Arihant Education Foundation's

ihant College of Arts, Commerce and Science,Bavdhan,Pune-21

Department of Science

S.Y.BSc. SYLLABUS STRUCTURE AS PER NEP-2020

Semester - III

Sr. No	Verticals	Course Code	Course Title	Credits	Theory/ Practical	No. of Lectures		Marking Evaluation		Total Marks
						Per Week	Total Lectures	Int.Exam	Ext.Exam	
1	Major Core	CHE-201-T MJ	Physical Chemistry-I	2	Theory	2	30	20	30	50
		CHE-202-T MJ	Inorganic Chemistry-I	2	Theory	2	30	20	30	50
		CHE-203-P MJP	Chemistry Practical- III	2	Practical	4	60	20	30	50
2	Minor (Any One)	MTS-241MN (B)	Mathematics for the Life Sciences-I	2	Theory	2	30	20	30	50
		BOT-241-MN	Horticulture	2	Theory	2	30			
		MTS-242MN (B)	Practical based on MTS-241-MN	2	Practical	4	60	20	30	50
		BOT-242-MN	Practical based on BOT-241-MN	2	Practical	4	60			
3	VSC	CHE-221-T VSC	Industrial Chemistry-I	2	Theory	2	30	20	30	50
4	IKS	CHE-201-T IKS	Ancient Indian Chemistry	2	Theory	2	30	20	30	50
5	OJT/FP	CHE-231 FP	Field Project	2	Practical	2	60	20	30	50
6	(GE)/(OE)	OE-PSY-201	Consumer Psychology	2	Theory	2	30	20	30	50
		OE 208 COM-T	.Personality devlopment for Business ProfessionalIII (Commerce)		Theory	2	30			
7	AEC (Any 1)	AEC-232-MAR	Marathi	2	Theory	2	30	20	30	50
		AEC-231-HIN	Hindi		Theory	2	30			
8	CC	CC-201	Personality Devlopment	2	Theory	2	30	20	30	50
Total				**22**						**550**

Arihant Education Foundation's
rihant College of Arts, Commerce and Science,Bavdhan,Pune-21
Department of Science
S.Y.BSc. SYLLABUS STRUCTURE AS PER NEP-2020
Semester - IV

Sr. No	Verticals	Course Code	Course Title	Credits	Theory/ Practical	No. of Lectures		Marking Evaluation		Total Marks
						Per Week	Total Lectures	Int.Exam	Ext.Exam	
1	**Major**	CHE-251-T MJ	Organic Chemistry-I	2	Theory	2	30	20	30	50
		CHE-252-T MJ	Analytical Chemistry-I	2	Theory	2	30	20	30	50
		CHE-253-P MJP	Chemistry Practical – IV	2	Practical	4	60	20	30	50
2	**Minor**	MTS 291 MN (B)	Mathematics for Life Science-II	2	Theory	2	30	20	30	50
		BOT-291-MN	Hybrid Seed Production	2	Theory	2	30			
		MTS 292 MN (B)	Practical based on MTS-291-MN	2	Practical	4	60	20	30	50
		BOT-292-MNP	Practical based on BOT-291-MN	2	Practical	4	60			
3	**VSc**	CHE-271-P VSC	Industrial Chemistry Practical-I	2	Theory	2	30	20	30	50
5	**CEP – (2C)**	CHE-281 CEP	Community Engagement Project	2	Practical	4	60	20	30	50
6	**(GE)/(OE)**	OE-PSY-251	Advertising Psychology	2	Practical	4	60	20	30	50
		OE 208 COM-T	.Personality devlopment for Business Professional IV (Commerce)	2	Theory	2	30			
7	**AEC (Any 1)**	AEC-281-HIN	Hindi	2	Theory	2	30	20	30	50
		AEC-282-MAR	Marathi	2	Theory	2	30			
8	**SEC**	SEC-201- P CHE (A	Basic Software in Chemistry	2	Theory	2	30	20	30	50
9	**CC**	CC-251	Personality Devlopment	2	Theory	2	30	20	30	50
Total				**22**						**550**

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

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.

Savitribai Phule Pune University, Pune

(Formerly, University of Pune)

Under Graduate Degree Program in Botany (B.Sc. Botany)

(Faculty of Science & Technology)

Revised Syllabi as per National Education Policy (2020) for

S.Y.B.Sc. Botany (Semester-III and IV)

(For Colleges Affiliated to Savitribai Phule Pune University, Pune)

To be implemented from

Academic Year 2025-2026

Framed by

BOARD OF STUDIES IN BOTANY

Savitribai Phule Pune University,
Ganeshkhind, Pune -07.

AIMS AND OBJECTIVES

- To develop employability oriented diversified course content.
- To introduce skill oriented specialized education by introducing in-depth learning concepts.
- To expose students to the process of systematic academic inquiry and exhibiting courtesy to the vast universe of basic and applied knowledge of plants.

PROGRAM OUTCOMES (POS)

According to NEP-2020 criteria, the Under Graduate degree in Botany (S.Y.B.Sc. Botany) program at Savitribai Phule Pune University, Pune's associated colleges, is structured to provide students with advanced field-related knowledge and essential fundamentals. Through a unique combination of required major core courses with in-depth exposure to multidisciplinary minor, elective, and vocational skill courses, among other courses, students will be trained and acquire the fundamental and advanced knowledge essential to the plant sciences industries.

With the knowledge gained in the field of plant sciences, this upgraded curriculum will develop educated, outcome-oriented candidates who are nurtured through discovery and learning, equipped with practice and skills to deal with practical problems, and competent with recent pedagogical trends in education, including E-learning, flipped class, hybrid learning, and experiential learning. These candidates will become responsible citizens, transforming the nation to lead the world in the future.

After successful completion of the Under Graduate (UG) Degree program, the students would be able to:

PO1: Attain thoughtful proficiency in the field of plant sciences.

PO2: Acquire the ability to perform in multidisciplinary domains.

PO3: Attain the ability to exercise intelligence of scientific knowledge for investigation and innovation and nourishment of the world.

PO4: Learn value based ethical practices and principles committed to professional ethics.

PO5: Incorporate 21st century skill oriented self-directed and life-long learning.

PO6: Obtain ability to inculcate the knowledge of plant science in diverse contexts with global perspective.

PO7: Attain maturity to harness the destiny and responds to one's calling.

PROGRAM SPECIFIC OUTCOMES (PSOs)

PSO1: Recall the diversity, classification, evolution and developmental changes among the plants with reference to lower and higher plant groups and create a knowledge base in understanding the basis of plant diversity, economic values and taxonomy of plants.

PSO2: Understand the advanced concepts of Genetics, Cell biology and Plant Biotechnology of plants and its implementation for the improvement of crop productivity.

PSO3: Acquire and utilize the skills of post-harvest, flower design, fruit processing and dehydration techniques, organic farming and various plant processing technologies for developing the economy to the growing world.

PSO4: Know about the importance of Medicinal plants and its useful parts, economically important plants in our daily life and also about the traditional medicines and herbs, and its relevance in modern times.

PSO5: Inculcate the methodology followed in plant breeding, pharmacognosy, herbal drug technology, plant protection, propagation and improvement.

PSO6: Adapt methods of scientific research in plant improvement program and create entrepreneurships, employment to the society.

PSO7: Analyze the impact of scientific and technological advances on the environment and society and understand the importance of biodiversity conservation, green cover development, carbon sequestration and utilize the knowledge for sustainable development.

PSO8: Explore the knowledge of biotic and abiotic stress tolerance, plant microbe interaction and Integrate pest management for making the revolution in the agriculture.

PSO9: Enrich the ability of critical thinking, development of scientific attitude, handling of problems and generating solutions, improve practical skills, and enhance communication skill.

PSO10: Apply the fruitful knowledge of plant sciences and plant resources for the sustainable development, betterment of society and environment by recognizing the ethical values.

PSO11: Become competent enough in various analytical and 21st century technical skills related to plant sciences for their exploration.

PSO12: Exhibit the potential to effectively accomplish tasks independently and as a member or leader in diverse teams, and in multidisciplinary settings.

PSO13: Employ critical thinking based problem solving and practical skills pertaining to botanical techniques and computational knowledge and apply strategies for environmental conservation.

PSO14: Demonstrate knowledge and scientific understanding to identify research problems, design experiments, use appropriate methodologies, analyze and interpret data and provide solutions. Exhibit organizational skills and the ability to manage time and resources.

1. Title of the Course: B.Sc. Botany (03 years) / B.Sc. with Honours in Botany (04 years)

Syllabus revised as per National Education Policy (NEP) 2020 for the Colleges Affiliated to Savitribai Phule Pune University, Pune

2. Faculty - Science and Technology

3. To be implemented -For S.Y.B.Sc. (Semester III and Semester IV), from June 2025.

4. Preamble -

Plants are the sole true foundation for all scientific disciplines since they create all kinds of ecosystems and are necessary for all other life forms on Earth to survive. Through both basic and applied research, the study of botany has a significant potential to assist the nation in achieving its sustainable goals. The world's overpopulation is having a concerning effect on the development and productivity of food (particularly plants), in addition to the ever-increasing challenges of environmental contamination brought on by unfavourable climatic changes, global warming, and natural disasters.

Botany is the only supreme foundation of all sciences, because plants, as producers of all kinds of ecosystems, play a critical role in the survival and existence of all other living things on the planet. Botany has tremendous potential for achieving the nation's long-term goals by utilizing it at both the basic and applied levels. In the current scenario, the world's over population, combined with the day-by-day increasing problems of environmental

pollution caused by adverse climatic changes, global warming, and natural calamities, is severely affecting the growth, development, and productivity of produce (particularly plants) to alarming levels.

Higher education in plant sciences should be encouraged for students with backgrounds in the life sciences, with an emphasis on applying the most recent data, expertise, and abilities from both basic and applied branches to develop solutions for sustainable development. In light of this curriculum has been designed to equip students with the knowledge and skills they will need to handle problems pertaining to the needs and worries of both the environment and the human population. In order to accomplish these goals, every effort is made to guarantee high standards of education by implementing numerous strategies to enhance the teaching-learning process, assessment and evaluation methods, and making sure that students are developed holistically in line with the goals and standards of NEP 2020.

The thoughtfully crafted S.Y.B.Sc. Botany curriculum combines a focus on subjects linked to advanced agriculture, the plant-based industry, and pharmaceutical companies with a deep comprehension of the subject's fundamental concepts. This will inspire and attract life science students to seek M.Sc. and Ph.D. degrees in botany in order to become prosperous entrepreneurs, proficient workers, or sophisticated farmers who can address social and environmental issues as a part of sustainable development.

The National Education Policy (NEP-2020), which is being implemented by the Ministry of Higher Education, the Government of India, and the University Grants Commission (UGC), offers opportunities for developing 21st century advanced skills based on the Indian knowledge system through research internships with renowned and esteemed faculty and researchers at their own or other HEIs / research institutes. Additionally, it acknowledges, pinpoints, and nurtures each student's distinct talents in order to support their overall growth and strengthen the country. This will empower Indian youngsters in the field of plant sciences globally and assist the country establish a solid foundation on the global market. Our nation boasts the highest percentage of young people, who, after receiving a top-notch education, have the potential to govern the world in the years to come.

In order to address problems pertaining to plant sciences, such as biodiversity conservation, soil health, plant nutrition, plant wealth and plant-based resource management, interactions between plants and microorganisms, plant pathogens and diseases, and carbon sequestration, the B.Sc. Botany curriculum offers a thorough theoretical and practical knowledge base. In the exploration of plant sciences, students will be able to stand independently and with confidence.

Program Duration and Exit Options

The UG Program lasts for four years or eight semesters.

Student may leave the program after the third year if, he/she would like to receive a three-year undergraduate degree.

If the student decides to withdraw after the first or second year, he/she will receive a UG Certificate or UG Diploma, depending on how many credits he/she is able to complete. Re-entering within three years to finish the degree program is allowed for students who leave with a UG certificate or UG diploma. A student must earn a minimum of 18 credits and a maximum of 26 credits each semester. It is recommended, nevertheless, that student should opt 22 credits per semester. This clause aims to give student the comfort of a flexible

semester-based course load. However, Table 1 lists the minimum number of credits required to be earned in order to be awarded an Undergraduate Certificate/Undergraduate Diploma/Bachelor Degree/Bachelor's Degree with Honors in Botany.

Table1: Type of Awards and Stages of Exit

Sr. No.	Type of Award	Stage of Exit	Mandatory Credits
1.	Undergraduate Certificate in Botany	After successful completion of First year Semesters	44
2.	Undergraduate Diploma in Botany	After successful completion of Second year Semesters	88
3.	Bachelor of Science in Botany	After successful completion of Third year Semesters	132
4.	Bachelor of Science in Botany (Honours)	After successful completion of Fourth yearSemesters	176

5. Eligibility Criteria -

The students who had opted Botany as a subject at FYBSc level and have qualified are eligible for SYBSc Botany Admission. Admissions will be given as per the selection procedure / policies adopted by the college keeping in accordance with the conditions laid down by the Savitribai Phule Pune University, Pune. Reservation and relaxation are as per the State Government rules.

6. Fee Structure – As per the norms of Savitribai Phule Pune University, Pune.

7. Duration of the Course

Certificate Course- 01 year (Completion of 02 Semesters)
Diploma Course- 02 years (Completion of 04 Semesters)
BSc Degree- 03 years (Completion of 06 Semesters)
BSc Degree with Honors- 04 years (Completion of 08 Semesters)

8. No. of semesters – Two semesters per year

9. Medium of instructions and teaching: English

10. Course Implementation Criteria for Theory and Practical:

a. Each semester comprises of 15 weeks (12 weeks Actual Teaching + 3 weeks for Continuous Internal Evaluation).

b. One Credit of the Theory is equal to15 clock hours (Teaching 1 hour per week for each credit, 12 hours Actual Teaching + 3 hours Continuous Internal Evaluation – Assignments, Tutorials, Practice, Problem solving sessions, Group discussion, Seminars and Unit Tests.

c. One Credit of Practical = 30 clock hours. (2 Contact hours per credit per week)

One Credit = 30 clock hours (24 hours' Actual Table work + 6 hours for journal competition, and Continuous Internal Evaluation of each practical).

d. Practical for each course comprises of 02 Credits = 60 clock hours. Therefore,

- Minimum 12 laboratory sessions of 04 clock hours must be conducted in one

semester.

- In case of short practical, two practicals should be conducted in one session.
- Each practical of 04 clock hours in the laboratory should consist of: Table performance for concerned practical, careful observations, calculation, writing results and conclusion, and submission of practical in written form.
- Pre-laboratory reading and post laboratory assignments should be given on each practical as a part of continuous internal evaluation.

e. Field Project (FP): 02 credits (60 hours including field study, labwork, presentations, assignments etc.)

f. Community Engagement Program (CEP): 02 Credits (60 hours including community engagement activities, labwork, presentations, assignments etc.)

11. Examination Pattern (For each Semester): The examinations will be conducted semester wise for both Theory as well as Practical courses.

- **Theory Paper of 02 Credits -**
  - Internal Exam (15 M) + University Theory Exam (35 M) = Total 50 M
  - Duration: For Internal exam = 40 Min. and For University Exam = 02 hours.
- **Practical Paper of 2 Credits -**
  - Internal Exam (15 M) + University Practical Exam (35 M) = Total 50 M
  - Duration: For Internal exam = 40 Min. and For University Exam = More than 04 hours.
- **Field Project: 02 credits**

  Student field project should be evaluated for total 50 marks (15 marks for internal and 35 marks for external evaluation). During internal assessment following points should be considered

  1. Appropriateness of the field project
  2. Punctuality of the student
  3. Field work
  4. Field diary
  5. Viva voce

  The criteria for external evaluation should be

  1. Originality and significance of the project, its relevance to the field, and potential impact.
  2. Soundness of methodology, research design, and approach.
  3. Quality, accuracy, and thoroughness of data collection, analysis, and interpretation.
  4. Validity and significance of findings, conclusions, and recommendations.
  5. Clarity, organization, and effectiveness of the project report and presentation.
- **Community Engagement Program (CEP): 02 Credits**

  Student Community Engagement Program (CEP) shall be evaluated for total 50 marks (15 marks for internal and 35 marks for external evaluation). During internal assessment following points shall be considered

  1. Effectiveness of program design and planning.
  2. Student participation and engagement in program activities.
  3. Effectiveness of student communication with community members.
  4. Demonstration of seed technology knowledge and skills.
  5. Maintenance of program records and documentation.

The criteria for external evaluation shall be

1. Clarity, organization, and effectiveness of the report and presentation.
2. Assessment of the program's impact on the local community.
3. Evaluation of student learning outcomes and skills development.
4. Assessment of the program's effectiveness in achieving its objectives.

12. Award of Class/Grade: The class / grade for the courses of each semester will be followed as per the norms and conditions laid down by SPPU, Pune.

13. ATKT Rules: As per the norms given by SPPU, Pune.

14. Important Note:

a. There shall be at least a short tour/field visit/industrial visit (1-2 days) per year for all UG students. Tours are the part of curriculum and obligatory to each student, failing which they will not be considered eligible to appear for the practical examination. Under unavoidable circumstances, if the student fails to attend the tour, he/she have to produce justifiable evidence for not attending the tour. However, in lieu of tour the candidate will have to complete the work assigned by the Department.

c. The documents to be produced by each student at the time of practical examination (at the end of each Semester) are:

- Submission of practical records (Journals).
- Submission of a Tour / Visit report duly signed by the concerned practical In-charge and Head of the Department.
- Any submissions / assignments, etc. based on the practical course.

15.Question paper pattern for Theory (2 Credit courses)

A student will have to solve the question paper of 35 marks for external exam. The paper setter should set the paper on entire syllabus, including optional questions. As the course is of 2 Credits (30 clock hour lectures), paper setter should allot 2.03 marks per lecture and accordingly, questions should be set for 30 lectures, 61 marks on entire syllabus.

Note: All questions are compulsory.

Time: 2 Hours

Que. 1) Answer any five of the following in one sentence 05 Marks

i.
ii.
iii.
iv.
v.
vi.

Que. 2a) Write any one of the following 06 Marks

i.
ii.

Que. 2b) Write any one of the following 04 Marks

i.
ii.

Que. 3a) Solve any one of the following 06 Marks

i.
ii.

Que. 3b) Solve any one of the following 04 Marks

i.
ii.

Que. 4) Write notes on (Any four) 10 Marks

a.
b.
c.
d.
e.
f.

S.Y.B.Sc. Botany [Semester - III]

Course Category – Minor Course (MN)

Course Code – BOT-241-MN

Course Title: Horticulture

[No. of Credits: 2 C] **[No. of Lectures: 30 L]**

OBJECTIVES:

1. To introduce students to the basic concepts, scope, and branches of horticulture.
2. To impart knowledge about the morphological features and economic importance of different horticultural plant parts.
3. To provide an understanding of plant propagation methods and the use of propagation structures and growth regulators.
4. To familiarize students with specialized horticultural practices and their application in crop improvement.
5. To develop knowledge about commercial cultivation practices and value addition techniques in horticultural crops.
6. To create awareness about landscaping techniques and the role of national agencies in the development of horticulture in India.

COURSE OUTCOMES:

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

CO1: Explain the basic principles, branches, and scope of horticulture.

CO2: Identify horticultural crops based on morphological parts and their economic significance.

CO3: Demonstrate understanding of various propagation methods and the role of plant growth regulators and propagation structures.

CO4: Apply special horticultural practices to enhance growth and productivity in selected crops.

CO5: Describe the commercial cultivation techniques and value addition processes of selected horticultural crops.

CO6: Design basic landscape gardens and explain the significance of governmental support in horticulture development.

Sr. No.	Topic Details	No. of Lectures
	CREDIT I	**15**
1	**Introduction to Horticulture** 1.1 Introduction and Definition 1.2 Branches of Horticulture – Fruits (Pomology), Vegetables (Olericulture), Flowers (Floriculture), Nursery Management, Landscaping, Plantation crops, Spices (Culinary Herbs), Medicinal Plants. 1.3 Importance and scope of horticulture.	**02**
2	**Morphology and importance of horticultural plant parts**	**03**

	2.1 Introduction 2.2 Morphology of horticultural plants with respect to their common name, botanical name, family, parts used and its importance: 2.2.1 Root – carrot 2.2.2 Bulb - onion 2.2.3 Rhizome – turmeric 2.2.4 Stem tuber - potato 2.2.5 Leaf - Cabbage 2.2.6 Flower bud – clove 2.2.7 Flower - rose 2.2.8 fruit - mango 2.2.9 Seed - cashew nut	
3	**Propagation of horticultural plants** 3.1 Introduction and definition of propagation; 3.2 Methods of plant propagation– 3.2.1 Cutting: Stem cutting; 3.2.2 Layering: Air-layering; 3.2.3 Grafting: Cleft and approach grafting; 3.2.4 Budding: T- budding. 3.3 Role of plant growth regulators in horticulture. 3.4 Plant propagation facilities and their applications – 3.4.1 Mist chamber 3.4.2 Humidifiers 3.4.3 Greenhouse 3.4.5 Phytotrons 3.4.6 Cold frames and 3.4.7 Hot beds.	**05**
4	**Special horticultural Practices** 5.1 Introduction, definition, concept and importance of horticultural practices– 4.1.1 Training 4.1.2 Pruning 4.1.3 Girdling 4.1.4 Notching 4.1.5 Bending 4.1.6 Earthing up 4.1.7 Staking 4.1.8 Blanching 4.1.9 Bahar treatment.	**05**
	CREDIT II	**15**
5	**Commercial cultivation of horticultural crops** 5.1 Introduction; 5.2 Commercial value of ***Gerbera*****, Pomegranate** and **Tomato.** 5.3 Commercial cultivation practices of ***Gerbera*****, Pomegranate** and **Tomato** with reference to: center of origin; soil and climatic conditions; varieties; cultivation techniques; irrigation, fertigation	**06**

	and weed management practices; diseases and pest control: harvesting; grading and packaging.	
6	**Value addition to horticultural crops** 6.1 Introduction and concept of value addition 6.2 Processing importance of value-added products of selected horticultural crops: 6.2.1 Rose – gulkand and rose water 6.2.2 Grapes – wine and raisins 6.2.3 Tomato – Sauce and Ketchup	**03**
7	**Landscape gardening** 7.1 Introduction to landscape gardening 7.2 **Landscape gardening components:** Lawns, hedges, pergolas, Pathways, Fountains and topiary. 7.3 **Ornamental plant display techniques:** Moss stick, hanging baskets, Wall planters, bonsai, and terrarium.	**04**
8	**Role of government agenciesin horticulture development** 8.1 National Horticulture Board (NHB) 8.2 Mission for Integrated Development of Horticulture (MIDH) 8.3 National Horticulture Mission (NHM)	**02**

References:

1. Horticulture: V. L Sheela, MJP Publications.
2. Plant Propagation, Principles and Practices: Hartmann and Koster.
3. Principles of Horticulture and Fruit Growing: Y. N Kunte, M.P Kawathalkar and K.S
4. Yawalkar (Agri- Horticultural Publication House, Nagpur).
5. Commercial Flowers, NayaProkash : Bose T. K & Yadav L. P.
6. Advances in Horticulture Vol. IV Malhotra Publications : Chadha K. L &Pareek O. P.
7. Post Harvest Technology of Horticultural Crops New Delhi Publications :Sudheer K. P and Indira V.
8. Principles of Horticulture, 4th Edt. Elsevier Publication, 2004: Adams C. R.
9. Introduction to ornamental horticulture. Kalyani Publishers, Ludhiana, India.: Arora, JS. 1999.
10. NambisanKMP.1992.: Design Elements of Landscape Gardening. Oxford & IBH
11. Bose TK, Maiti RG, Dhua RS and Das P. 1999. :Floriculture and Landscaping., NayaProkash.
12. Introduction to Horticulture – N. Kumar (Oxford & IBH).
13. Ornamental Horticulture" – S. C. Dey (Pointer Publishers).
14. Horticulture – Principles and Practices – George Acquaah (Pearson).
15. Plant Propagation: Principles and Practices – Hartmann & Kester (Prentice Hall).
16. Propagation of Horticultural Crops – S. K. Sadhu (New Age International).
17. Nursery Management" – L. C. De (Oxford & IBH).
18. Fruit Science (Fundamentals and Practices)" – V. K. Chattopadhyay (Kalyani Publishers).
19. Advances in Fruit Production" – R. R. Sharma (New India Publishing Agency).
20. A Textbook of Vegetable Crops" – T. S. Rana (Kalyani Publishers.
21. Vegetable Crops" – Bose, Som&Kabir (NayaUdyog).

22. Floriculture in India" – G. S. Randhawa & A. Mukhopadhyay (Allied Publishers).
23. Post-Harvest Technology of Horticultural Crops" – K. P. Sudhakar Rao (Agrotech Publishing).
24. Protected Cultivation of Horticultural Crops" – S. Prabhakar Rao (Kalyani Publishers).
25. Handbook of Horticulture" – (ICAR Publication)- K. L. Chadha.
26. Fundamentals of Horticulture. – Jitendra Singh (Kalyani Publishers).

S.Y.B.Sc. Botany [Semester - III]

Course Category – Minor Course (MN)

Course Code – BOT-244-MNP

Course Title: Practical based on BOT-241-MN

[No. of Credits: 2 C] **[No. of Lectures: 60 L]**

OBJECTIVES:

1. To study the morphology and economic importance of selected plant parts used in horticulture.
2. To impart knowledge and practical skills in using common horticultural tools and techniques.
3. To demonstrate and practice special horticultural methods such as pruning, training, girdling, and bending.
4. To provide hands-on training in vegetative propagation techniques including cutting, layering, grafting, and budding.
5. To develop skills in value-added product preparation (e.g., rose water, wine, sauces) and ornamental plant arrangements like bonsai and terrariums.

Course Outcomes (COs):

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

CO1: Identify and describe the morphology of various plant parts of horticultural importance (root, stem, leaf, flower, fruit, seed).

CO2: Efficiently handle and utilize horticultural tools and perform key horticultural practices such as pruning, earthing up, and staking.

CO3: Apply vegetative propagation techniques (cutting, layering, grafting, budding) for plant multiplication in both ornamental and fruit plants.

CO4: Prepare and present value-added horticultural products and ornamental structures like gulkand, rose water, moss sticks, bonsai, and terrariums.

CO5: Demonstrate knowledge of horticultural industries through field visits and compile structured reports based on nursery, orchard, or floriculture market observations.

Sr. No.	Title of the Practical	No. of Practical
1	Study of morphology of root – carrot; bulb - onion; rhizome – turmeric; stem tuber - potato; leaf - Cabbage; flower bud – clove; flower - Rose; fruit - mango; seed - cashew nut.	01 P
2	To study the horticultural tools.	01 P
3	Demonstration of special horticultural practices - Training, Pruning, Girdling, Notching, Bending, Earthing up, Staking, and Blanching.	01 P
4	Study of plant propagation by Cutting (stem and leaf) and Layering (air and soil).	01 P
5	Study of plant propagation by grafting (simple approach and stone) and Budding (I, T and patch).	02 P
6	Preparation of gulkand and rose water.	01 P
7	Demonstration on laboratory preparation of grape wine.	01 P

8	Preparation of tomato sauce and ketchup.	**02 P**
9	Preparation of moss-stick, hanging baskets, potted plants and wall planters.	**01 P**
10	Demonstration on bonsai and terrarium.	**01 P**
11	Preparation of plant growth regulator solutions and its applications for vegetative propagation.	**01 P**
12	Submission of potted plant, Hanging Basket, Moss stick, Wall planters and Bonsai.	**01 P**
13	Visit to Nursery / orchard / floriculture industry / floricultural market and report writing.	**01 P**

References:

1. Chadha, K. L. (2001). Handbook of horticulture. Indian Council of Agricultural Research (ICAR).
2. Sharma, R. R. (2002). Propagation of horticultural crops: Principles and practices. Kalyani Publishers.
3. Srivastava, H. C. (2006). Horticulture: Practices and postharvest technology. New India Publishing Agency.
4. Kumar, N. (2005). Introduction to horticulture. Rajalakshmi Publications.
5. Thamburaj, S., & Singh, N. (2001). Vegetables, tuber crops and spices. Indian Council of Agricultural Research (ICAR).
6. Jain, N. K. (2007). Fundamentals of food preservation. S. Chand & Company Ltd.
7. Bal, J. S. (2011). Fruit growing. Kalyani Publishers.
8. Randhawa, G. S., &Mukhopadhyay, A. (1986). Floriculture in India. Allied Publishers.
9. Singh, R. (2005). Basic horticulture. Kalyani Publishers.
10. Tamil Nadu Agricultural University (TNAU). (n.d.). Horticulture practical manual – B.Sc. (Agri./Horti.). Tamil Nadu Agricultural University.
11. Indian Council of Agricultural Research (ICAR). (n.d.). E-learning courses (eKrishiShiksha). https://ecourses.icar.gov.in
12. National Horticulture Board (NHB). (n.d.). Official website. http://nhb.gov.in
13. KrishiVigyan Kendra (KVK). (n.d.). Publications and video resources. https://kvk.icar.gov.in

S.Y.B.Sc. Botany [Semester - IV]

Course Category –Minor Course (MN)

Course Code – BOT-293-MN

Course Title: Herbal Product Technology

[No. of Credits: 2 C] **[No. of Lectures: 30 L]**

OBJECTIVES:

1. To introduce the concept, types, and importance of herbal products.
2. To familiarize students with methods of preparation and classification of herbal products.
3. To impart knowledge on extraction techniques and quality control of herbal formulations.
4. To understand the pharmacological uses of common medicinal plants.
5. To promote awareness about commercialization, marketing, and documentation of herbal knowledge.

Course Outcomes (COs):

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

CO1: Define and differentiate various types of herbal products and their applications.

CO2: Demonstrate preparation methods for herbal formulations like decoctions, tinctures, and powders.

CO3: Apply suitable extraction and standardization techniques for herbal products.

CO4: Describe the pharmacological importance of selected medicinal plants.

CO5: Collect, record, and report traditional herbal knowledge from local sources.

Sr. No.	Topic Details	No. of Lectures
	Credit I	**15**
1	**Introduction to Herbal Products** 1.1 Introduction and definition of herbs 1.2 Concept of Herbal products. 1.3 Scope and Importance of Herbal Products, 1.4 Identification and authentication of herbal materials, 1.5 Adulteration.	**02**
2	**Types of Herbal Products** 2.1 Introduction 2.2 Concept of Cosmetics, Nutraceuticals and pharmaceuticals. 2.3Herbal Cosmetics: Shampoos, Creams, Soaps, Lotions,Ointments. 2.4 Herbal Nutraceuticals: Health Drinks and Tea, Dietary Supplements. 2.5 Herbal Pharmaceuticals: Tablets, Syrups, Capsules.	**04**
3	**Herbal Products and Methods of Preparation** 3.1 Classification of Herbal products based on botanical characteristics: 3.1.1 Herbs –e.g., Tulsi, Brahmi 3.1.2 Shrubs – e.g., Adulsa, Lemon grass 3.1.3 Trees – e.g., Neem, Arjuna 3.1.4 Climbers and Creepers – e.g., Giloy, Betel/ pepper or pimpli 3.2 Methods of Herbal product preparation	**04**

	3.2.1 Decoctions (Kadha) – Boiling herbs in water 3.2.2 Infusions – Soaking herbs in hot/cold water 3.2.3 Tinctures – Alcoholic extracts 3.2.4 Powdered drugs (Churna) – Dried and powdered plant material 3.2.5 Medicated oils/ghee – Used in Ayurvedic treatments.	
4	**Extraction and Processing of Herbal Products** 4.1 Extraction Methods 4.1.1 Maceration- hot and cold method, 4.1.2 Simmering, 4.1.3 Soxhlet, 4.1.4 Steam Distillation, 4.1.5 Supercritical Fluid Extraction. 4.2 Purification and isolation of bioactive compounds - Standardization and Quality Control of Herbal drugs	**04**
	Credit-II	**15**
5	**Pharmacological evaluation** 5.1 Pharmacological properties and uses of common medicinal plants: Neem, Tulsi, *Aloe vera*, Ashwagandha, Adulsa and Turmeric.	**02**
6	**Quality Control and Regulatory Aspects** 6.1 WHO and AYUSH Guidelines for Herbal Products, 6.2 Good Manufacturing Practices (GMP) and Safety Standards, 6.3 Adulteration, Contaminants, and Detection Methods.	**04**
7	**Commercialization and marketing of herbal products** 7.1 Entrepreneurship in Herbal Industry, 7.2 Market research and analysis 7.3 Business planning 7.4 Market Trends and Consumer Demand for Herbal Products. 7.5 Packaging, Labelling, and Branding Strategies.	**04**
8	**Documentation of Local Herbal Knowledge** 8.1 Students interview with local vendors, traditional healers, or family members about herbs used for common ailments (cold, wounds, digestion, skin issues), 8.2 Introduction to Basic Observational Recording and Report preparation.	**05**

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4 Panda, H. (2004). Herbal Cosmetics Handbook: Formulations with Herbal Extracts. New Delhi, India: Asia Pacific Business Press Inc.

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13 Mehrotra, N. N., & Agarwal, S. S. (2003). Pharmacological Screening Methods in Pharmacognosy. New Delhi, India: CBS Publishers & Distributors.
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S.Y.B.Sc. Botany [Semester - IV]

Course Category – Minor Course (MN)

Course Code – BOT-296-MNP

Course Title: Practical based on BOT-293-MN

[No. of Credits: 2 C] **[No. of Lectures: 60 L]**

OBJECTIVES:

1. To introduce the fundamental principles of analytical and separation techniques used in biological sciences.
2. To provide hands-on experience in electrophoresis, chromatography, spectrophotometry, and instrumentation.
3. To demonstrate hybridization techniques for detection of nucleic acids and proteins.
4. To develop basic skills in data recording, analysis, and presentation using statistical tools.
5. To enhance analytical thinking and laboratory proficiency through practical experiments.

Course Outcomes (COs):

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

CO1: Explain the working principles and applications of biological instruments like pH and EC meters.

CO2: Perform and interpret results from electrophoresis, chromatography, and spectrophotometric techniques.

CO3: Demonstrate the process and significance of blotting techniques in molecular biology.

CO4: Apply biostatistical tools to analyze and represent biological data accurately.

CO5: Develop competency in handling laboratory procedures and troubleshooting technical errors.

Sr. No.	Title of the Practical	No. of Practical
1	Identification of Tulsi (*Ocimum sanctum*), Neem (*Azadirachta indica*), and Brahmi (*Bacopa monnieri*) based on color, odor, taste, texture, and microscopic characteristics such as stomata, trichomes, and vascular elements.	01
2	Study of diagnostic characters of powdered herbal drugs like Amla, Ashwagandha, and Reetha under compound microscope, focusing on trichomes, starch grains, vessels, fibers, and calcium oxalate crystals.	01
3	Detection of phytoconstituents such as alkaloids, flavonoids, saponins, tannins, phenolics, and steroids in aqueous and alcoholic extracts of selected herbs using qualitative color reactions.	01
4	Perform simple tests to detect adulterants in powdered herbal drugs such as turmeric (with chalk/starch), ashwagandha (with starch), and chili powder (with brick powder).	01
5	Estimate the presence of non-drug materials (e.g., insects, stones, stems) and evaluate moisture content using drying methods to assess shelf stability.	01
6	Determine total ash, acid-insoluble ash, and extractive values in water and alcohol to assess the purity and solubility profile of herbal raw drugs.	01

7	Prepare a natural shampoo using Reetha, Amla, and Shikakai. Evaluate parameters such as pH, foam height, viscosity, cleansing ability, and organoleptic properties.	**01**
8	Formulate a skin-friendly face pack using multani mitti, turmeric, and sandalwood. Evaluate texture, pH, drying time, spreadability, and user acceptability.	**01**
9	Prepare a health-promoting herbal tea using Tulsi, lemongrass, and ginger. Evaluate aroma, taste, appearance, and antioxidant potential (optional).	**01**
10	Prepare a traditional herbal decoction (Kadha) using Tulsi and Adulsa following Ayurvedic principles of boiling, filtration, and storage.	**01**
11	Prepare herbal tablets/capsules using powdered forms of Ashwagandha or Giloy. Evaluate weight variation, disintegration time, hardness, and packaging methods.	**01**
12	Prepare a hydro-alcoholic extract (tincture) from Neem leaves using maceration technique. Evaluate extraction yield and discuss solvent system and storage.	**01**
13	Prepare an infusion from peppermint or chamomile flowers and compare with decoction. Evaluate clarity, aroma, and organoleptic quality.	**01**
14	Prepare a multipurpose herbal balm using camphor, eucalyptus oil, menthol, and beeswax. Evaluate spreadability, melting point, and skin compatibility.	**01**
15	Industrial exposure visit to understand herbal raw material sourcing, processing, standardization, product formulation, quality control, and packaging. Students must submit a structured report.	**01**

References:

1. Kokate, C. K., Purohit, A. P., & Gokhale, S. B. (2017). Pharmacognosy (50th ed.). Pune, India: Nirali Prakashan.
2. Trease, G. E., & Evans, W. C. (2009). Pharmacognosy (16th ed.). London, UK: Elsevier Health Sciences.
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17. Nadkarni, K. M. (2002). Indian Materia Medica (Vol. I–II). Mumbai, India: Popular Prakashan.

Savitribai Phule Pune University, Pune

(Formerly, University of Pune)

Four Year (Semester 01 to 08)

B.A./B.Sc. (Honours/Honours with Research)

MATHEMATICS

[F. Y. B. Sc. Sem. 1 & 2:2024 Pattern]
[S. Y. B. Sc. Sem. 3 & 4:2025 Pattern]

Syllabus

National Education Policy-2020

To be Implemented From The Academic Year : 2024- 2025

Prepared by : B.O.S. MATHEMATICS, SPPU

Recommended by: Faculty, Science and Technology

Approved by : Academic Council, SPPU

References:

1. videG.R.No.NEP-2022/CRNo.09/VISHI-3/शिकाना,dated 20April,2023.
2. University Circular No. 97, Dated 31 May, 2023.
3. Circular Higher Education, Govt. of Maharashtra Dated 13th March, 2024

(For Colleges Affiliated to Savitribai Phule Pune University, Pune.)

Preamble

The board of studies in Mathematics of Savitribai Phule Pune University, made a rigorous attempt to revise the curriculum of degree program B.Sc. to align it with National Education Policy-2020 and UGC quality mandate for Higher Education Institutions-2021. The process of revamping the curriculum started with the series of meetings, workshops, webinars and discussions with sub-committees conducted by the university to orient the teachers about the key features of the National Education Policy, enabling them to revise the curriculum in sync with the policy. Appropriate orientation of the faculty about the vision and provisions of NEP-2020 made it easier for them to appreciate and incorporate the vital aspects of the policy in the revised curriculum focused on creating holistic, thoughtful, creative and well-rounded individuals equipped with the skill sets of 21^{st} century for the development of an enlightened, socially conscious, knowledgeable and skilled citizen of the nation.

With NEP-2020 in background, the revised curriculum will articulate the spirit of the policy by emphasizing upon integrated approach to learning, innovative pedagogies and assessment strategies, multidisciplinary and interdisciplinary education, creative and critical thinking, student-centric participatory learning, imaginative abilities and flexible curricular structures to enable creative combination of disciplines for the study. The credit structure is followed by university as it is as per the guidelines of state government to design the Degree Program. The curriculum is further modified as per the needs specified in NEP. The curriculum is developed to trigger the inquisitiveness, discussion, analytical ability and quest for discovery among learners.

Mathematics is a powerful tool for understanding and communicate globally that organizes our lives and prevents chaos, which helps us to understand the world and provides an effective way of building mental discipline. Along with mathematical skills, it is also expected that students will learn life skills like argumentation, communication and general social values which are necessary to life rich, productive and meaningful life. Additionally, the knowledge of mathematical modelling and computational training which the students acquire during the Program makes them highly sought after. In keeping with the demands of industry and academia, the syllabus is updated regularly, with inputs taken from various stakeholders including students, alumni and parents at different stages of the modification/addition of the syllabus. The new curriculum provides a synoptic overview of possible career paths mapped by a degree in mathematics teaching, research, engineering, computer programming, statistician, competitive examinations and many more.

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Four Year Degree Program in Mathematics
under the Faculty of
Science and Technology

B.A./B.Sc. (Honours/ Honours with Research)

ABOUT THE PROGRAM:

This B.Sc. Program is uniquely designed to impart essential knowledge in all major areas of pure or applied mathematics. This Program offers an exciting opportunity for specialization in constructing mathematical models for real-life problems and solve them. The program consists of total 08 semesters which are carefully selected blend of theory and practical. It provides feast of mathematical concepts and advanced knowledge in mathematics which are useful to students for specialist professional employment, research in academia and various industries for broader applications. Learner centric curriculum is designed in adherence to the principles of National Education Policy (NEP 2020) to acquire knowledge and skills with valuable experiences through VSC, SEC, AEC, VEC, IKS, hands-on activities, projects, internships and much more.

OBJECTIVES OF THE PROGRAM:

- To prepare the learners, who will understand and apply the basic as well as advanced principles of mathematics for solving problems from science with an emphasis on applications.
- To produce the learners who are well-grounded in the fundamentals of mathematics with the acquisition of the necessary skills, tools, and techniques required in many applications areas.
- To develop an ability to study the conceptual problem and critically analyze and also promote the use of mathematics in industry and applied sciences.
- To provide exposure and motivate students for research in current trends of mathematics.

SCOPE OF THE PROGRAM:

After successful completion of the B.Sc. Program, the learner has ample opportunities to use their mathematical knowledge in different areas:

- Career opportunities in government organizations like Defense Research and Development Organization (DRDO), Indian Space Research Organization (ISRO), research laboratories like Council of Scientific and Industrial Research or government owned scientific organizations.
- Job positions like Mathematics specialist, Quantitative risk analyst, Treasury management specialist, Public sector banking, Financial institutions, Engineering or Insurance sectors, etc.
- Job opportunities in the teaching profession at science and engineering colleges and universities.
- Scope for Higher Studies and find lucrative opportunities in the field of research.

PROGRAM OUTCOMES(PO's):

After successful completion of this program, students will be able to

1. enhance their logical thinking and apply advanced mathematical concepts to solve complex problems.
2. formulate research questions, design experiments or investigations, collect and analyze data and present their findings in a clear and coherent manner.
3. apply advanced mathematical techniques or tools to analyze and solve challenging problems encountered in mathematics and related fields.
4. formulate mathematical models that represent real-world phenomena, analyze the models using mathematical methods and interpret the results to make informed decisions or predictions.
5. develop proficiency in utilizing computational tools, software and programming languages to aid in mathematical analysis, numerical simulations and data visualization.
6. present complex mathematical concepts, proofs and research findings to both technical and non-technical audiences.
7. develop a strong foundation for professional growth and lifelong learning in Mathematics.
8. acquire lifelong learning skills which will lead important to better opportunities and improve quality of life.
9. gain knowledge with the holistic and multidisciplinary approach across the fields.
10. analyzing the results critically and applying acquired knowledge to solve the problems.
11. be independent innovations and published it though research papers and projects.

PROGRAM SPECIFIC OUTCOMES (PSO's):

The student will

1. have a strong foundation for being research in mathematics.
2. be able to apply mathematical skills for solving problems.
3. at least basic knowledge of programming and computational techniques as required for employment.
4. capable to analyze the results critically and apply acquired knowledge to solve the problems.
5. have at least four different skills and capable to think and communicate in three different languages.
6. be able prepare the models for real life problems.

BASIC INFORMATION:

1. **Title of the Program:** B.A./B. Sc. (Mathematics)
2. **Minimum Duration:**
   i) 3 years for B.Sc. Degree- Major in Mathematics.
   ii) 4 years for B.Sc. Honours with Major in Mathematics.
3. **Maximum Program Duration:** 7 years from the date of admission to the program, also referred as valid registration period.
4. **Medium of Instruction:** English
5. **Attendance:** Minimum 75% attendance for all type of courses.
6. **Teaching-Learning:** 15 weeks per semester
7. **Total Credits:** 132 credits for 3 years under graduate degree and 176 credits for 4 years under graduate (Honours) degree. As per UGC norms one credit means 30 hours for practical/lab sessions and 15 hours for theory.
8. **Semester Credits:** 22 credits in each semester.
9. **Continuous Assessment:** Continuous Assessment(CA) will be conducted for continuous evaluation during teaching-learning. 30% weightage may be considered for one or more of the following.
   i) Home assignment(s)
   ii) Seminar/Presentation (individual / group)
   iii) Laboratory Assignment
   iv) Group discussions / Oral
   v) Research paper review
   vi) Technology demonstration using ICT
10. **End Exam:** End Examination (EE) will be conducted for summative evaluation of the student for 70% weightage.
11. **Passing of course:** Min. 40% in CA and EE each.
12. **Eligibility:**

Admission eligibility for the Program	**Degree Certification Eligibility**
HSC/ (10+2) or equivalent from a recognized board **OR** 10+3 Diploma (any stream) awarded by any state board of technical education	Min 40% marks out of total 132 credits at Semesters 01 to 06 for B.A./B.Sc. Mathematics degree **OR** Min 40% marks out of total 176 credits at semesters I to VIII B.A./B.Sc. Mathematics Honours degree.

13. **Rules for A.T.K.T.:** A student who wishes to take admission to the second year (to register for third or fourth semester) of B. A. /B. Sc. (Mathematics) program has to earn at least 22 credits from the total credits of two semesters of the first year of B. A./B.Sc. (Mathematics).

14. **Multiple Entry and Multiple Exit:**

Level of the Program	Entry Option (with criteria)	Exit Option (with criteria)
Certificate Level	HSC (10+2) OR equivalent from the recognized Board OR 10+3 Diploma (any stream) awarded by any state board of technical education	Award of **UG certificate in Mathematics as Major with 44 credits** and an additional 4 credits core NSQF course/ Internship.
Diploma Level	UG Certificate in Mathematics as Major with 40-44 credits	Award of **UG Diploma in Mathematics as Major with 88 credits** and an additional 4 credits core NSQF course/Intern ship
Degree Level	UG Diploma in Mathematics as with 80-88 credits	Award of **UG Degree in Mathematics as Major with 132 credits**

15. **Abbreviation:**

VSC : Vocational Skill Course
IKS : Indian Knowledge System
FP : Field Project
OJT : On Job Training
CEP : Community Engagement and Service
GE/OE : Generic Elective / Open Elective
SEC : Skill Enhancement Course
AEC : Ability Enhancement Course
VEC : Value Education Course
CC : Co-curricular Courses
RP : Research Project
RM : Research Methodology
T : Theory
P : Practical

16. **Note:**

i) VSC, IKS, FP/OJT/CEP should be related to the Major subject.
ii) The Minor subject may be from the different disciplines of the same faculty of Major (Core) or they can be from different faculty altogether.
iii) OE is to be chosen compulsorily from faculty other than that of the Major.
iv) SEC Prepared by BOS or to be selected from the basket approved by university.
v) Wherever require the BOS can choose theory or practical course as per the need and within the given structure.

17. **EXAMINATION RULES:**

(a) A student cannot appear for semester end examination unless he/she has maintained 75% attendance during the teaching period of that course. If a student fails to maintain 75% attendance at the time of filling of examination forms, an undertaking from the student should be taken stating that he/she will be allowed to appear for examination subject to fulfilment of required attendance criteria during the remaining period of teaching of the course.

(b) Each credit will be evaluated for 25 marks Including End Examination (EE) and Continuous Assessment (CA).

(c) Each course of 04 Credits will have semester End Examination (EE) of 70 Marks and Continues Assessment (CA) of 30 Marks while each course of 02 Credit will have semester-end examination of 35 Marks and Continues Assessment of 15 Marks.

(d) To pass a course, the student has to obtain 40% marks for Continuous assessment (CA) and Semester-End Examination (EE) each of these separately.

(e) If any student is not able to appear for internal assessment examination, he/she may be allowed to appear for examination by the permission of higher authorities based on the verification of reason.

(f) Students who fail to score passing marks in semester-end exam/Continues Assessment may appear for the semester-end exam/ Continuous Assessment in the subsequent period but within allotted period for Program. The allotted period for two, three and four year degree programs is four, five and seven years respectively.

(g) A student cannot register for the subsequent year unless he/she achieves 50% credits of the total credits expected to be ordinarily completed for that particular year. The student can seek admission to third year only after achieving 100% Credits of the first year as well the student seeking admission to fourth year should achieve 100% Credits of second year.

(h) There shall be revaluation of the answer scripts of semester-end examination but not of internal assessment and Practical Examination.

(i) Even though the marks will be given for all examinations, they will be converted into grades. The semester end and final mark sheets and transcripts will have only grades and grade points average.

(j) Continuous Assessment of each Course will have weightage of 30% of marks and a teacher must select at least three components for the examination from the following

  i) Written Test / Mid Term Test/ An Open Book Test
  ii) Seminar/ Group discussion.
  iii) Journal/Lecture/Library notes.
  iv) PPT or poster Presentation.
  v) Short Quizzes.
  vi) Assignments
  vii) Mini Research Project
  viii) Field visit/ Industrial visit

(k) Evaluation of OJT/FP/RP/RM will be done during practical Examination through external examiners by dissertation, Presentation, Oral, Field work project report, etc.

MTS-241MN: (B) Mathematics for the Life Sciences-I

Course type: Minor **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Understand the role of mathematics in biological sciences.
2. Apply Algebra and Calculus to biological systems.
3. Extend mathematical modelling techniques to complex biological systems.
4. Use discrete mathematics and computational approaches in biological research.
5. Develop basic mathematical models for biological processes.
6. Students develop skills in identifying problems, choosing appropriate mathematical tools and communicating their findings in a clear and concise manner.

Course Content

Unit 1: Functions **(10 Hours)**

1.1 Real Number System

1.2 Sets and Their Representations

1.3 Functions

1.4 Linear Functions

1.5 Linear Inequalities

1.6 Other Sample Functions

1.7 More on Functions

1.8 Limit as x tends to infinity.

Unit 2: Exponential and Logarithm Functions **(10 Hours)**

2.1 Exponential Functions

2.2 Inverse Functions and Logarithms

2.3 Log-Log and Semi-log Plots

2.4 Natural Logarithms and Exponentials

2.5 Exponential Growth and Decay

Unit 3: Vectors and Matrices **(10 Hours)**

3.1 Vectors in Two Dimensions

3.2 The Inner Product

3.3 Relative Velocities

3.4 Forces

3.5 Matrices

3.6 Applications of Matrices

Recommended Book:

1. Jagdish C. Arya and Robin W. Lardner (1979), Mathematics for the Biological Sciences, Prentice-Hall, Inc.

Reference Books:

1. Erin N. Bodine, Suzanne Lenhart and Louis J. Gross, Mathematics for the Life Sciences, Princeton University Press, 2014.
2. Edward Batschelet, Introduction to Mathematics for Life Scientists, 3rd Edition (1979), Springer.

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MTS-241MN : (C) Mathematics for Computer Science-I
(Numerical Techniques)

Course type: Minor **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Understand and apply numerical methods to solve algebraic and transcendental equations, including bisection, false position, and Newton-Raphson methods, with an emphasis on error analysis and convergence.
2. Develop a strong foundation in finite difference concepts, including forward, backward, central, and other difference operators, and understand their roles in numerical approximation.
3. Apply interpolation techniques for estimating intermediate values, using Newton's Gregory formulas, Lagrange's interpolation, and divided differences.
4. Utilize numerical integration methods such as the trapezoidal rule, Simpson's one-third rule, and Simpson's three-eighth rule to approximate definite integrals.
5. Solve ordinary differential equations numerically using Euler's method, Euler's modified method, and Runge-Kutta methods, understanding their accuracy and applicability.
6. Analyze the efficiency, accuracy, and limitations of various numerical methods, enabling selection of appropriate techniques for solving real-world mathematical problems.

MTS-291MN: (B) Mathematics for the Life Sciences-II

Course type: Minor **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Understand the role of mathematics in biological sciences.
2. Apply Algebra and Calculus to biological systems.
3. Extend mathematical modelling techniques to complex biological systems.
4. Use discrete mathematics and computational approaches in biological research.
5. Develop basic mathematical models for biological processes.
6. Students develop skills in identifying problems, choosing appropriate mathematical tools and communicating their findings in a clear and concise manner.

Course Content

Unit 1: The Derivative **(10 Hours)**

1.1 Increments and Rates

1.2 Limits

1.3 More on Limits

1.4 Continuous Functions

1.5 The Derivative

1.6 Derivatives of Power Functions

1.7 Derivatives of Products and Quotients

1.8 Derivatives of Composite Functions

1.9 Higher Derivatives

Unit 2: Applications of Derivative **(10 Hours)**

2.1 Analysis of Curves

2.2 Maxima and Minima

2.3 Applications of Maxima and Minima

2.4 Newton's Method

2.5 The Differentials dx and dy.

2.6 Implicit Differentiation

2.7 Parametric Equations

Unit 3: Integration **(10 Hours)**

3.1 Antiderivatives

3.2 Method of Substitution

3.3 Tables of Integrals

3.4 Method of Partial Fractions

3.5 Trigonometric Substitutions

3.6 Integration by Parts

Recommended Book:

1. Jagdish C. Arya and Robin W. Lardner (1979), Mathematics for the Biological Sciences, Prentice-Hall, Inc.

Reference Book:

1. Erin N. Bodine, Suzanne Lenhart and Louis J. Gross, Mathematics for the Life Sciences, Princeton University Press, 2014.

2. Edward Batschelet, Introduction to Mathematics for Life Scientists, 3rd Edition (1979), Springer.

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MTS-291MN: (C) Mathematics for Computer Science-II (Computational Geometry)

Course type: Minor **No. of Credits: 02(T)**

Course Outcomes: Students will able to

1. Understand the fundamental concepts and mathematical representations of two-dimensional transformations, including translation, rotation, scaling, reflection, and shearing.

2. Apply transformation matrices to perform and combine 2D geometric transformations on points, lines, and simple shapes using homogeneous coordinates.

3. Analyze three-dimensional transformations such as scaling, shearing, reflection, and rotation about coordinate axes and planes, and their application in object manipulation.

4. Construct and interpret different types of projections, including orthographic, axonometric, and oblique projections, for visualizing 3D objects on 2D planes.

5. Develop parametric representations of common plane curves such as circles and hyperbolas, and generate these curves through mathematical methods.

6. Demonstrate the ability to integrate multiple transformation techniques and projections to solve basic computer graphics problems involving geometric modeling.