2. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd.
3. Finar, I.L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd.
4. Organic Chemistry, Volume I, II, III by S.M. Mukharjee, S.P. Singh, and R.P. Kapoor, Wiley Eastern Limited (New Age International).
5. Advanced Organic Chemistry by B.S. Bahl, Arun Bahl, S. Chand & Company, Ltd.
6. Chemistry by R.L. Madan, S. Chand and Company Ltd.
7. Indian Council of Agricultural Research (ICAR) Reports (2022).
8. Agricultural Chemistry by Dr. L. Rakesh Sharma.

PRCHMN-403 - Chemistry Practical Paper-IV**Course Code: PRCHMN-403 | Credits: 2 | Hours: 60 | Marks: 50****Practical**

Gravimetric Analysis	Apply principles of gravimetric analysis for quantitative estimation of metal ions. Perform precipitation, filtration, drying, and weighing techniques accurately. Calculate analytical results with precision and interpret the data.
Inorganic Preparations	Synthesize inorganic compounds using standard laboratory procedures. Explain reaction conditions and stoichiometric calculations involved in synthesis. Evaluate yield and purity of prepared compounds.
Semi-micro Qualitative Analysis	Identify cations and anions in mixtures using systematic qualitative analysis. Apply concepts such as solubility product, complex formation, and redox reactions. Interpret observations and report results logically.
Overall Course Outcome	Develop analytical, experimental, and problem-solving skills in chemistry. Demonstrate safe laboratory practices and proper handling of chemicals. Correlate theoretical concepts with practical applications in inorganic chemistry..

A) Inorganic Chemistry - Gravimetric Analysis (Any two)

1. Gravimetric estimation of iron as Fe_2O_3 from a solution containing Ferrous ammonium sulphate and free sulphuric acid.
2. Gravimetric estimation of barium as BaSO_4 from a solution containing barium chloride and free hydrochloric acid.
3. Gravimetric estimation of nickel as $\text{Ni}(\text{DMG})_2$ from a solution containing $\text{NiSO}_4 \cdot 7\text{H}_2\text{O}$ and free sulphuric acid.

Inorganic Preparations (Any Two)

1. Preparation of sodium cuprous thiosulphate.
2. Preparation of tris(ethylenediamine)nickel(II) thiosulphate.
3. Preparation of hexamminenickel(II) chloride.

Semi-micro Qualitative Analysis

Analysis of binary mixtures with non interfering cations and anions

Anions: Cl^- , Br^- , I^- , NO_3^- , CO_3^{2-} , SO_4^{2-} , S^{2-} Cu^{2+} , Cd^{2+} , Al^{3+} , Fe^{3+} , Cr^{3+} , Zn^{2+} , Mn^{2+} , Ni^{2+} , Co^{2+} , Ca^{2+} , Ba^{2+} , Mg^{2+} , NH_4^+ , K^+

Note:-Use of spot tests to be made whenever possible.

References:

1. Vogel's Quantitative Chemical Analysis. (2009). *Vogel's Quantitative Chemical Analysis* (6th ed.). Pearson Education.
2. Vogel's Textbook of Qualitative Inorganic Analysis. (3rd/6th eds.). Longman.
3. Practical Inorganic Chemistry. Palmer, W. G. *Practical Inorganic Chemistry*. Longman.
4. Fundamentals of Analytical Chemistry. (2014). *Fundamentals of Analytical Chemistry* (9th ed.). Cengage Learning.
5. Analytical Chemistry. (2004). *Analytical Chemistry* (6th ed.). Wiley.

6. Physical Chemistry of Inorganic Qualitative Analysis. Kuricose, J. C., & Rajaram, J. *Physical Chemistry of Inorganic Qualitative Analysis*. Tata McGraw-Hill.
7. Practical Manual in Water Analysis. Goyal, S. K., & Trivedi, R. K. *Practical Manual in Water Analysis*. Oxford & IBH Publishing.

B) Applied Organic Chemistry - 1) Organic Qualitative Analysis: Identification of Any Six organic compounds with reactions including chemical type

Acids - Succinic acid, Phthalic acid, Salicylic acid, Aspirin (any 2). Phenols - Alpha-Naphthol, p-nitrophenol (any 1). Bases - o-nitroaniline, p-nitroaniline, Diphenylamine (any 1). Neutrals - Urea, Acetanilide, Carbon tetrachloride, Bromobenzene, Methyl acetate, Nitrobenzene, Naphthalene, Anthracene, Ethyl methyl ketone (any 2). A systematic study of an organic substance involves reactions in the determination of elements and functional group.

2) Organic Preparations (Any two)

1. Preparation of p-nitroacetanilide from Acetanilide.
2. Preparation of Acetanilide from Aniline using anhydrous ZnCl_2 and Zn dust.
3. Preparation of Phthalimide from Phthalic anhydride.
4. Preparation of Benzoic acid from Benzamide.

3) Additional Biochemistry-Related Practicals (Note: the source document lists these three items immediately after the Organic Preparations list without its own sub-heading — reproduced here as a separate group for clarity; please confirm the intended heading at source.)

1. To determine the total sugar content in honey by Fehling's solution.
2. Synthesis of para red from m-nitroaniline and 2-naphthol by diazotization reaction.
3. Ninhydrin test and Biuret test for the detection of maltose.

References:

1. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
2. Vogel's Textbook of Qualitative Inorganic Analysis by A.I. Vogel, 3rd and 6th edition.
3. Vogel's Textbook of Quantitative Inorganic Chemistry by A.I. Vogel.
4. Physical Chemistry of Inorganic Qualitative Analysis by Kuricose & Rajaram.
5. Practical Manual in Water Analysis by Goyal & Trivedi.
6. Practical Organic Chemistry by A.I. Vogel.
7. Handbook of Organic Qualitative Analysis by H.T. Clarke.
8. A Laboratory Handbook of Organic Qualitative Analysis and Separation by V.S. Kulkarni, Dastane Ramchandra & Co.
9. Practical Organic Chemistry by F.G. Mann and B.C. Saunders. Low-priced Text Book. ELBS. Longman.

10. Advanced Practical Organic Chemistry by N.K. Vishnoi, Vikas Publishing House Private Limited.
11. Advanced Practical Chemistry by J. Singh, L.D.S. Yadav, R.K.P. Singh, I.R. Siddiqui et al., Pragati Prakashan.

Skill / Open Elective / Community Engagement Courses - Semester IV

CHSECPR- 401 - Practical Skills in Chemistry, Practical Paper-II

Course Code: CHSECPR-401 | Credits: 2 | Hours: 60 | Marks: 50

Course Outcomes:

After successful completion of this course, the students will be able to:

CO1	Gain the knowledge of preparation and standardization of solutions.
CO2	Gain knowledge of separation techniques.
CO3	Enhance their knowledge of the calibration of instruments.
CO4	Enhance their knowledge of maintenance of electrodes and equipment.

Practicals (Note: an explanation and understanding of theoretical concepts, mechanisms, reactions, and instrumentation are expected.)

1. Preparation of TLC plates using silica gel, identifying suitable solvent systems and applications in the separation of amino acids.
2. Preparation of column, identifying suitable solvent system and applications in separating organic components.
3. Preparation of ion exchange resin columns and applications in separating cations/anions.
4. Preparation of potassium hydrogen phthalate and its use as a primary standard for standardization of NaOH/KOH solution.
5. Preparation and standardization of HCl/HNO₃, H₂SO₄ solution (molar and normal).
6. Preparation and standardization of sodium thiosulphate solution.
7. Demonstrative experiment: preparation of KCl and KNO₃ salt bridges.
8. Draw the structure of organic molecules using software like ChemDraw/ISIS draw/ChemSketch.
9. Plot experimental results (graphs) using Excel and Origin software.
10. Calibration of electronic balance and maintenance of electrodes in the laboratory (glass, calomel, etc.).
11. Standardization of i) pH meter by using pH 4 buffer (buffer to be prepared by students), ii) conductivity meter and iii) potentiometer.
12. Recrystallization of organic compounds using suitable solvents.
13. Purification of compounds by sublimation.
14. Extraction of DNA from mashed onion.
15. Activity: preparation of charts to learn the periodic table innovatively.

References:

1. Fundamentals of Analytical Chemistry; Skoog, West, Holler and Crouch, 9th edition; Mary Finch (2014).

2. Principles of Instrumental Methods of Analysis; Skoog, Holler and Nieman, 5th edition, Saunders College Publishing, International Limited (1999).
3. Analytical Chemistry; Gary D Christian; 6th edition; John Wiley and Sons (2010).
4. Modern Analytical Chemistry; David Harvey; McGraw Hill Higher Education Publishers (2000).
5. Analytical Chemistry Principles; John H Kennedy, 2nd edition, published by Cengage Delmar Learning India Pvt (2011).
6. Vogel's Textbook of Quantitative Chemical Analysis; 6th edition, Pearson Education Limited (2007).
7. Industrial Chemistry by B.K. Sharma.

CHOEPR-401 - Chemistry in Everyday Life: Practicals**Course Code: CHOEPR-401 | Credits: 2 | Hours: 60 | Marks: 50****Course Outcomes:**

After successful completion of this course, the students will be able to:

CO1	Understand fundamental principles of various chemical processes, such as fermentation using yeast, properties of organic and inorganic acids, and the actions of soaps and detergents.
CO2	Develop skills in chemical analysis.
CO3	Comprehend the applications of chemistry in daily life.
CO4	Develop skills in adhering to laboratory safety protocols, proper use of equipment, and accurate observation of chemical processes.

Practicals (Note: as the students undertaking this course are from Arts and Commerce faculty, an explanation of the theoretical background, mechanism, instrumentation, and reactions is expected.)

1. To study the fermentation process using yeast.
2. To detect the presence of calcium and its salt present in toothpaste.
3. To test the foaming activity of soap and detergent in hard and soft water.
4. To test the solubility of three different substances in polar and non-polar solvents.
5. To study the difference in organic acid (lemon juice or vinegar) and inorganic acid (commercial HCl).
6. To identify chemical composition of talcum powder.
7. To study the chemical composition of an aspirin tablet.
8. To study the contents present in an antacid tablet and its action on acid.
9. Preparation of hand-wash or hand-sanitizer.
10. Preparation of nail polish remover.
11. Preparation of shampoo.
12. Preparation of ink.
13. Preparation of chalk.
14. Preparation of casein (plastic) from milk.
15. Preparation of liquid soap using castor oil.

References:

1. Vogel's Textbook of Practical Organic Chemistry — Arthur I. Vogel.
2. Comprehensive Practical Organic Chemistry — V.K. Ahluwalia & Rakesh Kumar Parashar.
3. Elementary Practical Organic Chemistry — Arthur I. Vogel.

4. Food Chemistry — L.H. Meyer.
5. Pharmaceutical Chemistry — K.A. Connors.
6. Laboratory Manual of Organic Chemistry — R.K. Bansal.
7. A Textbook of Applied Chemistry — Dr. A.K. Shrivastava.
8. Formulation and Development of Liquid Hand Wash and Sanitizer — International Journal of Pharmaceutical Sciences & Research.
9. Nail Polish Remover: Chemical Composition and Solvent Properties — Cosmetic Science Review.
10. Shampoo Formulation and Testing for Commercial Use — International Journal of Cosmetic Science.
11. Ink Composition and Manufacturing Techniques — Journal of Industrial Chemistry.
12. Chalk Composition and Methods of Preparation — Material Science Research Journal.
13. Casein Plastic Formation from Milk: A Sustainable Approach — Journal of Polymer Science.
14. Castor Oil-Based Liquid Soap: A Green Chemistry Approach — Green Chemistry Journal.

Community Engagement Programme (CEP) in Chemistry - CHCEP-401

Credit: 2 Practical Hours: 60 Marks: 50

Introduction

New generations of students are increasingly unaware of local rural and peri-urban realities surrounding their HEIs, as rapid urbanization has been occurring in India. A large percentage of the Indian population continues to live and work in rural and peri-urban areas of the country. While various schemes and programs of community service have been undertaken by HEIs, there is no singular provision of a well-designed community engagement course that provides opportunities for immersion in rural realities. Such a course will enable students to learn about challenges faced by vulnerable households and develop an understanding of local wisdom and lifestyle in a respectful manner.

Objectives

- To promote respect for rural culture, lifestyle, and wisdom among students.
- To learn about the present status of agricultural and development initiatives.
- To identify and address the root causes of distress and poverty among vulnerable households.
- To improve learning outcomes by applying classroom knowledge to real-world situations.

To achieve the objectives of the socio-economic development of New India, HEIs can play an important role through active community engagement. This approach will also contribute to improving the quality of both teaching and research in HEIs in India. India is a signatory to the global commitment for achieving Sustainable Development Goals (SDGs) by 2030. Achieving these 17 SDG goals requires generating locally appropriate solutions. Community engagement should not be limited to a few social science disciplines alone; it should be practiced across all disciplines and faculties of HEIs. These can take the forms of enumerations, surveys, awareness camps and campaigns, training, learning manuals/films, maps, study reports, public hearings, policy briefs, cleanliness and hygiene teachings, legal aid clinics, etc. For example, students of chemistry can conduct water and soil testing in local areas and share the results with the local community. Students of science and engineering can undertake research in partnership with the community on solid and liquid waste disposal. Students are therefore encouraged to foster social responsibility and community engagement in their teaching and research.

Learning Outcomes

After completing this course, students will be able to:

1. Gain an understanding of rural life, Indian culture, and social realities.
2. Develop empathy and bonds of mutuality with the local community.
3. Appreciate the significant contributions of local communities to Indian society and economy.
4. Learn to value local knowledge and wisdom.
5. Gain valuable skills such as communication, leadership, teamwork and problem solving, etc.
6. Identify opportunities to contribute to the community's socio-economic improvement.

Credits: Two-credit course; students are expected to complete 60 hours of participation.

Course Structure

Sr. No.	Module Title	Module Content	Teaching/Learning Methodology
1	Understanding CEP	Introduction, Necessities	Classroom discussions, Field visit.
2	Identification of the topic and area	Use of survey, field visits, communication with society	Survey, Individual/Group.
3	Organization of Activities	Organization of hands-on training, exhibitions, lectures, community conferences	—
4	Project	Detailed report of the outcome of the works	Conference, Report submission & VIVA.

Note: Faculty can make additions to the list of activities as per domain content.

Recommended Field-Based Activities (Tentative)

A community engagement program in chemistry generally aims to increase public understanding and appreciation of chemistry. It encourages engagement with scientific knowledge. These programs can involve activities like open days, workshops, exhibitions, awareness lectures, conducting surveys and partnerships with local schools to provide hands-on chemistry experiences.

Types of Engagement:

- Demonstrations and Workshops — showcasing chemistry through practical demonstrations and hands-on workshops. By making chemistry more accessible and relatable, community engagement can help the public understand its role in everyday life — for example, visits to elementary schools with chemistry experiments.
- Open Days and Science Festivals, Exhibitions — hosting open days and organizing science festivals allows the community to interact with chemists and learn about their work in an informal setting.
- Educational Outreach to Schools — collaborating with local schools to offer chemistry programs or demonstrations can inspire students to consider a career in science.
- Community-Based Research — helping identify and address environmental or social problems that affect the community, such as soil testing, waste management, drinking water analysis, use of renewable energy sources, adverse effects of pesticides, disadvantages of plastic/microplastic, and pollution due to industry effluents.
- Surveys — building solar-powered villages; energy use and fuel efficiency surveys; raising awareness about chemical hazards; assessing the impact of chemical pollution on human health and the environment; gathering feedback on the effectiveness of waste management programs; measuring public support for stricter chemical regulations and industry standards; evaluating public awareness and attitudes towards pesticide use and regulations; evaluating the societal benefits of new chemical technologies such as renewable energy sources.
- Any other activity addressing issues related to Chemistry can be added.

Important Rules and Regulations for CEP

Concurrent Fieldwork:

1. Students must conduct comprehensive studies on various challenges that they face in their chosen field. Every work relevant to the subject matter should be compiled and documented.
2. Students should keep a separate fieldwork diary or maintain a journal in order to record their fieldwork experiences, i.e. reading, e-contents, tasks, planning and work hours have to be recorded in the diary. Detailed work records/report on students' fieldwork experiences and activities are to be submitted and presented.
3. In addition to the principal curriculum, students engage in a variety of community-development-related activities. They are encouraged to plan and carry out programs, processions, and events for social causes. These activities seek to enhance students' personal and professional skills as well as foster self-development.

Reference: 1. Guidelines on "Fostering Social Responsibility & Community Engagement in Higher Education Institutions in India 2.0" (<https://www.ugc.gov.in/publication/ebook>). 2. Shivaji University Guidelines regarding CEP.

CEP Diary

Name of Student:				Roll No.:		
Sr. No.	Date	Activity	Type of Activity	Time Duration	Sign of Student	Signature of Teacher

Total 60 hours' participation is required.

Teacher in Charge

H.O.D.

Principal

Format of Report

- Front Page
- Certificate
- Index
- Introduction
- Diary
- Surveys, Field Visits
- Activities — Detailed Report
- Summary, Findings and Outcomes
- References

Evaluation / Assessment Scheme - Semester IV

The assessment pattern is internal and external, i.e. 40 + 10.

Particulars	Marks
Internal Continuous Assessment: 1. Participation in concurrent field visits (40%)	
a. Diary Completion, Attendance	10
b. Surveys / Field Visits	10
2. Individual/group field project conference, report/journal submission (40%)	
a. Organization/Participation in activities	10
b. Project	10
Total	40
External Assessment: Presentation of project findings (VIVA) (20%)	
Oral Examination	10
Total (Internal 40 + External 10)	50

Note: Oral Examination will be conducted along with the Semester IV Practical Examination.

Scheme of Examination

B.Sc. II Chemistry (Major) - Assessment Details

Nature of Question Paper (Theory)

Total Marks: 30. Time: 1.5 Hours.

- Q.1 Choose the correct alternative and rewrite the sentence again. (6 Marks) - a) b) c) d) e) f)
- Q.2 Attempt any **TWO** of the following (out of Three). (12 Marks) - a) b) c)
- Q.3 Answer any **THREE** of the following (out of Five). (12 Marks) - a) b) c) d) e)

Outline of Internal Assessment

Level	Semester	Activities Per Semester	Marks	Total
5	III	Oral Examination	05	20
		Group Discussion	05	
		Seminar	05	
		Mid-Term Test	05	
5	IV	Oral Examination	05	20
		Group Discussion	05	
		Seminar	05	
		Mid-Term Test	05	

Nature of Practical Examination

Semester-III, Practical Paper-III (50 Marks). Number of Days: 01.

Experiment No. 1 - 15 Marks; Internal : 10 Marks, Experiment No. 2 - 15 Marks; Internal : 10 Marks.

Semester-IV, Practical Paper-IV (50 Marks). Number of Days: 01.

Experiment No. 1 - 15 Marks; Internal : 10 Marks, Experiment No. 2 - 15 Marks; Internal : 10 Marks.

B.Sc. II Chemistry (Minor) - Assessment Details

Nature of Question Paper

Total Marks: 30. Time: 1.5 Hours.

- Q.1 Choose the correct alternative and rewrite the sentence again. (6 Marks) — a) b) c) d) e) f)
- Q.2 Attempt any **TWO** of the following (out of Three). (12 Marks) — a) b) c)
- Q.3 Answer any **FOUR** of the following (out of Five). (12 Marks) — a) b) c) d) e)

Outline of Internal Assessment

Level	Semester	Activities Per Semester	Marks	Total
5	III	Oral Examination	05	20
		Group Discussion	05	
		Seminar	05	
		Mid-Term Test	05	
5	IV	Oral Examination	05	20
		Group Discussion	05	
		Seminar	05	
		Mid-Term Test	05	

Nature of Practical Examination**Semester-III Practical Paper-I (50 Marks). Number of Days: 01.**

Experiment No. 1 - 15 Marks; Internal : 10 Marks, Experiment No. 2 - 15 Marks; Internal : 10 Marks.

Semester-IV Practical Paper-II (50 Marks). Number of Days: 01.

Experiment No. 1 - 15 Marks; Internal : 10 Marks, Experiment No. 2 - 15 Marks; Internal : 10 Marks.

Nature of Practical Examination - Vocational Skill Course**Semester III. Practical (50 Marks).No. of Examination Days: 01.**

Semester-III Practical Paper-I (50 Marks): Experiment No. 1 - 15 Marks; Internal : 10 Marks, Experiment No. 2 - 15 Marks; Internal : 10 Marks

Nature of Practical Examination — Skill Enhancement Course**Semester III. No. of Examination Days: 01.**

Semester-III Practical Paper-I (50 Marks): Experiment No. 1 - 15 Marks; Internal : 10 Marks, Experiment No. 2 - 15 Marks; Internal : 10 Marks

Semester IV. No. of Examination Days: 01.

Semester-IV Practical Paper-II (50 Marks): Experiment No. 1 - 15 Marks; Internal : 10 Marks, Experiment No. 2 - 15 Marks; Internal : 10 Marks

Nature of Practical Examination -Open Elective Course**Semester III. OE Practical Paper III (50 Marks). Number of Exam Days: 01.**

Experiment No. 1 -15 Marks; Internal : 10 Marks, Experiment No. 2 - 15 Marks; Internal : 10 Marks

Semester IV. OE Practical Paper IV (50 Marks). Number of Exam Days: 01.

Experiment No. 1 - 15 Marks; Internal : 10 Marks, Experiment No. 2 -15 Marks; Internal : 10 Marks