SOMAIYA VIDYAVIHAR

K J Somaiya College of Science & Commerce

Autonomous (Affiliated to University of Mumbai)

Somaiya TRUST

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Learning Outcomes based Curriculum Framework

(LOCF)

For

S.Y.B.Sc. Chemistry

Undergraduate Programme

From

Academic year

2024-25

Vision & Mission

Mission:

- Equip the student with knowledge and skills of their chosen vocation,
- Inculcate values.
- Provide them opportunities for all round growth and prepare them for life.

Vision:

- To equip the students with advanced knowledge and skills in their chosen vocation.
- To provide value-based education and opportunities to students.
- To help them to face challenges in life.
- To nurture a scientific attitude, temperament and culture among the students.
- To continually review, develop and renew the approach to build India of the Founder's dream.

Goals and Objectives:

- To build a strong Academia-Industry bridge.
- To provide flexibility in the courses offered and proactively adapt to the changing needs of students and the society.
- To establish a centre for multidisciplinary activities.
- To mould individuals who would nurture the cultural heritage of our country and contribute to the betterment of the society.

Board of studies in Chemistry

	Name	Designation	Institute/Industry
Head of the Department			
1	Dr. Bright O' Philip	Chairman	K J Somaiya college of science and commerce
Subject Expert nominated by Vice-Chancellor			
1	Prof. B. M. Bhanage (Inorganic chemistry)	Professor, Industrial and Engineering chemistry	ICT, Mumbai
Subject experts			
1	Prof. Kalpana Jain	Professor, and Principal	Royal College, Mumbai
2	Prof. Suresh Pawar	Professor, University department of Chemistry	University of Mumbai
3	Dr. Brijesh Singh	Head, Department of Chemistry	Jai Hind College
Representative from Industry/corporate sector/allied area			
1	Dr. Ajit Datar	Advisor	Shimadzu Analytical (I) Pvt. Ltd, Mumbai
2	Dr. P A Hasan	Scientific Officer H DIvision	BARC
Meritorious Alumnus			
1	Dr. Rajesh Rajshirke,	Senior Manager	Technology & Sourcing - Agricultural Solutions, BASF
2	Dr. Rikhil Shah	Lead, Intellectual	Avient

		Property Analyst	
3	Dr. Druman Utekar	Assistant Professor	K J Somaiya College of Engineering, Vidyavihar
Students Representative			
1	Mr. Shiv Gupta	Student	TYBSc Chemistry
2	Mr. Yash Shukla	Student	TYBSc Chemistry
3	Ms. Yogita Suvasiya	Student	SYBSc Chemistry
4	Tanishq Kumar	Student	SYBSc Chemistry
Faculty of the specialisation			
1	Dr. Pradnya. J. Prabhu	Principal	K J Somaiya college of science and commerce
2	Dr. Sugandha Shetye	Associate Professor	K J Somaiya college of science and commerce
3	Dr. Chitra Kamath	Associate Professor	K J Somaiya college of science and commerce
4	Dr. Veena Khilnani	Associate Professor	K J Somaiya college of science and commerce
5	Dr. Nishamol Kanat	Associate Professor	K J Somaiya college of science and commerce
6	Dr. Yogesh Ghalsasi	Associate Professor	K J Somaiya college of science and commerce
7	Dr. Vanita Kulkarni	Associate Professor	K J Somaiya college of science and commerce
8	Dr. Saurabh Shete	Assistant Professor	K J Somaiya college of science and commerce
9	Dr. Trupti Rane	Assistant Professor	K J Somaiya college of science and commerce

10	Dr. Rohit S. Chauhan	Assistant Professor	K J Somaiya college of science and commerce
11	Dr. Aniket Pawanoji	Assistant Professor	K J Somaiya college of science and commerce
12	Dr. Nanabhau Karanjule	Assistant Professor	K J Somaiya college of science and commerce
13	Dr. Dilip Kumar Yadav	Assistant Professor	K J Somaiya college of science and commerce
14	Dr. Afsar Ali Siddiki	Assistant Professor	K J Somaiya college of science and commerce
15	Dr. Mithun Mondal	Assistant Professor	K J Somaiya college of science and commerce
16	Mr. Jaidip Wable	Assistant Professor	K J Somaiya college of science and commerce
17	Dr. Amol Pawar	Assistant Professor	K J Somaiya college of science and commerce
18	Mrs. Meenakshi Wagh	Assistant Professor	K J Somaiya college of science and commerce
19	Mr. Sarang Gujar	Assistant Professor	K J Somaiya college of science and commerce

Foreword

Autonomy reflects efforts for excellence in academic performances, capability of self-governance and enhancement in the quality of education. In the year 2012, the UGC and University of Mumbai conferred the Autonomous Status to K J Somaiya College of Science and Commerce. Post this recognition and having several accolades to our credit, we made significant changes to our existing syllabi to reflect the changing business, industrial and social needs. A holistic education that provides opportunities to gain and share knowledge, experiment and develop beyond curriculum, is offered at our College.

Autonomous college carries a prestigious image for the students and the teachers and we have made a collaborative attempt to maintain a high level of quality in the standard of education that we impart.

Structured feedback obtained from the students, alumni and the experts from the industry and the changes suggested by them were duly incorporated in the syllabi. The Board of Studies constituted for each department meets to carry out in depth discussions about different aspects of the curriculum taking into cognizance the recent trends in the discipline.

The IQAC team has facilitated the conduct of a number of workshops and seminars to equip the faculty with the necessary skill set to frame the syllabi and competencies to deliver the same. Training was also provided to employ innovative evaluation methods pertaining to higher cognitive levels of revised Bloom's taxonomy. This

ensured the attainment of the learning outcomes enlisted in the syllabus. Audits are conducted to critically review the practices undertaken in teaching, learning and evaluation. Innovative learning methodologies such as project-based learning, experiential learning and flip- class learning practiced by a committed fleet of faculty, supported by several hands have been our unique outstanding propositions. All efforts have been made to nurture the academic ambitions as well as the skills in co-curricular activities of the most important stakeholder i. e. student.

With sincere gratitude, I acknowledge the constant support and guidance extended by Shri Samir Somaiya, President- Somaiya Vidyavihar, and all the esteemed members of the Governing board and Academic council of the College. I also would like to acknowledge the Heads of the Departments and all the faculty members for their meticulous approach, commitment and significant contribution towards this endeavour for academic excellence.

Dr. Pradnya Prabhu
Principal

Acknowledgement

At the outset, I would like to thank our Principal Dr. Pradnya Prabhu for her guidance and support during the curriculum restructuring process. I am also grateful to all the esteemed members of the Board of Studies, for their constructive suggestions and contributions.

Above all, I am deeply indebted to all the young and vibrant colleagues in the Department of Chemistry for the long and arduous work they have put in during the compiling of the restructured syllabus.

Dr. Bright O' Philip
Chairperson
Board of Studies in Chemistry

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Preamble

Chemistry is an indispensable part of our day-to-day life. We are surrounded everywhere with chemicals and their effects on our environment. All living organisms are mainly comprised of protein, fat, carbohydrate and minerals made up of basic constituent carbon, hydrogen, nitrogen, sulphur and water. Basically, chemistry is the branch of science which deals with study of matter, their properties and the energy changes involved during any process. Chemical technologies enrich our quality of life by providing new solutions to problems in health, material energy usage. Hence study of Chemistry prepares the student to meet challenges of the future.

Education is one of the most critical yardsticks in any country's development. The new National Education Policy (NEP) 2020 is an essential and comprehensive policy framework that aims to revamp the country's educational system from its foundation and to bring it at par with global standards. The larger aim of this policy is to transform the Indian education system by making it more inclusive, flexible and relevant to the changing needs of the society. Some of the key features of this policy are the introduction of vocational training, elective courses, emphasis on cultural studies, development of global skill sets and the promotion of multilingualism.

The policy seeks to bring about significant changes in the Higher Education structure, such as introducing a four-year undergraduate degree Programme, establishing multidisciplinary education and research universities, pooled credit bank and creating a National research Foundation to promote and support research activities in various fields. The new education policy enables every student to get quality education irrespective of their socio-economic background, gender

or disability. NEP 2020 enables teachers to use a variety of learning techniques and experiments.

In the current fast paced world, simply cascading the knowledge in the classroom is not sufficient especially when the global requirements keep changing. Every learner should be encouraged to exchange ideas and thoughts in a collaborative approach. This leads to develop an environment which is cognitive in nature and not a one-way information flow. Keeping all this in mind, the curriculum under Learning Outcome-based Curriculum Framework (LOCF) is designed.

This Learning Outcome-based Curriculum Framework (LOCF) supports the fundamental principle of providing quality education in India. Our focus is to involve young minds to participate, contribute and add value at each stage in the field of their study. The introduction of Choice Based Credit System (CBCS) has maximized the benefits of the newly designed curriculum in multiple folds.

The LOCF will certainly help teachers to envisage the outcome expected from the learners at the end of the programme. For students, it will be a guide which shows how this curriculum will help them acquire all the skills and knowledge which are essential in their personal and academic growth. Higher education qualifications such as Bachelor's Degree Programme are awarded on the basis of demonstrated achievement of outcomes and academic standards; and this is the very essence of this curriculum.

1. Introduction

The B.Sc. Chemistry programme is developed by keeping in mind interest of learners to explore the field of chemistry. The framework helps to maintain the standard of chemistry degrees/programmes through periodic programme review within a broad framework of agreed/expected graduate attributes, qualification descriptors, programme learning outcomes and course-level learning outcomes. The BSc programme is planned in such a way that it allows flexibility and innovation in programme design, syllabi development, teaching-learning process and quality assessment of students learning levels.

This curriculum framework is developed on the principles of student centric learning pedagogy. The platform intents to empower graduates with the skills required for pursuing Chemistry-related careers, higher education in Chemistry and allied subjects.

Various graduate attributes are emphasised in this framework such as critical thinking, basic psychology, scientific reasoning, moral ethical reasoning, etc. While designing this framework, an important aspect considered was the measurable teaching-learning outcome to ensure employability of the graduates. Implementation of modern pedagogical tools and concepts such as flip-class, hybrid learning, MOOCs and other e-learning platforms are suggested through this framework. The framework also focuses on issues relevant to India and also of the rest of the world;

Every course is designed in such a way that students get decent exposure to each topic by keeping an equilibrium between these topics and thus creating interest to pursue further education in the field of Chemistry. It covers the basic concepts of Chemistry to establish a strong foundation of the subject and helps students to explore the subject more. Topics varying from synthetic organic chemistry, stereochemistry, spectroscopy, environmental chemistry, polymers, coordination

chemistry, bio-organic chemistry, physical chemistry, analytical chemistry, group theory & its applications, quantum mechanics etc are taught. Chemical industry, Renewable and non-renewable sources of organic compounds, Green chemistry and Nanochemistry are taught as choice-based core course in semester III and IV. Business skills for chemist, Gas and liquid chromatography, Chemistry of cosmetics and Dairy chemistry are taught as skill enhancement course in semester V and VI respectively.

The practical sessions will help the students to gain sufficient skills in chemical analysis, preparations, solvent extraction, chromatography, as well as quantitative analysis. Students are also encouraged to improve their scientific writing skills through various assignments. The research-based project work in the curriculum ensures team building attitude within students and utilise every aspect of the team members in the success of any project. The project evaluation method is designed in such a way that it helps in creating a strong background for the research, skills to generate systematic reports and create effective presentation.

2. Learning Outcome based Curriculum Framework

LOCF focuses on curriculum framework, curriculum aims, learning targets and objectives. The curriculum framework also provides examples of effective learning, teaching and assessment practices. As the curriculum development is a collaborative and an on-going enhancement process, the LOCF instructs periodic reviews and revisions of the curriculum in accordance with the everchanging needs of students, teachers and society.

The framework describes how students are given exposure towards core knowledge of the subject, specialisation, choice based learning and other skill enhancement courses ensuring development of an integrated personality and employability. The template defines expected outcomes for the programme like core competency, communication skills, critical thinking, affective skills, problem-solving, analytical, reasoning, research-skills, teamwork, digital literacy, moral and ethical awareness, leadership readiness along with specific learning course outcomes at the starting of each course. The Learning Outcomes based Curriculum Framework (LOCF) for B.Sc. with Chemistry will certainly be a valuable document in the arena of outcome-based curriculum design.

2.1 Nature and extent of B.Sc. Chemistry

Degree programme in Chemistry is designed to include cutting edge and core topics from Physical, Inorganic, Organic and Analytical chemistry in a perfect balance. The scope of individual topics varies with the nature of specific chemistry branch. In our endeavour to improve the employability of graduates of chemistry programme, the curriculum offers courses on business skills in chemistry and food/cosmetic analysis. The B.Sc. chemistry programme is of three years duration. Each year is divided into two semesters. The total numbers of semester are six. The

teaching and learning in the B.Sc. chemistry programme will involve theory classes (lectures) and practical.

The curriculum will be taught through formal lectures with the aid of power-point presentations, audio and video tools and other teaching aids can be used as and when required. Wherever possible RBPT approach will be adopted to make the process of learning more learner-centric. ICT-based teaching-learning tools will be incorporated through which even the mundane aspects could be made more interesting and relevant.

2.2 Programme Education Objectives (PEOs)

The overall aims of bachelor's degree programme in chemistry are to:

1. Create a great learning environment for students to inculcate deep interests in chemistry.
2. Provide choice-based learning to students.
3. Empower students by providing appropriate tools of analysis to address issues and problems in the field of chemistry
4. Help students to develop the ability to use their knowledge and skills to handle the specific theoretical and applied problems in chemistry
5. Encourage students to pursue advanced studies related to chemistry by creating a strong and profound base of fundamental concepts.
6. Assist students to develop an array of generic skills which are helpful in creating employment and business opportunities.

3. Graduate Attributes in chemistry

Attributes expected from the graduates of B.Sc. Chemistry Programme are:

GA 1: Comprehensive knowledge and understanding of various concepts and theoretical principles in the field of chemistry and its different sub-fields.

GA 2: Information of safe handling of chemicals and role of chemistry while addressing environmental issues

GA 3: Proficiency in qualitative and quantitative laboratory techniques

GA 4: Ability to construct a research problem and communicate the results of scientific work in oral, written and e- formats.

GA 5: Sense of critical thinking and problem-solving skills in theoretical and applied chemistry.

GA 6: Enthusiasm for working individually and in diverse teams through interdisciplinary projects

GA 7: Respect for professional ethics and responsibilities of the chemical science practice

GA 8: Knowledge of subject-related and transferable skills that are relevant to chemistry related job trades and employment opportunities

4. Qualification descriptors

Undergraduate degree programmes of either 3 or 4-year duration, with multiple entry and exit points and re-entry options, with appropriate certifications such as:

- a UG certificate is awarded to students who opt to exit after completing 1 year (2 semesters) of study in the chosen fields of study with having secured 44 credits and in addition, they complete one vocational course of 4 credits during the summer vacation of the first year. These students are allowed to re-enter the degree programme within three years and complete the degree programme within the stipulated maximum period of seven years.
- a UG diploma is awarded to students who opt to exit after 2 years (4 semesters) of study with having secured 88 credits and in addition, they complete one vocational course of 4 credits during the summer vacation of the second year. These students are allowed to re-enter within a period of three years and complete the degree programme within the maximum period of seven years.
- a bachelor's degree is awarded after a 3-year (6 semesters) programme of study in major discipline with having secured 132 credits and minimum credit requirements as follows

Sr. No.	Category of Courses	Minimum credit requirements
1	Major Core Course	48
2	Minor Stream Course	20
3	Discipline Specific Elective Course	06
4	Ability Enhancement Course	08
5	Skill Enhancement Course	06
6	Value Education Course	04

7	Vocational Skill Course	08
8	Indian Knowledge System	02
9	Co-curricular Course	20
10	Open Elective Course	10
Total		132

- After completing the requirements of three year Bachelor's degree, candidate who meet the minimum CGPA of 7.5 shall be allowed to continue studies in the fourth year of undergraduate program to pursue and complete Bachelor's degree with honours/research (subject to change).
- a 4-year bachelor's degree (honours) is awarded after eight semesters programme of study with having secured 176 credits and minimum credit requirements as follows:

Sr. No.	Category of Courses	Minimum credit requirements
1	Major Core Course	76
2	Minor Stream Course	24
3	Discipline Specific Elective Course	14
4	Ability Enhancement Course	08
5	Skill Enhancement Course	06
6	Value Education Course	04
7	Vocational Skill Course	08
8	Indian Knowledge System	02
9	Co-curricular Course	24
10	Open Elective Course	10
Total		176

- They should do a research project or dissertation under the guidance of a faculty member of the University/College. The research project/dissertation will be in the major discipline. The students who secure 176 credits, including 12 credits from a research project/dissertation, are awarded UG Degree with Research.

The 4-year bachelor's degree programme is considered a preferred option since it would provide the opportunity to experience the full range of holistic and multidisciplinary education in addition to a focus on the chosen major and minors as per the choices of the student.

Upon successful completion of the programme, students receive B.Sc. degree in the Chemistry. B.Sc. Chemistry graduates of this department are expected to demonstrate the extensive knowledge of various concepts of chemistry and its application thus contribute in research, development, teaching, government and public sectors. This programme will establish a foundation for student to further pursue higher studies in chemistry. The list below provides a synoptic overview of possible employment areas provided by an undergraduate training in chemistry.

The list below provides a synoptic overview of possible career paths provided by an undergraduate training in Chemistry:

1. Academics
2. Research
3. Pharmaceutical company
4. Chemical Industry
5. Polymer Industry
6. Agrochemical Industry
7. Forensic science department
8. Oil and gas sectors

9. Cosmetic industry
10. Paints and dyes
11. Energy
12. Petrochemical Industry
13. Environmental monitoring and analysis
14. Packaging technology

Job Roles for B.Sc. Chemistry graduate:

After graduation one can seek a professional career as:

1. Lab chemist
2. R & D Chemist
3. Production officer
4. Quality control chemist
5. Academist
6. Environment analyst
7. Project fellow
8. Entrepreneur
9. Civil services
10. Competitive exams

Higher Education options for B.Sc. chemistry graduate:

1. M.Sc. in general chemistry/analytical chemistry/organic chemistry/physical chemistry/Drug chemistry/ Pharmaceutical chemistry/Environment chemistry/Polymer chemistry
2. Integrated M.Sc.-Ph.D. in Chemistry
3. PG Diploma in advance instrumental analysis/drug design/Intellectual Property rights/ Clinical research, etc

4. Courses in management
5. B.Ed

The learners who complete three years of full-time study of an undergraduate programme of study will be awarded a Bachelor's degree in chemistry.

5. Programme Specific Outcomes (PSOs)

After the successful completion of modules in different courses of B.Sc. Chemistry, the learner will be able to:

PSO I: Discuss the fundamental concepts in Physical, Inorganic, Organic and Analytical Chemistry.

PSO II: Relate Cutting-edge Knowledge acquired in different fields of chemistry such as mechanisms of organic and inorganic reactions, thermodynamics, Nanoscience, and Nuclear Chemistry to develop state of the art technologies for improving the quality of life.

PSO III: Use analytical skills, problem solving skills requiring applications of chemical principles.

PSO IV: Synthesize, separate and characterize compounds using laboratory and instrumentation techniques.

PSO V: Apply good laboratory practices and safety principles and create awareness about environmental issues.

PSO VI: Justify the central role of chemistry in society and have preparedness in lifelong learning of technological change.

5.1 Course Mapping

Semester	PSO / Course	I	II	III	IV	V	VI
III	MJ I	√	√	√		√	√
	MJ II	√	√	√	√	√	√
	MN						
	SEC	√	√	√	√	√	√
	VSC	√	√	√	√	√	√
	AEC						
	CC						
	OE						
	IKS						
IV	MJ I	√	√	√			√
	MJ II	√	√	√	√	√	√
	MN						
	SEC	√	√	√	√	√	√
	VSC	√	√	√	√	√	√
	AEC						
	CC						
	OE						

6. Structure of B.Sc. chemistry programme

The curriculum frame work is designed around the choice-based credit system (CBCS). The programme consists of three years UG having six semesters (two semesters per year) or four years UG (Honours) having eight semesters (two semesters per year). Credit Distribution for Eight Semester is as follows:

Semester	MJ	DSE	SEC	VSC	MN	AEC	VEC	IKS	CC	FP	INT/ APT	OE	Total
I	6	-	-	-	6	4	2	-	2	-	-	2	22
II	6	-	-	-	6	3	2	1	2	-	-	2	22
III	6	-	3	2	4	1	-	1	2	-	-	3	22
IV	6	-	3	2	4	-	-	-	2	2	-	3	22
V	12	-	-	-	-	-	-	-	-	2	8	-	22
VI	12	6	-	4	-	-	-	-	-	-	-	-	22

BSc with Honours – 22 credits in Sem VII and VIII

BSc with Research – 22 credits in Sem VII and VIII

To acquire a degree in B.Sc. chemistry a learner must study

1. **Major Core Courses (MJ):**

a) A course which is required to be opted by a candidate as a major core course. The course designed under this category aims to cover the basics that a student is expected to imbibe in that particular subject or discipline.

b) Students may be allowed to change major within the broad discipline at the end of the second semester by giving her/him sufficient time to explore interdisciplinary courses during the first year.

c) There are twenty four Major Core courses (MJ), two each, in semesters I to IV; and four each in semesters V and VIII.
d) Each Major Core Courses is compulsory.
e) Each Major Core Course from semester I to VI is comprised of 2 credits for theory ie. 30 hours; 2 lectures of each 1 hr per week and 1 credit for practical of two hours per week in every semester.
f) Each Major Core Course from semester VII and VIII is comprised of 2 credits for theory ie. 30 hours; 2 lectures of each 1 hr per week and 1.5 credit for practical of three hours per week in every semester.
g) The purpose of fixing major core papers is to ensure that the institution follows a minimum common curriculum so as to adhere to common minimum standards with other universities/institutions.

2. Minor Stream Course (MN):

a) A course is chosen by a candidate from interdisciplinary stream as a minor course. Minor Stream course helps a student to gain a broader understanding beyond the major discipline.
b) Students who take a sufficient number of courses in interdisciplinary area of study other than the chosen major will qualify for a minor in that discipline.
c) Students may declare the choice of the minor stream course at the end of the second semester after exploring various courses.
d) There are two each Minor stream course (MN), in semesters I and II. This Minor stream is comprised of 2 credits for theory ie. 30 hours; 2 lectures of each 1 hr per week and 1 credit for practical of two hours per week in every semester.
e) There is one each Minor stream course (MN) in semester III and IV. This Minor stream is comprised of 2 credits for theory ie. 30 hours; 2 lectures of

each 1 hr per week and 2 credits for practical of four hours per week in every semester.

f) Each Minor stream Courses is compulsory.

3. Ability Enhancement Courses (AEC)

a) The courses aim at enabling the students to acquire and demonstrate the core linguistic skills, including critical reading and expository and academic writing skills, that help students articulate their arguments and present their thinking clearly and coherently and recognize the importance of language as a mediator of knowledge and identity.

b) Students are required to achieve competency in a Modern Indian Language (MIL) and in the English language with special emphasis on language and communication skills.

c) There are five AE courses in spread over three semesters (I to III).

d) Each student is supposed to take two AE in semester I - English language and Modern Indian language of 2 credits each.

e) There are two AE in semester 2 - English language of two credits and Modern Indian language of 1 credit.

f) There is one AE in semester 3 - Modern Indian language of 1 credit.

4. Value Education Courses (VEC)

a) The course seeks to equip students with the ability to apply the acquired knowledge, skills, attitudes and values required to take appropriate actions for mitigating the effects of environmental degradation, climate change, and pollution, effective waste management, conservation of biological diversity, management of biological resources, forest and wildlife conservation, and sustainable development and living.

b) The VEC courses offered are:

VEC I- Environmental Science I (2 credits) (Semester I),

VEC II- Environmental Science II (2 credits) (Semester II).

5. Co-Curricular courses (CC):

a) They are designed to provide skill-based knowledge and contain both lab/hands on training/field work.

b) The main purpose of these courses is to provide life skills in hands-on mode to increase employability.

c) There are two CC each in semester I to III – NCC (compulsory 1 credit course) and Other one from Music/Sports training program/Yoga/ Study Circle

d) There are three CC each in semester IV – NCC (compulsory 1 credit course), second one from Music/Sports training program/Yoga/ Study Circle of 1 credit and third one is Field project of 2 credits.

6. Open Elective (OE)

a) They are designed to provide multidisciplinary education.

b) Students can opt for one interdisciplinary Open Elective Course (OE) in each of the semester I and II of two credit each.

c) Students can opt for one interdisciplinary Open Elective Course (OE) in each of the semester III and IV of three credit each.

d) Open courses are offered in cognate disciplines by different departments in the college.

7. Indian Knowledge System (IKS)

a) They are designed to recognizes the rich heritage of ancient and eternal Indian knowledge and thought as a guiding principle.
b) Students can opt for one General IKS in semester II – Indian cultural Heritage of one credit.
c) There is one IKS based on major subject in semester III of 1 credit.

8. Skill Enhancement Course (SEC):

a) They are designed to provide skill-based knowledge pertaining to the Major course to the learner.
b) The main purpose of these courses is to provide life skills in hands on mode to increase employability.
c) There are Two skill enhancement courses offered. Each student is supposed to take one SEC in each semester III and IV of 3 credit each (2 credit theory and 1 credit practical).

9. Discipline Specific Elective Courses (DSE):

a) Elective courses offered under the major course subject of study.
b) There are two discipline specific elective courses (DSE), offered in semesters VI of 2 credits theory and 1 credit practical.
c) There is one discipline specific elective course (DSE), offered in semesters VII and VIII each of 2 credits theory and 2 credit practical.
d) There is one advance level disciplinary course – Research Methodology of 4 credits offered in semester VII.

10. Vocational Skill Course (VSC)

a) Vocational courses are designed to provide practical, hands-on training, competencies, and proficiency to students, ultimately enhancing their skills and employability.
b) These courses are tailored to prepare individuals for specific careers and industries.
c) There are two VSC offered one each in semester III to IV, each one is of two credts.
d) There is one VSC offered in semester VI of 4 credits.

11. On Job Training (OJT)

a) On Job training of 4 credits is offered in semester VIII to enhance the specific skills and competencies required for a particular job
b) OJT bridges the gap between theory and practical application, promoting a deeper understanding of concepts.

Internship/ Apprenticeship have a prominent role in linking higher education with the requirements of industry and the world of work. Students are offered internship/ apprenticeship embedded degree program to fulfil the objective of improving employability and forming robust industry academia linkage.
Internship/Apprenticeship of 8 credits is offered in semester V.

Field based learning /project will provide opportunities for students to understand the different socio-economic contexts. It aims at giving the students exposure to development related issues in rural and urban settings.

Two field projects each 2 credits are offered one in each semester IV and V

6.1 Content

Sr. No	Semester	Course number	Course Code	Course title
1	III	MJ I	24US3CHMJIPAC1	Physical and Analytical Chemistry I
2		MJ II	24US3CHMJ2OIC1	Organic and Inorganic chemistry I
3		MJ P	24US3CHMJP	Based on MJ I and MJ II
4		MN		Course from Biochemistry/ Physics/ Mathematics/ Physics/ Microbiology/ Botany/ Zoology/ Geology
5		MN P		Based on MN
6		SEC	24US3CHSECGCS	Green Chemistry and Stereochemistry
7		SECP	24US3CHSECP	Based on SEC
8		IKS	24US3CHIKSAIC	Ancient Indian Chemistry
9		VSC	24US3CHVSCP	Environmental Monitoring
10		AEC		
11		CC		
12		OE		
13	IV	MJ I	24US4CHMJIPAC2	Physical and Analytical Chemistry II
14		MJ II	24US4CHMJ2OIC2	Organic and Inorganic

				chemistry II
15		MJ P	24US4CHMJP	Based on MJ I and MJ II
16		MN		Course from Biochemistry/ Physics/ Mathematics/ Physics/ Microbiology/ Botany/ Zoology/ Geology
17		MN P		Based on MN
18		SEC	24US4CHSECNAR	Nanochemistry and Retrosynthesis
19		SECP	24US3CHSECP	Based on SEC
20		VSC P	24US4CHVSCP	Analysis of pharmaceutical products as per IP/BP/USP
21		AEC		
22		CC		
23		OE		

6.2 Credit distribution for S.Y.B.Sc. Chemistry

Semester	Course number	Course title	Credits		
			Theory	Practical	Total
III	MJ I	Physical and Analytical Chemistry I	2	1	3
	MJ II	Organic and Inorganic chemistry I	2	1	3
	MN	Course from Biochemistry/ Physics/ Mathematics/ Physics/ Microbiology/ Botany/ Zoology/ Geology	2	2	4
	SEC	Green Chemistry and Stereochemistry	2	1	3
	VSC	Environmental monitoring	-	2	2
	IKS	Ancient Indian Chemistry	1	-	1
	AEC		1	-	1
	CC		2	-	2
	OE		3		3
	Total				22
IV	MJ I	Physical and Analytical Chemistry II	2	1	3
	MJ II	Organic and Inorganic chemistry II	2	1	3
	MN	Course from Biochemistry/ Physics/ Mathematics/ Physics/ Microbiology/	2	2	4

		Botany/ Zoology/ Geology			
	SEC	Nanochemistry and Retrosynthesis	2	1	3
	VSC	Analysis of pharmaceutical products as per IP/BP/USP	-	2	2
	CC		2 + 2FP	-	4
	OE		3		3
	Total				**22**

6.3 Semester Schedule

Semester	Major Core Courses (MJ)	Minor Stream Courses (MN)	Skill Enhancement Courses (SEC)	Vocational Skill Course (VSC)	Indian Knowledge System (IKS)	Ability Enhancement Courses (AEC)	Co-Curricular Course (CC)	Open Elective (OE)
III	1]MJ I Physical and Analytical Chemistry I 2] MJ II Organic and Inorganic chemistry I	MN Course from Biochemistry/ Physics/ Mathematics/ Physics/ Microbiology/ Botany/ Zoology/ Geology	Green chemistry and Stereochemistry	Environment Monitoring	Ancient Indian Chemistry			
IV	1] MJ I Physical and Analytical Chemistry II 2] MJ II Organic and Inorganic chemistry II	1] MN Course from Biochemistry/ Physics/ Mathematics/ Physics/ Microbiology/ Botany/ Zoology/ Geology	Nanochemistry and Retrosynthesis	Analysis of pharmaceutical products as per IP/BP/USP	-			

6.4 Course Learning Objectives

The three-year undergraduate Chemistry programme is designed to familiarize students with significant developments in Chemistry. The objective of structured syllabus in Chemistry is to make the concepts and basics of Chemistry clear and interesting to students and also to ensure the development of vertical growth in the subject. The idea behind this is to enable students to develop analytical skills and critical thinking.

It is our attempt that students achieve this objective through systematic reading and class lectures and through feedback on their written work-assignments, project/research papers, presentations, discussions, debates, etc. our intention is to enable students to formulate cogent arguments, presenting the necessary evidence to establish these, based on a training in Chemistry.

7. Detailed B.Sc. Chemistry Syllabus

S. Y. B.Sc. Syllabus with effect from the Academic year 2024–2025

Syllabus - S. Y. B.Sc. Chemistry

Course No.	Course Title	Course Code	Credits	Periods (1 Hr)	Module	Lectures per module (1 hr)	Examination		
							Internal Marks	External Marks	Total Marks
SEMESTER III									
Major Core courses THEORY									
I	Physical and Analytical Chemistry I	24US3CHMJ 1PAC1	2	30	2	15	20	30	50
II	Organic and Inorganic chemistry I	24US3CHMJ 2OIC1	2	30	2	15	20	30	50
Core courses PRACTICAL									
		24US3CHMJ P	2	60			CIA		50
SEMESTER IV									
Major Core courses THEORY									
I	Physical and Analytical Chemistry II	24US4CHMJ 1PAC2	2	30	2	15	20	30	50
II	Organic and Inorganic chemistry II	24US4CHMJ 2OIC2	2	30	2	15	20	30	50
Core courses PRACTICAL									
		24US4CHMJ P	2	60			CIA		50

S.Y. B. Sc. (CHEMISTRY) SEMESTER III

Major Core Course- I

COURSE TITLE: Physical and Analytical Chemistry-I

COURSE CODE: 24US3CHMJIPAC1 [CREDITS - 02]

Course Learning Outcome		
After the successful completion of the Course, the learner will be able to: 1. Find the role of photochemical and photophysical phenomena in our life 2. Identify strong and weak electrolytes in terms of conductance of solutions. 3. Apply appropriate gravimetric or titration method for quantitative analysis.		
Module 1	**Photochemistry and Solutions of Electrolyte**	**[15L]**
Learning Objectives: The module is intended to 1. Introduce basic concepts of photochemistry and its significance in our Life 2. Impart the knowledge about properties of electrolytic solutions.		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Explain the Jablonski diagram, radiative and non-radiative transitions, fluorescence, and phosphorescence. 2. Describe the primary and secondary processes of photochemical reactions with suitable examples.		
1.1	**Photochemistry**	**8L**
1.1.1	Consequences of light absorption- The Jablonski	2

	diagram, radiative and non -radiative transitions, fluorescence and phosphorescence, Singlet and triplet states, Energy transfer in photochemical reactions: Photosensitization, Bioluminescence, Chemiluminescence,	
1.1.2	Laws of photochemistry- Grotthus Drapers law and Stark Einstein Law, Definition of energy of a photon and einstein in different unit, quantum efficiency, reasons for low and high quantum yield, experimental determination of quantum yield,	4
1.1.3	Mechanism of photochemical reactions: a. Primary and secondary processes with suitable examples: 1) Reaction between hydrogen and chlorine, 2) Dissociation of hydrogen iodide b. Photocatalysis and its applications	2
1.2	**Solutions of Electrolytes**	**7L**
1.2.1	Electronic and electrolytic conductors, conductance, specific conductance, equivalent conductance, molar conductance, variation of molar conductance with concentration for strong and weak electrolytes. Concept of limiting molar conductance.	
1.2.2	Debye-Huckel theory of conductance of strong electrolytes. Ionic atmosphere, relaxation effect, electrophoretic effect.	
1.2.3	Kohlrausch's law of independent migration of ions, applications of the law – determination of limiting	

	molar conductance of weak electrolytes, determination of dissociation constant of a weak acid, determination of solubility product of a sparingly soluble salt. Transport Number	

References:

- Photochemistry - Principles of Physical Chemistry, Puri, sharma, Pathania, Vishal Publishing House, pg 1112-1146, 46th. Ed.
- Electrolyte Solution, R. A. Robinson and R.H. Stokes, Second Revised Edition, Butterworth & Co (Publishers) Ltd.

Module 2	Gravimetric and Volumetric Analysis II	[15L]

Learning Objectives:

The module is intended to explain basic gravimetric and titrimetric methods for quantitative analysis.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Explain the steps involved in gravimetric analysis.
2. Discuss the basic concepts and methodology of complexometric and precipitation titrations.

2.1	**Gravimetric Analysis:** Basic principle recapitulation. Mechanism of precipitation, Von Weimarn theory, digestion, filtration and washing. Role of organic precipitants in gravimetric analysis.	5L
2.2	**Volumetric Analysis** **Complexometric titrations:** General introduction to	10L

	Complexes and factors affecting complexation. Use of EDTA as a titrant, absolute and conditional stability constant of metal-EDTA complexes, Types of EDTA titrations, methods for increasing selectivity of EDTA titrations.Theory of metallochromic indicators-examples and uses, Applications of EDTA titrations. **Precipitation Titrations** Introduction, theoretical aspects of precipitation, basic conditions for precipitation, Argentometric titration, construction of titration curves, Mohr's method, Volhard's method for determination of halides, Use of adsorption indicators.	

References:

- Fundamentals of Analytical Chemistry by Skoog, Holler and Nieman, Saunder Publications Ninth edition
- Inorganic quantitative analysis by Vogel, Longmans publications, Sixth edition.

Question Paper Template

S.Y. B. Sc. (CHEMISTRY) SEMESTER III

Major Core Course- I

COURSE TITLE: Physical and Analytical Chemistry I

COURSE CODE: 24US3CHMJIPAC1 [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	5	5	8	4	3	-	25
II	5	9	3	4	4	-	25
Total marks per objective	10	14	11	8	7	-	50
% Weightage	20	28	22	16	14	-	100

S.Y. B. Sc. (CHEMISTRY) SEMESTER III

Major Core Course- II

COURSE TITLE: Inorganic and Organic Chemistry - I

COURSE CODE: 24US3CHMJ2IOCI [CREDITS - 02]

Course Learning Outcome		
After the successful completion of the Course, the learner will be able to: 1. Explain the chemistry of coordination compounds. 2. Describe general methods used to synthesize organometallic compounds of main group elements. 3. Illustrate the synthesis, chemical reactivity and applications of carbonyl compounds and epoxides.		
Module 1	Chemistry of Coordination compounds and Organometallic chemistry	[15L]
Learning Objectives: The module is intended to 1. Describe the basic concepts involved in coordination chemistry. 2. Understand the basic theories of bonding in coordination compounds. 3. Describe general methods used to synthesize organometallic compounds of main group elements.		
Learning Outcome: After the successful completion of the module, the learner will be able to: 1. Illustrate applications of coordination compounds in various fields such as Photography, qualitative estimation, volumetric estimation, metallurgy, colorimetry and spectrophotometry. 2. Predict the isomerism in coordination compounds.		

3. Recognize chemical reactions of organometallic compounds.		
1.1	**Chemistry of coordination compounds**	**9L**
1.1.1	Basic concepts: Distinction between double salts and coordination compounds. Terms involved in coordination chemistry, complex ion, ligands. Ambidentate ligands: NO_2^- SCN^-, CN^- $S_2O_3^{2-}$ Bridging ligands: OH^-, NH_2^-, NH_2^-, O_2^{2-}, NO_2^- Flexidentate ligands: SO_4^{2-}, CO_3^{2-} Chelating ligands	
1.1.2	Werner's theory of coordination compounds and EAN. (Problem based)	
1.1.3	Isomerism: Conformation: Ionisation, Hydrate, coordination, linkage, coordination position, ligand, polymerization. Stereoisomerism: Geometrical isomerism in square planar and octahedral geometry Optical isomerism	
1.1.4	Applications of coordination compounds, Complex formation in various fields: Photography, qualitative estimation, volumetric estimation, metallurgy, colorimetric and spectrophotometry	
1.2	**Organometallic compounds of main group elements**	**6L**
1.2.1	Introduction: General synthetic methods. (i) direct reaction of metals (Oxidative addition), (ii) Metal-Metal exchange (Transmetallation reactions), (iii) Carbanion-Halide exchange reaction (Metathesis), (iv) Metal-Hydrogen exchange (Metallation reaction)	

1.2.2	Chemical reaction: (i) Reaction with oxygen and halogens, (ii) Alkylation and arylation reactions, (iii) Reaction with protic reagents, (iv) Redistribution reactions.	

References:

- Satyaprakash, G. D. Tuli, S. K. Basu, Advanced Inorganic Chemistry, Vol. 1.
- Satyaprakash, G. D. Tuli, S. K. Basu, Advanced Inorganic Chemistry, Vol. 2.

Module 2	Chemistry of carbonyl compounds, and epoxides	[15L]

Learning Objectives:

This module is intended to

1. Explain the preparation and applications of carbonyl compounds and epoxides
2. Discuss the characteristic reactions of carbonyl compounds and epoxides

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Evaluate the importance of carbonyl compounds and epoxides in organic chemistry
2. Illustrate the preparation methods and reactions of carbonyl compounds and epoxides
3. List the applications of carbonyl compounds and epoxides

2.1	**Aldehydes and Ketones**	7L
2.1.1	Preparation of aldehydes using: terminal geminal dihalides, acid chlorides (Rosenmund Reduction), nitriles (Using Dibal-H), CO (Gattermann- Koch reaction), HCN (Gattermann reaction), $DMF/POCl_3$ (Vilsmeier Haack reaction), side chain chlorination of alkyl benzene and	

	Phenol (Reimer-Tiemann reaction).	
2.1.2	Preparation of ketones using: non-terminal geminal dihalides, acid chlorides (using Grignard reagent), nitriles (Using Grignard reagent) and Aromatic compounds (Friedel-Crafts acylation)	
2.1.3	General reactions of aldehyde and ketones: Reaction with HCN, ROH, $NaHSO_3$, NH_2-G derivatives. Haloform reaction, Aldol Condensation, Knoevenagel reaction, Cannizzaro's reaction, Clemensen reduction, Wolff Kishner reduction.	
2.2	**Carboxylic acids**	5L
2.2.1	Preparation of Carboxylic acids using: Alcohol, Esters, Amides. Grignard reagents, Nitriles, side chain oxidation of alkyl benzenes and Phenol (Kolbe-Schmidt reaction)	
2.2.2	Factors affecting acidity of carboxylic acid. Reactions of carboxylic acids: Conversion to ester, acid chloride, amide and anhydride. Reduction and decarboxylation of carboxylic acid.	
2.3	**Epoxides**	2L
2.3.1	Preparation using: olefins, vicinal halohydrins.	
2.3.2	Reactivity of epoxides Reactions:. Ring opening reactions by nucleophiles (a) In acidic conditions; hydrolysis, reaction with – HX, alcohol, HCN. (b) In neutral or basic conditions: ammonia, amines, metal cyanides, Grignard reagents, alkoxides.	
2.4	Applications of aldehyde, ketone, carboxylic acids and epoxides (including chiral epoxides)	1L
References:		

- Morrison R.T. and Boyd, R.N. Organic chemistry, Dorling Kindersley (India) pvt. Ltd. (Pearson Education), 2012.
- Mc Murry, J.E.Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
- B.Y.Paula Organic Chemistry 8th edition, 2020, Pearson.

Question Paper Template

S.Y. B. Sc. (CHEMISTRY) SEMESTER III

Major Core Course- II

COURSE TITLE: Inorganic and Organic Chemistry - I

COURSE CODE: 24US3CHMJ2IOC1 [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	5	5	5	5	5	-	25
II	5	5	5	5	5	-	25
Total marks per objective	10	10	10	10	10	-	50
% Weightage	20	20	20	20	20	-	100

S. Y. B. Sc. (CHEMISTRY)

SEMESTER III – Major Core Course Practical

COURSE CODE: 24US3CHMJP Credit- 02

Learning Objectives:

The Practical is intended to

1. Investigate the amounts of solutes using instrumental methods of analysis.
2. Discuss the Semi Micro Qualitative Analysis for an inorganic mixture
3. Discuss the estimation of the amount of organic compound in the given solution

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Estimate the amount of solute present in a given solution using instrumental methods.
2. Use the Semi Micro Qualitative Analysis for an inorganic mixture.
3. Estimate the amount of organic compound in the given solution

Major Core Course I: Physical and Analytical Chemistry- I

Physical Chemistry

1. Introduction to instrumental methods of analysis
2. Preparation of buffer solution and calibration of pH meter.
3. Demonstration of calibration of UV-visible Spectrophotometer using standard solution of potassium dichromate.
4. To determine the amount of strong acid present in the given solution by titration with strong base conductometrically.
5. To determine the amount of strong and weak acid present in the given solution by titration with strong base conductometrically.
6. To verify Ostwald's dilution law using a weak acid
7. To determine dissociation constant of a weak acid using Henderson's equation
8. To verify Beer-Lambert law, using potassium permanganate solution.

Analytical Chemistry

1. Estimation of chloride in water by Mohr's method.
2. Determine the strength of Copper solution with EDTA complexometrically using fast sulphon black F indicator
3. Determine the strength of sodium chloride solution using Fajans method with fluorescein as an indicator.
4. Gravimetric estimation of Barium as $BaSO_4$ from a given solution of $BaCl_2.2H_2O$

5. Gravimetric estimation of Nickel as Ni-DMG
6. Estimation of Nickel from given solution complexometrically by EDTA using Murexide indicator.
7. Estimation of Nitrite from Sodium nitrite solution by using Potassium permanganate solution.

References:

- Experimental Physical Chemistry, V. D. Athawale, 2007 New Age International Publishers.
- Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960
- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Text book of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.

Major Core Course II: Organic and Inorganic Chemistry-I

Organic Chemistry

Estimation of organic compounds

1. Estimation of Acetone/Formaldehyde by oxidation using iodine and alkali.
2. Estimation of Aniline/Phenol by bromination method using brominating solution.
3. Estimation of Ester/Amide by hydrolysis
4. Estimation of equivalent weight of water soluble/insoluble organic acid/base by alkalimetry.
5. Estimation of amino acid by Sorensen's method.

Inorganic Chemistry Semi Micro Qualitative Analysis
References: • Experimental Physical Chemistry, V. D. Athawale, 2007 New Age International Publishers. • Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012. • Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960

S.Y. B. Sc. (CHEMISTRY) SEMESTER III

Skill Enhancement Course

COURSE TITLE: Green Chemistry and Stereochemistry

COURSE CODE: 24US3CHSECGCS [CREDITS - 02]

Course Learning Outcome		
After the successful completion of the Course, the learner will be able to: 1. Describe the fundamental aspects of Green Chemistry 2. Elaborate the fundamental aspects of Stereochemistry		
Module 1	**Green Chemistry**	**[15L]**
Learning Objectives: The module is intended to 1. Understand the principles of Green Chemistry and their importance in addressing environmental issues 2. Design and evaluate chemical processes that minimize the use of hazardous substances and energy **3.** Apply the principles of Green Chemistry to solve real-world problems		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Explain the principles of Green Chemistry and their importance in addressing environmental issues. 2. Design and evaluate chemical processes that minimize the use of hazardous substances and energy. 3. Apply the principles of Green Chemistry to solve real-world problems.		
1.1	**Principles and Concepts of Green Chemistry** Introduction, Sustainable Development and Green Chemistry, Atom Economy and Atom Economic	(3L)

	Reactions-Rearrangement, Addition Reactions, Atom Un-economic Reactions-Substitution Reactions, Elimination Reactions, Wittig Reaction, Reducing and Measuring Toxicity	
1.2	**Catalysis and Green Chemistry** Introduction to Catalysis, Types of catalysis- Heterogenous and Homogenous Catalysis Heterogeneous Catalysts: Use of Zeolites as Catalysts, Heterogeneous Catalysis in the Fine Chemical and Pharmaceutical Industries Homogeneous Catalysts: Greener Lewis Acids, Asymmetric Catalysis Phase Transfer Catalysis: Hazard Reduction, C-C Bond Formation, Oxidation using Hydrogen Peroxide Biocatalysis Photocatalysis	(4L)
1.3	**Organic Solvents: Environmentally Benign Solutions** Organic Solvents and Volatile Organic Compounds Solvent-free Systems Supercritical Fluids: Supercritical Carbon Dioxide (scCO2), Supercritical Water Water as the solvent Ionic Liquids Comparing Greenness of Solvents	(4L)
1.4	**Emerging Greener Technologies: Alternative Energy Sources and Renewable Energy Resources** Photochemical Reactions: Advantages of and Challenges Faced by Photochemical Processes, examples Microwave-assisted Reactions Ultrasound assisted reactions	(4L)

	Electrochemical Synthesis Energy : Fossil Fuels, Energy from Biomass, Solar Power, Other Forms of Renewable Energy, Fuel Cells, Chemicals and Polymers from Renewable Feedstocks	

References:

- Green Chemistry : An Introductory Text by Mike Lancaster, 2nd Edition, RSC.
- Introduction to green Chemistry by Albert S. Matlack, 2nd Edition, CRC Press
- Experimental Organic Chemistry by Joaquin Isac-Garcia, Elsevier.

Module 2	Stereochemistry	[15L]

Learning Objectives:

The module is intended to

1. Explain the concept of isomerism.
2. Describe the representation of organic compounds using Fischer, Newman and Sawhorse projection formula.
3. Illustrate the conformational analysis of alkanes.
4. Discuss the identification of the stereocenters in a molecule and assignment of configuration.
5. Explain the various resolution techniques.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Differentiate structural isomers and stereoisomers.
2. Draw structures of organic compounds using Fischer, Newman and Saw horse projection formulae
3. Discuss the stability in various conformations of simple alkanes

4. Identify the stereocenters in a molecule and assign the configuration. 5. Illustrate suitable methods of resolution of racemic mixture.		
2.1	**Isomerism:** Types of isomerism, structural isomerism (chain, position & functional) and stereoisomerism (Geometrical & optical).	3L
2.2	**Chirality:** Asymmetric carbon atom, enantiomers, stereogenic centre, configuration, Representation of configuration by flying wedge formula & projection formula- Fischer, Newmann, sawhorse.	3L
2.3	**Assigning stereo descriptors to chiral centres** Cahn-Ingold-Prelog (CIP) Rules of assigning absolute configuration (R and S) to stereogenic centres, Assigning absolute configuration to molecules having maximum two chiral carbon atoms.	3L
2.4	**Diastereomers** (geometrical isomerism) due to restricted rotation around carbon-carbon double bonds. E and Z stereo descriptors to geometrical isomers. Diastereomers of disubstituted cycloalkanes (3 and 4 membered rings).	2L
2.5	**Resolution of enantiomers:** chemical and chromatographic method	2L
2.6	Conformational analysis of ethane, propane and n-butane	2L
References: • Eliel E.L. and Wilen, S.H. Stereochemistry of organic compounds, John		

Wiley & Sons, 2008.

- Kalsi, P.S. Stereochemistry Conformation and Mechanism, New Age International, 2005.
- Stereochemistry of Organic compounds: Principles and Applications, D. Nasipuri, 4th Edition, New Age International Publishers, 2012.

Question Paper Template

S.Y. B. Sc. (CHEMISTRY) SEMESTER III

Skill Enhancement Course

COURSE TITLE: Green Chemistry and Stereochemistry

COURSE CODE: 24US3CHSECGCS [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	05	05	05	05	05		25
II	05	05	05	05	05		25
Total marks per objective	10	10	10	10	10		50
% Weightage	20	20	20	20	20		100

S. Y. B. Sc. (CHEMISTRY)

SEMESTER III – Skill Enhancement Course Practical

COURSE CODE: 24US3CHSECP Credit- 01

Learning Objectives:

The practical is intended to

1. Make the students understand that light can be polarized and that plane polarized light is rotated by chiral molecules.
2. Use polarimetry to determine the identity and concentration of an unknown solution.

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Differentiate two enantiomers of an optically active organic compound
2.. Identify unknown sugar sample
3. Determine concentration of sugar sample

Green Chemistry:

1. Green synthesis of Acetanilide using Zn/Acetic acid.
2. Green method- Bromination of Acetanilide using Potassium Bromate and Potassium Bromide
3. Solvent free synthesis of Benzilic acid from Benzil.
4. Green Synthesis of tris(acetylacetonato) Fe(III) complex.
5. To prepare Nickel dimethylgyoxime by applying green chemistry principle.

Stereochemistry

1. Determine the specific and molecular rotation of an optically active substance and hence find out the intrinsic rotation of the substance
2. Determination of concentration of unknown sugar solution
3. Identifying sugars using polarimetry
4. Determine the percentage of two optically active substances in a mixture polarimetrically.
5. To study the inversion of cane sugar by polarimetry

References::

- Advanced Practical Organic Chemistry - 3rd Edn by N K Vishnoi
- Systematic Lab Experiments in Organic Chemistry by Arun Sethi.

S. Y. B. Sc. (CHEMISTRY) SEMESTER III

Vocational skill Course

Course Tittle: Environmental Monitoring

COURSE CODE: 24US3CHMJVSCP Credit- 02

Course Learning Outcomes:

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

1. Explain the importance and objectives of water and soil monitoring programs, regulatory frameworks (WHO, BIS standards), and environmental variability and sampling considerations in monitoring programs.
2. Acquire theoretical knowledge of analytical methods for assessing physical, chemical, and biological parameters of water and soil, including the use of spectrophotometry and electrochemical techniques.
3. collect and preserve water and soil samples, perform analyses for critical parameters such as pH, DO, BOD, COD, heavy metals, and nutrients, and apply methods like Winkler's, Mohr's, and Walkley-Black.
4. Analyse experimental data using statistical tools, interpret the quality of water and soil samples, and effectively present findings and recommendations through structured reports.

Environmental Monitoring: Water and Soil (Theory)

Learning Objectives:

The module is intended to –

1. Understand the importance of water and soil monitoring in environmental science, including regulatory frameworks (WHO, BIS standards) and variability in sampling methods.
2. Acquire knowledge of various sampling techniques and analytical methods for assessing water and soil quality parameters.

Learning Outcome:

After the successful completion of the module, the learner will be able to:

1. Design and implement water and soil quality monitoring programs, including sampling, preservation, and analysis, while adhering to regulatory standards.
2. Interpret analytical results, apply statistical tools, and prepare comprehensive reports with recommendations for remediation strategies.

Theory	Environmental Monitoring: Water and Soil	15 h
1.1	**Introduction to Water and Soil Monitoring:** Importance of water and soil monitoring in environmental science. Objectives and functions of monitoring programs. Overview of regulatory frameworks for water and soil quality (WHO, BIS standards, etc.). Environmental variability: Spatial and temporal considerations in water and soil sampling	3h

1.2	**Sampling Techniques for Water and Soil:** **Water Sampling:** Methods: Grab, composite, and integrated sampling. Preservation and transportation of water samples: Avoiding contamination, labelling, and documentation. Sampling for specific parameters: pH, DO, BOD, COD, and heavy metals. **Soil Sampling:** Types of soil sampling: Random, grid, and stratified sampling. Soil sample preservation and preparation: Moisture content, sieving, and storage protocols	4h
1.3	**Analytical Methods for Water and Soil Quality:** **Water Quality Analysis:** Types – Drinking and waste water, Physical Parameters: Turbidity, temperature, and solids (TSS, TDS). Chemical Parameters: pH and alkalinity (potentiometric method), Hardness, chloride, and nitrate (titrimetric methods), Heavy metals like Fe, Cu, and Cr using spectrophotometry, Biological Parameters: BOD, COD, and TOC. **Soil Quality Analysis:** Soil pH and conductivity (electrochemical methods), Organic matter content (Walkley-Black method). Heavy metals and nutrients (Nitrogen, Phosphorus, Potassium) using spectrophotometry.	5h

1.4	**Data Interpretation and Reporting:** Statistical tools for analysing water and soil quality data (mean, standard deviation, and error analysis). Interpretation of water and soil quality parameters: Case study: Comparing urban and rural sites for water and soil pollution levels. Structuring reports for water and soil quality monitoring: Data presentation techniques (charts, graphs). Recommendations for remediation based on analysis.	3h

References:

1. Soil and Water Chemistry: An Integrative Approach, Michael E. Essington
2. Soil Sampling and Methods of Analysis, M.R. Carter and E.G. Gregorich
3. Environmental Chemistry, Stanley E. Manahan
4. Environmental Monitoring and Characterization, Janick Artiola, Ian L. Pepper, and Mark L. Brusseau
5. A Handbook of Soil, Fertilizer, and Manure Analysis, D.K. Das
6. Water Quality Monitoring: A Practical Guide to the Design and Implementation of Freshwater Quality Studies and Monitoring Programmes, Jamie Bartram and Richard Ballance

Environmental Monitoring: Water and Soil (Practical)

Learning Objectives:
The Practical is intended to –

1. To develop practical skills in analysis of water and soil samples for physical, chemical parameters.
2. To understand and apply standard laboratory techniques for determining key water and soil quality indicators, including nutrients and organic content.

Learning Outcomes:
After the successful completion of the Practical, the learner will be able to:

1. Perform laboratory analyses of water and soil using established methods and interpret the results effectively.
2. Demonstrate the ability to assess environmental quality.

Practical	Environmental Monitoring: Water and Soil	30 h
1.1	**Laboratory work (Water) – any 3** 1. Physical analysis - colour, transparency, odour, turbidity 2. Total dissolved solids/ Dissolved oxygen/Cl^-/SO_4^{2-} ions 3. Hardness/Total Alkalinity of water	12h
1.2	**Laboratory work (Soil) – any 3** 1. Physical parameters - bulk density, pH, Electrical conductivity 2. Water soluble salts in soil – Na^+, K^+ by flame photometer 3. Estimation of available nutrients - Organic carbon	12h
1.3	**Industrial visit**	6h

References:

- Soil, Plant, Water and fertilizer Analysis by P K Gupta
- Chemistry of water by Alla Appa Rao, New Age International Publication
- Vogels inorganic chemistry analysis
- Environmental Chemistry by A K De, New Age International Publication
- Soil Analysis Handbook of Reference Methods, J. Benton Jones Jr., J. R. Brown, and others.
- Handbook of Water Analysis, Leo M. L. Nollet and Leen S. P. De Gelder.
- Soil Chemical Analysis, M.L. Jackson.
- Practical Manual on Water and Wastewater Analysis, Neelima Rajvaidya and Dilip Kumar Markandey.

S.Y.B. Sc. (CHEMISTRY) SEMESTER III

Indian Knowledge System

COURSE TITLE: Ancient Indian Chemistry

COURSE CODE: 24US3CHIKSAIC [CREDITS - 01]

Course Learning Outcomes
After successful completion of the course, learner should be able to: 1. Illustrate the role of IKS in fostering local solutions based on traditional wisdom. 2. Justify the role of Indians in the development of Chemistry. 3. Discuss the historical development and significance of metallurgy in ancient India, including its technological and cultural impact.
Learning Objectives: The Module is intended to 1. Recognize the role of ancient knowledge in shaping modern societies. 2. Appreciate the historical and cultural context in which these figures worked, understanding how their environment influenced their discoveries and innovations. 3. Comprehend the historical development and significance of metallurgy in ancient India.
Learning Outcomes: After the successful completion of the module, the learner will be able to: 1. Recognize the importance of the precise process in alchemical work and the role of alchemical laboratories in achieving material and spiritual transformation.

2. Illustrate the significant contributions of ancient, medieval, and modern Indian scientists.
3. Describe various ancient metallurgical techniques, including extraction, smelting, and alloying of metals.

Module 1	Introduction to Indian Knowledge System	[5L]

An Overview, Need of IKS, Importance of Ancient Knowledge, Defining IKS, The Vedic Corpus Philosophical Systems, Wisdom through the Ages, Alchemy, Indian Alchemy and its characteristics, possible origin of Indian Alchemy, Laboratory and Apparatus

Module 2	Contribution of the Indian Scientists	[5L]

Kanad, Varahamihira, Nagarjuna, Bhairava (Shiva), Acharya Nalina, Govinda, Govindacharya, Kakachandesvarimata, Somdev, Yashodhar, Iatrochemical period (1300 AD1550 AD) Vishnudeva, Siddha Nityanatha, Devdatta, Vagbhata, Mathanasimba, , Kautilya, Brhatsamhita, Siddhas Vrndakunda, Cakrapanidatta, Sambhu, Ramchandra, , PC Ray, Yellapragada Subbarow (1895 - 1948), Kamala Sohonie (1912 - 1998), Asima Chatterjee (1917 - 2006), C. N. R. Rao (1934-present), Venkatraman Ramakrishnan (1952-present), Darshan Ranganathan (1941 - 2001).

Module 3	Chemical in Practical Arts	[5L]

Introduction, Metallurgy and working of metals: Zinc (Zn), Mercury (Hg), Gold (Au), Silver (Ag), Copper (Cu), Bronze and Brass, and iron (Fe), Tinning and alloying, enamelling, gunpowder, saltpetre, mineral acid, alum and green vitriol, paper, ink, soap, cosmetics and perfumery.

References:

- Indian contributions to Science by Vijnana Bharati, third edition, 2018.
- History of Chemistry in ancient and medieval India Acharya Prafulla Chandra Ray (Edited by P.Ray, Indian Chemical Society, Calcutta, 1956.
- India's Glorius Scientific Tradition by Suresh Soni
- Chapter 15- SCIENTISTS OF ANCIENT INDIA http://digital.nios.ac.in/topic.php?id=223en

Priyadaranjian Ray - History of Chemistry in Ancient & Medieval India -AMS Press (1979)

S.Y. B. Sc. (CHEMISTRY) SEMESTER IV

Major Core Course- I

COURSE TITLE: Physical and Analytical Chemistry II

COURSE CODE: 24US4CHMJIPAC2 [CREDITS - 02]

Course Learning Outcome		
After the successful completion of the Course, the learner will be able to 1. Identify the method of separation for ideal and non-ideal binary solutions of non-electrolytes 2. Predict the rate of reactions on the basis of surface adsorption properties. 3. Apply appropriate extraction methods for separation of the analyte from complex mixture.		
Module 1	**Solution of non-electrolytes and surface chemistry**	**[15L]**
Learning Objectives: The module is intended to 1. Differentiate between ideal and non-ideal binary solutions of non-electrolytes.. 2. Understand how surfaces can affect the rates of chemical reactions		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Predict the separation techniques to be used for the binary solutions of non-electrolytes. 2. Write the extent of surface coverage in terms of isotherms derived on the basis of dynamic equilibria between adsorbed and free molecules		
1.1	**Solutions of non-electrolytes**	**8L**

1.1.1	Solution of gasses in liquids, Henry's law	
1.1.2	Solutions of liquids in liquids – Completely miscible liquids, Raoult's law, ideal solutions, phase diagrams – pressure vs. composition and temperature vs. composition. Distillation of mixtures forming ideal solutions, fractional distillation, distillation under reduced pressure, deviation from Raoult's law – positive and negative deviation, non-ideal solutions, azeotropes, distillation of azeotropic mixtures, breaking of azeotropic mixtures.	
1.1.3	Partially miscible liquids – (i) with upper critical solution temperature (UCST) (ii) with lower critical solution temperature (LCST), (iii) with UCST & LCST	
1.1.4	Completely immiscible liquids, steam distillation	
1.2	**Surface Chemistry**	**7L**
1.2.1	Prerequisite : Arrhenius equation and Basic ideas of chemical kinetics (recap) Physisorption and Chemisorption, Determination of the extent and rates of adsorption and desorption-Gravimetry, Second harmonic generation (SHG),Surface plasmon resonance (SPR)	2
1.2.2	Adsorption Isotherms - Langmuir isotherm isosteric Enthalpy of adsorption , BET Isotherm The Temkin and Freundlich isotherms	3
1.2.3	The rates of adsorption and desorption- Precursor State and Sticking Probability	2
References:		

- Principles of Physical Chemistry, Puri, Sharma, Pathania, 41st Millennium Edition, Vishal Publishers.
- Atkin's Physical Chemistry .11th Edition ,Peter Atkins, Julio de Paula and James Keeler 2018. Oxford University press (Topic 19 A & B)

Module 2	Isolation and Extraction chemistry	[15L]

Learning Objectives:

The module is intended to discuss the classical and advanced extraction techniques and classical chromatographic methods used in analytical chemistry.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Explain the basic principles and applications of solvent extraction.
2. Use solvent extraction technique for the separation of desired components.
3. Discuss the use and applications of classical chromatographic methods like paper chromatography and TLC

2.1	**Classical methods of Separation** Solvent extraction efficiency, selectivity, Nernst distribution law, distribution coefficient, derivation for the most efficient extraction, applications and numerical problems. Methods- batch and continuous extraction of liquids, continuous solid- liquid extraction (Soxhlet extraction of phytochemicals). **Advanced Method of Separation** Supercritical fluid extraction, Ultrasonic extraction, Microwave assisted extraction,	10L
2.2	**Classical Chromatographic method**	5L

	Adsorption, Gel (Size exclusion & Molecular sieve), Ion exchange, Partition chromatography.	

References:

- Inorganic quantitative analysis by Vogel, sixth edition
- Analytical use of Ethylene Diamine Tetraacetic acid -Welcher.
- Fundamentals of Analytical Chemistry-Skoog, Holler- IX the edition

Question Paper Template

S.Y. B. Sc. (CHEMISTRY) SEMESTER IV

Major Core Course- I

COURSE TITLE: Physical and Analytical Chemistry- II

COURSE CODE: 24US4CHMJIPAC2 [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	5	5	8	4	3		**25**
II	5	8	5	4	3		**25**
Total marks per objective	10	13	13	8	6		50
% Weightage	20	26	26	16	12		**100**

S.Y. B. Sc. (CHEMISTRY) SEMESTER IV

Major Core Course- II

COURSE TITLE: Inorganic and Organic Chemistry - II

COURSE CODE: 24US4CHMJ2IOC2 [CREDITS - 02]

Course Learning Outcome
After the successful completion of the module, the learner will be able to: 1. Apply the concept of MOT to homonuclear and heteronuclear diatomic molecules. 2. Illustrate the structures of various compounds based on hybridization involved on the basis of valence bond theory. 3. Compare the valence bond theory and molecular orbital theory.

Module 1	Theories of chemical bonding: MOT and VBT	[15L]

Learning Objectives:

This module is intended to

1. Discuss salient features of Molecular orbital theory.
2. Illustrate necessary conditions to be satisfied by atomic orbitals to combine together to form molecular orbitals.
3. Explain the concept of Valence bond theory, resonance energy and formal charge.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Apply the concept of MOT to homonuclear and heteronuclear diatomic molecules.
2. Illustrate the structures of various compounds based on hybridization involved on the basis of valence bond theory.
3. Compare the valence bond theory and molecular orbital theory.

1	**Theories of chemical bonding: MOT and VBT**	
1.1	**Molecular orbital theory**	**10 L**
1.1.1	Salient feature of MOT	
1.1.2	LCAO – MO approach, variation of electron charge density with internuclear distance in H_2 molecule.	
1.1.3	Molecular orbitals formed by the combination of two s-orbitals, s and px orbitals. Characteristics of and orbitals	
1.1.4	Necessary conditions to be satisfied by atomic orbitals to combine together to form molecular orbitals, Comparison between AO and MOs	
1.1.5	Application of LCAO-MO for the formation of homonuclear diatomic molecules. H_2, He_2, Li_2, Be_2, B_2, C_2, N_2, O_2, F_2, Ne_2 with respect to bond order, bond length, bond energy, magnetic properties, mixing orbitals.	
1.1.6	Bond order in O_2, O_2^+, O_2^- and O_2^{2-}.	
1.1.7	Heteronuclear diatomic molecules of molecular ions CO, NO, CN^-, HCl with respect to bond order, stability, magnetic properties and polarity	
1.2	**Valence Bond Theory (VBT)**	**5L**
1.2.1	Hybridization involving the use of d orbitals as in PCl_5 (sp^3d), $BaCl_2$ (sd), and MnO_4^- (d^3s)	
1.2.2	Concept of Resonance and Resonance energy, Formal charge with examples	
1.2.3	Limitations of VBT	

References:

- Satyaprakash, G. D. Tuli, S. K. Basu, Advanced Inorganic Chemistry, Vol. 1.

- Satyaprakash, G. D. Tuli, S. K. Basu, Advanced Inorganic Chemistry, Vol. 2.

Module 2	Alcohol, Phenol and Compounds containing Nitrogen	[15L]

Learning Objectives:

This module is intended to This module is intended to

1. Understand the preparations and applications of alcohols, phenols and compounds containing nitrogen.
2. Discuss the characteristic reactions of alcohols, phenols and compounds containing nitrogen.

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Evaluate the importance of alcohols, phenols and compounds containing nitrogen in organic chemistry.
2. Illustrate the preparation methods and reactions of alcohols, phenols and compounds containing nitrogen.
3. List the applications of alcohols, phenols and compounds containing nitrogen.

2.1	**Alcohol**	3L
	Preparation of 1°, 2° and 3° alcohols using: carboxylic acid (Reduction - LiAlH4), aldehydes and ketones (Grignard reagent and Reduction - NaBH4, Na/alcohol, Catalytic), Reactions: With sodium, esterification, oxidation (with PCC, alk. $KMnO_4$, acidic dichromate),	
2.2	**Phenol**	2L
	Preparation from: Cumene (Industrial method) and aniline. Factors affecting the acidity of Phenol. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation.	

	Schotten Baumann Reaction	
2.3	**Aromatic Nitro compounds**	4L
2.3.1	Preparation of nitro compounds through nitration of benzene, toluene, chlorobenzene, naphthalene, anisole, nitrobenzene.	
2.1.2	Reactions: Reduction of aromatic nitro compounds using – catalytic hydrogenation, dissolving metal reduction using – Fe-HCl, Sn-HCl and Zn/AcOH, partial reduction using NaSH.	
2.4	**Aromatic amino compounds**	6L
2.4.1	Preparation:. Reduction of aromatic nitro compound, Amination of halobenzenes, Chemoselective reduction of dinitrobenzene, Hoffmann bromamide reaction.	
2.4.2	Factors affecting the basicity of aromatic amines – Reactions:, N-alkylation, N-acylation, halogenation, reductive alkylation, Diazotization of aromatic primary amines, Reactions of aryl diazonium salts, Sandmeyer and Gattermann reactions, Gomberg reaction, Replacement of diazo group by -H, -OH, -CN, Azo-coupling reaction with phenols/naphthols and aromatic amines, Reduction of diazonium salt to aryl hydrazine. Formation of azo- and hydrazo benzenes.	

References:

- Morrison R.T. and Boyd, R.N. Organic chemistry, Dorling Kindersley (India)pvt. Ltd. (Pearson Education), 2012.
- Mc Murry, J.E.Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.

- B.Y.Paula Organic Chemistry 8th edition, 2020, Pearson.

Question Paper Template

S.Y. B. Sc. (CHEMISTRY) SEMESTER IV

Major Core Course- II

COURSE TITLE: Inorganic and Organic Chemistry - II

COURSE CODE: 24US4CHMJ2IOC2 [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	5	5	5	5	5		25
II	5	5	5	5	5		25
Total marks per objective	10	10	10	10	10		50
% Weightage	20	20	20	20	20		100

S. Y. B. Sc. (CHEMISTRY)

SEMESTER IV – Major Core Course Practical

COURSE CODE: 24US4CHMJP Credit- 02

Learning Objectives:

The Practical is intended to

1. Investigate the order of reactions, molecular weight of polymers and Nernst Distribution Law.
2. Discuss the volumetric and gravimetric estimation
3. Discuss identification of monofunctional organic compounds based on solubility, elemental analysis, chemical type, functional group and physical constant.

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Predict the order of reaction, molecular weight of polymers and Distribution coefficient.
2. Perform the volumetric and gravimetric analysis
3. Identify unknown organic compounds by using qualitative analysis (Organic spotting).

Major Core Course I: Physical and Analytical Chemistry- II

Physical Chemistry

1. Introduction to experimental determination of physical parameters.
2. Preparation of O.1 N KCl and calibration of conductivity meter.
3. To determine the rate constant for hydrolysis of methyl acetate by HCl and show that it is a first order reaction.
4. To determine the order of the reaction Potassium persulphate and KI by fractional change method.
5. To determine the ΔGo and equilibrium constant for the cell reaction in the cell set up with Silver and Copper electrodes. (Cu – Ag) cell
6. To determine partition coefficient of iodine between water and carbon tetrachloride
7. To determine the molecular weight of polyvinyl alcohol (PVA) from viscosity measurements.

Analytical Chemistry

1. To separate the food colors using paper chromatography
2. Extraction of caffeine from tea powder using methylene chloride.
3. Qualitative analysis of drugs (Aspirin, Caffeine, Phenacetin) using TLC
4. Separation and identification of O-nitroaniline and P-nitroaniline by paper chromatography .
5. Separation of Fe(III) and Mg (II) using solvent extraction and estimation of Mg(II) complexometrically.
6. Separation of Ni(II) from mixture of Ni(II) and Zn(II) solution using column chromatography and estimation of Zn(II) complexometrically.
7. To separate the metal ions of the second group (Ca, Mg, Ba) and determine the Rf values for the same.

References:

- Experimental Physical Chemistry, V. D. Athawale, 2007 New Age International Publishers.
- Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960
- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Text book of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.

Major Core Course II: Organic and Inorganic Chemistry-II

Organic Chemistry

1. Organic Spotting (5 compounds)
2. Demonstration of Thin layer Chromatography of organic compounds. (Calculation of Rf value)

Inorganic Chemistry

1. **Volumetric Analysis**

i. Estimation of Fe^{+3} from a solution of ferric alum by redox titration

ii. Determination of volume strength of hydrogen peroxide using $KMnO_4$.

iii. Estimation of Cu^{+2} from a solution of $CuSO_4.5H_2O$ by iodometry.

2. **Inorganic Preparations**

i. Pottassium trioxalatoferrate (III)

ii. Ferric ammonium sulphate (Ferric alum)

iii. Prussian Blue

iv. Sodium Cobaltinitrite

References:

- Experimental Physical Chemistry, V. D. Athawale, 2007 New Age International Publishers.
- Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960

S.Y. B. Sc. (CHEMISTRY) SEMESTER IV

Skill Enhancement Course

COURSE TITLE: Nanochemistry and Retrosynthesis

COURSE CODE: 24US4CHSECNAR [CREDITS - 02]

Course Learning Outcome		
After the successful completion of the Course, the learner will be able to 1. Describe the fundamental aspects of Nano Chemistry 2. Illustrate the multistep synthesis and retrosynthesis		
Module 1	**Nanochemistry-An emerging science**	**[15L]**
Learning Objectives: The module is intended to 1. Introduce the science of nanotechnology and its relevance 2. Discuss types of nanomaterials and their synthesis. 3. Describe applications of nanomaterials.		
Learning Outcome: After the successful completion of the module, the learner will be able to 1. Discuss the basics of nanochemistry and its relevance. 2. Illustrate different synthetic approaches and applications of nanomaterials.		
1.1	**Introduction to nanochemistry**	**7L**
1.1.1	Introduction to nanotechnology, comparison between bulk and nano materials. Types of nanomaterials-zero, one, three dimensional nanomaterials,	2L
1.1.2	Synthesis approach of nanomaterials Physical methods, Chemical methods and biological methods.	5L
1.2	**Nanomaterials special properties and applications**	**8L**
1.2.1	Properties of nano material with respect to structural, mechanical, electrical, optical and	3

	magnetic properties.	
1.2.2	Some important nanomaterials- carbon nanotubes, porous silicon, mesoporous materials and aerogels	3
1.2.3	Applications of nanomaterials in different industries and medical sciences.	2

References:

- Nanotechnology by Sulbha Kulkarni, CRC press, 4th edition, 2010
- Concepts of nanochemistry by Cadmitri and others, Wiley publications

Module 2	Organic Synthesis	[15L]

Learning Objectives:

The module is intended to

1. The different terms and strategies involved in synthesizing organic compounds
2. Elucidate structure and design multistep synthesis of polysubstituted aromatic compounds

Learning Outcome:

After the successful completion of the module, the learner will be able to

1. Elucidate the structure of specific organic compounds.
2. Design the synthesis of simple organic compounds using the principles of retrosynthetic analysis.

2.1	**Structure Determination and Multistep Synthesis**	**5L**
2.1.1	Structure determination through a series of reactions.	**2L**
2.1.2	Planning multistep synthesis of polysubstituted benzenes.	**3L**
2.2	**Retrosynthetic Analysis and Application**	**10 L**
2.2.1	Introduction, Different terms used – Disconnection, Synthon, Synthetic equivalence, FGI, TM. One group	**2L**

	disconnection with examples.	
2.2.2	Retrosynthesis and Synthesis of Following Target Molecules- i. Acetophenone ii. t-butyl alcohol iii. Crotonaldehyde iv. Cyclohexene v. Cyclohexene-3-one vi. Benzoin vii. Cyclopentyl methanol viii. Benzylbenzoate ix. 2-Phenyl ethylbromide x. Benzyl diethyl malonate xi. Benzocaine xii. Amelfolide xiii. Paracetamol xiv. 2,4 dichloro acetic acid xv. Ofornine	**8L**
References: • Clayden, Greeves ,Warren and Wothers, Organic Chemistry		

Question Paper Template

S.Y. B. Sc. (CHEMISTRY) SEMESTER IV

Skill Enhancement Course

COURSE TITLE: Nanochemistry and Retrosynthesis

COURSE CODE: 24US4CHSECNAR [CREDITS - 02]

Module	Remembering/ Knowledge	Understanding	Applying	Analysing	Evaluating	Creating	Total marks
I	4	8	5	4	4	-	25
II	5	8	5	4	3	-	25
Total marks per objective	9	16	10	8	7	-	50
% Weightage	18	32	20	16	14	-	100

S. Y. B. Sc. (CHEMISTRY)

SEMESTER IV – Skill Enhancement Course Practical

COURSE CODE: 24US4CHSECP Credit- 01

Learning Objectives:

The practical is intended to

1. Introduce synthesis of nanoparticles
2. Synthesize and purify various organic compounds
3. Discuss the mole concept for percentage yield calculation of organic reaction.

Learning Outcome:

After the successful completion of the practical, the learner will be able to

1. Synthesize CuO nanoparticles by chemical method.
2. Characterisation of nanoparticles by UV VIS spectroscopy and other techniques
3. Perform organic synthesis involving nitration, oxidation, hydrolysis etc.
4. Practice the techniques involving drying and purification by various methods.
5. Estimate percentage yield of organic reaction.

Nanochemistry

1. Synthesis of CuO nanoparticles with wet chemical method.
2. Synthesis of metal nanoparticles of silver by chemical method.
3. Synthesis of ZnO nanoparticles by chemical method.
4. Synthesis of Fe2O3 nanoparticles by chemical method.
5. Demonstration of synthesis of nanoparticles by CVD method
6. Visit to Mumbai University Nanocentre/ IIT/ TIFR lab for demonstration of characterisation methods of nanomaterials using SEM/TEM and other methods.

Organic Synthesis

1. Synthesis of phthalimide from phthalic anhydride and urea.
2. Synthesis of quinone
3. Synthesis of semicarbazone derivative of aldehyde/ketone.
4. Dibromo derivative of cinnamic acid by green method
5. Synthesis of Chalcone by green synthesis.
6. Nitration of Methyl benzoate

References:

- Preparation and thermal conductivity of CuO nanofluid via a wet chemical method Haitao.Zhu , Dongxiao Han, Zhaoguo Meng, Daxiong Wu, Canying Zhang. Zhu et al. Nanoscale Research Letters 2011, 6:181 http://www.nanoscalereslett.com/content/6/1/181
- Synthesis and Electrical and Acoustic Characterization of CuO Nanofluids" Jitendra Pendharkar, Yogesh Ghalsasi. Online International Interdisciplinary Research Journal, {Bi-Monthly}, ISSN 2249-9598, Volume-VI, Issue-VI, Nov-Dec 2016 Issue
- Systematic Lab Experiments in Organic Chemistry by Arun Sethi
- Advanced Practical Organic Chemistry - 3rd Edn by N K Vishnoi

S. Y. B. Sc. (CHEMISTRY) SEMESTER IV

Vocational skill Course

Course Tittle: Analysis of pharmaceutical products as per IP/BP/USP

COURSE CODE: 24US4CHMJVSCP Credit- 02

Course Learning Outcomes:

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

1. Explain the role and importance of the Indian Pharmacopoeia in the regulation and standardization of drugs in India.
2. Apply the quality standards and guidelines set forth in the IP to ensure compliance in pharmaceutical practice and manufacturing.
3. Prepare and standardize pharmaceutical reagents, buffers, and perform limit tests for selected pharmaceutical products as per the Indian Pharmacopoeia (IP).
4. Develop the skills necessary to perform pharmaceutical assays (e.g., aspirin tablet, sodium chloride injection) using techniques such as UV, HPLC, and titrimetric methods, following pharmacopeial guidelines.

Introduction to Pharmaceutical Chemistry (Theory)

Learning Objectives:

The module is intended to –

1. To understand the principles of pharmaceutical analysis, including its role in ensuring drug quality, safety, and compliance with regulatory standards.
2. To develop skills in utilizing pharmacopeial monographs, regulatory guidelines, and literature resources for pharmaceutical assay development.

Learning Outcomes:

After the successful completion of the module, the learner will be able to:

1. Describe the importance of pharmaceutical analysis, apply regulatory guidelines, and identify key analytical techniques used in drug development and quality control.
2. Analyse, interpret pharmacopeial monographs, and conduct literature surveys to design suitable assay methods for pharmaceutical products.

Theory	Introduction to Pharmaceutical Chemistry	15 h
1.1	**Introduction to Pharmaceutical Analysis:** Importance of pharmaceutical analysis in the industry. Overview of drug development and quality control. Regulatory standards: ICH, USP, BP, IP. Common analytical techniques used in pharmaceuticals.	3h
1.2	**Quality Control and Regulatory Standards:** Good Manufacturing Practices (GMP) in quality control. Quality Assurance (QA) and Quality Control (QC). Limits of impurities and degradation products (ICH guidelines). Dissolution testing and bioavailability considerations.	3h
1.3	**Role of Pharmacopeias (IP/BP/USP):** Overview of pharmacopeias (Indian Pharmacopeia, British Pharmacopeia, United States Pharmacopeia). Standard setting and the importance of pharmacopeial monographs. Role of pharmacopeias in: Determining drug purity, potency, and safety. Assay and certification of	5h

	pharmaceutical products. Impurity profiling and acceptable limits. Harmonization of pharmacopeial standards (ICH guidelines).	
1.4	**Literature Survey for Pharmaceutical Assays:** Importance of literature surveys in drug assay development. Databases and tools for literature search: Reaxys, SciFinder, PubMed, and Google Scholar. Common methods for pharmaceutical assays (UV, HPLC, titrimetric, etc.). Case studies of assay development for selected drugs (e.g., aspirin, ibuprofen).	4h

References:

1. Pharmaceutical Analysis: A Textbook for Pharmacy Students and Pharmaceutical Chemists, David G. Watson
2. Pharmaceutical Analysis: A Practical Approach, N.K. Jain and S.K. Jain
3. Modern Pharmaceutical Analysis, Gary D. Christian
4. Good Manufacturing Practices for Pharmaceuticals, Graham Bunn
5. Pharmaceutical Quality Control: A Guide for the Analytical Chemist, William E. Roush
6. Practical Pharmaceutical Chemistry, P. D. Sethi and P. S. Sethi
7. Pharmaceutical Analysis: A Laboratory Manual, A.H. Beckett and J.B. Stenlake

Pharmaceutical Analysis (Practical)

Learning Objectives:

The Practical is intended to –

1. To understand the preparation, standardization, and usage of pharmaceutical reagents and standard solutions in pharmaceutical analysis.
2. To develop practical skills in performing limit tests, pH measurement, and pharmaceutical product assays as per IP standards.

Learning Outcomes:

After the successful completion of the module, the learner will be able to:

1. Prepare and standardize pharmaceutical reagents, buffer solutions, and perform essential tests, including limit tests for pharmaceutical products.
2. Perform assays for pharmaceutical products (e.g., aspirin, sodium chloride injection, Mebendazole tablet) following the protocols outlined in the Indian Pharmacopoeia (IP).

Practical	Pharmaceutical Analysis	30 h
1.1	**Pharmaceutical reagents and standard solutions** 1. Preparation and standardisation of pharmaceutical reagents - 0.1 M solution of NaOH, Cu^{2+} and EDTA 2. Preparation of standard buffer - Acidic, Basic and Neutral and measure of its pH. 3. Limit tests for some pharmaceutical products selected from IP - Pb, Fe, Cl^- and SO_4^{2-}	12h

1.2	**Assay of some pharmaceutical products as per IP** 1. Aspirin tablet 2. Sodium chloride injection 3. Iodex/Tiger balm for methyl salicylate content 4. Iron Tablet 5. Antacid tablet	18h

References:

- Pharmaceutical Analysis: A Textbook for Pharmacy Students and Pharmaceutical Chemists, David G. Watson
- Practical Pharmaceutical Chemistry, P.D. Sethi and P.S. Sethi
- Indian Pharmacopoeia (IP), The Indian Pharmacopoeia Commission
- Pharmaceutical Analysis: A Practical Approach, N.K. Jain and S.K. Jain
- Practical Pharmaceutical Analysis, P. D. Sethi
- Pharmaceutical Analysis: A Laboratory Manual, A.H. Beckett and J.B. Stenlake
- "Pharmaceutical Dosage Forms: Tablets, Larry L. Augsburger and Stephen W. Hoag

8. Teaching learning process

The pedagogic methods adopted, involve direct lectures, tutorial discussions, as well as technology- supported presentations. We believe that education is interactive and all sessions between students and teachers are based upon reciprocity and respect.

I) The lectures (of 1 hr duration) delivered to one whole class at a time systematically deal with the themes of the syllabus. This constitutes the core of the teaching- learning process. The students are provided with bibliographic references and encouraged to go through at least some readings so that they could be more interactive and ask more relevant questions in the class. This also helps obtain knowledge beyond the boundaries of the syllabi.

2) Wherever needed, teachers use audio-video based technology devices (e. g. power point, YouTube videos) to make their presentations more effective. Some courses require that students see a documentary or feature film and course themes are structured so that discussions of these will further nuance the critical engagement of students with ideas introduced in their textual materials.

3) Remedial coaching, bridge courses are adopted to enhance the scope of learning for the learners. Remedial sessions are conducted to offer assistance on certain advanced topics. Bridge courses facilitate to develop a concrete basis for the topics to be learnt in the coming academic year.

9. Assessment Methods

Evaluation Pattern: Theory

- Assessments are divided into two parts: Mid Semester Examination (MSE) and End Semester Examination (ESE).
- The Mid Semester Examination shall be conducted by the College at the Mid of each semester (20 M) – Duration: 30 Min.
- The End Semester Examination shall be conducted by the College at the end of each semester. (30M) Duration: 1 hours

End Semester Examination Paper Pattern

Question No	Module	Marks with Option	Marks without Option
1	I	5 M x 5 Q = 25 M	5 M x 3 Q = 15 M
2	II	5 M x 5 Q = 25 M	5 M x 3 Q = 15 M

Each question will have six sub questions a, b, c, d, e, f and out of which any three should be answered.

Evaluation pattern: Practical

- Continuous Assessment for 50 Marks throughout entire semester.
- 50 Marks Evaluation as per the following rubrics

Major Core Course	CIE	Experimental Report	Viva	Total
MJ I	15 M	5 M	5 M	25 M
MJ I	15 M	5 M	5 M	25 M

10. Programme and Course Code Format

The course is coded according to following criteria:

1. First two numbers in each course code indicates year of implementation of syllabus (24- year of implementation is 2024-25)
2. Third letter 'U' designates undergraduate
3. Fourth letter 'S' designate Science discipline and the digit followed is for semester number (S1 – 1st Semester)
4. Letter 'CH' is for Chemistry discipline (CH- Chemistry). This forms the programme code 23USCH. For the further course codes programme code is amended as follows
5. To represent Major Core Course (MJ) followed by course number digit (1/2/3/4) and three lettered code representing the title of the course.
6. To represent Minor Stream Course (MN) followed by course number digit (1/2/3/4) and three lettered code representing the title of the course.
7. For Ability enhancement course code, (AE) alphabets followed by a digit (1/2) followed by 'FOC'- Foundation course, 'EVS'-Environmental science are used.
8. For Value Added course code, (VA) alphabets followed by a digit (1/2) followed by 'FOC'- Foundation course, 'EVS'-Environmental science are used.
9. For Indian Knowledge System course code, (IK) alphabets followed by a digit (1/2) followed by 'ICH'- Indian Cultural Heritage is used.
10. For Co-curricular course code, (CC) alphabets followed by a digit (1/2).
11. For Open Elective course code, (OE) alphabets followed by a digit (1/2).
12. 'P' followed by digit indicates practical course number. (Practical course number will be added for semesters only where there is more than one course.

13. For Skill enhancement course code, (SEC) alphabets followed by 'GCS'-Green chemistry and Stereochemistry, 'NAR'-Nanochemistry and Retrosynthesis are used.
14. For Vocational Skill Course code (VSC) followed by P-practical is used.