Savitribai Phule Pune University, Pune

(Formerly University of Pune)

Under-Graduate Program in

Chemistry

(Faculty of Science and Technology)

New Syllabus of

Second Year Bachelors of Science (S.Y.B.Sc.)

(As Per National Education Policy-2020)

(For Colleges Affiliated to Savitribai Phule Pune University)

(To be implemented with effect from Academic Year 2025-2026)

Board of Studies in Chemistry

Savitribai Phule Pune University, Pune

Table of Contents

Abbreviations used

- POs : Program Outcomes
- PS : Program Structure
- PSOs : Program Specific Outcomes
- COs : Course Outcomes
- TLP : Teaching-Learning Process
- AM : Assessment Method
- DSC : Discipline Specific Core
- DSE : Discipline Specific Elective
- GE : Generic Elective
- OE : Open Elective
- VSC : Vocational Skill Course
- SEC : Skill Enhancement Course
- IKS : Indian Knowledge System
- AEC : Ability Enhancement Course
- VEC : Value Education Course
- OJT : On Job Training (Internship)
- FP : Field project
- CEP : Community engagement project
- CC : Co-curricular Courses
- RM : Research Methodology
- RP : Research Project
- MJ : Major Course
- MN : Minor Course

Introduction to Undergraduate Degree in Chemistry

As per the recommendations of UGC and Savitribai Phule University guidelines, the undergraduate (UG) degree course in Chemistry is a 6-semester course for 3-academic years **OR** 8-semester course for 4-academic years. The Teaching-Learning Process (TLP) is student-centric. It involves theory, practical and also vocational and skill- based components. It offers flexibility in Programme structure and ensures a strong foundation and in-depth knowledge in subject. Besides the DSCs (Major Core), students have optional courses from the syllabus comprising of DSEs (Minor), VSCs, SECs, IKSs and OEs. Thus, it will facilitate the interdisciplinary as well as multidisciplinary approach within the curriculum framework. It will also allow students to have maximum flexibility in pursuing studies at UG level to the extent of having the freedom to eventually design the degree with multiple exit options. Students will have these exit options depending upon the needs and aspirations in terms of his/her career goals. This will suit the present-day needs of students in terms of securing their paths toward higher studies or employment

Program Duration and Exit Options

The duration of the UG Program is 4 years or 8 semesters. Students who desire to undergo a 3-year UG Program will be allowed to exit after completion of the 3rd year. If a student wants to leave after the completion of the first or second year, the student will be given a UG Certificate or UG Diploma, respectively, provided they secure the prescribed number of credits. Students who exit with a UG certificate or UG diploma are permitted to re-enter within three years and complete the degree Program. The minimum credit to be earned by a student per semester is 18 and the maximum 26 respectively. However, students are advised to earn 22-credits per semester. This provision is meant to provide students the comfort of the flexibility of semester-wise academic load. However, the mandatory numbers of credits which have to be secured for the award of Undergraduate Certificate/Undergraduate Diploma/Bachelor Degree in Chemistry are listed in **Table 1**.

Table1: List of award of Undergraduate Certificate/ Undergraduate Diploma/Appropriate Bachelor's Degree in Chemistry

S. No.	Type of Award	Stage of Exit	Mandatory Credits to be Secured for the Award
1	Undergraduate Certificate in Chemistry	After successful completion of Semester First year	**44**
2	Undergraduate Diploma in Chemistry	After successful completion of Semester Second Year	**88**
3	Bachelor of Science in Chemistry	After successful completion of Third year	**132**
4	Bachelor of Science in Chemistry (Honours)	After successful completion of Semester Fourth year	**176**

Objectives of the Program

The UG degree in Chemistry aims to provide:

a. Comprehensive knowledge and coherent understanding of the Chemistry.

b. Knowledge and skills in Chemistry and related interdisciplinary areas thereby enhancing students' employability /entrepreneurship.

c. In-depth knowledge in Chemistry through understanding of key concepts, principles, theories and their manifestations.

d. Critical and analytical thinking, scientific reasoning, creativity, problem-solving skills, communication skills and teamwork.

e. Competence and skill in solving both theoretical and applied problems.

f. Exposure to the latest advances in Chemistry, allied disciplines and research.

g. Inculcate digital skills in Chemistry and interdisciplinary areas.

h. Moral and ethical awareness, leadership qualities, innovation, and life-long learning.

i. Multicultural and multilingual competence, inclusive spirit, and value education.

j. Responsibility for Community engagement and service.

Program Outcomes

PO No.	PO Statement After completing the Bachelor of Science Program, students will be able to-	Knowledge and Skill
PO-1	Gain a thorough knowledge and understanding of concepts and principles in Chemistry and other subjects.	Disciplinary knowledge
PO-2	Communicate the subject knowledge in a clear and simple manner in writing and oral.	Communication skill
PO-3	Identify the given problem and apply, theories/assumptions for solving the same related to real life situations	Critical thinking & problem solving
PO-4	Plan, execute, interpret and report the results of the experiments to investigate.	Research related skill
PO-5	Work effectively and respectfully as a team member in the classroom, laboratory and field-based situations.	Co-operation / teamwork
PO-6	Correlate the ideas, evidences and experiences to analyze and interpret the scientific information with learned scientific reasoning	Scientific reasoning
PO-7	Get sensibly aware with the subject facts that can be applied for the society.	Reflective thinking
PO-8	Apply modern library search tools to locate, retrieve, and evaluate subject-related information.	Information /digitally literacy
PO-9	Identify the subject resources required for a project and manage different projects	Self-directed learning
PO-10	Motivate and inspire other colleagues/students in the subject- related activities.	Leadership readiness / qualities
PO-11	Inculcate continuous learning habit through multiple Techniques	Lifelong readiness / qualities

Program Specific Outcomes

PSO No.	PSO Statement After completing the Bachelor of Science in Chemistry, students will be able to-	Knowledge and Skill
PSO-1	Demonstrate comprehensive knowledge and understanding of core principles, theories, and concepts in chemistry	Disciplinary knowledge
PSO-2	Apply critical thinking skills to analyze complex chemical phenomena, evaluate experimental data, and propose innovative solutions to theoretical and practical problems in chemistry.	Critical thinking & problem solving
PSO-3	Utilize resources such as textbooks, scientific literature, online courses, and professional networks to pursue self-directed learning and stay abreast of recent advancements in chemistry.	Self-directed learning
PSO-4	Utilize digital tools, software, and databases effectively for literature research, data analysis, simulation, and visualization in chemistry.	Digitally literacy
PSO-5	Exhibit leadership qualities and interpersonal skills essential for collaboration, teamwork, and effective communication within multidisciplinary research teams and professional environments.	Leadership
PSO-6	Demonstrate readiness for professional practice or further education in chemistry by exhibiting qualities such as adaptability, resilience, professionalism, and a commitment to lifelong learning.	Readiness/qualities

Structure of S. Y. B. Sc. Chemistry

The detailed framework of Undergraduate Degree Program in Chemistry is provided in Table 2.

Table 2 Program Structure of undergraduate degree Program in Chemistry

Credit Framework for Under Graduate (2024-25) (3 Subjects) for Faculty of Science and Technology

First Year (UG Degree)											
Level	**Sem**	**Subject-1**	**Subject-2**	**Subject-3**	**GE/OE**	**SEC**	**IKS**	**AEC**	**VEC**	**CC**	**Total**
4.5/100	I	2(T) + 2(P)	2(T) + 2(P)	2(T) + 2(P)	2(T)	2(T/P)	2(T) (Generic)	2(T)	2	--	22
	II	2(T) + 2(P)	2(T) + 2(P)	2(T) + 2(P)	2(T/P)	2(T/P)	--	2(T)	2	2(T)	22
										Total	**44**

Exit Option: Students on exit shall be awarded Undergraduate Certificate in Chemistry after securing the requisite 44 credits after completion of Semester II, followed by an exit 4-credit core NSQF Course(s) or Internship.

Continue Option: Student will select one subject as a major and one subject as a minor. One subject will be dropped.

Second Year (UG Degree)													
Level	**Sem**	**Credits Related to Major**				**Minor**	**GE/OE**	**SEC**	**IKS**	**AEC**	**VEC**	**CC**	**Total**
		Major Core	**Major Elective**	**VSC**	**FP/OJT/CEP**								
5.0/200	III	4(T) + 2(P)	--	2(T/P)	2(FP)	2(T) + 2(P)	2(T)	--	2(T) (Major Subject Specific)	2(T)	--	2	**22**

	IV	4(T) + 2(P)	--	2(T/P)	2(CEP)	2(T) + 2(P)	2(P)	2(T/P)	--	2(T)	--	2	**22**
Total													**44**

Exit Option: Students on exit shall be awarded Undergraduate Diploma in Major and Minor with 88 credits and additional 4-credit core NSQF Course (s) or Internship.

Continue Option: Student will continue with major and minor.

Third Year (UG Degree)													
Level	**Sem**	**Credits Related to Major**				**Minor**	**GE / OE**	**SEC**	**IKS**	**AEC**	**VEC**	**CC**	**Total**
		Major Core	**Major Elective**	**VSC**	**FP/OJT/ CEP**								
5.5/ 300	V	8(T) + 4(P)	2(T) + 2(P)	2(T/ P)	2(FP/CEP)	2(T)	--	--	--	--	--	--	**22**
	VI	8(T) + 4(P)	2(T) + 2(P)	2(T/ P)	4OJT	--	--	--	--	--	--	--	**22**
												Total	**44**

Exit Option: Students on exit shall be awarded UG Degree in Major after securing the requisite 132 credits after completion of Semester VI. Or Continue with Major

Fourth Year (Honours Degree with Research)													
Level	**Sem**	**Credits Related to Major**				**Minor**	**GE/ OE**	**SEC**	**IKS**	**AEC**	**VEC**	**CC**	**Total**
		Major Core	**Major Elective**	**VSC**	**FP/OJT/ CEP**								
6.0/ 400	VII	6(T) + 4(P)	2(T) + 2(T/P)	--	4(RP)	4 (RM)	--	--	--	--	--	--	**22**
	VIII	6(T) + 4(P)	2(T) + 2(T/P)	--	8(RP)	--	--	--	--	--	--	--	**22**
												Total	**44**

Students on exit shall be awarded Bachelor of Science (Honours with Research Degree) after securing the requisite 176 credits after completion of Semester VIII.

Fourth Year (Honours Degree without Research)													
Level	**Sem**	**Credits Related to Major**		**VSC**	**FP/OJT/ CEP**	**Minor**	**GE/ OE**	**SEC**	**IKS**	**AEC**	**VEC**	**CC**	**Total**
		Major Core	**Major Elective**										
6.0/ 400	VII	10(T) + 4(P)	2(T) + 2(T/P)	--	--	4 (RM)	--	--	--	--	--	--	22
	VIII	10(T) + 4(P)	2(T) + 2(T/P)	--	4 (OJT)	--	--	--	--	--	--	--	22
												Total	**44**

Students on exit shall be awarded Bachelor of Science (Honours Degree) after securing the requisite 176 credits after completion of Semester VIII.

General guidelines for the selection of subjects

1. Student has to choose three subjects from the same faculty in first year and at the start of second year he/she has to opt one subject as Major subject and one (from other two subjects) as Minor subject and the last one will be dropped by the students.
2. Student cannot select a subject as major or minor other than the subjects taken in first year.
3. OE is to be chosen compulsorily from faculty other than that of the major.
4. SEC to be selected from the basket of Skill courses approved by the university.
5. VSC, FP/OJT/CEP should be related to the major subject.
6. AEC, VEC, IKS (Generic), and CC will be provided by the university separately.

Teaching-Learning Process

a. The courses will be taught through the traditional chalk and talk method, laboratory work, ICT enabled teaching learning tools, project work, seminars, case studies, field work, internships, hands-on training, etc.
b. Students will be engaged in various student centric activities like experiential learning, problem solving methodologies, participative learning and ICT based teaching learning process.
c. ICT tools in Basic and Advanced Chemistry software will be used to make the teaching learning process efficient and engaging.
d. Critical, analytical and problem-solving abilities will be developed through projectbased learning, internships, industrial visits and hands-on training.
e. The problem-solving methodologies like quizzes, review of books and research papers, like workshops, research-based competitions will be used.
f. The vocational and skill training will be done through vocational and skill-based courses.
g. The students will be introduced to advanced laboratory instruments for hands-on training.

Methods of Assessment

The primary objective of assessment will be to assess the learning outcomes of the course in tune with the broad outcomes of strengthening core theoretical knowledge base, practical laboratory skills, and research. Assessment will be based on continuous evaluation methods and end of semester examination of Savitribai Phule Pune University, Pune.

Continuous Internal Evaluation:

During a semester, students' mastery of the various learning outcomes as described in the syllabus will be assessed through like Short Questions, Class Tests, Seminars, Presentations, Group Discussion, Quizzes, MCQs, Assignments, Tutorials, Project work, etc. Each theory paper and practical paper will have 15 marks for internal assessment for 2 credit courses and 30 marks for internal assessment for 4 credit courses.

End Semester University Examinations:

The end-semester university examinations will be conducted for both theory and practical courses. Besides internal assessment, both theory paper and practical paper will be of 35 marks each (2 credit course) and 70 marks (4 credit course) for end of semester examination of the university.

Note: For open elective subjects, the examination should be conducted in both Marathi and English

Scheme of Examination:

The total marks for a 2-credits course are 50, and for a 4-credits course is 100.
Internal exams will be conducted by the college and external exams will be conducted by Savitribai Phule Pune University, Pune at the end of each semester.

Important for Practical Course:

a. It is mandatory to have a certified journal during the practical examination.
b. Use molar concentrations for volumetric/ estimation / synthesis experiment.
c. Use optimum concentrations and volumes.
d. Two burette methods should be used for volumetric analysis. (Homogeneous mixtures)
e. Use of microscale technique is recommended wherever possible

List of courses

Course Type	Semester	Course Code	Title of the Course	Credits
Major Core	III	CHE-201-T MJ	Physical Chemistry-I	2
		CHE-202-T MJ	Inorganic Chemistry-I	2
		CHE-203-P MJP	Chemistry Practical- III	2
Major Core	IV	CHE-251-T MJ	Organic Chemistry-I	2
		CHE-252-T MJ	Analytical Chemistry-I	2
		CHE-253-P MJP	Chemistry Practical – IV	2
Vocational Skill Courses(VSC)	III	CHE-221-T VSC	Industrial Chemistry-I	2
	IV	CHE-271-P VSC	Industrial Chemistry Practical-I	2
Minor	III	CHE-241-T MN	Physical and Inorganic Chemistry	2
		CHE-242-P MNP	Physical and Inorganic Chemistry Practical	2
	IV	CHE-291-T MN	Organic and Analytical Chemistry	2
		CHE-292-P MNP	Organic and Analytical Chemistry Practical	2
Generic Elective (GE)/Open Elective (OE) Courses **(any one)**	III	OE-201-T-CHE (A)	Chemistry of Cosmetics and Perfumes-I	2
		OE-201-T-CHE (B)	Dairy Chemistry	2
Generic Elective (GE)/Open Elective (OE) Courses **(any one)**	IV	OE-251-T-CHE (A)	Chemistry of Cosmetics and Perfumes-II	2
		OE-251-T-CHE (B)	Agricultural Chemistry	2
Indian Knowledge System (IKS)	III	CHE-201-T IKS	Ancient Indian Chemistry	2
Skill Enhancement Courses (SEC) **(any one)**	IV	SEC-201- P CHE (A)	Basic Software in Chemistry	2
		SEC-201- P CHE (B)	Clinical Chemistry Practical	2
Field Project (FP)	III	CHE-231 FP	Field Project	2
Community Engagement Project (CEP)	IV	CHE-281 CEP	Community Engagement Project	2

CHE-201-T MJ : Physical Chemistry-I

Course Type: Major (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course student will be able to

1. Remember definitions, laws, and formulas related to reaction kinetics, thermodynamics, electrolytic conductance, and phase equilibrium.
2. Understand the rate laws of third-order reactions, thermodynamic concepts like entropy and free energy, ionic conductance, and phase diagrams.
3. Solve numerical problems using the Arrhenius equation, entropy changes, conductance laws, phase rule etc .
4. Compare methods for determining reaction order, thermodynamic processes, and conductance and phase systems.
5. Assess reaction mechanisms, thermodynamic feasibility, and conductance behavior of electrolytes.
6. Summarize the effect of temperature on reaction rate, phase stability, or ion mobility in solution.

Course Contents

Chapter 1 : Chemical Kinetics **[8 Hours]**

(Recapitulation: rate of chemical reaction, order of reaction, integrated rate law :zero-order, first order, second order) Third-order reactions, Derivation of integrated rate law for third-order reactions with equal initial concentrations, characteristics and examples of third-order reaction. Methods to determine the order of reaction using: Integrated rate equation method, Graphical method, Half-life method and Differential method. Effect of temperature on reaction rate, Arrhenius equation, temperature dependence of reaction rates, interpretation of Arrhenius parameters, **Numericals**. [Ref. 1:Pages 731-735, 745, 752-755, 757-759, Ref. 2: Pages 7-11, 18-21, 26, 39-44, Ref. 3: Pages: 1038-1046, 1050-1052, 1056-1060]

Chapter 2 : Chemical Thermodynamics **[7 Hours]**

(Recapitulation: Introduction, terminology of thermodynamics, thermodynamic equilibrium, properties, thermodynamic processes) First law of thermodynamics, Enthalpy, Heat capacity, Relation between Cp and Cv, Expansion of ideal gas and changes in thermodynamic properties: Isothermal process, Adiabatic process, Limitations of the first law: Need for the second law,

Cyclic process, Carnot cycle, Second law of thermodynamics. Concept of entropy, Entropy change in isothermal expansion, Reversible and irreversible processes, Phase change and entropy of mixing of ideal gases, Work and free energy function. **Numericals** [Ref. 1: Pages-236-237, 303-327, Ref. 3: Pages-528-535, 571-582, Ref. 4: Pages-134-140, 175-189]

Chapter 3 : Electrolytic Conductance **[8 Hours]**

(*Recapitulation: Electrolytes, Ohm's law and Electrical units, electrolytic conductance, resistance and specific resistance*) Electrolytic Conductance, Specific and equivalent conductance, Variation of equivalent conductance with concentration. **Kohlrausch's law and its applications to determine:** Equivalent conductance at infinite dilution of a weak electrolyte, The ionic product of water, Solubility of sparingly soluble salts. Migration of ions and ionic mobilities, Absolute velocity of ions, **Transport number determination by:** Hittorf's method, Moving boundary method, Relation between ionic mobility, ionic conductance and transport number, Ionic theory of conductance. **Numericals** [Ref. 1: Pages-860-861, 865-868, 883-896, Ref. 3: Pages- 801-815, Ref. 4: Pages- 303-306, 318-326]

Chapter 4 : Phase Equilibrium **[7 Hours]**

Introduction, Phase, Components and Degree of Freedom of a system, Stability of Phases, Criteria of Phase equilibrium, Gibb's Phase rule and its thermodynamic derivation, Phase Diagrams of One Component system: Water, Carbon Dioxide and Sulphur system, **Numericals.** [Ref. 3: Pages – 661-672, Ref. 4: Pages – 393-397, Ref. 5: Pages- 925-930, 941-948]

References

1. Essentials of Physical Chemistry by Arun Bahl, B.S. Bahl and G.D.Tuli –Multicolor Edition
2. Chemical Kinetics, Keith J. Laidler (4^{th} Ed)
3. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma, M. S. Pathania (46^{th} Ed.)
4. Physical Chemistry, G. M. Barrow (5^{th} Ed.)
5. Physical Chemistry: A Molecular Approach by D. A. McQuarrie & J. D. Simon
6. Introduction to Chemical Thermodynamics by A. K. Chandra (4th Ed.)

CHE-202-T MJ : Inorganic Chemistry-I

Course Type: Major (Theory) **No. of Credits: 2**

Course Outcomes

The end of the course, student will be able to

1. Learn key terms and concepts such as types of ligands, isomerism, hybridization, d-orbital shapes, and theories like VBT and CFT.
2. Explain the principles of coordination bonding, types of isomerism, and the structural implications of VBT and CFT in coordination compounds
3. Apply VBT and CFT to predict geometry, magnetic properties, and hybridization of coordination complexes
4. Compare types of isomerism and interpret orbital splitting patterns in octahedral, tetrahedral, and square planar complexes.
5. Determine the magnetic moment, ligand field strength and geometry of complexes.
6. Summarize the coordination compounds according to their geometry, spin state, and ligand environment using CFT and VBT concepts.

Course Contents

Chapter 1 : Introduction to Coordination Compounds **[6 Hours]**

Double salt and coordination compound, basic definitions: coordinate bond, ligand, types of ligands, chelate, central metal ion, charge on complex ion, calculation of oxidation state of central metal ion, metal ligand ratio; Werner's work and theory, Effective atomic number, equilibrium constant (**Ref-6: 138-140**), chelate effect, IUPAC nomenclature. (**Ref.-1:** 194-200, 222-224; **Ref-4:** 483-492)

Chapter 2 : Isomerism in coordination complexes **[3 Hours]**

Introduction, polymerization isomerism, ionization isomerism, hydrates isomerism, linkage isomerism, coordination isomerism, coordination position isomerism, geometric isomerism, optical isomerism. ***(Ref-1:** 232-236)*

Chapter 3 : Valance Bond Theory of Coordination Compounds **[6 Hours]**

Paramagnetic and diamagnetic nature coordination complexes, calculation of magnetic moment from number of unpaired electrons, Aspects and assumptions of VBT, applications of VBT on the basis of hybridization to explain the structure and bonding in $[Ag(NH_3)^{2+}]$, $[Ni(Cl_4)]^{2-}$, $[MnCl_4]^{2-}$, $[Ni(CN)_4]^{2-}$, $[PtCl_4]^{2-}$, $[Cr(H_2O_6)]^{3+}$, $[Co(NH_3)_6]^{3+}$, $[Fe(CN)_6]^{3-}$ (Inner orbital complex) and

$[FeF_6]^{3-}$(outer orbital complex). Use of observed magnetic moment in deciding the geometry in complexes with C.N.4, limitations of VBT. (**Ref-2:** 592-597, **Ref-3:**350-351).

Chapter 4 : Crystal Field Theory **[15 Hours]**

Shapes of d-orbitals, **Crystal field Theory** (CFT): Assumptions, Application of CFT to - **i) Octahedral complexes**: splitting of 'd' orbitals in Oh ligand field, effect of weak and strong ligand fields, low spin and high spin complexes, spin only magnetic moment of low spin and high spin complexes, colour absorbed and spectrochemical series, crystal splitting energy, Crystal field stabilization energy and factors affecting it, tetragonal distortion in Cu(II) complexes; **ii) Square planar complexes –** Formation of Sq. Pl. complexes from distorted Oh complex, examples and spin only magnetic moments of Cu(II), Ni(II), Pt(II) square planar complexes; **iii) Tetrahedral complexes**: Splitting of d orbitals in tetrahedral ligand field, Crystal field splitting parameter (Δt), spin only magnetic moment, CFSE in Td complexes, Comparison of Δt and Δo, **(Ref-1:**194-225).

References

1. Concise inorganic chemistry, J. D. Lee, 5th Ed (1996), Blackwell Science
2. Inorganic Chemistry, James E. House, Academic Press (Elsevier), 2008
3. Inorganic Chemistry by Miessler and Tarr, Third Ed. (2010), Pearson.

CHE-203-P MJP : Chemistry Practical- III

Course Type: Major (Practical) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to learn,

1. Know the experimental procedures, formulas, and theoretical principles related to kinetics, thermodynamics, conductance, and coordination chemistry.
2. Understand the principles behind rate laws, enthalpy changes, conductometric titrations, colorimetry, and coordination complex formation.
3. Perform laboratory experiments to determine reaction order, heat changes, cell constants, and synthesize coordination compounds.
4. Analyze the reaction rates, calculate thermodynamic parameters, determine ligand ratios, and analyze chromatographic separations.
5. Evaluate the accuracy of results by comparing with theoretical values, validate Beer's Law, and evaluate coordination complex properties like color and magnetism.
6. Design experiments for synthesis, analysis, and characterization of coordination compounds.

Course Contents

Section-I : Physical Chemistry

A. Chemical Kinetics (Any two)

1. To determine the order of reaction between $K_2S_2O_8$ and KI by half-life method.
2. Energy of activation of the reaction between $K_2S_2O_8$ and KI with unequal initial concentration.
3. To study the kinetics of saponification reaction between sodium hydroxide and ethyl acetate
4. To study the effect of concentration of the reactants on the rate of hydrolysis of an ester.
5. To study the kinetics of iodination of acetone.

B. Thermodynamics (Any Two)

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.

C. Electrolytic Conductance (Compulsory)

1. To determine the cell constant of the given cell using 0.01 M KCl solution and hence determine dissociation constant of a given monobasic weak acid.
2. To investigate the conductometric titration of Strong acid against strong base a) Strong acid against strong base b) Strong base against weak acid. (standardization of base must be performed with KHP)

Section-II: Inorganic Chemistry

A. Synthesis of Coordination compounds (Any three)

1. Synthesis of sodium cobaltinitrite (a laboratory chemical) from Co(II) salt and $NaNO_2$ salts. Comment on colour and magnetic properties of the complex.
2. Synthesis of Potassium Tris(oxalato)Fe(III). Comment on colour and magnetic properties of the complex.
3. Synthesis of Tris(acetylacetonato)iron(III) by green chemistry method by reaction between $Fe(OH)_3$ and acetylacetone. Comment on colour and magnetic properties of the complex. (Ref.- 5,6).
4. Synthesis of $[Ni(NH_3)_6]Cl_2$ from $NiCl_2$. Comment on colour and magnetic properties of the complex.
5. Synthesis of $[Cu(NH_3)_4]SO_4$, Comment on colour and magnetic properties of the complex.

B. Inorganic colorimetric investigations (Any two)

1. Estimation of Cu(II) by complexation with R-Nitrso salt/ammonia by colorimetry: Determination of linearity range for Cu^{2+} using different ranges of Cu(II) concentrations and verification Beer's law.
2. Prepare solution of Fe(III) and SCN^- of in different molar proportion, record their absorbance and calculate equilibrium constant of $[Fe(SCN)]^{2+}$ complex.
3. Solution state synthesis of $[Ni(en)_3]^{2+}$ complex and determination of i) λmax and calculate 10Dq ii) equilibrium constant of the same complex.

C. Determination Metal ligand ratio (any one)

1. Potassium Tris(oxalate)Fe(III) complex (From synthesized complex by volumetric method).
2. Fe(III) or Cu(II)–Salicylic acid complex by colorimetric method.

D. Determination of transition metal ions by paper chromatography using colour forming ligands.

References

Section-I : Physical Chemistry

1. Systematic experimental physical chemistry, S. W. Rajbhoj, T. K. Chondekar, Anjali publication.
2. Practical Physical Chemistry, Vishwanathan and Raghwan , Viva book.
3. Practical Chemistry, O. P. Pandey, D. N. Bajpai Dr. S. Giri, S Chand Publication
4. Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publication.
5. Practical Physical Chemistry, 3rd Edn. A. M. James and F. E. Prichard, Longman publication.
6. Experiments in Physical Chemistry, R. C. Das and B. Behra, Tata McGraw Hill.
7. Advanced Practical Physical Chemistry, J. B. Yadav, Goel Publishing House.
8. Advanced Experimental Chemistry, Vol-I, J. N. Gurtu and R. Kapoor, S. Chand and Company.
9. Physical Chemistry Experiments, Raghvan and Vishwanathan.

Section-II : Inorganic chemistry

1. Advanced Practical Chemistry, Jagdamba Sing et al, Pragati Prakashan, Merrut.
2. Practical Chemistry, Panday, Bajpai, Giri, S.Chand and Co.
3. Handbook of Preparative Inorganic Chemistry, Volume 2, Second Edition, Edited By Georg Braue R, Academic Press, New York, London, 1965. (Page-1541)
4. Inorganic Syntheses Vol -1 by H S Booth. First Ed, 1939. (page-36).
5. Novel Synthesis of Tris(acetylacetonato)-iron(III), Journal of Chem. Soc. Dalton Trans. 1983
6. Metal Acetylacetonate Synthesis Experiments: Which Is Greener?, Journal of Chemical Education, 2011, 88, 947–953, dx.doi.org/10.1021/ed100174f
7. Experimental Inorganic/Physical Chemistry: An Investigative, Integrated Approach to Practical Project Work, MounirA. Malati, Woodhead Publishing Limited, 1999.
8. Colorimetric Determination of the Iron(III)-Thiocyanate Reaction Equilibrium Constant with Calibration and Equilibrium Solutions Prepared in a Cuvette by Sequential Additions of One Reagent to the Other, Journal of Chemical Education, Vol.88 No.3 March 2011.
9. Experiments in chemistry, D. V. Jahagirdar, Himalaya publication.

10. A spectrophotometric study of complex formation between Fe(III) and salicylic acid, Kinya Ogawa, Nobuko Tobe, Bulletin of chemical society of Japan, 39, 227-232, 1966.
11. Salicylate determination by complexation with Fe(III) and optical absorbance spectroscopy
12. Determination of Equilibrium Constants of Metal Complexes from Spectrophotometric Measurements: An Undergraduate Laboratory Experiment, Journal of Chemical Education, Vol. 76, No. 9, September 1999.

CHE-251-T MJ : Organic Chemistry-I

Course Type: Major (Theory) **No. of Credits: 2**

Course Outcomes

1. Recall basic concepts of acidity, basicity, reaction mechanisms, oxidation, reduction, and stereochemistry.
2. Explain the mechanisms of organic reactions involving halides, oxidizing and reducing agents, and stereochemical outcomes in cyclic systems.
3. Apply knowledge of acidity, basicity, nucleophilic substitution, oxidation, reduction, and stereochemical principles to predict the behavior of organic compounds.
4. Analyze reaction mechanisms, reactivity trends of halogenated hydrocarbons, and stability of substituted cyclohexane conformations.
5. Evaluate the choice of reagents and reaction conditions for achieving specific transformations in organic synthesis.
6. Develop synthetic strategies using organic reactions and stereochemical concepts.

Course Contents

Chapter 1 : Structure, Acidity and Basicity **[6 Hours]**

Introduction to acidity and basicity, Lowry-Brønsted and Lewis acids and bases, concept of conjugate acids and bases, pKa, simple and substituted aliphatic acids, phenols, aromatic carboxylic acids, bases, pKb, aliphatic and aromatic bases, Introduction to types of organic reactions, concept of Reaction Mechanisms, energetics of reaction

Chapter 2 : Reactivity and Reactions of halogenated hydrocarbons **[10 Hours]**

Introduction and classification, general methods of preparation, reactivity of alkyl, aryl, allyl and vinyl halides, Nucleophilic substitution reactions: S_N1 and S_N2, Factors affecting S_N1 and SN2 reactions, Elimination reactions: E1 and E2, and comparative study of substitution and elimination reactions of alkyl halides, Nucleophilic aromatic substitution (S_NAr) reactions.

Chapter 3 : Oxidizing and reducing agents **[8 Hours]**

Oxidizing Reagents: Jones oxidation, Potassium permanganate, m-CPBA, Osmium tetroxide, Criegee Oxidation, O_3, Selenium dioxide, Reducing Reagents: Catalytic hydrogenation, LAH, SBH, DIBAL, Reduction of alkynes by Lindlar's catalyst and Na/NH_3, Clemmensen reduction, Wolff-Kishner reduction

Chapter 4 : Stereochemistry of mono and di-substituted cyclohexane [6 Hours]

Stability of chair conformation, ring flipping, Mono and di-substituted cyclohexanes, 1, 3-diaxial and butane-gauche interactions, cis and trans stereochemistry, optical activity, energy profile diagrams and stability.

References

1. A Guidebook to Mechanism in Organic Chemistry by Peter Sykes. 6th ed. Essex, England: Longman Scientific & Technical
2. Organic Chemistry by Morrison and Boyd, 7th Edition, Pearson Education
3. Advanced Organic Chemistry by Jerry March, 7th Edition, Wiley
4. Organic Chemistry by Jonathan Clayden, Nick Greeves, and Stuart Warren, 2nd Edition, Oxford University Press
5. Stereochemistry of Organic Compounds by D. Nasipuri, 3rd Edition, New Age International.
6. The Art of Writing Reasonable Organic Reaction Mechanisms" by Robert B. Grossman, 1st Edition, Springer
7. Reaction Mechanisms in Organic Chemistry" by S. M. Mukherjee and S. P. Singh, 1st Edition, New Age International
8. W. Carruthers and I. Coldham Search Results, Modern Methods of Organic Synthesis, Cambridge University Press, 2004
9. Francis A. Carey and Richard J. Sundberg, Advanced Organic Chemistry, Part B: Reactions and Synthesis, Springer, 2007
10. Richard O.C. Norman, James M. Coxon, Principles of Organic Synthesis, CRC Press, 1993

CHE-252-T MJ : Analytical Chemistry-I

Course Type: Major (Theory) **No. of Credits: 2**

Course Outcomes

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

1. Learn concepts, definitions, and reagents used in volumetric analysis, colorimetry, chromatography, and solvent extraction.
2. Explain the principles of titrations, Beer-Lambert law, chromatographic separation, and solvent extraction mechanisms.
3. Use standard analytical techniques to determine concentrations of substances through titration, colorimetry, chromatography, and extraction.
4. Interpret titration curves, calibration plots, chromatograms, and extraction efficiencies to assess analytical results.
5. Compare the accuracy, precision, and suitability of analytical techniques like redox titrations vs. complexometry or paper chromatography vs. TLC.
6. Perform an analytical procedure of titrimetric, colorimetric, or extraction methods to determine unknown concentrations in a sample.

Course Contents

Chapter 1: Volumetric Analysis: **[12 Hours]**

Introduction, Classification of reaction in volumetric analysis, standard solutions, equivalents, normalities, oxidation numbers, primary and secondary solutions, Types of volumetric analysis:

1. **Neutralization titrations:** Theory of indicators, neutralization curves for strong acid-strong base, weak acid-strong base, weak base-strong acid, Preparation of 0.1 M HCl and standardization with sodium carbonate, determination of sodium carbonate in washing soda.
2. **Complexometric Titrations:** Definition of complexing agents and complexometric titrations, EDTA, standard EDTA solution, Types of EDTA titrations, metal ion indicator, total hardness of water.
3. **Redox Titrations:** Definition of oxidizing agent, reducing agent, redox titrations, $K_2Cr_2O_7$ and $KMnO_4$ as oxidizing agent, $KMnO_4$ as self-indicator, Determination of H_2O_2.

4. **Precipitation Titrations:** Principle, precipitation reaction, determination of end point, standard silver nitrate solution, standardization of silver nitrate solution, determination of chloride and bromide.

   (**Ref.-1**: Pages-257-275, 286, 295, 309-322, 328-332, 340-351, 364-372, **Ref.-2**: Pages-282-302, 322-334, 366-374, 437-452).

Chapter 2: Colorimetry: **[6 Hours]**

Introduction, interaction of electromagnetic radiation with matter, essential terms-radiant power, transmittance, absorbance, Lambert's Law, Beer's Law, Lambert's-Beer's Law, molar absorptivity, deviations from Beer's law, Colorimeter: Principle, Construction and components, working, Applications-unknown concentration by calibration curve method, Determination of unknown concentration of Fe (III) by thiocyanate method, Numericals (**Ref. 1**: Pages-645-651, 658-661, 690, **Ref.3**: Pages-97, 100, 159-172, **Ref. 4**: Pages-144-153, 157-160).

Chapter 3: Chromatography: **[6 Hours]**

Introduction, Principle, Types of chromatography, Paper Chromatography-Introduction, Principle, Migration parameters, Types of paper chromatography, Experimental details, Applications. Thin layer chromatography-Introduction, Experimental Techniques, Applications of TLC, Limitations. (**Ref.5**: Pages-2.588-2.615)

Chapter 4: Solvent extraction: **[6 Hours]**

Introduction solvent extraction, organic Phase, Partitition the theory of extraction, distribution coefficient, Distribution ratio, solute remaining unextracted separation coefficient, factor favouring solvent extraction, Quantitative treatment to solvent extraction equilibrium, ion association complexes, synergic extraction, some extraction reagents specially used for inorganic ion (Acetyl acetone, 8-Hydroxy quinoline, Diphenylthiocarbazone, sodium diethyl dithiocarbamate, ammonium pyrrolidine, dithiocarbamate), some practical aspects, applications, determination of copper as the diethyl dithiocarbamate complex, Determination of Fe(III) with 8-hydroxy quinoline, determination of Ni by synergistic extraction solid phase extraction, Numericals; (**Ref.6**: Pages-579-593)

References

1. Vogel's Textbook of Quantitative Chemical Analysis, 5th Ed. G. H. Jeffry, J. Basset. J. Mendham, R. C. Denny, Longman Scientific and Technical, 1989.
2. Analytical Chemistry, G. D. Christian, P. K. Dasgupta, K. A. Schug, 7th Ed, Wiley, 2004.

3. Basic Concept of Analytical Chemistry, S. M. Khopkar, 3rd Ed. New Age International Publishers.
4. Vogel's Textbook of Practical Organic Chemistry, Durniss, Hannaford, Smith, Tatchel, 5th Ed. Longman Scientific and Technical, 2004.
5. Instrumental Methods of Chemical Analysis, Gurdeep R. Chatwal, Sham K. Anand, Himalaya Publishing House.
6. Vogel's Textbook of Inorganic Quantitative Analysis, 6th Ed. Mendham, Deney Barnes Pearson Education.

CHE-253-P MJP : Chemistry Practical – IV

Course Type: Major (Practical) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to

1. Remember the fundamental concepts, reagents, and functional group tests used in organic estimation, preparation, and volumetric analysis.
2. Explain the principles behind organic reactions, separation techniques, and titration methods used in qualitative and quantitative analysis.
3. Perform organic synthesis, separation of binary mixtures, and estimations using volumetric and chromatographic methods in laboratory settings.
4. Differentiate between organic functional groups in mixtures, interpret chromatograms, and analyze titration results to identify and quantify substances.
5. Assess the purity and identity of synthesized or separated compounds using melting point, TLC, and confirmatory tests; validate volumetric results through standardization.
6. Execute multi-step analytical procedures combining organic preparation, separation, and titration.

Course Contents

Section-I: Organic Chemistry Practicals

A. Organic Estimations (any two)

1. Determination of molecular weight: Determination of molecular weight of organic acid by titration against standardized NaOH - a) monobasic acid or b) dibasic acid
2. Estimation of amides: Determine the amount of Acetamide in given solution by volumetric method. (Standardization of acid must be performed)
3. Estimation of Ethyl benzoate: To determine the amount of ethyl benzoate in give in solution volumetrically. (Standardization of acid must be performed).

B. Organic Qualitative Analysis (Two mixtures: solid-solid type)

Determination of type and separation of two components from given binary mixture of organic compounds containing mono-functional group (Ex. - carboxylic acid,phenols, amines, amide, nitro, etc.) and systematic identification of any one component qualitatively.

C. Organic Preparations (Any two)

1. Preparation of benzoic acid from ethyl benzoate (Identification and confirmatory Test of – COOH group, M.P and purity by TLC)
2. Base catalysed Aldol condensation (Confirm the conversion by Wilson test in product, M.P and purity by TLC)
3. Preparation of Quinone from hydroquinone (Confirm the conversion by absence of phenolic –OH group in product, M.P and purity by TLC)

Section-II: Analytical Chemistry

A. Volumetric Analysis (Any Five)

1. Estimation of sodium carbonate content of washing soda.
2. Determination of acetic acid in commercial vinegar by titrating with standard NaOH.
3. Determination of amount of $CaCO_3$ in Chalk using standard HCl & NaOH Solution.
4. Estimation of Ca from calcium supplementary tablet by complexometric titration.
5. Determination of the strength of given H_2O_2 solution with standard $KMnO_4$ solution.
6. To study the neutralization of HCl by NaOH.
7. Estimation of Aspirin from a given tablet

B. Chromatography (Any One)

1. Separation of constituents of mixtures by Chromatography: Measure the Rf value in each case. Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acids)/ pigments from plant extract / 2 organic compounds by paper chromatography.
2. Chromatography Separation of a mixture of two organic compound by ascending Thin Layer Chromatography.

References

Section-I : Organic Chemistry

1. Vogel's Textbook of Practical Organic Chemistry" by A. I. Vogel, 5th Edition, Pearson Education
2. Vogel's Textbook of Quantitative Chemical Analysis by G.H. Jeffery, J. Bassett, J. Mendham, and R.C. Denney, 5th Edition, Longman Scientific & Technical

Section-II : Analytical Chemistry

1. Vogel's Textbook of Practical Organic Chemistry" by A. I. Vogel, 5th Edition, Pearson Education
2. Vogel's Textbook of Quantitative Chemical Analysis by G.H. Jeffery, J. Bassett, J. Mendham, and R.C. Denney, 5th Edition, Longman Scientific & Technical

CHE-221-T VSC: Industrial Chemistry-I

Course Type: VSC (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to

1. Remember the definitions, industrial processes, pollution norms, raw materials, and key chemical manufacturing techniques used in large- and small-scale industries.
2. Understand the principles behind unit operations, pollution control technologies, green chemistry approaches, and the roles of industrial and plant chemists.
3. Apply knowledge of industrial processes like distillation, crystallization, and polymerization to real-world chemical production systems
4. Compare unit operations and unit processes, renewable vs. non-renewable resources, and heavy vs. fine chemical manufacturing.
5. Assess the environmental impact of industrial processes by interpreting pollution control standards (CPCB, EPA) and recommending improvements through green chemistry.
6. Design sustainable chemical production workflows that incorporate energy-efficient unit operations and eco-friendly purification methods for fine chemicals.

Course Contents

Chapter 1: Introduction to Industrial Chemistry **[4 Hours]**

Definition, scope, and significance of industrial chemistry, Classification of industries: large-scale, medium-scale, small-scale, Importance of the chemical industry in daily life and national economy, Types of raw materials: minerals, fossil fuels, air, water, agricultural materials, Difference between renewable and non-renewable raw materials, Role of industrial chemists and plant chemists.

Reference 1 (pp.1-35), 2 (pp.3-30), 3(pp.5-15), (pp.29-35)

Chapter 2: Industrial Pollution Control **[4 Hours]**

Overview of Industrial Pollution, Pollution Control Technologies: Scrubbers, Electrostatic Precipitators (ESP), Bag filters. Water: Effluent Treatment Plant (ETP), Reverse Osmosis (RO), Zero Liquid Discharge (ZLD). Solid waste: Incineration, Landfilling, Composting, Waste to Energy. Cleaner Production and Green Chemistry Approaches: Principles of green chemistry, Waste minimization and solvent recovery, Energy-efficient processes.

Reference: 1(pp. 789–810), 3 (pp. 221–263), (pp. 325–345), 4(pp. 563–588)

Chapter 3: Unit Operations and Unit Processes [11 Hours]

Overview of chemical industries in India. Definition and distinction between Unit Operations and Unit Processes. Importance in industrial chemical manufacturing.

Unit Operations:

Distillation: Principle, Types of distillation, application in alcohol and petroleum industries. Drying: Drying principles, types of industrial dryers (rotary, spray, drum dryers), application in chemical industries. Filtration: Media types, equipment, example (sugar industry). Extraction: Liquid-liquid extraction, equipment, example (antibiotic extraction). Crystallization Supersaturation, nucleation, example (salt, sugar production).

Unit Processes:

Nitration: Concept, industrial method (nitrobenzene synthesis), Sulfonation: Concept, industrial method (detergent manufacturing), Halogenation: Mechanism, example (chloroform production), Polymerization: Introduction to addition and condensation polymerization processes, applications in plastics and fibers.

Reference: 1 (pp. 1–22), (pp. 175-178), 5 (pp. 1–12), (pp. 186–190) 6 (pp. 159–184), (pp. 213–240), (pp. 386–419), (pp. 658–688), (pp. 773–802), 7 (pp. 145–176)

Chapter 4: Heavy and Fine Chemicals [11 Hours]

Overview and significance of Heavy and Fine Chemicals in chemical industries. Distinction between bulk production (Heavy Chemicals) and high-purity specialty production (Fine Chemicals). Importance in sectors such as fertilizers, explosives, pharmaceuticals, and electronics.

Heavy Chemical Manufacturing Processes:

Contact Process: Manufacture of sulfuric acid. Haber Process: Synthesis of ammonia. Solvay Process: Production of sodium carbonate. Chlor-alkali Process: Electrolysis of brine for chlorine, hydrogen, and sodium hydroxide production. Importance of Catalysts: Catalytic roles in sulfuric acid and ammonia production for energy-efficient processes.

Fine Chemical Manufacturing:

Batch manufacturing: Penicillin production in fermentation reactors. Continuous manufacturing: Large-scale paracetamol intermediate production.

Physicochemical principles and their application of Heavy Chemical and Fine Chemical. Purification Techniques for Fine Chemicals: Recrystallization, chromatography, high-vacuum distillation for high-purity products. Reference: 1 (pp. 125–141), 5 (pp. 45–52), 7 (pp. 24–37), 8 (pp. 12–16)

References

1. Industrial Chemistry, B. K. Sharma, Goel publishing House, 18th Ed. (2014)
2. Sharma, B.K., & Gaur, H.K. (2016). Industrial Chemistry (8th ed.). Meerut: Goel Publishing House.
3. Pandey, G.N. (2015). Engineering Chemistry (9th ed.). Meerut: Vikas Publishing House Pvt. Ltd.
4. Shukla, S.D., & Pandey, G.N. (2014). A Textbook of Chemical Technology (2nd ed.). Meerut: Vikas Publishing House Pvt. Ltd.
5. Outline of Chemical Technology, 3rd Edition, Dryden (Edited by Gopala Rao and M. Sitapathi Rao)
6. Unit Operations of Chemical Engineering, 7th Edition, Warren L. McCabe, Julian C. Smith, Peter Harriott
7. Shreve's Chemical Process Industries, 5th Edition, George T. Austin
8. Green Chemistry and Engineering: A Pathway to Sustainability, Anne E. Marteel-Parrish and Martin A. Abraham
9. C.S. Rao, Environmental Pollution Control Engineering, 2nd Edition, New Age International Publishers.

CHE-271-P VSC: Industrial Chemistry Practical-I

Course Type: VSC (Practical) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to

1. Learn basic concepts of industrial preparations, qualitative estimations, and pollution control techniques used in chemical laboratories and industries
2. Explain the principles behind organic synthesis, water hardness estimation, and environmental sampling methods including their industrial significance.
3. Demonstrate the preparation of industrially important compounds like paracetamol and dyes, and perform titrimetric analysis for water and soil quality assessment.
4. Compare experimental results to evaluate chemical purity, water salinity, and environmental parameters using field and lab-based methods.
5. Evaluate the efficiency of pollution indicators, safety protocols, and synthetic routes based on lab outcomes and industrial practices.
6. Design and present a project/report synthesizing learnings from industrial visits and practical's to propose improvements in industrial or environmental chemical practices.

Course Content

[A] Preparations (Any Four)

1. Synthesis of m-dinitrobenzene from nitrobenzene
2. Synthesis of p-nitroacetanilide from acetanilide (Green Approach)
3. To prepare urea-formaldehyde plastic from urea and formaldehyde
4. Synthesis of phenol-formaldehyde polymer
5. Diels-Alder reaction between furan and maleic acid (Green Approach)
6. Preparation of Soap (Saponification)
7. Preparation of Ferrous Ammonium Sulfate (Mohr's Salt)

[B] Quantitative and Qualitative Analysis (Any four)

8. Estimation of available chlorine in bleaching powder (iodometric method)
9. Estimation of calcium in CAN fertilizer (complexometric method)
10. Determination of composition of dolomite (by complexometric titration).
11. Determine the saponification value of a given oil sample.
12. Analysis of AR grade and LR grade HCl and compare their molarity.
13. Determination of strength of commercially available H_2O_2

14. Assay glacial acetic acid as per Indian pharmacopeia (7 Ed, Volume-2)

[C] Sampling, Safety and pollution control (Any three)

15. Identification of bio-indicators of pollution (field/lab-based survey)
16. Estimation of alkali content in water and soap samples
17. Qualitative soil analysis (pH and water-soluble ions)
18. pH and conductivity comparison of tap vs. polluted water
19. Criteria of purity- Determination of melting and boiling points (2 organic solids/liquids)

[D] Industrially important techniques (Any one)

21.Deionization water using ion exchange resin or zeolites (https://www.watertechnologies.com/handbook/chapter-08-ion-exchange; https://ideaexchange.uakron.edu/honors_research_projects/345/; https://www.sciencedirect.com/science/article/abs/pii/S0011916406000956)

22. Identification of presence or absence of salicylic acid in aspirin tablet by TLC (https://scilearn.sydney.edu.au/fychemistry/SummerSchool/LabManual/E29.pdf)

[E] Industrial Visit (Compulsory)

Visit to an Industry (ETP/Chemical Plant/Pharma Unit) and submission of a short project/report.

References

1. A.I. Vogel, A.R. Tatchell, B.S. Furnis, A.J. Hannaford, P.W.G. Smith, Vogel's Textbook of Practical Organic chemistry (1989)
2. Study Material in Vocational Subject to Industrial Chemistry (B.Sc. I, UGC) Sponsored (Text Book)
3. Experiments in polymer science, New Age Publication.
4. Unit Operations in Chemical Engineering W.L. McCabe and J.C Smith, Mc Graw- Hill Books co., New York.
5. Riegel's Handbook of Industrial Chemistry, J.A. Kent, J.A.(ed), CBS Publishers, New Delhi.
6. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher (2009)
7. S. E. Stocchi: Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK.
8. R. M. Felder, R. W. Rousseau: Elementary Principles of Chemical Processes, Wiley Publishers, New Delhi.

9. Betsy, K. J., et al. "Determination of alkali content & total fatty matter in cleansing agents." *Asian Journal of Science and Applied Technology* 2.1 (2013): 8-12.
10. Tremayne, M.; Kariuki, B. M.; Harris, K. D. M. Angew. Chem. Int. Ed. Engl. 1997, 36, 770-772. (Synthesis of fluorescein dye)
11. Polymer Science by V.R. Gowariker
12. Practical Medicinal Chemistry, Dr. K.N. Jayaveera Dr. S. Subramanyam, Dr. K. Yogananda Reddy, S. Chand & Company Pvt. Ltd.

Suggested links for e-resources:

- ✓ https://swayam.gov.in/
- ✓ https://nptel.ac.in/courses/112/104/112104113/
- ✓ https://onlinecourses.nptel.ac.in/noc19_ph14/preview
- ✓ http://heecontent.upsdc.gov.in/Home.aspx
- ✓ https://ncert.nic.in/textbook.php?kech1=0-7
- ✓ https://www.labster.com/chemistry-virtual-labs/
- ✓ http://chemcollective.org/vlabs
- ✓ https://biocyclopedia.com/index/enivronmental_science_engineering_laboratory_methodology/determination_of_available_chlorine_in_bleaching_powder.php
- ✓ https://www.egyankosh.ac.in/bitstream/123456789/16340/1/Experiment-22.pdf

CHE-241-T MN: Physical and Inorganic Chemistry

Course Type: Minor (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to

1. Learn key concepts such as the laws of thermodynamics, electrolytic conductance, and definitions related to coordination chemistry.
2. Know thermodynamic processes, conductivity variations, and bonding theories in coordination compounds.
3. Use formulas and concepts to calculate entropy changes, conductance values, and oxidation states in complexes.
4. Differentiate between various chemical processes like isothermal vs. adiabatic expansion, strong vs. weak electrolytes, and inner vs. outer orbital complexes.
5. Examine the effectiveness of theoretical models such as VBT and determine the feasibility of chemical processes based on thermodynamic and conductivity data.
6. To investigate conductance behavior or predict geometry and magnetism in coordination complexes.

Course Content

Chapter 1: Chemical Thermodynamics **[8 hours]**

(Recapitulation: Introduction, terminology of thermodynamics, thermodynamic equilibrium, properties, thermodynamic processes)

First law of thermodynamics, Enthalpy, Heat capacity, Relation between Cp and Cv, Expansion of ideal gas and changes in thermodynamic properties: Isothermal process, Adiabatic process, Limitations of the first law: Need for the second law, Cyclic process, Carnot cycle, Second law of thermodynamics. Concept of entropy, Entropy change in isothermal expansion, Reversible and irreversible processes, Phase change and entropy of mixing of ideal gases, Work and free energy function. **Numericals** [Ref. 1: Pages- 236-237, 303-327, Ref. 2: Pages-528-535, 571-582, Ref. 3: Pages-134-140, 175-189]

Chapter 2: Electrolytic Conductance **[8 hours]**

(*Recapitulation: Electrolytes, Ohm's law and Electrical units, electrolytic conductance, resistance and specific resistance*) Electrolytic Conductance, Specific and equivalent conductance, Variation of equivalent conductance with concentration. Kohlrausch's law and

its applications to determine: Equivalent conductance at infinite dilution of a weak electrolyte, The ionic product of water & Solubility of sparingly soluble salts, Migration of ions, ionic mobilities & Absolute velocity of ions. Transport number determination by: – Hittorf's method & – Moving boundary method. **Numericals** [Ref. 1: Pages- 860-861, 865-868, 883-896, Ref. 2: Pages- 801-815, Ref. 3: Pages- 303-306, 318-326]

Chapter 3 : Chemistry of Coordination Compounds [6 Hours]

Definition and difference between Double salt and coordination compound, basic definitions: coordinate bond, ligand, types of ligands, chelate, central metal ion, charge on complex ion, calculation of oxidation state of central metal ion, metal ligand ratio; Werner's work and theory, Effective atomic number, equilibrium constant, chelate effect, IUPAC nomenclature. (**Ref.-4:** 194-200, 222-224)

Chapter 4 : Valance Bond Theory of Coordination Compounds [8 Hours]

Paramagnetic and diamagnetic nature coordination complexes, calculation of magnetic moment from number of unpaired electrons, Aspects and assumptions of VBT, applications of VBT on the basis of hybridization to explain the structure and bonding in $[Ag(NH_3)_2]$, $[Ni(Cl_4)]^{2-}$, $[MnCl_4]^{2-}$, $[Ni(CN)_4]^{2-}$, $[PtCl_4]^{2-}$, $[Cr(H_2O_6)]^{3+}$, $[Co(NH_3)_6]^{3+}$, $[Fe(CN)_6]^{3-}$ (Inner orbital complex) and $[FeF_6]^{3-}$ (outer orbital complex). Use of observed magnetic moment in deciding the geometry in complexes with C.N.4, limitations of VBT. (**Ref-5:** 592-597, **Ref-6:**350-351).

References

1. Essentials of Physical Chemistry by Arun Bahl, B.S. Bahl and G.D.Tuli –Multicolor Ed.
2. Principles of Physical Chemistry by B. R. Puri, L. R. Sharma, M. S. Pathania (46th Ed.)
3. Physical Chemistry, G. M. Barrow (5th Ed.)
4. Concise inorganic chemistry, J. D. Lee, 5th Ed (1996), Blackwell Science, Wiley
5. Inorganic Chemistry, James E. House, Academic Press (Elsevier), 2008
6. Inorganic Chemistry by Miessler and Tarr, Third Ed. (2010), Pearson.

CHE-242-P MNP : Physical and Inorganic Chemistry Practical

Course Type: Minor (Practical) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to learn,

1. Recall experimental procedures, formulas, and theoretical principles related to kinetics, thermodynamics, conductance, and coordination chemistry.
2. Explain the principles behind rate laws, enthalpy changes, conductometric titrations, colorimetry, and coordination complex formation.
3. Perform laboratory experiments to determine reaction order, heat changes, cell constants, and synthesize coordination compounds.
4. Interpret experimental data to evaluate reaction rates, calculate thermodynamic parameters, determine ligand ratios, and analyze chromatographic separations.
5. Assess accuracy of results by comparing with theoretical values, validate Beer's Law, and evaluate coordination complex properties like color and magnetism.
6. Design and conduct experiments for synthesis, analysis, and characterization of coordination compounds.

Course Contents

Section-I : Physical Chemistry

A. Chemical Kinetics (Any two)

1. To determine the order of reaction between $K_2S_2O_8$ and KI by half-life method.
2. Energy of activation of the reaction between $K_2S_2O_8$ and KI with unequal initial concentration.
3. To study the kinetics of saponification reaction between sodium hydroxide and ethyl acetate
4. To study the effect of concentration of the reactants on the rate of hydrolysis of an ester.
5. To study the kinetics of iodination of acetone.

B. Thermodynamics (Any Two)

1. Determination of heat capacity of calorimeter for different volumes.
2. Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
3. Determination of enthalpy of ionization of acetic acid.

C. Electrolytic Conductance (Compulsory)

1. To determine the cell constant of the given cell using 0.01 M KCl solution and hence determine dissociation constant of a given monobasic weak acid.
2. To investigate the conductometric titration of Strong acid against strong base a) Strong acid against strong base b) Strong base against weak acid. (standardization of base must be performed with KHP)

Section-II: Inorganic Chemistry

A. Synthesis of Coordination compounds (any three)

1. Synthesis of sodium cobaltinitrite (a laboratory chemical) from Co(II) salt and $NaNO_2$ salts. Comment on colour and magnetic properties of the complex.
2. Synthesis of Potassium Tris(oxalate)Fe(III). Comment on colour and magnetic properties of the complex.
3. Synthesis of Tris(acetylacetone)iron(III) by green chemistry method by reaction between $Fe(OH)_3$ and acac. Comment on colour and magnetic properties of the complex. (Ref.- 5,6).
4. Synthesis of $[Ni(NH_3)_6]Cl_2$ from $NiCl_2$. Comment on colour and magnetic properties of the complex.
5. Synthesis of $[Cu(NH_3)_4]SO_4$, Comment on colour and magnetic properties of the complex.

B. Inorganic colorimetric investigations (Any two)

1. Estimation of Cu(II) by complexation with R-Nitrso salt/ammonia by colorimetry: Determination of linearity range for Cu^{2+} using different ranges of Cu(II) concentrations and verification Beer's law.
2. Prepare solution of Fe(III) and SCN^- of in different molar proportion, record their absorbance and calculate equilibrium constant of $[Fe(SCN)]^{2+}$ complex.
3. Solution state synthesis of $[Ni(en)_3]^{2+}$ complex and determination of i) λmax and calculate 10Dq ii) equilibrium constant of the same complex.

C. Determination Metal ligand ratio (any one)

1. Potassium Tris(oxalate)Fe(III) complex (From synthesized complex by volumetric method).
2. Fe(III) or Cu(II)–Salicylic acid complex by colorimetric method.

D. Determination of transition metal ions by paper chromatography using colour forming ligands.

References

Section-I : Physical Chemistry

1. Systematic experimental physical chemistry, S. W. Rajbhoj, T. K. Chondekar, Anjali publication.
2. Practical Physical Chemistry, Vishwanathan and Raghwan , Viva book.
3. Practical Chemistry, O. P. Pandey, D. N. Bajpai Dr. S. Giri, S Chand Publication
4. Experiments in Chemistry, D. V. Jahagirdar, Himalaya Publication.
5. Practical Physical Chemistry, 3rd Edn. A. M. James and F. E. Prichard, Longman publication.
6. Experiments in Physical Chemistry, R. C. Das and B. Behra, Tata McGraw Hill.
7. Advanced Practical Physical Chemistry, J. B. Yadav, Goel Publishing House.
8. Advanced Experimental Chemistry, Vol-I, J. N. Gurtu and R. Kapoor, S. Chand and Company.
9. Physical Chemistry Experiments, Raghvan and Vishwanathan.

Section-II : Inorganic chemistry

1. Advanced Practical Chemistry, Jagdamba Sing et al, Pragati Prakashan, Merrut.
2. Practical Chemistry, Panday, Bajpai, Giri, S.Chand and Co.
3. Handbook of Preparative Inorganic Chemistry, Volume 2, Second Edition, Edited By Georg Braue R, Academic Press, New York, London, 1965. (Page-1541)
4. Inorganic Syntheses Vol -1 by H S Booth. First Ed, 1939. (page-36).
5. Novel Synthesis of Tris(acetylacetonato)-iron(III), Journal of Chem. Soc. Dalton Trans. 1983
6. Metal Acetylacetonate Synthesis Experiments: Which Is Greener?, Journal of Chemical Education, 2011, 88, 947–953, dx.doi.org/10.1021/ed100174f
7. Experimental Inorganic/Physical Chemistry: An Investigative, Integrated Approach to Practical Project Work, MounirA. Malati, Woodhead Publishing Limited, 1999.
8. Colorimetric Determination of the Iron(III)-Thiocyanate Reaction Equilibrium Constant with Calibration and Equilibrium Solutions Prepared in a Cuvette by Sequential Additions of One Reagent to the Other, Journal of Chemical Education, Vol.88 No.3 March 2011.
9. Experiments in chemistry, D. V. Jahagirdar, Himalaya publication.

10. A spectrophotometric study of complex formation between Fe(III) and salicylic acid, Kinya Ogawa, Nobuko Tobe, Bulletin of chemical society of Japan, 39, 227-232, 1966.
11. Salicylate determination by complexation with Fe(III) and optical absorbance spectroscopy
12. Determination of Equilibrium Constants of Metal Complexes from Spectrophotometric Measurements: An Undergraduate Laboratory Experiment, Journal of Chemical Education, Vol. 76, No. 9, September 1999.

CHE-291-T MN: Organic and Analytical Chemistry

Course Type: Minor (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to learn,

1. Learn types of halogenated hydrocarbons, definitions, principles, and classification of titrations, chromatography techniques, acid-base theories, and .
2. Understand the theory behind the mechanisms of nucleophilic substitution and elimination, volumetric and chromatographic techniques.
3. Determine the acidity and basicity of organic compounds, prepare and standardize solutions of different concentration.
4. Differentiate between substitution mechanisms (S_N1 vs. S_N2), including the influence of structural and electronic factors, and types of titrations (e.g., redox vs. complexometric), chromatographic techniques.
5. Investigate the reactivity of halogenated hydrocarbons and suitability of indicators, titration methods, and chromatographic techniques for given analytical tasks.
6. Categorize the organic compounds based on their structure and reactivity, titration or chromatography techniques.

Course Content

Chapter 1 : Structure, Acidity and, Basicity **[8 hours]**

Introduction to acidity and basicity, Lowry-Brønsted and Lewis acids and bases, concept of conjugate acids and bases, pK_a, simple and substituted aliphatic acids, phenols, aromatic carboxylic acids, bases, pK_b, aliphatic and aromatic bases.

Chapter 2 : Reactivity and Reactions of halogenated hydrocarbons **[7 hours]**

Introduction and classification, general methods of preparation, reactivity of alkyl, aryl, allyl and vinyl halides, Nucleophilic substitution reactions: S_N1 and S_N2, Factors affecting S_N1 and S_N2 reactions, Elimination reactions: E1 and E2. Nucleophilic aromatic substitution (S_NAr) reactions.

Chapter 3: Volumetric Analysis: **[9 Hours]**

Introduction, Classification of reaction in volumetric analysis, standard solutions, equivalents, normalities, oxidation numbers, primary and secondary solutions, Types of volumetric analysis:

1. **Neutralization titrations:** Theory of indicators, neutralization curves for strong acid-strong base, weak acid-strong base, weak base-strong acid, Preparation of 0.1 M HCl and standardization with sodium carbonate, determination of sodium carbonate in washing soda.
2. **Complexometric Titrations:** Definition of complexing agents and complexometric titration, EDTA, standard EDTA solution, Types of EDTA titration, metal ion indicator, total hardness of water.
3. **Redox Titration:** Definition of oxidizing agent, reducing agent, redox titration, $K_2Cr_2O_7$ and $KMnO_4$ as oxidizing agent, $KMnO_4$ as self-indicator, Determination of H_2O_2.
4. **Precipitation Titration:** Principle, precipitation reaction, determination of end point, standard silver nitrate solution, standardization of silver nitrate solution, determination of chloride and bromide.

   (**Ref.-1**: Pages-257-275, 286, 295, 309-322, 328-332, 340-351, 364-372, **Ref.-2**: Pages-282-302, 322-334, 366-374, 437-452).

Chapter 4: Chromatography: **[6 Hours]**

Introduction, Principle, Types of chromatography, Paper Chromatography-Introduction, Principle, Migration parameters, Types of paper chromatography, Applications. Thin layer chromatography-Introduction, Experimental Techniques, Applications of TLC, Limitations.

(**Ref.5**: Pages-2.588-2.615)

References

1. Vogel's Textbook of Quantitative Chemical Analysis, 5th Ed. G. H. Jeffry, J. Basset. J. Mendham, R. C. Denny, Longman Scientific and Technical, 1989.
2. Analytical Chemistry, G. D. Christian, P. K. Dasgupta, K. A. Schug, 7th Ed, Wiley, 2004.
3. Instrumental Methods of Chemical Analysis, Gurdeep R. Chatwal, Sham K. Anand, Himalaya Publishing House.
4. A Guidebook to Mechanism in Organic Chemistry by Peter Sykes. 6th ed. Essex, England: Longman Scientific & Technical
5. Organic Chemistry by Morrison and Boyd, 7th Edition, Pearson Education
6. Advanced Organic Chemistry by Jerry March, 7th Edition, Wiley
7. Organic Chemistry by Jonathan Clayden, Nick Greeves, and Stuart Warren, 2nd Edition

CHE-292-P MNP : Organic and Analytical Chemistry Practical

Course Type: Minor (Practical) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to

1. Remember the fundamental concepts, reagents, and functional group tests used in organic estimation, preparation, and volumetric analysis.
2. Explain the principles behind organic reactions, separation techniques, and titration methods used in qualitative and quantitative analysis.
3. Perform organic synthesis, separation of binary mixtures, and estimations using volumetric and chromatographic methods in laboratory settings.
4. Differentiate between organic functional groups in mixtures, interpret chromatograms, and analyze titration results to identify and quantify substances.
5. Assess the purity and identity of synthesized or separated compounds using melting point, TLC, and confirmatory tests; validate volumetric results through standardization.
6. Execute multi-step analytical procedures combining organic preparation, separation, and titration to solve real-world chemistry problems.

Course Contents

Course Contents

Section-I: Organic Chemistry Practicals

D. Organic Estimations (any two)

4. Determination of molecular weight: Determination of molecular weight of organic acid by titration against standardized NaOH - a) monobasic acid or b) dibasic acid
5. Estimation of amides: Determine the amount of Acetamide in given solution by volumetric method. (Standardization of acid must be performed)
6. Estimation of Ethyl benzoate: To determine the amount of ethyl benzoate in give in solution volumetrically. (Standardization of acid must be performed).

E. Organic Qualitative Analysis (Two mixtures: solid-solid type)

Determination of type and separation of two components from given binary mixture of organic compounds containing mono-functional group (Ex. - carboxylic acid,phenols,

amines, amide, nitro, etc.) and systematic identification of any one component qualitatively.

F. Organic Preparations (Any two)

4. Preparation of benzoic acid from ethyl benzoate (Identification and confirmatory Test of – COOH group, M.P and purity by TLC)
5. Base catalysed Aldol condensation (Confirm the conversion by Wilson test in product, M.P and purity by TLC)
6. Preparation of Quinone from hydroquinone (Confirm the conversion by absence of phenolic –OH group in product, M.P and purity by TLC)

Section-II: Analytical Chemistry

C. Volumetric Analysis (Any Five)

8. Estimation of sodium carbonate content of washing soda.
9. Determination of acetic acid in commercial vinegar by titrating with standard NaOH.
10. Determination of amount of $CaCO_3$ in Chalk using standard HCl & NaOH Solution.
11. Estimation of Ca from calcium supplementary tablet by complexometric titration.
12. Determination of the strength of given H_2O_2 solution with standard $KMnO_4$ solution.
13. To study the neutralization of HCl by NaOH).
14. Estimation of Aspirin from a given tablet

D. Chromatography (Any One)

3. Separation of constituents of mixtures by Chromatography: Measure the Rf value in each case. Identify and separate the components of a given mixture of 2 amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acids)/ pigments from plant extract / 2 organic compounds by paper chromatography.
4. Chromatography Separation of a mixture of two organic compound by ascending Thin Layer Chromatography.

References

Section-I : Organic Chemistry

3. Vogel's Textbook of Practical Organic Chemistry" by A. I. Vogel, 5th Edition, Pearson Education
4. Vogel's Textbook of Quantitative Chemical Analysis by G.H. Jeffery, J. Bassett, J. Mendham, and R.C. Denney, 5th Edition, Longman Scientific & Technical

Section-II : Analytical Chemistry

3. Vogel's Textbook of Practical Organic Chemistry" by A. I. Vogel, 5th Edition, Pearson Education
4. Vogel's Textbook of Quantitative Chemical Analysis by G.H. Jeffery, J. Bassett, J. Mendham, and R.C. Denney, 5th Edition, Longman Scientific & Technical

OE-201-T-CHE (A) : Chemistry of Cosmetics and Perfumes-I

Course Type: Open Elective (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to

1. Remember the classification, ingredients, and historical background of cosmetics and perfumes.
2. Understand the functions and composition of skin and hair care products including cleansers, shampoos, and conditioners.
3. Apply the knowledge of cosmetic ingredients and formulations to identify appropriate products for various skin and hair types.
4. Differentiate between types of cosmetic products such as moisturizers, hair colorants, sunscreens, and understand their ingredient functions.
5. Assess the significance of natural and synthetic ingredients in perfumes and essential oils based on their chemical properties and roles.
6. Design a basic cosmetic formulation, such as a herbal skin cream or a fragrance blend, incorporating suitable ingredients and essential oils.

Course Contents

Chapter 1 : Introduction to Cosmetics: **[8 Hours]**

Cosmetics: definition, historical background and development of cosmetics, classification of cosmetics according to their use, functions and their physical nature, ingredients of cosmetics: water, oils, fats and waxes, surfactants and humectants, preservatives, perfumes, colors, herbal or plant materials, ingredients and their significance.

Chapter 2 : Cosmetics for skin **[7 Hours]**

Cleansers: soaps, micellar water, exfoliating, Skin creams and lotions: cold, night, vanishing, all purpose, hand and body, sunscreens, Moisturizers: creams, lotions, gels, Face powders: loose, compact, talcum, baby, Skin colorants: lipsticks, skin rouges, Antiperspirants and deodorants: Roll-ons, Sprays, Sticks.

Chapter 3 : Cosmetics for hair: **[7 Hours]**

Shampoos: characteristics, composition, types of shampoos viz. liquid cream, cream, gel, powder, anti-dandruff, conditioners: rinse-off, leave-in, deep conditioners, Hair colorants: hair

dyes, colour protectants, hair dye remover, styling products: gels, mousses, sprays, Hair care treatments: hair masks, oils, serums.

Chapter 4 : Introduction to Perfumes and Essential oil [8 Hours]

History of perfumes, Classification of perfumes based on fragrance, Development and role of natural products in cosmetics, Essential oils and their importance in cosmetic industries its reference to chemistry of- Eugenol, Geranoil, Sandalwood oil, Eucalyptus oil, rose oil, Jasmone, Civetone, Muscone.

References

1. Cosmetic Formulation: Principles and Practice - Heather A.E. Benson, Michael S. Roberts, Vania Rodrigues Leite-Silva, Kenneth Walters, CRC Press, 1st edition, 2019.
2. Perfumes, Cosmetics and soaps, tenth edition, – W. A. Poucher.
3. COSMETICS Formulation, Manufacturing & Quality Control, Fourth Edition - P. P. Sharma
4. Butler H., Poucher's perfumes, cosmetics and soaps, Kluwer Academic Publisher, 10th edition.
5. Perfumes: History & Chemistry Vol-I- Dr. D. D. Wasul
6. Manufacture of Perfumes, Cosmetics & Detergents – Giriraj Prasad
7. Perfumes, Cosmetics and soaps, ninth edition, – W. A. Poucher.
8. For Marathi Version: Soundarya Prasadanechya Duniyet by Dr. Varsha Joshi

OE-201-T-CHE (B) : Dairy Chemistry

Course Type: Open Elective (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to

1. Remember the composition of milk from various animals and identify key components such as proteins, fats, lactose, vitamins, and minerals.
2. Explain the functional roles of milk constituents in nutrition and dairy product processing such as coagulation and fermentation.
3. Apply knowledge of milk composition to detect adulteration and interpret changes in physicochemical properties like pH, viscosity, and acidity.
4. Differentiate between the types and functions of milk proteins and fats in the preparation of dairy products like cheese, butter, and yogurt.
5. Assess the quality and nutritional value of various dairy products by analyzing their chemical composition and processing methods.
6. Formulate or improve a dairy product (e.g., flavored yogurt or low-fat cheese) based on understanding of milk chemistry and processing techniques.

Course Contents

Chapter 1 : Introduction to Dairy Chemistry **[8 Hours]**

Importance of milk and dairy products in human nutrition, General composition of milk: water, proteins, fats, lactose, minerals, and vitamins, Milk from different animals (cow, buffalo, goat, etc.) and their characteristics

Chapter 2 : Composition of Milk **[10 Hours]**

Water: Role in milk and its properties, **Proteins**: Casein, whey proteins (albumin, globulin, etc.), Classification of milk proteins, Properties of casein and whey proteins, Role of proteins in coagulation, milk processing, and cheese making, **Fats**: Structure of milk fat, types of milk fats, and their emulsification, The role of lactose in fermentation processes, **Minerals and Vitamins**: Essential minerals (calcium, phosphorus) and vitamins (A, D, B-group)

Chapter 3 : Physicochemical Properties of Milk **[4 Hours]**

pH of milk and its effect on quality, Acidity of milk (titratable acidity), Freezing point, boiling point, density, Viscosity and surface tension of milk, Milk adulteration, Methods for detecting milk adulteration.

Chapter 4 : Dairy Products and Their Chemistry **[8 Hours]**

Milk Powders: Production, composition, and uses, **Cheese**: Types, production processes, chemical reactions involved, **Butter**: Chemistry of butter production, including emulsification, **Ice Cream**: Chemical composition, stabilizers, emulsifiers, **Yogurt**: Biochemical processes involved in yogurt production

References

1. Introduction to Dairy Chemistry by J. G. R. McCall.
2. Milk and Milk Products by S. K. Bhatia.
3. Methods of Analysis of Dairy Products by H. C. Jung.
4. Fundamentals of Dairy Chemistry by N. M. T. P. Law.
5. Principles of Dairy Chemistry by W. D. H. O. McFarlane.
6. Dairy Science and Technology Handbook edited by R. K. Robinson.
7. Methods of Analysis of Dairy Products by H. C. Jung.

OE-251-T-CHE (A) : Chemistry of Cosmetics and Perfumes-II

Course Type: Open Elective (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to

1. Recall key raw materials of herbal origin and classify various herbal cosmetics based on their use and form.
2. Explain the advantages of herbal cosmetics over synthetic products and describe the role of herbal ingredients in skincare, haircare, and oral hygiene.
3. Apply knowledge of herbal ingredients to identify suitable formulations for skin, hair, and dental care applications.
4. Differentiate between various herbal product forms and evaluate the function of individual ingredients in oral and topical formulations.
5. Assess the quality and effectiveness of herbal cosmetics and dental care products using standard evaluation criteria.
6. Design a basic herbal cosmetic or oral hygiene product by selecting appropriate herbal ingredients for specific cosmetic or therapeutic purposes.

Course Contents

Chapter 1: Introduction to Herbal Cosmetics **[8 hours]**

Definition and Classification of Herbal Cosmetics, Overview and categories of herbal cosmetics, Advantages of Herbal Cosmetics, Benefits compared to synthetic products, Raw Materials of Herbal Origin, Sources and description of key raw materials used in herbal cosmetics: Fixed Oils, Waxes, Gums, Colors, Perfumes, Protective Agents, Bleaching Agents, Antioxidants

Chapter 2: Herbal Skin and Hair Care Products **[9 hours]**

Herbal Skin Care Products: Classifications Based on Function: Cleansers, Moisturizers, Toners, Exfoliators, Suncare, Anti- aging, Acne Treatments, Herbal Products Forms: Creams, Lotions, Oils, Gels, Masks, Powders. **Herbal Hair Care Products**: Herbal hair cleansers, shampoos, conditioners, Styling Products: Gels, hair loss treatments, and hair growth products. Hair Color: Herbal hair coloring solutions.

Chapter 3: Herbal Oral Hygiene and Dental Care **[9 Hours]**

Herbal Oral Hygiene Products: Herbal toothpastes, mouthwashes, tooth powders, and chewing sticks. **Dental Care Preparations:** Dentifrices: Definition and primary functions, Toothpastes: Characteristics of a good toothpaste, Basic ingredients in toothpaste. Tooth Powders: Basic ingredients in tooth powder. Evaluation criteria for dental care products.

Chapter 4: Mouth Washes and Evaluation Criteria **[4 Hours]**

Mouth Washes, Characteristics of a good mouth wash. Components of a good mouth wash, Evaluation criteria for mouthwashes.

References

1. Herbal Cosmetics by H.Pande, Asia Pacific Business press, Inc, New Delhi
2. Mithal B.M., Saha R.N., A handbook of cosmetics, 1 stEd.,Vallabh Prakashan
3. Sagarine Edward, Cosmetics: science & technology, 2ndEd. 1972, John Wiley & Sons publisher
4. Chemistry and Technology of Flavors and Fragrances Edited by David Rowe Blackwell Publications (page no 1-11)
5. The Chemistry of Fragrances Complied by David H Pybus, Charles S Sell (page no 174-186)
6. Poucher's Perfumes, Cosmetics and Soaps (page no746-764)
7. For Marathi Version: Soundarya Prasadanechya Duniyet By Dr. Varsa Joshi

OE-251-T-CHE (B) : Agricultural Chemistry

Course Type: Open Elective (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to

1. Recall the types, composition, and properties of soil, fertilizers, pesticides, and key terms related to agricultural chemistry.
2. Understand the role of agricultural chemistry in crop nutrition, soil fertility, and pest control.
3. Demonstrate the ability to carry out basic soil tests, fertilizer selection, and pest control techniques in an agricultural setting.
4. Compare the types of fertilizers and pesticides based on composition, use, and environmental impact.
5. Examine the impact of various agricultural inputs like fertilizers and pesticides on crop productivity and environmental safety.
6. Design a sustainable farming plan integrating organic practices, appropriate fertilizers, and pest control strategies.

Course Contents

Chapter 1 : Introduction to Agricultural Chemistry **[2 Hours]**

Introduction, Role of Chemistry, Scope and Importance

Chapter 2 : Soil chemistry **[8 Hours]**

Definition of Soil, Types, Physical and chemical properties of soil, surface soil and sub soil,texture, structure, color, density, temperature, moisture, porosity of soil, Importance and objectives of soil testing, soil sampling, determination of PH ,density , moisture, soil erosion and factors affects erosion of soil, buffering capacity, soil fertility.

Chapter 3 : Fertilizers and Organic farming **[10 Hours]**

Plant nutrients, classification of fertilizers, mixed and complex fertilizers, primary nutrients NPK and its role, deficiency symptoms in plants, micro nutrients, nanofertilisers, vermi compost preparation, mode of application of fertilizers, deficiency symptoms, definition of organic farming, manure, principles and its scope , components of organic farming, farm yard manure(FYM),method of preparation, handling and storage.

Chapter 4 : Crop Protection **[10 Hours]**

Concept methods of pest control, pesticide classification and mode of action, pesticide application techniques, Insecticides classification, chemical properties, plant originated compounds, herbicides classification and mode of action, fungicides classification, copper fungicide and sulphur and mode of action, equipments and accessories, application of integrated pest management, Effect of pesticides ,insecticides, herbicides on human health and its control.

References

1. Essentials of Agriculture - 4th Revised Edition Narayan Nagre 2023
2. Soil Chemistry Hinrich L. Bohn Rick A.Myer George A.O Corner 2002 John Wiley & Sons.
3. Basics of Organic Farming (2020) BANSAL M.
4. Recent Trends in Plant Protection Sachin Kumar Yadav, Saurabh Kumar, Dr. Anuj Shakya, Prince Sahu and Shailja Jaiswal
5. Introduction to Principles of Plant Pathology by R.S.Singh
6. Principles of Agronomy by Reddy
7. Fundamentals of Agriculture, ArunKalyan
8. A text book of Agronomyby B. Chandrasekaran, K. Anndurai, E. Shamsundaran
9. Fundamental of soil sciences by C.E.Millar and L.M.Turk,Bio-tech, New Delhi(1St edition 2001)

CHE-201-T IKS: Ancient Indian Chemistry

Course Type: IKS (Theory) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to

1. Know the Indian Knowledge System and its significance in the protection of traditional knowledge.
2. Understand the need of the Indian Knowledge System (IKS) and significance of the ancient Indian Chemistry.
3. Relate the various concepts of ancient chemistry with the concepts of modern Chemistry.
4. Organize the contributions made by the ancient Indians in the field of Science and related concepts.
5. Evaluate the contribution of Indians in the development of chemistry.
6. Outline the chemistry heritage of ancient India.

Course Contents

Chapter 1: Ancient Indian Chemistry **[5 Hours]**

From Alchemy to Chemistry: Early Chemical Techniques, Technology and Arts, Different Areas of Development in Ancient India: Glass Making (Literary Sources, Foreign Travellers' Account, Archaeological Evidences), Paints and Dyes, Perfumes and Cosmetics, Chemicals in Ancient India, Paper and Ink Making, Alcoholic Liquors.

Chapter 2: Indian Alchemy in medicines **[5 Hours]**

Rasayanas, Etymology of Rasayana, Rasayana as Elixir, The position of Rasayana in Indian medicines Charaka and two categories of medicines, Herbal Rasayanas, Metallic preparations as Rasayana, Iron as a reducing Agent, Charaka's incidental mention of a gold preparation, Calcined metals as Phlogiston, Calcined metals as alchemical preparations, Pulverization of calcined metals, Calcined gold as the ideal herbo-metallic preparation, Indian alchemy (500 A.D.), Indian alchemy (1000 A.D.)

Chapter 3: Metallurgy in India **[15 Hours]**

Primary Texts on Metallurgy in India: Rig-Veda (tr. adapted from R.T.H. Griffith), Arthaśāstra (tr. R.P. Kangle), Varāhamihira (b. ~ 485 CE), Khaḍgalakṣaṇam (tr. Vibha Tripathi), Nāgārjuna (7th or 8th century CE), Rasendramaṅgalam (tr. H.S. Sharma), Vāgbhaṭa (13th century), Rasaratnasamuccaya (tr. INSA) **Classification of metals: Survarṇa** (gold) :

Varieties, Description of different types of suvarṇa (Prākṛta suvarṇa, Sahaja suvarṇa, Vahni sambhūta suvarṇa, Khanija suvarṇa, Rasendra vedhaja suvarṇa), Pharmaco-therapeutic properties of gold. **Rajata (silver) :** Varieties, Description of different types of rajata (Sahaja rajata, Khanija rajata, Kṛtrima rajata), Qualities of superior and inferior silver, Pharmaco-therapeutic properties of silver **Tāmra (copper):** Varieties, Description of different types of tamrsa (mleccha and nepālaka tāmra), Qualities and inferior tāmra**,** Pharmaco-therapeutic properties of tāmra **Loha (iron):** Varieties, subvarieties, Pharmaco-therapeutic properties of muṇḍa loha **Vaṅga (tin):** Varieties, Physical properties, Pharmaco-therapeutic properties of vaṅga **Nāga / śīśa (lead): Physical properties of lead,** Pharmaco-therapeutic properties of lead **Pittala (brass) :** Varieties, Physical properties of superior pittala, Physical properties of superior and inferior properties of pittala, Pharmaco-therapeutic properties of pittala; **Knowledge of Fundamental Concepts of Chemistry:** Concept of atom, nano particles, metallurgy in India (extraction, Purification, alloying process): copper, iron, zinc, gold and silver, Disappearance of metallurgical skills

Chapter 4: Contribution of Indian Chemists [5 Hours]

Nagarjuna, Vagbhata, Govindacharya, Yashodhar, Ramchandra, Somdev, Acharya Prafulla Chandra Ray, Sir Har Gobind Khorana, Shanti Swarup Bhatnagar, C. N. R. Rao, Raghunath Anant Mashelkar

References

1. Indian Alchemy Or Rasayana By S. Mahdihassan https://archive.org/details/IndianAlchemyOrRasayanaByS.Mahdihassan/page/n79/mode/2up
2. History of Chemistry in ancient and medieval India Acharya Prafulla Chandra Ray (Edited by P.Ray, Indian Chemical Society, Calcutta, 1956, page no. 208-239
3. India's Glorius Scientific Tradition by Suresh Soni
4. Chapter 15- Scientists of Ancient India, https://digital.nios.ac.in/content/223en/CH.15.pdf
5. Some famous Indian Scientists by S Chandrasekhar, https://www.tifr.res.in/~outreach/biographies/scientists.pdf
6. **Other source:** Wikipedia https://en.wikipedia.org/wiki/List_of_Indian_scientists

SEC-201- P CHE (A) : Basic Software in Chemistry

Course Type: SEC (Practical) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to

1. Name and draw structures of diverse organic compounds and determine their basic properties.
2. Illustrate key organic reactions (2,4-DNP, aldol, phthalimide) and their mechanisms.
3. Understand the fundamentals of computational chemistry (modeling, optimization, structure-property).
4. Build, analyze, and compare 3D molecular structures using visualization software.
5. Interpret periodic trends and predict chemical behavior using online resources.
6. Perform virtual titrations, solubility and basic thermodynamic calculations using online tools.

Course Contents

A. Draw Chemical Structure, reaction, reaction mechanism (Any three)

1. Draw a structure of different aromatic monosubstituted (at least 6 structures), disubstituted (at least 6 structures) and polysubstituted (at least 3 structures) compounds, give IUPAC names, Molecular formula, Density, composition, molecular weight, and dielectric constant
2. Draw a structure of aliphatic and aromatic compounds with different functional groups and prepare a Word file containing the structure of functional groups, their common name and IUPAC name.
3. To draw the chemical reaction between an aldehyde or ketone and 2,4-dinitrophenylhydrazine (2,4-DNP), resulting in the formation of a 2,4-DNP derivative.
4. To draw the reaction mechanism-
   a. Benzoic acid from ethyl benzoate
   b. Base catalysed aldol condensation
   c. Quinone from hydroquinone

B. Graph plotting using excel- Prepare graphs for any three physical chemistry experiments listed in the CHE-203-P MJP syllabus.

C. Introduction to Computational Chemistry (Compulsory)

To understand the fundamentals of computational chemistry, including molecular modelling, structure optimization, and structure-property relationships

D. Building and Optimizing 3D Molecules (Any three)

1. To build and optimize 3D structures of benzene, toluene, phenol, and nitrobenzene.
2. To compare ball-and-stick and space-filling models of toluene and phenol.
3. To measure bond parameters in H_2O, CH_4, NH_3 using Avogadro.
4. To visualize and interpret HOMO and LUMO orbitals of H_2O and NH_3.
5. To study the effect of substitution on the polarity and boiling point of benzene derivatives.
6. To optimize geometry and compare bond angles and dipole moments of CH_4, NH_3, and H_2O.
7. To compare the stability of chair and boat conformations of cyclohexane.

E. Exploring the Periodic Table – Trends, Tools, and Applications (Any two)

1. To analyze the trends in atomic radius, ionization energy, and electronegativity for alkali (Group 1) and alkaline earth (Group 2) elements Ptable.
2. To identify an unknown element by correlating it's given physical and chemical properties with the data available on Ptable.
3. To predict the type of chemical bond that will form between pairs of elements and infer basic properties of the resulting compounds based on their electronegativity differences obtained from Ptable.
4. To understand the concept of isotopes of hydrogen, carbon, chlorine and bromine, utilize the Periodic table to find the isotopic composition of a selected element, and calculate its average atomic mass.

F. Virtual Acid-Base Titration Using Online Simulations (Any one)

1. Standardization of NaOH with a KHP solution: Acid Base Titration
2. Titration of Strong Acid and Base or Weak Acid and Base Problems
3. Determination of the pH Scale by the Method of Successive Dilutions

G. Virtual Experiments based on Solubility (Any one)

1. Determining the solubility product of copper chloride at different temperatures
2. Determining the solubility product of Silver chloride at different temperatures

H. Simple Thermodynamic Property Calculations Using Wolfram Alpha online tool or any other chemistry software. (Compulsory)

References

Free Chemistry Software and Applications for Students

Sr. No.	Name of software	Link
1.	Avogadro	https://avogadro.cc/ https://medevel.com/15-3d-molecular-protein-modelling/ https://molview.org/
2.	Periodic table	https://periodic-table.rsc.org/ https://sciencenotes.org/printable-periodic-table/ https://ptable.com/?lang=en#Properties https://iupac.org/what-we-do/periodic-table-of-elements/ https://www.webelements.com/ https://pubchem.ncbi.nlm.nih.gov/periodic-table/
3.	ACD chemsketch, markinsketch, chemdraw, chemcompute	https://www.acdlabs.com/resources/free-chemistry-software-apps/chemsketch-freeware/ https://chemaxon.com/products/marvin/marvinsketch https://chemistrydocs.com/chemdraw-pro-8-0/ https://chemcompute.org/gamess/submit https://pubchem.ncbi.nlm.nih.gov/
4.	Virtual lab	https://chemcollective.org/vlabs Virtual Lab Simulations https://phet.colorado.edu/
5.	Wolfram Alpha	https://www.wolframalpha.com/

SEC-201- P CHE (B) : Clinical Chemistry Practical

Course Type: SEC (Practical) **No. of Credits: 2**

Course Outcomes

At the end of the course, student will be able to

1. Recall the normal biochemical composition of urine and blood plasma, and the procedures used for their analysis.
2. Explain the principles and significance of biochemical tests such as colorimetry and titrimetry used in clinical diagnosis.
3. Perform standard biochemical tests on simulated blood and urine samples to analyze compounds such as creatinine, vitamin C, glucose, and cholesterol.
4. Differentiate between normal and abnormal biochemical test results to identify potential physiological conditions.
5. Assess the accuracy and reliability of biochemical test methods and their relevance in clinical diagnosis.
6. Design a complete workflow for biochemical analysis of a clinical sample, including sample preparation, test selection, execution, and reporting.

Course Contents

1. Visit to clinical lab to observe functioning in clinical lab / preparation of lab reports. (**Compulsory**)
2. Table work/Visit to hospital: Urea and blood collection method and their preservation: (**Compulsory**)

   Body fluid analysis practical's: All practical described here should be performed on simulated laboratory samples which has same composition as urine / blood plasma.

   a) *The typical composition of urine of normal person is 0.05% Ammonia, 0.18% sulfate, 0.12 %phosphate, 0.01% Mg, 0.015% calcium, 0.6% K, 0.1% Na, 0.1% creatinine, water soluble Vitamins, 2% urea.* (For salts add NH_4SO_4, Na_2HPO_4, KCl, $CaCl_2$)

   b) *Typical blood plasma composition: 100 ml blood plasma contains approximately: glucose 80 to 140 mg (normal person), total proteins - 5 g, Calcium - 7 mg, phosphate - 11 mg, Mg - 1.5 mg, Na - 320 mg, potassium – 16 mg; Cl^- - 100 mg, vit-C - 0.5 to 2 mg, thiamine - 2.5 to 6 microgram, riboflavin - 3 to 19 microgram.*

etc. ***Thus, prepare simulated blood plasma sample by adding appropriate quantity of each constituents.***

Any Ten Experiments from given list

1. Qualitative test for reducing sugars and proteins.
2. Physical observation of urine sample for its pH, colour, turbidity, etc.
3. Analysis of urea from urine sample by colorimetry.
4. Analysis of creatinine from urine sample by colorimetry.
5. Analysis of Vit-C from urine sample by titrimetric method.
6. Analysis of urine and blood glucose level by colorimetry.
7. Analysis of blood cholesterol level by colorimetry.
8. Calcium in blood.
9. Estimation bilirubin.
10. Estimation of total plasma proteins by Lowry Method.
11. Oral glucose tolerance test.
12. Estimation of chloride in urine.
13. Estimation of Sulphate in Urine

References

1. Clinical Chemistry A Laboratory Perspective, Wendy Arneson, Jean Brickell, F. A. Davis Company, 2007
2. Standard Methods of Clinical Chemistry Volume I By The American Association Of Clinical Chemists, Editor-in-Chief: Miriam Reiner, Academic Press New York, San Francisco, London, 1953
3. Basic Concepts in Clinical Biochemistry: A Practical Guide, Vijay Kumar • Kiran Dip Gill, Springer.

CHE-231 FP : Field Project

Course Type: Field Project (FP) **No. of Credits: 2**

Objective:

To engage students in field-based experiential learning by applying chemistry concepts to real-life problems or environments.

Course Outcomes

At the end of the course, student will be able to

1. Learn the fundamental chemistry concepts to real-world environmental and community
2. Understand the appropriate methodologies for collecting chemical and environmental data through fieldwork.
3. Apply the chemistry concepts to real life problems or environments
4. Analyse the experimental or observational data to derive meaningful conclusions about local chemical or environmental conditions.
5. Evaluate local problems through a scientific lens and suggest chemistry-based solutions or awareness strategies.
6. Prepare a scientific report and presentations based on their findings.

Field Project (FP) Guidelines

1. **Project Themes (Chemistry-Oriented):**
    - Water quality analysis of local sources.
    - Soil sampling and pH, salinity, and metal analysis.
    - Survey of household or industrial waste disposal and chemical hazards.
    - Study of local industries and their chemistry-related processes.
    - Investigation of adulteration in food samples.
    - Air quality monitoring.
    - Testing of cleaning agents, soaps, or cosmetics from local markets.
    - Chemistry awareness in nearby schools or communities.
    - Use of herbal medicines and local knowledge in chemistry.
    - Any other related to chemistry

2. **Process:**
    - Students may work individually or in groups (preferably 2–3 students/group).
    - Selection of project topic in consultation with a faculty mentor.

- Planning of field visits, data collection tools, and methodology.
- Minimum 1 field visit is mandatory.
- Compilation of data, interpretation, and report writing.

3. **Duration:**

   Minimum **60 hours** (including planning, fieldwork, and report preparation).

4. **Report Structure:**
   - Tittle page
   - Certificate of completion of Field project from mentor and HOD.
   - Declaration by candidate regarding plagiarism
   - Index
   - Abstract of the project
   - Chapter-1: Introduction to problem (introduction, signification of research problems selected, aims and objectives) (5 to 6 pages)
   - Chapter-2: Review of Literature (Related Research Problem) (5-6 pages)
   - Chapter-3: Material and Methods/Methodology/Experimental (5-7 pages)
   - Chapter-4: Results and Discussion or Data and Interpretation of data (8 – 10 pages)
   - Chapter-5: Conclusions (1-2 pages)
   - Bibliography/References
   - Acknowledgement

   Assessment Criteria (Suggested):

Criteria	Marks
Relevance and Originality	7
Data Collection & Analysis	7
Fieldwork Involvement	7
Report	7
Presentation/Viva	7
Total	**35 Marks**

   Note: Remaining 15 marks for internal assessment

5. **General Guidelines (Common to FP and CEP):**
   - Projects can be interdisciplinary but must involve chemistry as a core element.
   - Ethical conduct and respect for community are essential.

- Students are encouraged to present their work in college exhibitions or seminars.
- Photographic or video evidence should support fieldwork/CEP.

6. **Faculty Responsibilities:**
   - Approve project topics.
   - Guide students throughout the project.
   - Monitor and document student participation.
   - Organize viva/presentation for evaluation.

CHE-281 CEP: Community Engagement Project (CEP)

Course Type: Community Engagement Project (CEP) **No. of Credits: 2**

Objective:

To sensitize students towards societal needs, promote citizenship behaviour, and contribute to community well-being using chemistry knowledge.

Course Outcomes

At the end of the course, Student will be able to

1. Identify the chemical aspects of local community issues such as water quality, waste management, or household chemical safety.
2. Understand the societal issues and can provide a scientific solution
3. Apply chemistry knowledge to promote awareness about safe chemical practices, sustainability, and green alternatives in daily life.
4. Analyse the effectiveness of community engagement activities based on feedback and participation data.
5. Assess the societal issues through the group-based outreach and community interactions.
6. Plan chemistry-related awareness activities such as demonstrations, campaigns, or surveys in schools or local communities.

Community Engagement Project (CEP) Guidelines

1. **Themes (Chemistry Related):**
   - Awareness campaign on safe use of chemicals.
   - Awareness drives on e-waste or plastic waste segregation.
   - Demonstrations of eco-friendly household products (detergents, soaps, cleaners).
   - Community survey on water purification methods and promoting alternatives.
   - Public education on food safety (e.g., adulteration tests).
   - Tree plantation with explanation of soil-plant-chemistry interaction.
   - Participating in science exhibitions or awareness sessions in schools.
   - Any other related to chemistry

2. **Key Activities:**
   - Group discussions with community members.
   - Designing posters, pamphlets, or short videos for awareness.
   - Science demonstration sessions for school children or villagers.

- Surveys and interviews to collect feedback and awareness levels.

3. **Duration:**

   Minimum **60 hours** of engagement (including preparation, visits, interaction, and reflection).

4. **Report Structure:**

- Tittle page
- Certificate of completion of Field project from mentor and HOD.
- Declaration by candidate regarding plagiarism
- Index
- Abstract of the project
- Chapter-1: Introduction to problem (introduction, signification of research problems selected, aims and objectives) (5 to 6 pages)
- Chapter-2: Review of Literature (Related Research Problem) (5-6 pages)
- Chapter-3: Material and Methods/Methodology/Experimental (5-7 pages)
- Chapter-4: Results and Discussion or Data and Interpretation of data (8 – 10 pages)
- Chapter-5: Conclusions (1-2 pages)
- Bibliography/References
- Acknowledgement

5. **Assessment Criteria (Suggested):**

Criteria	**Marks**
Planning and Initiative	7
Community Interaction	7
Contribution to Social Cause	7
Report & Reflection	7
Presentation	7
Total	**35 Marks**

Note: 15 marks for internal assessment

6. **General Guidelines (Common to FP and CEP):**

- Projects can be interdisciplinary but must involve chemistry as a core element.
- Ethical conduct and respect for community are essential.
- Students are encouraged to present their work in college exhibitions or seminars.
- Photographic or video evidence should support fieldwork/CEP.

7. **Faculty Responsibilities:**
    - Approve project topics.
    - Guide students throughout the project.
    - Monitor and document student participation.
    - Organize viva/presentation for evaluation.

S.Y. B.Sc. Chemistry Question Paper Pattern

Total Marks: 35 **Time:** 2 Hours

Instructions to the Candidate:

1. All questions are compulsory.
2. Use of scientific calculator and log table is allowed where applicable.
3. Figures to the right indicate full marks.
4. Illustrate your answers with neat diagrams wherever necessary.

Q-1] Solve any five of the following [5 marks]

Three def. type, two tricky questions and two questions problem type (if applicable)

i.

ii.

iii.

iv.

v.

vi.

vii.

Q-2: A] Solve any two of the following [6 marks]

(Note or Describe type questions)

i.

ii.

iii.

Q-2: B] Solve the following [4 marks]

Single question Problem type or tricky reasoning type question (compulsory)

Q-3: A] Solve any two of the following [6 marks]

Reasoning type / Differentiate type questions

i.

ii.

iii.

Q-3: B] Solve the following [4 marks]

Single question of four marks or two questions of 2 marks.

Problem type or Derive equation or Tricky discussion type question

Q-4] Solve any four of the following [10 marks]

Application type, Justification type question

i.

ii.

iii.

iv.

v.