સૌરાષ્ટ્ર યુનિવર્સિટી

એકેડેમિક વિભાગ

યુનિવર્સિટી કેમ્પસ, યુનિવર્સિટી રોડ, રાજકોટ-૩૬૦૦૦૫

ફોન નં.(૦૨૮૧)૨૫૭૮૫૦૧ એક્સટે. નં.૨૦૨, ૩૦૪ ફેક્સ નં.(૦૨૮૧)૨૫૭૬૩૪૭ ઈ-મેઈલ : academic@sauuni.ac.in

નં.એકે/વિજ્ઞાન/૨૩૦૭૬૪/૨૦૨૫ તા.25/૦૬/૨૦૨૫

બી.એસસી.(રસાયણશાસ્ત્ર)

પરિપત્ર:-

સૌરાષ્ટ્ર યુનિવર્સિટીની વિજ્ઞાન વિદ્યાશાખા હેઠળની સ્નાતક કક્ષાના બી.એસસી.(રસાયણશાસ્ત્ર)ના અભ્યાસક્રમ ચલાવતી સર્વે સંલગ્ન કોલેજોના આચાર્યશ્રીઓને આથી જાણ કરવામાં આવે છે કે, રસાયણશાસ્ત્ર વિષયની અભ્યાસ સમિતિનાં ચેરપર્સનશ્રી તથા વિજ્ઞાન વિદ્યાશાખાનાં ડીનશ્રી દ્વારા રજુ કરાયેલ બી.એસસી.(રસાયણશાસ્ત્ર) સેમેસ્ટર - ૦૫ અને ૦૬ નો SOP મુજબનો અભ્યાસક્રમ અધિકાર મંડળોની બહાલીની અપેક્ષાએ મંજુરી આપવા માન.કુલપતિ સાહેબને ભલામણ કરેલ જે માન.કુલપતિશ્રીએ મંજુર કરેલ છે. જેથી સંબંધિત તમામે તે મુજબ તેની અમલવારી કરવી.

(મુસદ્દો કુલસચિવશ્રીએ મંજુર કરેલ છે.)

સહી/-
(ડૉ. આર. જી. પરમાર)
I/C કુલસચિવ

બિડાણ:- ઉક્ત અભ્યાસક્રમ (સોફ્ટ કોપી) રવાના કર્યું

25/6/25

એકેડેમિક ઓફીસર

પ્રતિ,

(૧) વિજ્ઞાન વિદ્યાશાખા હેઠળની બી.એસસી.(રસાયણશાસ્ત્ર) વિષય ચલાવતી સ્નાતક કક્ષાની સર્વે સંલગ્ન કોલેજોના આચાર્યશ્રીઓ તથા અનુસ્નાતક ભવનનાં અધ્યક્ષશ્રીઓ તરફ.
(૨) રસાયણશાસ્ત્ર વિષયની અભ્યાસ સમિતિનાં સર્વે સભ્યશ્રીઓ
(૩) ડીનશ્રી, વિજ્ઞાન વિદ્યાશાખા

નકલ જાણ અર્થે રવાના:-

૧. માન.કુલપતિશ્રી/કુલસચિવશ્રીના અંગત સચિવ

નકલ રવાના (યોગ્ય કાર્યવાહી અર્થે):-

૧. પરીક્ષા વિભાગ
૨. પી.જી.ટી.આર.વિભાગ
૩. જોડાણ વિભાગ

SAURASHTRA UNIVERSITY

FACULTY OF SCIENCE

Course Structure and Syllabus for Science FYUGP

B.Sc. Honours/ Honours with Research in Chemistry

(T. Y. B.Sc.- Chemistry - Semester V)

Based on

UGC's guidelines NEP-2020 "Curriculum and Credit Framework for Undergraduate Programmes- CCFUP" and

Education Department, Government of Gujarat's
Uniform Credit Structure for all HEIs of Gujarat State and
Implementation of the Common Curriculum and Credit Framework under the National Education Policy-2020
(No: KCG/admin/2023-24/0607/kh.1 Sachivalaya, Gandhinagar dated 11/07/2023) and

Standard Operating Procedure for Implementation of NEP-2020 for the State of Gujarat- HEIs of Gujarat
(No: KCG/admin/2023-24/865/ dated 26/07/2023) and

Additional content to be added to SOP published by KCG
(No: KCG/NEP-2020/2023-24/893/ dated 28/07/2023)

General Guidelines for Implementation of **Four Year Under Graduate Programmes** for Saurashtra University (16 pages) published in August 2023
(E-mail from Academic Section Saurashtra University dated Oct 11, 2023)

Effective from June–2025& onwards
(Submitted on 14/06/2025)

PREFACE

Timely revision of the curriculum to encompass new knowledge and information is a prime criterion of IQAC and a prime need for the institute educational systems affiliated with Universities. Under the NEP -2020 and UGC guidelines, a student must be offered the latest courses of varied requirement of technology with societal, environmental, and economic implications. The curriculum should offer multiple entry-exits and a choice of vast subjects to choose from to a student to facilitate his learning abilities, aptitude, and inclination. Chemistry is a foundation subject for Chemical Sciences, Life Sciences, Chemical Engineering, Agriculture, Environmental Science, Genetic engineering, Pharmaceuticals, Fertilizers, Textiles, Polymers, and so many and hence holds the central position in the curriculum of these subjects. Looking at the rapid inventions and technological developments in the field of Chemistry and keeping in view the recommendations of UGC, NEP-2020 and Standard Operating Procedure for Implementation of NEP-2020 for the State of Gujarat- HEIs of Gujarat. This syllabus has been formulated by the combined and coordinated efforts of all the faculty members of Chemistry Departments of all the Colleges affiliated to Saurashtra University.

The composition of a curriculum for a particular subject requires the following criteria to be Considered:

1. Guidelines, Model curriculum, SOP and Evaluation norms provided by the UGC, State Government, and the University.
2. Regional needs and Present National and International trends in the subject.
3. Geographical parameters of the University and its demographic property.
4. Relationship with other related subjects and resources of educational needs.
5. Financial and statutory provisions of the State Government.

The content of a syllabus should be such that it maintains continuity with the course content of Higher secondary classes and post-graduate courses. Keeping this in mind, the current curriculum is made; and is an effort to impart fundamental knowledge of the subject needed at this level. The curriculum is designed as per the guidelines of UGC, NEP-2020 and Standard Operating Procedure for Implementation of NEP-2020 for the State of Gujarat- HEIs of Gujarat, reflects the courses' total credit, teaching hours, and question paper style. The syllabus units are well defined, and the scope of each is given in detail. A list of reference books is provided at the end of each course. Chemistry being a logical and application based subject, sufficient emphasis is given to problem solving skills.

The following objectives have been considered while formulating the curriculum:

1. To provide an updated, feasible, and modern syllabus to the students, emphasizing knowledge andskill to build up their employment oriented career.
2. To frame the comprehensive syllabus in accordance with the CBCS, UGC- NEP 2020recommendations and considering the Standard Operating Procedure for Implementation of NEP-2020 in the State of Gujarat- HEIs of Gujarat,University guidelines andin consultation with all stakeholders.
3. To offer the students an array of Core, Interdisciplinary, Multidisciplinary, Skill enhancement,Ability enhancement and Value-added courses to select from and to facilitate their academic,intellectual and social grooming.

The Board of Studies for Chemistry expresses heartfelt gratitude to the Dean, Faculty of Science,Saurashtra University, for valuable guidelines and the Academic Section for much-neededcooperation. The Board wishes all the students a very bright future.

Date: 14th June 2025

On behalf of the BoS- Chemistry,

Dr. V. N. Patolia,
Chairman,
BoS- Chemistry
Saurashtra University, Rajkot

Dr. K.D. Ladva,
BoS- Chemistry
Saurashtra University, Rajkot

,

Graduate Attributes:

Graduates should be able to demonstrate the acquisition of the following:

- **Graduate attributes for FOUR YEAR UNDER GRADUATE PROGRAM**

- **Academic excellence**: Ability to identify key questions, research and pursue rigorous evidence-based arguments
- **Critical Thinking and Effective communications:** Analysis and evaluation of information to form a judgement about a subject or idea and ability tocommunicate effectively the same in a structured form.
- **Global Citizenship:** Mutual understanding with others from diverse cultures, perspectives and backgrounds
- **Research-related skills:** the ability to understand basic research ethics and skills in practicing/doing ethics in the field/ in personal research work, regardless of the funding authority or field of study.
- **Leadership qualities and Teamwork abilities:** The graduates should be able to demonstrate the capability for mapping out the tasks of a team and setting direction and inspiring vision, and building a team that can help achieve the goals
- **Life Long Learning:** Open, curious, willing to investigate, and consider new knowledge and ways of thinking

Program Learning Outcomes:

The student graduating with the Degree B.Sc. (Honours/Honours with Research) Chemistry should be able to acquire;

1. **Core Competency**: Students will acquire core competency in the subject chemistry, and in allied subject areas with following competencies:
   - Systematic and coherent understanding of the fundamental concepts in Physical chemistry, Organic Chemistry, Inorganic Chemistry, Analytical Chemistry and all other related allied chemistry subjects.
   - Students will be able to use the evidence based comparative chemistry approach to explain the chemical synthesis and analysis.
   - The students will be able to understand the characterization of materials.
   - Students will be able to understand the basic principle of equipment, instruments used in the chemistry laboratory.
   - Students will be able to demonstrate the experimental techniques and methods of their area of specialization in Chemistry.
2. **Disciplinary knowledge and skill**: A graduate student isexpected to be capable of demonstrating comprehensive knowledge and understanding of both theoretical and experimental/applied chemistry knowledge in various fields of interest like Analytical Chemistry, Physical Chemistry, Inorganic Chemistry, Organic Chemistry, Material Chemistry etc. Further, the student will be capable of using of advanced instruments and related software for in-depth characterization of materials/chemical analysis and separation technology.

3. **Skilled communicator**: The course curriculum incorporates basics and advanced training in order to make a graduate student capable of expressing the subject through technical writing as well as through oral presentation.
4. **Critical thinker and problem solver**: The course curriculum also includes components that can be helpful to graduate students to develop critical thinking ability by way of solving problems/numerical using basic chemistry knowledge and concepts.
5. **Sense of inquiry**: It is expected that the course curriculum will develop an inquisitive characteristics among the students through appropriate questions, planning and reporting experimental investigation.
6. **Team player**: The course curriculum hasbeen designed to provide opportunity to act as team player by contributing in laboratory, field based situation and industry.
7. **Skilled project manager**: The course curriculum has been designed in such a manner as to enabling a graduate student to become a skilled project manager by acquiring knowledge about chemistry project management, writing, planning, study of ethical standards and rules and regulations pertaining to scientific project operation.
8. **Digitally literate**: The course curriculum has been so designed to impart a good working knowledge in understanding and carrying out data analysis, use of library search tools, and use of chemical simulation software and related computational work.
9. **Ethical awareness/reasoning**: A graduate student requires understanding and developing ethical awareness/reasoning, which the course curriculum adequately provides.
10. **Lifelong learner**: The course curriculum is designed to inculcate a habit of learning continuously through use of advanced ICT technique and other available techniques/books/journals for personal academic growth as well as for increasing employability opportunity.

PROGRAM EDUCATIONAL OUTCOMES (PEO):

This program will produce Graduates who will attain the following PEOs after a few years..

PEO_1	**Core competency**	Understand and apply the fundamental core of chemistry to a broad variety of chemical problems.
PEO_2	**Breath of knowledge**	Competent chemistry graduates with strong fundamental knowledge to cater the needs of GOs and NGOs related to chemical science domain.
PEO_3	**Preparedness**	Demonstrate ability to use necessary tools & techniques of applied chemistry domain.
PEO_4	**Professionalism**	Graduates who can work individually or in teams to interpret chemical literature and propose solutions for problems significant to industries and society as a whole.
PEO_5	**Learning environment**	Inculcate the aptitude to engage in life- long learning from social, economic, and scientific activities of the time.

PROGRAM OUTCOMES (PO): After completion of the FYUGP Chemistry, the Graduate will be able to:		
PO_1	**Foundational Knowledge**	Understand major concepts, theoretical principles and experimental findings in chemistry.
PO_2		Conduct experiments, analyse data, and interpret results, while maintaining responsible and ethical scientific conduct.
PO_3	**Scientific Aptitude**	Employ critical thinking and efficient problem-solving skills in the four basic areas of chemistry - organic, inorganic, analytical, and physical.
PO_4		Exhibit awareness about safety and chemical hygiene regulations and good laboratory practices.
PO_5	**Modern Tool Usage**	Apply classical and minor instruments for chemical analysis and separation.
PO_6		Able to use computers and electronic resources for data management and retrieval.
PO_7		Communicate effectively in written and oral forms to transmit technical information in a clear and concise manner.
PO_8	**Lifelong Learning**	Comprehend and exhibit fundamental aspects of chemical sciences facilitating placement into PG programs, professional organizations, or other related job.
PO_9		Effectively work in diverse teams in all curricular, co-curricular and extra-curricular activities.
PO_{10}	**Global Citizenship**	Appraise and demonstrate Universal brotherhood

PROGRAM SPECIFIC OUTCOMES (PSO): After completion of the program, the Graduate will…	
PSO_1	Acquire knowledge on the fundamentals aspects of chemistry leading to functional understanding of emerging concepts and technologies in chemical sciences.
PSO_2	Able to pursue higher education and research in the institutes of national and international repute.
PSO_3	Apply conceptual knowledge of Chemistry to identify practical & innovative solutions for socio-economically relevant issues.
PSO_4	Demonstrate ability to skilfully utilize the chemical literature to identify existing problems and employ tools & techniques of applied chemistry for finding sustainable & ethical solutions.
PSO_5	Acquire the ability to engage in life- long learning in the broadest context of socio- technological changes.

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester V

SN	Course Category As per GoG- NEP-SOP - July 2023& additional content 28/7/23	Course Title	Credit			Hrs./ Wk.		Evaluation - Weightage CCE: SEE = 50:50				
			T	P	Total	T	P	CCE Marks		SEE Marks		Total Marks
								T	P	T	P	
1	**Major (Core)-11** (IKS based Chemistry)	**Chemistry -11:** Chemistry of Natural Products **(4- Credit Course** including Theory & Practical components)	**3**	**1**	**4**	**3**	**2**	**25**	**25**	**50**	**-**	**100**
2	**Major (Core)-12** (Chemistry)	**Chemistry -12:** Advanced Inorganic & Analytical Chemistry **(4- Credit Course** including Theory & Practical components)	**3**	**1**	**4**	**3**	**2**	**25**	**25**	**50**	**-**	**100**
3	**Major (Core)-13 (**Chemistry**)**	**Chemistry -13:** Industrial Chemistry **(4- Credit Course** including Theory & Practical components)	**3**	**1**	**4**	**3**	**2**	**25**	**25**	**50**	**-**	**100**
4	**Skill Enhancement Course-5** (SEC-5)	**Skill based Course-5: Separation Techniques (2- Credit Course** including Theory & Practical components)	**1**	**1**	**2**	**1**	**2**	**-**	**25**	**25**	**-**	**50**
5	**Minor-04(Elective)** (Chemistry)	Opto & Electro Analytical Techniques-I **(4- Credit Course** including Theory & Practical components)	**2**	**2**	**4**	**2**	**4**	**-**	**50**	**50**	**-**	**100**
6	**Minor-05(Elective)** (Chemistry)	Opto & Electro Analytical Techniques-II **(4- Credit Course** including Theory & Practical components)	**2**	**2**	**4**	**2**	**4**	**-**	**50**	**50**	**-**	**100**

7	**Ability Enhancement Course** (AEC)	(As per GoG- NEP-SOP July 2023& additional content 28/7/23 – Clause 3.3.4)			**NA**							NA
Total Credits and Marks (Semester-V)			14	08	**22**	14	16	**75**	**200**	**275**	**-**	**550**

Courses Offered by BoS - Chemistry to other FYUGP- B.Sc. Program in Semester-V												
SN	**Course Category** As per GoG- NEP-SOP - July 2023& additional content 28/7/23	**Course Title**	**Credit**			**Hrs./ Wk.**		**Evaluation - Weightage CCE: SEE = 50:50**				
			T	**P**	**Total**	**T**	**P**	**CCE** Marks		**SEE** Marks		**Total** Marks
								T	**P**	**T**	**P**	
	NA	NA			**NA**							NA

Evaluation Scheme: (As per GoG- NEP-SOP July 2023& additional content 28/7/23 – Chapter-7: Evaluation Reforms)

The evaluation process should be formulated to make a systematic evaluation of students' progress based on UGC guidelines. The evaluation must be designed with learner attributes in mind. These attributes have clear linkages to Programme Education Objectives and Outcomes. The evaluation consists of the following two components:

1. Continuous and Comprehensive Evaluation (CCE)- Formative
2. Semester End Evaluation (SEE)- Summative

CCE carries 50% of the total marks allotted to a subject and the other 50% being assigned to the SEE.

In each course, every credit carries 25 marks, of which 50% marks is assigned for CCE and rest 50% marks for SEE. The 50% marks assigned to the CCE is distributed between the continuous classroom evaluation and mid-term evaluation. The pattern may be as follow:

SN	**Evaluation**	***T-3 + P-1 = Total 4 credit subjects (Marks)**	***** **T-1 + P-1 = Total 2 credit SEC# (Marks)**	***T-2 + P-2 = Total 4 credit Minor# (Marks)**
1	**CCE (50%)** Classroom/Lab & Mid-Term/Course End Evaluation	**T-25 + P- 25**	**P#- 25**	**P#- 50**
2	**SEE (50%)**	**50**	**T#- 25**	**T#-50**
	Total	**100**	**50**	**100**

***T = Theory; P= Practical #Details are given with syllabus**

Continuous and Comprehensive Evaluation (CCE)

Subject–wise CCE will be undertaken by the concerned faculty member. The mode of evaluation will be decided by the faculty member concerned with the subject. Normally CCE consists of class participation, case analysis and presentation, assignment, tutorials, slip tests (announced/ surprised), quizzes, attendance etc. or any combination of these. The students are expected to submit their answer scripts/ reports of internal evaluation within the stipulated time. Failure to do so may result in the script not being valued. Another part of CCE consists of mid-term written evaluation, which is compulsory for all students. It can be done in a scheduled manner. The duration of the mid-term evaluation shall be one hour.

Semester End Evaluation (SEE)

The SEE carries 50% of the marks assigned to a course. SEE shall be of 2 ½ hours for 3/4 credit course and 2 hours in case of 1/2 credit courses. The controller of the examination will conduct these examinations. Paper setting and evaluation will be done by the external examiners to an extent of 50% of the evaluation process. This examination shall be conducted as per a schedule which shall be notified in advance.

The backlog exam will be conducted twice a year just after the result declared of the semester evaluation. Students shall have a second chance to clear their backlog and avoid the burden to carry forward the backlog with the next semester exam.

Appearance in all the evaluations is mandatory and no exemption can be granted except in the following case:

1. In case of inability to attend the exam due to reasons considered genuine by the controller of examination in consultation with the Director/Board.

2. In case of medical emergency, a certificate from the registered medical practitioner must be produced before the commencement of exams. The evaluation board will then take final decision on the recommendation for exemption.

Eligibility Criteria to appear in SEE

To be able to appear for the SEE, a student must comply with the following conditions:

1. Should have at least 75% of attendance in all the courses put together.

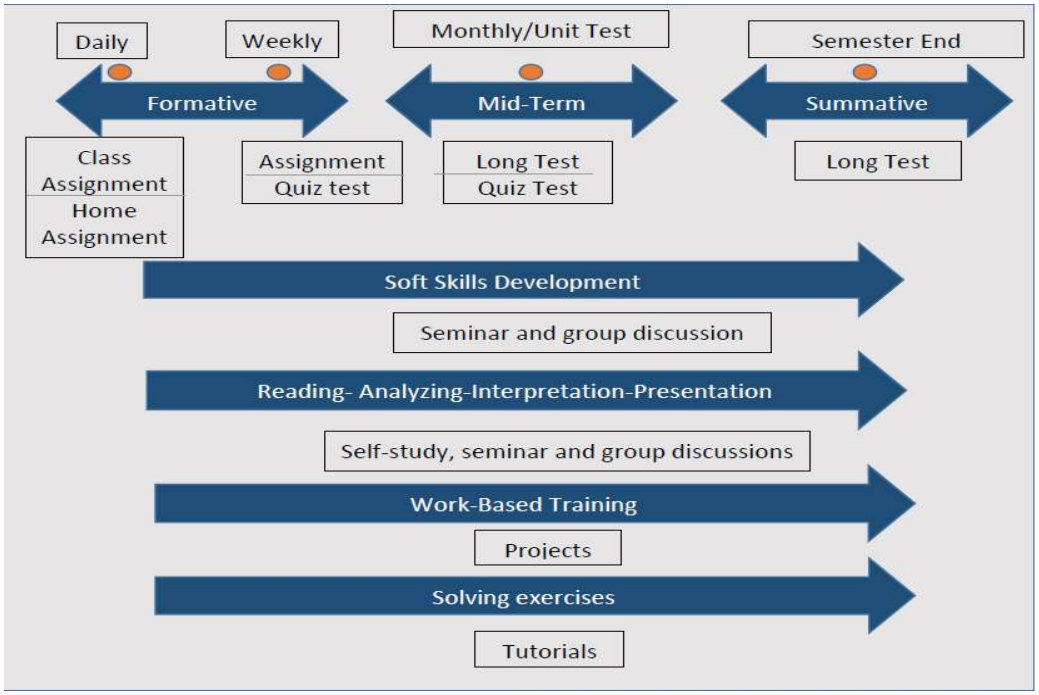
2. Should have at least 70% of attendance in each course/subject.

3. Should not have any disciplinary proceedings pending against him/her.

4. Should have no pending due.

Continuum of Evaluation

Evaluation must be continuous which may include both formative and summative components in a timely manner for continuous feedback as follow:



Mode of Evaluation

A wide range of modes of evaluation for evaluating students is available for the teachers/ institutions to use. A suitable compendium of such a mode needs to be carefully chosen for a particular program depending on its nature, objectives, and available resources. The mode of evaluation n can be as below:

Written Mode	Oral Mode	Practical Mode	Integrated Mode
Semester Exam Class Test Open book exam/test Open note exam/test Self-test/Online test Essay/Article writing Quizzes/Objective test Class assignment Home assignment Reports writing Research/Dissertation Class Studies	Viva/Oral exam Group Discussion Role Play Authentic Problem Solving Quiz Interview	Lab work Computer simulation/virtual labs Craft work Co-curricular work	Paper presentation/Seminar Field Assignment Poster Presentation

Written Mode		
Evaluation Type	**Nature**	**Objective**
Semester Exam	Traditionally essay type, with objective / short answer questions to evaluate Lower Order Thinking	For depth and planned preparation

	(LOT) OBE skills	
Class test	Traditionally essay type	Fixed date forces students to learn
Open book test	Allowed choice of reference book	Measures what students can do with resources, less stress on memory
Open note test	To get used to the system	Encourage good note taking
Self-test	For subjective and objective items	Mastery learning occurs with proper feedback
Article/essay writing	Individual long written assignment	Individual expression and creativity
Quizzes/Objective test	Short duration structured test	Excellent validity as greater syllabus coverage
Class assignment	With defined time	Student's performance to make decision
Home assignment	With undefined time	Reinforce learning and facilitate mastery of specific skills
Reports Writing	On activities performed or event observed	Develop a key transferable skill
Research/Dissertation	Detailed research-based report	To judge creativity and research skills
Case Studies	Analyse a given case (real or fictional)	To assess thinking, value, and attitude
Oral Mode		
Evaluation Type	**Nature**	**Objective**
Viva/Oral exam	Individually or in small group	Practical experience towards job interview situation
Group discussion	Small group of 2-5 members work on a joint task	Encourage teamwork
Role Play	Small group of 2-5 members work on a joint task	Develop personality
Authenticate problem solving	Small group of 2-5 members work on a joint task	Communication of ideas
Quiz	Small group of 2-5 members work on a joint task	Assess memory power
Interview	Individually	Judge the personal confidence level

Practical Mode		
Evaluation Type	**Nature**	**Objective**
Lab work	Component of working with one's hand	Keep the students on the task
Computer simulation/virtual labs	Component of working with one's hand	To understand the practical exposure
Craft work	Component of working with one's hand	Encourage application of concepts learnt
Co-curricular work	Component of working with one's hand	For immediate feedback

Integrated Mode

Evaluation Type	Nature	Objective
Paper presentation/Seminar	Group or individual work	Learn from others presentation
Field Assignment	Field visit with report	Develop observation and recording skills
Poster presentation	Group or individual work	Develop research, creativity, and discussion skills
Paper presentation/Seminar	Group or individual work	Learn from others presentation

Models of Evaluation

Based on the types of evaluation, various models of evaluation implementation are suggested for theory, practical, self-study and work-based learning. The focus of these models is to encourage the students to improve on skills and performance.

Evaluation Norms &Question Paper Pattern for Theory &Practical Courses: Please refer General Guidelines for Implementation of **Four Year Under Graduate Programmes** for Saurashtra University (16 pages) published in August 2023.

Model for Theory Courses- Theory-3+ Practical-1 = 4 Credit Course	
CCE-50% (50 Marks)SEE-50% (50 Marks)	
Exam Pattern	**Marks**
Class Test (Average of **TWO** tests)	**T-25 + P-25**
Quiz (Average of **TWO quiz**)	
Home Assignment	
Active Learning- PBL/CSBL/Seminar/Flipped Class Room etc. OBE evaluation tools.	
Class Assignment	
Attendance	
Continuous and Comprehensive Evaluation	**T & P - 50**
Semester-End Evaluation	**T-50**
1 Credit Practical Course : CCE-100% (25 Marks)	
Lab work assessment	10
Viva voce/Lab quiz	10
Attendance	05
Continuous and Comprehensive Evaluation	**P- 25**

Model for Theory Courses- Theory-2+ Practical-2= 4 Credit Course	
CCE-50% (50 Marks) SEE-50% (50 Marks)	
Exam Pattern – SoP- OBE	**Marks**
Written : Lab batch wise Test Objective/MCQ	10
Journal writing / Assignment	05
Course End Practical Exam & Viva Voce by Internal & External Examiners (3 Hrs.)	30 + 5
Continuous and Comprehensive Evaluation	**P-50**
Semester-End Evaluation	**T-50**

Model for Skill Enhancement Course SEC (1 Credit theory + 1 Credit Practical)	
CCE-P-50% (25 Marks) and SEE-T-50% (25 Marks)	
Evaluation Components	**Marks**
Lab work Assessment – Performance : Lab quiz, Attendance, Aim achievement & Journal- Record book	05+05
Course End Practical Examination & Viva voce –One and half Hours Duration	10+05
Total marks of CCE- Continuous and Comprehensive Evaluation	**25**
Semester-End Evaluation- Theory Examination– One Hours Duration	**25**
Total Marks for the Skill Enhancement Course	**50**

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester V

Course Category	**Major Chemistry-11**
Title of the Course	**Chemistry -11: Chemistry of Natural Products**
Course Credit	**03**
Teaching Hours per Sem.	**45**
Total Marks	**CCE- 25 + SEE- 50**

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skillsનાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		~~Yes~~/No	Ability Enhancement Courses		~~Yes~~/No
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	Yes/~~No~~	Interdisciplinary	Yes/~~No~~
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					Yes/~~No~~
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Course Outcomes – COS

By the end of this course, students will be able to:

CO1: Identify and classify various classes of natural products including alkaloids, terpenoids, carbohydrates, amino acids, peptides, proteins, and plant pigments based on their chemical structure and biological origin.

CO2: Understand the basic biosynthetic pathways and structural features of **alkaloids** and **terpenoids**, and their pharmaceutical and ecological significance.

CO3: Explain the structure, stereochemistry, and biochemical functions of **monosaccharides, disaccharides, and polysaccharides**, with emphasis on their role in metabolism and cell recognition.

CO4: Describe the chemistry, structure-function relationship, and analytical techniques used for **amino acids, peptides, and proteins**, including peptide bond formation and levels of protein structure.

CO5: Analyze the classification, structures, and color-producing mechanisms of **plant pigments** such as carotenoids, xanthophylls, anthocyanins, betalains, and flavonoids, and their importance in nature and industry.

CO6: Apply the concepts of natural product chemistry in identifying potential leads for drug discovery, nutrition, and sustainable product development from plant-based sources.

Unit No.	Topics	Hrs	Mks
1	**UNIT-1 Alkaloids** • Introduction and Occurrence • Classification of Alkaloids • Isolation and General method of proving structure of alkaloids, • Constitution, Properties and synthesis ofConiine, Nicotine, Papaverine	9	10
2	**UNIT- 2: Terpenoids** • Introduction and Occurrence • Isolation and General characteristics of Terpenoids • Isoprene Rule • Constitution and Synthesis of (i)Citral, (ii)α-Terpineol and (iii) Camphor	9	10
3	**UNIT-3: Carbohydrates** • Introduction, classification and nomenclature, general reaction of monosaccharides (with reference to Glucose and Fructose) • Inter-conversions: (a) Conversion of Aldose to the corresponding ketose (b) Conversion of Aldose to the next higher Ketose (wolform method) (c) Conversion of Aldose to the Ketose having two more carbon atoms (Swoden method) (d) Conversion of Ketose to the corresponding Aldose • Step-up reaction (Ascending in Aldose series) (a) Kiliani reaction (b) Swodennitromethane reaction • Step-down reaction (Descending in Aldose series – Aldohexose to Aldopentose) byRuff's method • Configuration of monosaccharides • Ring structure of Aldoses • Determination of ring size of Glucose by (a) Methylation method (b) Periodic oxidation method • Mutarotation of D (+) glucose	9	10

4	**UNIT-4: Amino acids, Peptides and Proteins** • Introduction, Classification of amino acids name and formula • Synthesis of amino acids by: a. Amination of α-halogen acids b. Gabriel pthalimide synthesis c. Erlenmeyer azlactone synthesis d. Hydantoin method • Physical properties of amino acids, Chemical properties of amino acids, Isoelectricpoint • Introduction to Polypeptides, • Synthesis of Polypeptides by: a. Bergmann Method b. Sneehan's Method (use of Phthaloyl group) c. Fischer's Method (use of p-toluenesulphonylchloride) • Introduction and classification of proteins, • Constitution of Thyroxine, Synthesis of Thyroxine	**9**	**10**
5	**UNIT-5: Plant Pigments** • **Introduction to Plant Pigments:** Definition and classification of plant pigments, Overview of light absorption and color perception. • **Carotenoids (YOR - Yellow, Orange, Red) :** Structure, classification: Carotenes (α-carotene, β-carotene) and Xanthophylls (lutein, zeaxanthin), Biosynthesis pathway (brief)., Chemical properties and stability, Role in photosynthesis (light-harvesting and photoprotection), Applications: Nutritional value (provitamin A), antioxidants, and industrial uses. • **Anthocyanins (RPB - Red, Purple, Blue) :** Flavylium cation structure and pH-dependent color changes, Glycosylation and acylation effects, Factors affecting stability (light, temperature, pH), Extraction and identification techniques, Applications in food coloring and health benefits. • **Betalains (RY - Red, Yellow) :** Occurrence (Caryophyllales vs. anthocyanin-containing plants), Structure and types: Betacyanins (red-violet), Betaxanthins (yellow-orange), Biosynthesis overview from tyrosine, Chemical behavior and stability, Uses in food, pharmaceuticals, and natural dyes. • **Flavonoids :** General structure and classification: Flavones, flavonols, isoflavones, flavanones, Biosynthetic origin (shikimic acid and acetate pathway), Role as antioxidants and UV filters, Importance in plant signaling and human health.	**9**	**10**

Reference books:

1. O. P. Agarwal (2015, 1 st edition) Chemistry of organic natural products, Krishna Prakashan Media (P) Ltd (ISBN: 978-8182836891).
2. V. K. Ahluwalia (2008, 2 nd edition) Chemistry of Natural Products, Vishal Publishing Co. (ISBN: 81-88646-62-8).
3. B. A. Naga Sappagi, M. Shivakumar, S. V. Bhat (2013, 1st edition). Chemistry of Natural Products CBS Publishers & Distributors Pvt. Ltd. (ISBN: 978-8184873184).
4. Prof.Dr. Dieter Sicker, Prof.Dr. Klaus-Peter Zeller, Prof.Dr. Hans-Ullrich Siehl, Prof.Dr. Stefan Berger (2019, 1st edition).Natural Products: Isolation, Structure Elucidation and History (ISBN: 9783527341948).
5. J. Singh, Ali, Jaya Singh (2010, 1st edition). Natural Products Chemistry PragatiPrakashan (ISBN: 978-9350063293).
6. R. H. Thomson (1993, 2nd edition). The Chemistry of Natural Products Springer (ISBN: 978-0751400144).
7. Ayodhya Singh (2004, 2nd edition). Chemistry of Natural Products: Alkaloids and Terpenoids, Campus Books International (ISBN: 978-8180300653).

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice

Suggested MOOCs: SWAYAM-NPTEL

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester V

Course Category	**Major Chemistry Practical -11**
Title of the Course	**Chemistry Practical-11:** **Organic Qualitative Analysis of Solid Binary Mixtures**
Course Credit	**01**
Teaching Hours per Sem.	**30**
Total Marks	**CCE- 25**

Course Outcomes – Cos

By the end of this practical course, students will be able to:

CO1: Systematically analyze and identify the individual components of solid organic binary mixtures using classical separation and purification techniques.

CO2: Perform preliminary tests, solubility analysis, and functional group identification to classify organic compounds.

CO3: Apply techniques such as crystallization, sublimation, and solvent extraction for effective separation of mixture components.

CO4: Confirm the identity of separated compounds by conducting suitable **derivative preparation** and comparing their melting points with literature values.

CO5: Maintain accurate laboratory records and practice safety, precision, and ethical handling of reagents and chemical waste.

CO6: Interpret experimental data and apply scientific reasoning to validate the identification process and communicate results effectively.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skills નાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		Yes/~~No~~	Ability Enhancement Courses		Yes/~~No~~
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	~~Yes~~/No	Interdisciplinary	~~Yes~~/No
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે ?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					~~Yes~~/No
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Chemistry Practical-11
Organic Qualitative Analysis of Solid Binary Mixtures Chemical nature wise combination of organic compound: **Acid+Base, Base+Phenol, Acid+Phenol, Acid+Neutral ,Base+Neutral, Phenol+Neutral, Neutral+Neutral** (one component be water soluble) **Minimum 10 mixtures**

Reference Books:

1. Furniss, B. S. (1996, 5th edition). *Vogel's textbook of practical organic chemistry*. Pearson Education India. (ISBN: 978-0582462366).
2. Arthur I.(1974 3rd edition).A Text-Book of practical organic chemistry including Qualitative organic analysis. (ISBN: 0-582-44245-1)

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice
5. Laboratory Accessories

Suggested MOOCs: Swayam-NPTEL

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester V

Course Category	**Major Chemistry-12**
Title of the Course	**Chemistry 12-Advanced Inorganic & Analytical Chemistry**
Course Credit	**03**
Teaching Hours per Sem.	**45**
Total Marks	**CCE- 25+ SEE- 50**

Course Outcomes– COs
By the end of this course, the students will be able to: **CO1:** Describe the electronic configurations and spectral terms of **multi-electron systems** using Hund's rules, term symbols, and selection rules. **CO2:** Explain the principles of **Crystal Field Theory (CFT)** and analyze the splitting of d-orbitals in various geometries like octahedral, tetrahedral, and square planar complexes. **CO3:** Interpret electronic spectra and magnetic properties of transition metal complexes based on **Crystal Field Stabilization Energy (CFSE)** and orbital occupancy. **CO4:** Understand the **principles and classifications of volumetric analysis**, and apply them to prepare standard solutions and perform accurate titrations. **CO5:** Demonstrate knowledge of **qualitative analysis principles** of inorganic and organic compounds, including systematic group separation, identification, and confirmation tests. **CO6:** Apply the concepts of **analytical errors, accuracy, precision, and statistical treatment of data** to evaluate and interpret experimental results effectively.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skillsનાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		~~Yes~~/No	Ability Enhancement Courses		~~Yes~~/No
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	Yes/~~No~~	Interdisciplinary	Yes/~~No~~
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					Yes/~~No~~
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Unit No.	Topics	Hrs	Mks
1	**UNIT-1: Multi Electron System** • Introduction • Concept of spectral terms and term symbols • s-s coupling, l-l coupling, l-s coupling, j-j coupling and L-S coupling with vector diagram. • Derivation of spectral term symbol for P^1, P^2, P^3, & d^1 to d^9 • Micro states: Definition, calculation and derivation of microstates for p^1, p^2, d^1 & d^2 • Hole-Pigeon diagram • Hund's rule for the determination of ground state spectral term • All types of examples including calculation of S. M_s, L, M_L, J, M_J and microstates. • Hole formalism • Splitting of D and F ground terms using hole formalism • Orgel Diagram of D and F states	9	10
2	**UNIT-2: Crystal Field Theory - I** • Introduction • Concept of crystal field theory • d-orbitals splitting and CFSE in octahedral and tetrahedral filed with examples • Weak field and strong field ligand • Factors affecting splitting energy. • High spin and low spin complexes with paring energy with Examples • Magnetic behaviour of transition metal complexes • Orbital angular momentum contribution to magnetic momentum of complexes	9	10
3	**UNIT-3: Crystal Field Theory II** • Introduction to the concept • Jahn-Teller effect: Statement and explanation • Tetragonal distortion with example • Splitting of d-orbital in square planar complexes with examples • Selection rules for d-d transition • Relaxation in selection rules • Characteristics of Absorption Spectrum • Types of electronic transition in metal complexes • Discussion of Absorption spectrum of Ti^{+3}, Cu^{+2}& Ni^{+2}	9	10
4	**UNIT-4: Principles of Volumetric Analysis** Ostwald's law- Regarding indicator – necessary derivation and formula of indicator used in Neutralization, redox, precipitation titration. • Primary and secondary standard explanation • Explanation of neutralization titration with graph (Strong acid - Strong base, Weak acid - Strong base , Strong acid – Weak base, Poly protic acid - Strong base titration) • Redox Titration	9	10

	➢ Principle of external and internal indicator in redox titration. e.g. Diphenyl amine, starch & $K_3[Fe(CN)_6]$ ➢ Redox Titration with graph and calculation ➢ Iodometry and Iodimetry titration ➢ Preparation of standard sodium thiosulphate solution • Precipitation Titration Argentometric Titration (I) Mohr's method (II) Fazan's method (III) Volhard's method with use of proper indicator, graph and its practical application • complexometry titration ➢ Method of preparation of standard EDTA solution ➢ Velcher's law explanation, Graph of "pM versus volume of EDTA", stability constant value. ➢ Different types of EDTA titration e.g.(i)Direct titration,(ii) Back titration, (iii) Replacement titration (iv) Alkalimetry titration ➢ Masking and demasking ➢ Principle of metal ion indicator and brief introduction to metal-ion indicators with structure and characteristics; e.g. EBT, calcon, muroxide.		
5	**UNIT-5:Principles of Organic and Inorganic Qualitative Analysis** • Basic principle of qualitative analysis and types of qualitative analysis. • Inorganic qualitative analysis : Principle and its application • Separation of the following in presence of each other (i) Cl^{-1} , Br^{-1} , I^{-1} (ii) NO_2^{-1} ,NO_3^{-1} , Br^{-1} (iii) S^{-2} , SO_3^{-2} , SO_4^{-2} (iv) CO_3^{-2} , SO_3^{-2} , S^{-2} (v) Cu^{+2} , Cd^{+2} (vi) Fe^{+3}& Al^{+3} (vii) Co^{+2}& Ni^{+2} (viii) Sr^{+2}& Ca^{+2} • Organic Qualitative Analysis: Principle and its application • Separation of mixture of organic compounds on the basis of their physical state(S+S,S+L,L+L) and their nature.(A+B,A+N,B+N,A+P,P+B,P+N) • Error and statistics ➢ conceptual introduction ➢ Calibration of Instruments , blank measurement , independent method parallel method, Standard addition method ➢ Explanation of Significant figure and its laws with complete Interpretation ➢ Mean and standard deviation , variance and coefficient of variance ➢ Gausian curve and its explanation ➢ Importance of Q test and T -test (Student T-test) ➢ Example on errors, significant figures, Q test & T-tests.	**9**	**10**

Reference Books:

1. Jeffery, G.H., Bassett, J., Mendham, J.• & Denney, R.C. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley & Sons, 1989.
2. Willard, H.H., Merritt, L.L., Dean, J.• & Settoe, F.A. Instrumental Methods of Analysis, 7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
3. Christian, Gary D; Analytical Chemistry, 6th Ed. John Wiley• & Sons, New York, 2004.
4. Harris, Daniel C: Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.•
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age, International• Publisher, 2009. Skoog, D.A. Holler F.J.• & Nieman, T.A.
6. Principles of Instrumental Analysis, Cengage Learning India Ed. Mikes, O.
7. Laboratory Hand Book of Chromatographic• & Allied Methods,
8. Elles Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
9. Ditts, R.V. Analytical Chemistry; Methods of Separation, van Nostrand, 1974
10. Fundamental of analytical chemistry by Skoog& West
11. Instrumental Method & Chemical Analysis by B.K. Sharma Analytical
12. Water Analysis and Water pollution by V.P. Kudesia
13. Instrumental Method & Chemical Analysis by ChatwalAnand
14. Thin layer chromatography by Egal Stall
15. Book for Water Analysis by R. K. Trivedi, V. P. Kudesia
16. Analytical Chemistry by Dick
17. Inorganic Qualitative analysis by Vogel and Gehani Parekh
18. Electrometric Methods of analysis by Browning
19. Principle of instrumental analysis by Skoog

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice

Suggested MOOCs: Swayam-NPTEL

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester V

Course Category	**Major Chemistry Practical -12**
Title of the Course	**Chemistry Practical-12: Volumetric Analysis**
Course Credit	**01**
Teaching Hours per Sem.	**30**
Total Marks	**CCE- 25**

Course Outcomes – COS
CO1: Demonstrate understanding of the theoretical principles and procedures of iodometric, iodimetric, redox, and complexometric titrations. **CO2:** Accurately prepare standard solutions and carry out volumetric estimations including water analysis using suitable indicators. **CO3:** Apply knowledge of titration methods to determine concentrations of various analytes in environmental and laboratory samples. **CO4:** Analyze and interpret results with attention to precision, accuracy, and possible sources of error in volumetric methods. **CO5:** Follow safe laboratory practices, proper waste disposal, and documentation standards during chemical analysis. **CO6:** Develop collaborative skills, maintain laboratory records, and communicate experimental findings effectively.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skills નાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		Yes/~~No~~	Ability Enhancement Courses		Yes/~~No~~
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	~~Yes~~/No	Interdisciplinary	~~Yes~~/No
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે ?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					~~Yes~~/No
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Major Chemistry Practical-12

Iodometric:-

- To determine amount of Cu^{+2} in the given solution of $CuSO_4.5H_2O$ using 0.05 N $Na_2S_2O_3.5H_2O$ by Iodometric titration.

Iodimetric:-

- To determine amount of As^{+3}in the given solution of As_2O_3 using 0.05 N $Na_2S_2O_3.5H_2O$ by Iodimetric titration.

Volumetric Analysis

- To determineamountof chlorides in given water sample using 0.02N $AgNO_3$.
- To determine purity of $NaHCO_3$ in given sample
- To prepare and standardize 0.1 M ammonium thiocyanate solution.
- To determine % w/v of borax and boric acid present in the given sample.
- To determine percentage purity of sodium acetate by nonaqueous titration according to IP 2007
- To determine the percentage purity of citric acid as per IP 2007
- To determine the relative molecular mass of organic diprotic acid.

Complexometric titration

- Estimation of amount of $Mg^{+2}$and Pb^{+2} presents in the given solution of Mg^{+2} and Pb^{+2} using 0.02N EDTA solution.
- Estimation of amount of $Ca^{+2}$and Zn^{+2}presents in the given solution of Ca^{+2} and Zn^{+2} using 0.02N EDTA solution.
- Estimation of amount of Fe^{+3} and Cr^{+3} presents in the given solution of Fe^{+3} and Cr^{+3} using 0.02N/0.01M $Pb(NO_3)_2$ and 0.02N/0.01M EDTA solution.
- To determine % purity of calcium gluconate according to IP 2007

Redox titrations:-

- To determine amount of NO_2^{-1} in the given $NaNO_2$ and KNO_2 solution by reduction method using 0.1 N $KMnO_4$ solution.
- To determine% w/v and volumestrength of H_2O_2 by using $KMnO_4$

Reference Books:

1. Jeffery, G. H.; Bassett, J.; Mendham, J.; Denny, R. C. (1989, 5th edition) *Vogel's Textbook of Quantitative Chemical Analysis*. Hoboken: John Willey & Sons (ISBN: 0-582-44693-7).

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice
5. Laboratory Accessories

Suggested MOOCs: SWAYAM-NPTEL

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester V

Course Category	**Major Chemistry-13**
Title of the Course	**Chemistry-13 Industrial Chemistry**
Course Credit	**03**
Teaching Hours per Sem.	**45**
Total Marks	**CCE- 25+ SEE- 50**

Course Outcomes– Cos
CO1: Describe the chemical principles and manufacturing processes involved in the production of soaps and detergents, including raw materials and formulation techniques. **CO2:** Explain the composition, classification, and production steps of cement and analyze its chemical setting and industrial applications. **CO3:** Discuss the synthesis, classification, and therapeutic applications of synthetic drugs used in the pharmaceutical industry. **CO4:** Identify the composition and functions of various chemical fertilizers, and assess their role in agriculture and environmental sustainability. **CO5:** Understand the formulation and application of paints, primers, and coatings, including the chemical principles involved in pigment dispersion and film formation. **CO6:** Recognize the relevance of industrial chemical processes in daily life and evaluate their contribution to sustainable industrial practices.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skillsનાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		~~Yes~~/No	Ability Enhancement Courses		~~Yes~~/No
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	Yes/~~No~~	Interdisciplinary	Yes/~~No~~
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					Yes/~~No~~
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Unit No.	Topics	Hrs	Mks
1	**UNIT-1: Soap and Detergents** • Introduction to soap, Types of soap (Toilet soap, Transparent soap, Shaving soap, Neem soap, Liquid soap) • Manufacturing of soap (Batch process, Continuous process) • Recovery of glycerine from spent lye. • Introduction to detergents • Principal group of synthetic detergents • Biodegradability of surfactants • Classification of surface active agents • Anionic detergents (Manufacture of anionic detergents (i) Oxo Process (ii) Alfol Process (iii) Welsh Process) • Cationic detergents (Manufacture process) • Non Ionic detergents (Manufacture by batch process) • Amphoteric detergents • Manufacture of shampoo	**9**	**10**
2	**UNIT-2: Cement** • Introduction and type of cement. • Raw materials and manufacturing process (1) Dry process (2) Wet process. • Setting of cement (1) Hydrolysis (2) Hydration. • Properties of cement. • Testing of cement and ISI specification of cement. • Mortar, concrete, RCC • Curing and decay of cement. • Uses of cement.	**9**	**10**
3	**UNIT-3: Synthetic Drugs** • Synthesis, Uses and Side effects of following class of drugs **Antidiabetic Drugs:** • **Metformin** – A small, biguanide molecule; improves insulin sensitivity. *Structure:* HN=C(NH2)N(CN)CN • **Glipizide** – A sulfonylurea; stimulates insulin release. *Functional groups:* Sulfonylurea core, aromatic rings. • **Sitagliptin** – A small DPP-4 inhibitor molecule. *Structure:* Contains a triazolopyrazine ring. **Anticancer Drugs:** • **Anastrozole** – Aromatase inhibitor; has a triazole ring. • **Letrozole** – Similar to Anastrozole, another triazole-based aromatase inhibitor. • **Cisplatin** – A very simple coordination complex of platinum with two chloride and two ammonia ligands. *Formula:* $[Pt(NH_3)_2Cl_2]$ **Antiviral Drugs:** • **Acyclovir** – A purine nucleoside analog. *Looks like:* Guanine + acyclic sugar.	**9**	**10**

	• **Oseltamivir (Tamiflu)** – A neuraminidase inhibitor; small ester molecule. *Simple ester + amine functionalities.* • **Favipiravir** – A pyrazinecarboxamide derivative used for influenza and COVID-19. *Structure:* Small pyrazine ring with a carboxamide group		
4	**UNIT-4: Fertilizers** • Introduction to fertilizers, role of plant nutrients. • Classification and properties of fertilizers. • Nitrogenous fertilizers. • Manufacturing process of (1) Ammonium nitrate (by prilling method), (2) Ammonium sulphate (sindri process), (3) Urea (from Ammonium carbonate), (4) Calcium cyanamide(by electro carbonate) and action of fertilizers(of all above). • Phosphate fertilizer: (1) Normal super phosphate and its manufacturing process, (2) Triple super phosphate and its manufacturing process, (3) manufacture of mono ammonium and diammonium phosphate. • Potassium fertilizer: NPK fertilizers and nomenclature, Murate of potash and Karnelite from sea water • Comparison of Natural and Synthetic Fertilizers	**9**	**10**
5	**UNIT-5: Paints and Primers** • Introduction to Paints : Definition and Importance, Composition of Paints : pigment, vehicle (binder), solvent, and additives, Types of Paints: Categorize paints based on their application (e.g., architectural, automotive, industrial) and chemical composition (e.g., oil-based, water-based). • Pigments : Types of Pigments, properties, and applications, Function of Pigments, Manufacturing of Pigments • Vehicles/Binders : Types of Vehicles: Different types of binders, including natural and synthetic resins, oils, and polymers, Function of Vehicles: holding pigments together, forming a film, and providing properties like adhesion and durability, Manufacturing of Vehicles • Solvents : Types of solvents used in paints including organic solvents and water-based systems, Function of Solvents: Controlling viscosity, facilitating application, and ensuring proper film formation, Selection of Solvents: Choice of solvents for specific paint types. • Additives : Types of Additives: dryers, dispersants, antifoams, etc., Function of Additives: • Enhancing paint performance and durability, Selection of Additives: choice of additives for specific paint types.	**9**	**10**

	• Manufacturing of Paints : Mixing and Grinding: mixing pigments with vehicles and solvents, including milling and dispersion, Quality Control: testing and analysis.		

Reference books :

1. Sharma, B. K. (2021) Industrial chemistry-I, Krishna publication, (ISBN; 9388140435).
2. Sharma, B. K. (2021) Industrial chemistry-II, Krishna publication, (ISBN; 9389594138).
3. Flick, E. W. (2013, 1 st edition). Advanced cleaning product formulations (Vol.2). Elsevier.(ISBN: 9780815516064)
4. Hannan, H. J. (2007). Technician's Formulation Handbook for Industrial and Household Cleaning Products. Lulu. com.(ISBN: 978-0615156019).
5. Flick, E. W. (2014,1 st edition). Cosmetic and toiletry formulations (Vol. 3). Elsevier (ISBN: 9780815516712).

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice

Suggested MOOCs: Swayam-NPTEL

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester V

Course Category	**Major Chemistry Practical -13**
Title of the Course	**Chemistry Practical -13: Organic Qualitative Analysis of Liquid Binary Mixtures (Solid + Liquid, Liquid + Liquid)**
Course Credit	**01**
Teaching Hours per Sem.	**30**
Total Marks	**CCE- 25**

Course Outcomes – COs

By the end of this course, the students will be able to:

CO1: Identify the physical properties (boiling point, miscibility, odor, etc.) of individual components in a binary liquid mixture.

CO2: Perform systematic separation of binary liquid mixtures based on physical and chemical properties (e.g., distillation, extraction).

CO3: Detect functional groups present in each separated component using preliminary and confirmatory organic qualitative tests.

CO4: Analyze and interpret chemical reactions and observations to confirm the identity of individual compounds.

CO5: Record experimental data accurately and report results logically with appropriate chemical reasoning and safety practices.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skills નાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		Yes/~~No~~	Ability Enhancement Courses		Yes/~~No~~
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	~~Yes~~/No	Interdisciplinary	~~Yes~~/No
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે ?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					~~Yes~~/No
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Chemistry Practical-13
Organic Qualitative Analysis of Liquid Binary Mixtures 1. **Liquid + Liquid** =Low BP+ High BP, Low BP + Low BP and High BP + High BP 2. **Liquid + Solid** =Low BP + Solid (soluble in the Low bp liquid) Minimum 6 + 4 mixtures

Reference Books:

1. Furniss, B. S. (1996, 5th edition). *Vogel's textbook of practical organic chemistry*. Pearson Education India. (ISBN: 978-0582462366).
2. Arthur I.(1974 3rd edition).A Text-Book of practical organic chemistry including Qualitative organic analysis. (ISBN: 0-582-44245-1)

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice

Suggested MOOCs: Swayam-NPTEL

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester V

Course Category	**(SEC-5) Skill Enhancement Course (SEC)-2 Credit** Skill based Theory + Practical Course;
Title of the Course	**Separation Techniques**
Course Credit	**02 (1T + 1P)**
Teaching Hours per Sem.	**15 hrs. Theory & 30 hrs. Practical**
Total Marks	**As per SU SOP: CCE-25 marks + SEE-25 marks**

Course Outcomes– COs

By the end of this course, the students will be able to:

CO1: Describe the fundamentals of chromatography, including classification, principles, and efficiency based on solubility, adsorption, and volatility.

CO2: Explain key physical characteristics influencing chromatographic separation such as Rf and Rx values, adsorption nature, and solubility.

CO3: Distinguish between qualitative and quantitative chromatographic methods and apply them for chemical analysis.

CO4: Demonstrate the principles and procedures of column chromatography for separating pigments, vitamins, salts, and carotenoids from natural sources.

CO5: Perform partition chromatography and paper chromatography using various experimental setups (ascending, descending, one-dimensional, two-dimensional, and circular) and interpret results using appropriate spray reagents.

CO6: Prepare chromatoplates and conduct thin-layer chromatography (TLC), understanding its advantages and applying it to separate and identify organic and inorganic mixtures.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skillsનાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		Yes/~~No~~	Ability Enhancement Courses		Yes/~~No~~
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	Yes/~~No~~	Interdisciplinary	Yes/~~No~~
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે ?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					~~Yes~~/No
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Skill Enhancement Course (SEC)-5

Separation Techniques : Chromatographic Techniques **[15 Hours]**

Chromatography

- Introduction to Chromatography, Classification, principle and efficiency of the technique.
- Application such as main physical characteristic of chromatography: Solubility, adsorption value, volatility, Rf value, Rx value, nature of adsorption etc.
- Qualitative and quantitative aspects of various chromatographic methods of analysis
- Column chromatography:Principle, Method of separation of green leafpigment, mixture of inorganic salts, vitamins,colors of flowers etc. separation of α,β,γ carotene from carrot.

Partition chromatography and TLC:

- Paper chromatography: Principle of paper chromatography, Experimental methods like :Ascending and Descending method containing one dimensional and two dimensional method; circular method and its Rf value , Rx value; circular method, separation of amino acids and metal ions(Fe^{+} , Co^{+2}, $Ni^{+2)}$ mixture using spray reagent ninhydrine and aniline phthalate
- TLC:Principle, Method of preparation of chromatoplate, Experimental techniques, superiority of TLC over other chromatographic Techniques, Application of TLC.

Practical **(30 Hours)**

- To determine Rf value of individual and mixture of different amino acid by ascending paper chromatography. (Total 4)
- To determine Rf value of individual and mixture of different amino acid by circular paper chromatography. (Total 4)
- To determine Rf value of individual and mixture of different metal ions (Pb^{+2}& Cu^{+2}) by ascending paper chromatography.
- To determine Rf value of individual and mixture of different metal ions (Ni^{+2}& Co^{+2}) by ascending paper chromatography.
- To determine Rf value of individual and mixture of different metal ions (Cu^{+2}& Fe^{+3}) by ascending paper chromatography.
- To determine Rf value of individual and mixture of different metal ions (Cu^{+2}& Co^{+2}) by ascending paper chromatography.
- To determine Rf value of individual and mixture of different metal ions (Pb^{+2}& Cu^{+2}) by circular paper chromatography.
- To determine Rf value of individual and mixture of different metal ions (Ni^{+2}& Co^{+2}) by circular paper chromatography.
- To determine Rf value of individual and mixture of different metal ions (Cu^{+2}& Fe^{+3}) by circular paper chromatography.
- To determine Rf value of individual and mixture of different metal ions (Cu^{+2}& Co^{+2}) by circular paper chromatography.
- Demonstration of preparation of TLC plate. (1)
- To separate mixture of organic compounds by thin layer chromatography. (1)

➢ Demonstration of Column Preparation ($KMnO_4$ + $K_2Cr_2O_7$). (1)

Reference Book/ Manual:

1. Gurdeep, R., Chatwal, S., &nand, K. (2016,7 th edition). Instrumental methods of chemical analysis. Himalaya publishing house (ISBN: 978-9350512067).
2. Braithwaite, A., & Smith, J. F. (2012, 5 th edition). Chromatographic methods. Springer Science & Business Media(ISBN: 978-0751401585).
3. Dr. A. V. Kasture, Dr. S. G. Wadodkar, Dr. K. R. Mahadik, Dr. H. N. More (2008, 7 th edition) Pharmaceutical Analysis Vol.- II.NiraliPrakashan. (ISBN: 978-8185790084).
4. Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug (2013, 7 th edition) Analytical chemistry. John Wiley & sons, Inc. (ISBN: 978-0-470-88757-8).
5. B. K. Sharma (2014) Instrumental method of chemical analysis. Meerut: Krishna Prakashan Media (P) Ltd. (ISBN: 978-8182836730).

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice
5. Laboratory Accessories

Suggested MOOCs: SWAYAM-NPTEL

Evaluation of Skill Enhancement Course -:

SEC (1 Credit theory + 1 Credit Practical)	
CCE-P-50% (25 Marks) and SEE-T-50% (25 Marks)	
Evaluation Components	**Marks**
Lab work Assessment – Performance : Lab quiz, Attendance, Aim achievement & Journal- Record book	05+05
Course End Practical Examination & Viva voce - One & Half Hours Duration	10+05
Total marks of CCE- Continuous and Comprehensive Evaluation	**25**
Semester-End Evaluation- TheoryExamination– One Hours Duration	**25**
Total Marks for the Skill Enhancement Course	**50**

Semester End Exam Question Paper Pattern for SEC Theory:-

Time: 1 Hour **Marks: 25**

Q. 1	**10 Marks**
(A) Objective QA: 06 Out of 10 MCQs carrying 01 mark each (B) Subjective QA: 02 Out of 04 Subjective Que. carrying 02 mark each	(A) 06 Marks (B) 04 Marks
Q. 2	**10 Marks**
(A) Objective QA: 06 Out of 10 Objective Que. carrying 01 mark each (B) Subjective QA: 02 Out of 04 Subjective Que. carrying 02 mark each	(A) 06 Marks (B) 04 Marks
Q. 3	**05 Marks**
Subjective QA: 01 Out of 03 Subjective Question related to Experimental Procedures	05 Marks

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester V

Course Category	**Minor Chemistry-4**
Title of the Course	**Minor Chemistry -4: Opto & Electro Analytical Techniques- I**
Course Credit	**02**
Teaching Hours per Sem.	**27**
Total Marks	**SEE- 50**

Course Outcomes– COs

By the end of this course, the students will be able to:

CO1: Explain the working principles of electroanalytical techniques such as pH metry, potentiometry, and conductometry for chemical analysis.

CO2: Perform accurate measurements of pH and electrode potentials and interpret titration curves in acid-base and redox reactions.

CO3: Apply conductometric methods to determine ionic conductance and analyze titration data for strong and weak electrolytes.

CO4: Describe the principles of colourimetry and apply Beer-Lambert's law to estimate the concentration of colored compounds in solution.

CO5: Understand the principle of optical rotation and perform polarimetric measurements to analyze optically active substances.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skillsનાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		~~Yes~~/No	Ability Enhancement Courses		~~Yes~~/No
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	Yes/~~No~~	Interdisciplinary	Yes/~~No~~
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઇકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					Yes/~~No~~
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Unit No.	Topics	Hrs	Mks With Option
1	**UNIT-1: pH Metry and Potentiometry** • Introduction & Classification of Electro analytical methods • Basic principle of pH metric, potentiometric titrations • Importance of indicator and reference electrode in the measurement of EMF and pH. • E.M.F. method(Potentiometry) • Study of acid-base Titration • Redox Titration • Argentometric titration includes mixture of Cl^-, Br^-, I^- with graph and proper explanation. • pH metry: Definition, Interpretation of various methods of determining pH value like pH paper method, potentiometric method using only hydrogen electrode as indicator electrode and calomel electrode as reference electrode to determine pH value • Techniques used for the determination of equivalence points. • Techniques used for the determination of pK_a values of Weak acid-strong base	9	10+ ≅≅10
2	**UNIT- 2: Conductometry** • Electric transport, Ohms law, resistance in metals and in electrolyte solution conductance, specific resistance, specific conductance, equivalent conductance, • Molecular conductance in electrolyte solution, • Importance of conductivity electrodes and platinization of electrodes etc. • Effect of dilution on different type of conductance • Introduction to conductivity cell, different types of conductivity cells, area of cross section of dip type electrode and distance between two plates of electrodes etc. • Kohlrausch law and its importance, • cell constant and its importance. • Importance of conductivity water and temperature for the measurement of conductivity **<u>Conductometry Titrations:</u>** 1. Strong acid - strong base 2. Strong acid - Weak base 3. Weak acid – Strong base 4. Mixture of (strong acid + Weak acid) versus strong base / weak base	9	10+ ≅10

	Precipitation Titration: (1) $AgNO_3$ – NaCl (2) $BaCl_2$ – K_2SO_4 (3) $Ba(OH)_2$ – $MgSO_4$ **Replacement Titration:** • Salt of weak acid – strong acid • Salt of weak base – strong base **Applications of conductometry titrations:-** 1. To determine degree or hydrolysis and hydrolysis constant 2. To determine degree of dissociation and dissociation constant 3. To determine solubility and solubility product of sparingly soluble salt		
3	**UNIT-3: Colourimetry and Polarimetry** Colourimetry • Introduction • Grothus- Draper law, Lambert's law, Beer's law, Lambert's-beer's law and Derivation, application & deviation of Lambert's law • Spectrophotometric titration with graph and proper explanation • Deficit of absorbance by product and titrant • Deficit of absorbance by product and reagent • Deficit of absorbance by reagent and titrant • Deficit of absorbance by product only Polarimetry • Introduction and definition • Optical activity and factors affecting it • Specific rotation • Polarimeter : Instrumentation and working • Applications of Polarimetry	**9**	**10+ ≅10**

Reference books:

1. Sharma, B. K. (2014) Instrumental Method of Chemical Analysis. Meerut: GOEL publishing House (ISBN: 978-81-8283-099-8).
2. Douglas A. Skoog, West, Holler, Crouch (2004, Eighth edition) Fundamental of Analytical Chemistry. Mexico: Thomson-Brooks/Cole (ISBN: 81-315-0051-9).
3. Bahl, Arun; Bahl, B. S.; Tuli, G. D. (2010) Essential of Physical Chemistry. New Delhi : S. Chand (ISBN No. 81-219-2978-4)
4. Christian, Gary D.; Dasgupta, Purnendu K.; Schug, Kevin A. (2007, Sixth edition) Analytical Chemistry. Hoboken: Wiley-Blackwell Science Ltd. (ISBN: 978-81-265-1113-6).

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice

Suggested MOOCs: SWAYAM-NPTEL

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester V

Course Category	**Minor Chemistry Practical -04**
Title of the Course	**Minor Chemistry Practical -04: Opto & Electro Analytical Techniques-I**
Course Credit	**02**
Teaching Hours per Sem.	**60**
Total Marks	**CCE- 50**

Course Outcomes – COS

By the end of this practical course, the students will be able to:

CO1: Operate and calibrate pH meters to measure the acidity or basicity of solutions accurately.

CO2: Use potentiometric techniques to determine end-points of redox and acid-base titrations and evaluate electrode potentials.

CO3: Perform conductometric titrations to analyze ionic strength and dissociation properties of electrolytes.

CO4: Apply colourimetric techniques for the quantitative estimation of substances using Beer-Lambert's law.

CO5: Determine the specific rotation of optically active compounds using a polarimeter and interpret their stereochemical nature.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skillsનાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		Yes/~~No~~	Ability Enhancement Courses		Yes/~~No~~
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	~~Yes~~/No	Interdisciplinary	~~Yes~~/No
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે ?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					~~Yes~~/No
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Minor Chemistry Practical-4 (Opto & Electro Analytical Techniques-I)
Exercise–I: pH metry ➢ To determine normality and gms/lit. of xHCl by pH metry using 0.1 N NaOH. ➢ To determine normality and gm/lit. of CH_3COOH by pH metry. ➢ To determine normality and gm/lit. of NH_4OH by pH metry. ➢ To determine normality and gm/lit. of lactic acid by pH metry. ➢ To determine the amount of aspirin in a given tablet **Potentiometry** ➢ To determine normality and of given acid xN HCl using 0.5N NaOH solution. ➢ To determine normality of given acid xN CH_3COOHusing 0.5N NaOH solution.
Exercise-II: Conductometry ➢ To determine normality and gms/lit of x N HCl and also determine specific conductance by conductometry. ➢ To determine normality and gms/lit of sulphuric acid by conductometry. ➢ To determine normality and gms/lit of the mixture of HCl + CH_3COOH by conductometry. ➢ To determine the normality and gm/lit of weak acid CH_3COOH by conductometry using NaOH ➢ To determine the normality of $AgNO_3$ using 0.5 N NaCl by conductometry ➢ To determine the normality of aniline by conductometry
Exercise-III: Colourimetry ➢ To perform calibration of colourimeter ➢ Find out the amount of Ni^{+2} in the given solution by colorimetry method. ➢ Find out the amount of Fe^{+3} in the given solution by colorimetry method. ➢ To determine amount of paracetamol in given tablet by colorimetry method. ➢ To determine amount of aspirin in given tablet by colorimetry method. ➢ Find out the amount of $KMnO_4$ in the given solution by colorimetry method. **Polarimetry** ➢ To determine specific rotation of three different concentration (10%, 5%, 2.5%) of dextrose solution. From graph find out the unknown. ➢ Study the inversion rate of sugar in presence of 1 N HCl and determine the rate of reaction.

Reference Books:

1. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley & Sons, 1989.
2. Willard, H. H., Merritt, L.L., Dean, J. & Settle, F.A. Instrumental Methods of Analysis, 7thEd. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
3. Christian, G.D; Analytical Chemistry, VI Ed. John Wiley & Sons, New York, 2004.
4. Harris, D. C. Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
   Skoog, D. A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed, 2017.

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice

Suggested MOOCs: Swayam-NPTEL

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year –B.Sc. Degree in Chemistry)

Semester V

Course Category	**Minor Chemistry-5**
Title of the Course	**Minor Chemistry -5: Opto & Electro Analytical Techniques- II**
Course Credit	**02**
Teaching Hours per Sem.	**27**
Total Marks	**SEE- 50**

Course Outcomes – COs

By the end of this course, the students will be able to:

CO1: Explain fundamental principles of photochemistry, including Jablonski diagrams, quantum yield, and photochemical reactions.

CO2: Describe the concepts of electrolytic conductance, transport number, and ionic mobility in Electrochemistry-I.

CO3: Apply the Nernst equation, understand electrode potentials, and evaluate electrochemical cell reactions in Electrochemistry-II.

CO4: Analyze electrochemical and photochemical data for application in industrial, biological, and environmental systems.

CO5: Correlate theoretical principles with modern instrumentation used in electrochemical and photochemical analysis.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skillsનાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		~~Yes~~/No	Ability Enhancement Courses		~~Yes~~/No
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	Yes/~~No~~	Interdisciplinary	Yes/~~No~~
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					Yes/~~No~~
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Unit No.	Topics	Hrs	Mks
1	**UNIT-1: Photo Chemistry** • Laws of photo chemistry **:** Grothus –Drapper law, Lambert-beer law, Stark-Einstein law • Quantum efficiency and factors affecting quantum efficiency • Reasons for low and high quantum yield • Photo sensitization • Fluorescence • Phosphorescence • Chemiluminescence	**9**	**10+ ≅10**
2	**UNIT- 2: Electrochemistry-I** • Introduction to basic concepts related to electrochemistry (e.g. oxidation, reduction, redox reaction, electrolytes and their types, oxidation number, oxidation potential, reduction potential etc) • Differences between "electrochemical cell" and "electrolytic cell". • Electrode, Half-cell, electrochemical cell • Standard half-cell, standard electrochemical cell • Types of electrodes such as Metal-Metal ion electrode, Metal-metal insoluble salt electrode, Metal-Metal amalgam electrode, Gas electrode and Inert (Redox type) electrode • Conventional sign and representation of electrochemical cell (Galvanic cell) • Standard electrode potential and its measurement • emf series • Hydrogen electrode, calomel electrode, glass electrode • Reversible cell and Irreversible cell • Nernst equation for the calculation of single electrode potential • Examples based on theory	**9**	**10+ ≅10**
3	**UNIT-3: Electrochemistry-II** • Concentration cells: Definition, (1) Electrode concentration cells (2)Electrolyte concentration cells • Concentration cells without transference • Concentration cells with transference • Liquid junction potential, Elimination of liquid junction potential. • Applications of emf measurements: Determination of • Solubility of sparingly soluble salts • Valency of metal ion • Dissociation constant of weak acid	**9**	**10+ ≅10**

	• Transport number of ion • Ionic product of water • Degree of hydrolysis • pH by different • electrodes Example		

Reference books:

1. Sharma, B. K. (2014) Instrumental Method of Chemical Analysis. Meerut: GOEL publishing House (ISBN: 978-81-8283-099-8).
2. Douglas A. Skoog, West, Holler, Crouch (2004, Eighth edition) Fundamental of Analytical Chemistry. Mexico: Thomson-Brooks/Cole (ISBN: 81-315-0051-9).
3. Bahl, Arun; Bahl, B. S.; Tuli, G. D. (2010) Essential of Physical Chemistry. New Delhi : S. Chand (ISBN No. 81-219-2978-4)
4. Christian, Gary D.; Dasgupta, Purnendu K.; Schug, Kevin A. (2007, Sixth edition) Analytical Chemistry. Hoboken: Wiley-Blackwell Science Ltd. (ISBN: 978-81-265-1113-6).

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice

Suggested MOOCs: SWAYAM-NPTEL

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester V

Course Category	**Minor Chemistry Practical-5**
Title of the Course	**Minor Chemistry Practical-5: Opto & Electro Analytical Techniques-II**
Course Credit	**02**
Teaching Hours per Sem.	**60**
Total Marks	**CCE- 50**

Course Outcomes – COs

By the end of this course, the students will be able to:

CO1: Operate and calibrate instruments such as pH meters, potentiometers, conductivity meters, and refractometers with accuracy and precision.

CO2: Determine the pKa of acids and evaluate the strength of acids and bases using pH-metric titrations.

CO3: Analyze redox and precipitation titrations using potentiometric methods to identify equivalence points.

CO4: Estimate electrolyte concentrations and study ion conductance behavior through conductometric titrations.

CO5: Measure refractive index of liquids and solutions, and apply it for purity assessment and concentration estimation.

CO6: Interpret and report experimental results with scientific reasoning and proper documentation.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skillsનાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		Yes/~~No~~	Ability Enhancement Courses		Yes/~~No~~
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	~~Yes~~/No	Interdisciplinary	~~Yes~~/No
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે ?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					~~Yes~~/No
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Minor Chemistry Practical-05(Opto & Electro Analytical techniques-II)
Exercise–I: Refractometry ➢ To determine specific refractivity and molecular refractivity of given pure liquid A, B, C, D. ➢ To determine specific refractivity and molecular refractivity of glycerine (10%, 5%, 2.5%) and unknown glycerine solution. ➢ To study the variation of refractive index with composition of given liquid and also determine composition of unknown mixture. ➢ To determine the molar refraction and refractive index of a given salt.
Exercise-II: pH Metry ➢ To perform the calibration of pH meter ➢ To determine normality and dissociation constant of weak acid (xNC_6H_5COOH) by pH metry. ➢ To determine normality and dissociation constant of dibasic acid xN Oxalic acid using 0.5N NaOH solution. ➢ To determine normality and dissociation constant of dibasic acid malonic acid using 0.5N NaOH solution. ➢ To determine normality and dissociation constant of dibasic acid maleic acid using 0.5N NaOH solution. ➢ To determine normality each component of mixture of $xNHCl+xNCH_3COOH$ by pH metry **Potentiometry** ➢ To perform the calibration of potentiometer ➢ To determine normality and gms/lit of sulphuric acid by Potentiometry. ➢ To determine normality and dissociation constant of benzoic acid using 0.5N NaOH ➢ To determine normality and dissociation constant of given acid xN oxalic acid using 0.5N NaOH solution.
Exercise-III: Conductometry ➢ To perform the calibration of conductometer ➢ To determine the concentration of very weak acid like hydroquinone ➢ To determine the concentration of NH_4Cl by conductometry ➢ To determine normality and dissociation constant of CH_3COOH by using NH_4OH ➢ To determine the concentration of $CH_3COONa+NH_4Cl$ by conductometry ➢ To determine solubility and solubility product of sparingly soluble salt by conductometry using $Pb(NO_3)_2$ and K_2SO_4.

Reference Books:

1. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley & Sons, 1989.
2. Willard, H. H., Merritt, L.L., Dean, J. & Settle, F.A. Instrumental Methods of Analysis, 7thEd. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
3. Christian, G.D; Analytical Chemistry, VI Ed. John Wiley & Sons, New York, 2004.
4. Harris, D. C. Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
   Skoog, D. A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed, 2017.

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice

Suggested MOOCs: SWAYAM-NPTEL

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SAURASHTRA UNIVERSITY

FACULTY OF SCIENCE

Course Structure and Syllabus for Science FYUGP

B.Sc. Honours/ Honours with Research in Chemistry

(T. Y. B.Sc.- Chemistry - Semester VI)

Based on

UGC's guidelines NEP-2020 "Curriculum and Credit Framework for Undergraduate Programmes- CCFUP" and

Education Department, Government of Gujarat's
Uniform Credit Structure for all HEIs of Gujarat State and
Implementation of the Common Curriculum and Credit Framework under the National Education Policy-2020
(No: KCG/admin/2023-24/0607/kh.1 Sachivalaya, Gandhinagar dated 11/07/2023) and

Standard Operating Procedure for Implementation of NEP-2020 for the State of Gujarat- HEIs of Gujarat
(No: KCG/admin/2023-24/865/ dated 26/07/2023) and

Additional content to be added to SOP published by KCG
(No: KCG/NEP-2020/2023-24/893/ dated 28/07/2023)

General Guidelines for Implementation of **Four Year Under Graduate Programmes** for Saurashtra University (16 pages) published in August 2023
(E-mail from Academic Section Saurashtra University dated Oct 11, 2023)

Effective from November–2025 & onwards
(Submitted on 14/06/2025)

PREFACE

Timely revision of the curriculum to encompass new knowledge and information is a prime criterion of IQAC and a prime need for the institute educational systems affiliated with Universities. Under the NEP -2020 and UGC guidelines, a student must be offered the latest courses of varied requirement of technology with societal, environmental, and economic implications. The curriculum should offer multiple entry-exits and a choice of vast subjects to choose from to a student to facilitate his learning abilities, aptitude, and inclination. Chemistry is a foundation subject for Chemical Sciences, Life Sciences, Chemical Engineering, Agriculture, Environmental Science, Genetic engineering, Pharmaceuticals, Fertilizers, Textiles, Polymers, and so many and hence holds the central position in the curriculum of these subjects. Looking at the rapid inventions and technological developments in the field of Chemistry and keeping in view the recommendations of UGC, NEP-2020 and Standard Operating Procedure for Implementation of NEP-2020 for the State of Gujarat- HEIs of Gujarat. This syllabus has been formulated by the combined and coordinated efforts of all the faculty members of Chemistry Departments of all the Colleges affiliated to Saurashtra University.

The composition of a curriculum for a particular subject requires the following criteria to be Considered:

1. Guidelines, Model curriculum, SOPand Evaluation norms provided by the UGC, State Government, and theUniversity.
2. Regional needs and Present National and International trends in the subject.
3. Geographical parameters of the University and its demographic property.
4. Relationship with other related subjects and resources of educational needs.
5. Financial and statutory provisions of the State Government.

The content of a syllabus should be such that it maintains continuity with the course content of Higher secondary classes and post-graduate courses. Keeping this in mind, the current curriculum ismade; and is an effort to impart fundamental knowledge of the subject needed at this level. Thecurriculum is designed as per the guidelines of UGC, NEP-2020 andStandard Operating Procedure for Implementation of NEP-2020 for the State of Gujarat- HEIs of Gujarat,reflects the courses' totalcredit, teaching hours, and question paper style. The syllabus units are well defined, and the scope ofeach is given in detail. A list of reference books is provided at the end of each course. Chemistry being a logical and application based subject, sufficient emphasis is given to problem solving skills.

The following objectives have been considered while formulating the curriculum:

1. To provide an updated, feasible, and modern syllabus to the students, emphasizing knowledge andskill to build up their employment oriented career.
2. To frame the comprehensive syllabus in accordance with the CBCS, UGC- NEP 2020recommendations and considering the Standard Operating Procedure for Implementation of NEP-2020 in the State of Gujarat- HEIs of Gujarat,University guidelines andin consultation with all stakeholders.
3. To offer the students an array of Core, Interdisciplinary, Multidisciplinary, Skill enhancement,Ability enhancement and Value-added courses to select from and to facilitate their academic,intellectual and social grooming.

The Board of Studies for Chemistry expresses heartfelt gratitude to the Dean, Faculty of Science,Saurashtra University, for valuable guidelines and the Academic Section for much-neededcooperation. The Board wishes all the students a very bright future.

Date: 14th June 2025

On behalf of the BoS- Chemistry,

Dr. K.D. Ladva, BoS- Chemistry Saurashtra University, Rajkot	**Dr. V. N. Patolia,** Chairman, BoS- Chemistry Saurashtra University, Rajkot

Graduate Attributes:

Graduates should be able to demonstrate the acquisition of the following:

- **Graduate attributes for FOUR YEAR UNDER GRADUATE PROGRAM**

- **Academic excellence**: Ability to identify key questions, research and pursue rigorous evidence-based arguments
- **Critical Thinking and Effective communications:** Analysis and evaluation of information to form a judgement about a subject or idea and ability tocommunicate effectively the same in a structured form.
- **Global Citizenship:** Mutual understanding with others from diverse cultures, perspectives and backgrounds
- **Research-related skills:** the ability to understand basic research ethics and skills in practicing/doing ethics in the field/ in personal research work, regardless of the funding authority or field of study.
- **Leadership qualities and Teamwork abilities:** The graduates should be able to demonstrate the capability for mapping out the tasks of a team and setting direction and inspiring vision, and building a team that can help achieve the goals
- **Life Long Learning:** Open, curious, willing to investigate, and consider new knowledge and ways of thinking

Program Learning Outcomes:

The student graduating with the Degree B.Sc. (Honours/Honours with Research) Chemistry should be able to acquire;

1. **Core Competency**: Students will acquire core competency in the subject chemistry, and in allied subject areas with following competencies:
   - Systematic and coherent understanding of the fundamental concepts in Physical chemistry, Organic Chemistry, Inorganic Chemistry, Analytical Chemistry and all other related allied chemistry subjects.
   - Students will be able to use the evidence based comparative chemistry approach to explain the chemical synthesis and analysis.
   - The students will be able to understand the characterization of materials.
   - Students will be able to understand the basic principle of equipment, instruments used in the chemistry laboratory.
   - Students will be able to demonstrate the experimental techniques and methods of their area of specialization in Chemistry.
2. **Disciplinary knowledge and skill**: A graduate student isexpected to be capable of demonstrating comprehensive knowledge and understanding of both theoretical and experimental/applied chemistry knowledge in various fields of interest like Analytical Chemistry, Physical Chemistry, Inorganic Chemistry, Organic Chemistry, Material Chemistry etc. Further, the student will be capable of using of advanced instruments and related software for in-depth characterization of materials/chemical analysis and separation technology.

3. **Skilled communicator**: The course curriculum incorporates basics and advanced training in order to make a graduate student capable of expressing the subject through technical writing as well as through oral presentation.
4. **Critical thinker and problem solver**: The course curriculum also includes components that can be helpful to graduate students to develop critical thinking ability by way of solving problems/numerical using basic chemistry knowledge and concepts.
5. **Sense of inquiry**: It is expected that the course curriculum will develop an inquisitive characteristics among the students through appropriate questions, planning and reporting experimental investigation.
6. **Team player**: The course curriculum hasbeen designed to provide opportunity to act as team player by contributing in laboratory, field based situation and industry.
7. **Skilled project manager**: The course curriculum has been designed in such a manner as to enabling a graduate student to become a skilled project manager by acquiring knowledge about chemistry project management, writing, planning, study of ethical standards and rules and regulations pertaining to scientific project operation.
8. **Digitally literate**: The course curriculum has been so designed to impart a good working knowledge in understanding and carrying out data analysis, use of library search tools, and use of chemical simulation software and related computational work.
9. **Ethical awareness/reasoning**: A graduate student requires understanding and developing ethical awareness/reasoning, which the course curriculum adequately provides.
10. **Lifelong learner**: The course curriculum is designed to inculcate a habit of learning continuously through use of advanced ICT technique and other available techniques/books/journals for personal academic growth as well as for increasing employability opportunity.

PROGRAM EDUCATIONAL OUTCOMES (PEO):

This program will produce Graduates who will attain the following PEOs after a few years..

PEO_1	**Core competency**	Understand and apply the fundamental core of chemistry to a broad variety of chemical problems.
PEO_2	**Breath of knowledge**	Competent chemistry graduates with strong fundamental knowledge to cater the needs of GOs and NGOs related to chemical science domain.
PEO_3	**Preparedness**	Demonstrate ability to use necessary tools & techniques of applied chemistry domain.
PEO_4	**Professionalism**	Graduates who can work individually or in teams to interpret chemical literature and propose solutions for problems significant to industries and society as a whole.
PEO_5	**Learning environment**	Inculcate the aptitude to engage in life- long learning from social, economic, and scientific activities of the time.

PROGRAM OUTCOMES (PO): After completion of the FYUGP Chemistry, the Graduate will be able to:		
PO_1	**Foundational Knowledge**	Understand major concepts, theoretical principles and experimental findings in chemistry.
PO_2		Conduct experiments, analyse data, and interpret results, while maintaining responsible and ethical scientific conduct.
PO_3	**Scientific Aptitude**	Employ critical thinking and efficient problem-solving skills in the four basic areas of chemistry - organic, inorganic, analytical, and physical.
PO_4		Exhibit awareness about safety and chemical hygiene regulations and good laboratory practices.
PO_5	**Modern Tool Usage**	Apply classical and minor instruments for chemical analysis and separation.
PO_6		Able to use computers and electronic resources for data management and retrieval.
PO_7		Communicate effectively in written and oral forms to transmit technical information in a clear and concise manner.
PO_8	**Lifelong Learning**	Comprehend and exhibit fundamental aspects of chemical sciences facilitating placement into PG programs, professional organizations, or other related job.
PO_9		Effectively work in diverse teams in all curricular, co-curricular and extra-curricular activities.
PO_{10}	**Global Citizenship**	Appraise and demonstrate Universal brotherhood

PROGRAM SPECIFIC OUTCOMES (PSO): After completion of the program, the Graduate will…	
PSO_1	Acquire knowledge on the fundamentals aspects of chemistry leading to functional understanding of emerging concepts and technologies in chemical sciences.
PSO_2	Able to pursue higher education and research in the institutes of national and international repute.
PSO_3	Apply conceptual knowledge of Chemistry to identify practical & innovative solutions for socio-economically relevant issues.
PSO_4	Demonstrate ability to skilfully utilize the chemical literature to identify existing problems and employ tools & techniques of applied chemistry for finding sustainable & ethical solutions.
PSO_5	Acquire the ability to engage in life- long learning in the broadest context of socio- technological changes.

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester VI

SN	Course Category As per GoG- NEP-SOP - July 2023& additional content 28/7/23	Course Title	Credit			Hrs./ Wk.		Evaluation - Weightage CCE: SEE = 50:50				
			T	P	Total	T	P	CCE Marks		SEE Marks		Total Marks
								T	P	T	P	
1	**Major (Core)-14** (Chemistry)	**Chemistry -14:** Advanced Inorganic and Physical chemistry **(4- Credit Course** including Theory & Practical components)	**3**	**1**	**4**	**3**	**2**	**25**	**25**	**50**	**-**	**100**
2	**Major (Core)-15** (Chemistry)	**Chemistry -15:** Modern Analytical Techniques-MAT **(4- Credit Course** including Theory & Practical components)	**3**	**1**	**4**	**3**	**2**	**25**	**25**	**50**	**-**	**100**
3	**Major (Core)-16 (**Chemistry**)**	**Chemistry -16:** Advanced Organic Chemistry **(4- Credit Course** including Theory & Practical components)	**3**	**1**	**4**	**3**	**2**	**25**	**25**	**50**	**-**	**100**
4	**Minor-06** (Chemistry)	Advanced Physical Chemistry **(4- Credit Course** including Theory & Practical components)	**2**	**2**	**4**	**2**	**4**	**25**	**25**	**50**	**-**	**100**
6	**Ability Enhancement Course -5** (AEC-5)	**English Language**	**1**	**1**	**2**	**1**	**2**	**-**	**25**	**25**	**-**	**50**
7	**Internship**	**Internship**	**0**	**4**	**4**	**0**	**8**	**-**	**50**	**-**	**50**	**100**
Total Credits and Marks (Semester-VI)			12	10	**22**	12	20	**100**	**170**	**225**	**50**	**550**

Courses Offered by BoS - Chemistry to other FYUGP- B.Sc. Program in Semester-VI												
SN	Course Category As per GoG- NEP-SOP - July 2023& additional content 28/7/23	Course Title	Credit			Hrs./ Wk.		Evaluation - Weightage CCE: SEE = 50:50				
			T	P	Total	T	P	CCE Marks		SEE Marks		Total Marks
								T	P	T	P	
	NA	NA			**NA**							NA

Evaluation Scheme:(As per GoG- NEP-SOP July 2023& additional content 28/7/23 – Chapter-7: Evaluation Reforms)

The evaluation process should be formulated to make a systematic evaluation of students' progress based on UGC guidelines. The evaluation must be designed with learner attributes in mind. These attributes have clear linkages to Programme Education Objectives and Outcomes. The evaluation consists of the following two components:

1. Continuous and Comprehensive Evaluation (CCE)- Formative
2. Semester End Evaluation (SEE)- Summative

CCE carries 50% of the total marks allotted to a subject and the other 50% being assigned to the SEE.

In each course, every credit carries 25 marks, of which 50% marks is assigned for CCE and rest 50% marks for SEE. The 50% marks assigned to the CCE is distributed between the continuous classroom evaluation and mid-term evaluation. The pattern may be as follow:

SN	Evaluation	*T-3 + P-1 = Total 4 credit subjects (Marks)	* T-1 + P-1 = Total 2 credit SEC# (Marks)	*T-2 + P-2 = Total 4 credit Minor# (Marks)
1	**CCE (50%)** Classroom/Lab & Mid-Term/Course End Evaluation	**T-25 + P- 25**	**P#- 25**	**P#- 50**
2	**SEE (50%)**	**50**	**T#- 25**	**T#-50**
	Total	**100**	**50**	**100**

***T = Theory; P= Practical #Details are given with syllabus**

The concept note on Internship - 4 credit major course of semester- 6 is enclosed as an annexure.

Continuous and Comprehensive Evaluation (CCE)

Subject–wise CCE will be undertaken by the concerned faculty member. The mode of evaluation will be decided by the faculty member concerned with the subject. Normally CCE consists of class participation, case analysis and presentation, assignment, tutorials, slip tests (announced/ surprised), quizzes, attendance etc. or any combination of these. The students are expected to submit their answer scripts/ reports of internal evaluation within the stipulated time. Failure to do so may result in the script not being valued. Another part of CCE consists of mid-term written evaluation, which is compulsory for all students. It can be done in a scheduled manner. The duration of the mid-term evaluation shall be one hour.

Semester End Evaluation (SEE)

The SEE carries 50% of the marks assigned to a course. SEE shall be of 2 ½ hours for 3/4 credit course and 2 hours in case of 1/2 credit courses. The controller of the examination will conduct these examinations. Paper setting and evaluation will be done by the external examiners to an extent of 50% of the evaluation process. This examination shall be conducted as per a schedule which shall be notified in advance.

The backlog exam will be conducted twice a year just after the result declared of the semester evaluation. Students shall have a second chance to clear their backlog and avoid the burden to carry forward the backlog with the next semester exam.

Appearance in all the evaluations is mandatory and no exemption can be granted except in the following case:

1. In case of inability to attend the exam due to reasons considered genuine by the controller of examination in consultation with the Director/Board.

2. In case of medical emergency, a certificate from the registered medical practitioner must be produced before the commencement of exams. The evaluation board will then take final decision on the recommendation for exemption.

Eligibility Criteria to appear in SEE

To be able to appear for the SEE, a student must comply with the following conditions:

1. Should have at least 75% of attendance in all the courses put together.

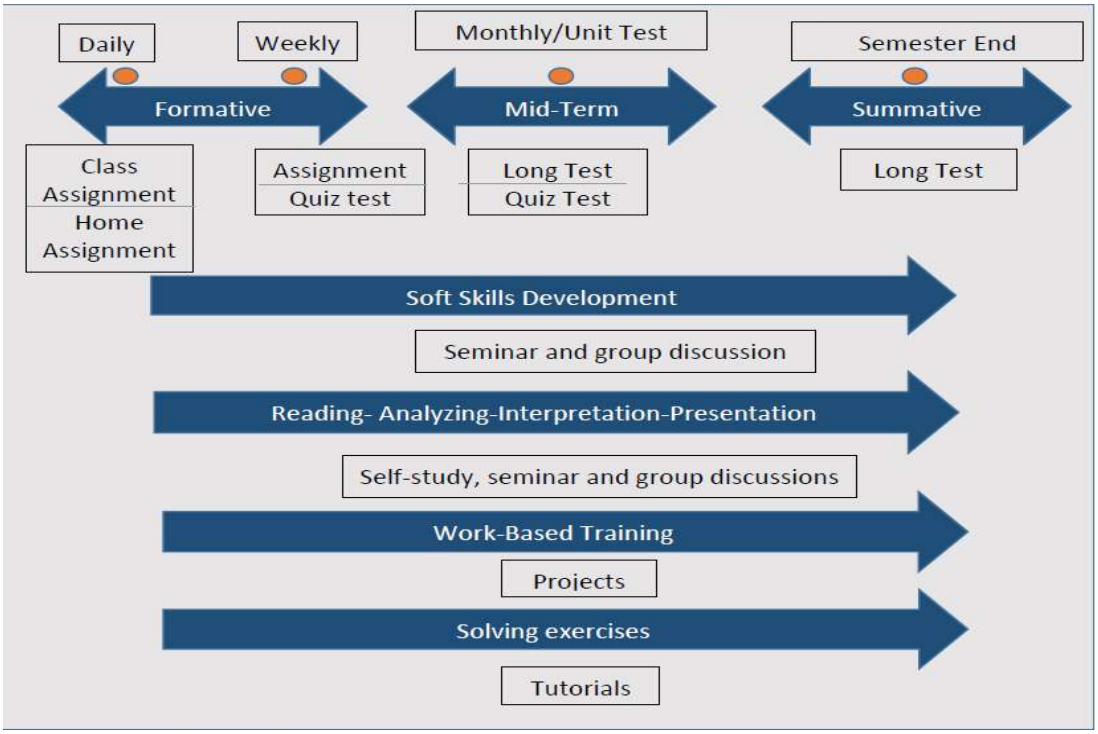
2. Should have at least 70% of attendance in each course/subject.

3. Should not have any disciplinary proceedings pending against him/her.

4. Should have no pending due.

Continuum of Evaluation

Evaluation must be continuous which may include both formative and summative components in a timely manner for continuous feedback as follow:



Mode of Evaluation

A wide range of modes of evaluation for evaluating students is available for the teachers/ institutions to use. A suitable compendium of such a mode needs to be carefully chosen for a particular program depending on its nature, objectives, and available resources. The mode of evaluation can be as below:

Written Mode	Oral Mode	Practical Mode	Integrated Mode
Semester Exam Class Test Open book exam/test Open note exam/test Self-test/Online test Essay/Article writing Quizzes/Objective test Class assignment Home assignment Reports writing Research/Dissertation Class Studies	Viva/Oral exam Group Discussion Role Play Authentic Problem Solving Quiz Interview	Lab work Computer simulation/virtual labs Craft work Co-curricular work	Paper presentation/Seminar Field Assignment Poster Presentation

Written Mode		
Evaluation Type	**Nature**	**Objective**
Semester Exam	Traditionally essay type, with objective / short answer questions to evaluate Lower Order Thinking (LOT) OBE skills	For depth and planned preparation
Class test	Traditionally essay type	Fixed date forces students to learn
Open book test	Allowed choice of reference book	Measures what students can do with resources, less stress on memory
Open note test	To get used to the system	Encourage good note taking
Self-test	For subjective and objective items	Mastery learning occurs with proper feedback
Article/essay writing	Individual long written assignment	Individual expression and creativity
Quizzes/Objective test	Short duration structured test	Excellent validity as greater syllabus coverage
Class assignment	With defined time	Student's performance to make decision
Home assignment	With undefined time	Reinforce learning and facilitate mastery of specific skills
Reports Writing	On activities performed or event observed	Develop a key transferable skill
Research/Dissertation	Detailed research-based report	To judge creativity and research skills
Case Studies	Analyse a given case (real or fictional)	To assess thinking, value, and attitude

Oral Mode		
Evaluation Type	**Nature**	**Objective**
Viva/Oral exam	Individually or in small group	Practical experience towards job interview situation
Group discussion	Small group of 2-5 members work on a joint task	Encourage teamwork
Role Play	Small group of 2-5 members work on a joint task	Develop personality
Authenticate problem solving	Small group of 2-5 members work on a joint task	Communication of ideas
Quiz	Small group of 2-5 members work on a joint task	Assess memory power
Interview	Individually	Judge the personal confidence level

Practical Mode		
Evaluation Type	**Nature**	**Objective**
Lab work	Component of working with one's hand	Keep the students on the task
Computer simulation/virtual labs	Component of working with one's hand	To understand the practical exposure
Craft work	Component of working with one's hand	Encourage application of concepts learnt
Co-curricular work	Component of working with one's hand	For immediate feedback

Integrated Mode		
Evaluation Type	**Nature**	**Objective**
Paper presentation/Seminar	Group or individual work	Learn from others presentation
Field Assignment	Field visit with report	Develop observation and recording skills
Poster presentation	Group or individual work	Develop research, creativity, and discussion skills
Paper presentation/Seminar	Group or individual work	Learn from others presentation

Models of Evaluation

Based on the types of evaluation, various models of evaluation implementation are suggested for theory, practical, self-study and work-based learning. The focus of these models is to encourage the students to improve on skills and performance.

Evaluation Norms &Question Paper Pattern for Theory &Practical Courses: Please refer General Guidelines for Implementation of **Four Year Under Graduate Programmes** for Saurashtra University (16 pages) published in August 2023.

Model for Theory Courses- Theory-3+ Practical-1 = 4 Credit Course	
CCE-50% (50 Marks)SEE-50% (50 Marks)	
Exam Pattern	**Marks**
Class Test (Average of **TWO** tests)	**T-25 + P-25**
Quiz (Average of **TWO quiz**)	
Home Assignment	
Active Learning- PBL/CSBL/Seminar/Flipped Class Room etc. OBE evaluation tools.	
Class Assignment	
Attendance	
Continuous and Comprehensive Evaluation	**T & P - 50**
Semester-End Evaluation	**T-50**
1 Credit Practical Course : CCE-100% (25 Marks)	
Lab work assessment	10
Viva voce/Lab quiz	10
Attendance	05
Continuous and Comprehensive Evaluation	**P- 25**

Model for Theory Courses- Theory-2+ Practical-2= 4 Credit Course	
CCE-50% (50 Marks) SEE-50% (50 Marks)	
Exam Pattern – SoP- OBE	**Marks**
Written : Lab batch wise Test Objective/MCQ	10
Journal writing / Assignment	05
Course End Practical Exam & Viva Voce by Internal & External Examiners (3 Hrs.)	30 + 5
Continuous and Comprehensive Evaluation	**P-50**
Semester-End Evaluation	**T-50**

Model for Skill Enhancement Course SEC (1 Credit theory + 1 Credit Practical)	
CCE-P-50% (25 Marks) and SEE-T-50% (25 Marks)	
Evaluation Components	**Marks**
Lab work Assessment – Performance : Lab quiz, Attendance, Aim achievement & Journal- Record book	05+05
Course End Practical Examination & Viva voce –One and half Hours Duration	10+05
Total marks of CCE- Continuous and Comprehensive Evaluation	**25**
Semester-End Evaluation- Theory Examination– One Hours Duration	**25**
Total Marks for the Skill Enhancement Course	**50**

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester VI

Course Category	**Major Chemistry-14**
Title of the Course	**Chemistry -14: Advanced Inorganic and Physical Chemistry**
Course Credit	**03**
Teaching Hours per Sem.	**45**
Total Marks	**CCE- 25+ SEE- 50**

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skillsનાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		~~Yes~~/No	Ability Enhancement Courses		~~Yes~~/No
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	Yes/~~No~~	Interdisciplinary	Yes/~~No~~
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					Yes/~~No~~
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Course Outcomes – COs

By the end of this course, the students will be able to:

CO1: Explain the basic principles of wave mechanics and apply Schrödinger's equation to simple quantum systems.

CO2: Describe magnetic properties of substances, types of magnetism, and evaluate magnetic susceptibility and moment.

CO3: Analyze the bonding and reactivity of transition metal complexes involving π-acid ligands such as CO, NO, and phosphines.

CO4: Interpret the Second Law of Thermodynamics, entropy changes, and the concept of spontaneity using various thermodynamic criteria.

CO5: Understand the significance of the Third Law of Thermodynamics and calculate absolute entropies of substances at different temperatures.

Unit No.	Topics	Hrs	Mks
1	**UNIT-1 Wave Mechanics** • Outline of basic concepts of wave mechanics. • Operator's algebra (Addition, Subtraction, multiplication), commutative property, linear operation, commutation operation, the operator $\nabla$and ∇_2, momentum operator, Hamiltonian operator. • Particle in one dimensional box; normalised wave equation and energy related to particle moving in one dimensional box, energy equation and itsinterpretation with energy levels, linear polyenes as one dimensional box model, examples based on one dimensional box model. • Particle in three dimensional box; Derivation of normalised wave equation, energy related with it, energy levels and degeneracy example. • Wave equation for hydrogen atom: To derive the relation between Cartesian and polar coordinates, Schrodinger equation in polar coordinates, separation of variables to derive R(r), $\theta(\theta)$ and $\phi(\phi)$ equations. • Energy of 1s orbital, normalisation condition and problems on it (in polar coordinates for three dimension)	9	10
2	**UNIT- 2: Magneto Chemistry** • Introduction (Magnetic field, Magnetic pole, Intensity of magnetization) Magnetic induction, Magnetic Permeability, intensity of magnetism, magnetic susceptibility, molar magnetic susceptibility • Magnetic behaviour: Diamagnetism, Paramagnetism, Ferromagnetism and Antiferromagnetism • Effect of temperature on magnetic behaviour of substances • Derivation of equation for total angular magnetic momentum and diamagnetic Momentum • Determination of magnetic susceptibility by Gouy method, NMR method, Faraday method • Examples on magnetic induction, magnetic permeability, intensity of magnetism, magnetic susceptibility, molar magnetic susceptibility	9	10
3	**UNIT-3: Transition Metal Complexes of π-acid Ligands** • Metal carbonyls: Definition, preparation, physical and chemical properties. • nature of M-CO linear bond based on MO theory with spectral support, • classification of metal carbonyls, type of CO group and detection of CO group, using IR spectra	9	10

	• Structure of $Fe(CO)_5$, $Fe_2(CO)_9$, $Co_2(CO)_8$ and $Mn_2(CO)_{10}$ • Metal Nitrosyls: Structure and bonding in complexes of NO^+, NO^- and NO.		
4	**UNIT-4:Second law of thermodynamics** Limitations of first law of thermodynamics Spontaneous process, Carnot cycle & theorem Statements of second law of thermodynamics Perpetual motion of second kind (briefly) Concept of entropy, Definition of entropy, ΔS in reversible & irreversible (spontaneous) process, ΔS in ideal gases, ΔS of mixture of ideal gas, ΔS in physical transformations Entropy and second law of thermodynamics, Physical significance of entropy	**9**	**10**
5	**UNIT-5: Third law of thermodynamics** Nernst heat theorem, Third law of thermodynamics, Determination of absolute entropies of solids, liquids and gases Applications of third law of thermodynamicsΔS^0, ΔG^0 and equilibrium constant of chemical reaction, Tests of third law of thermodynamics, Residual entropy.s	**9**	**10**

Reference books:

1. Peter Atkins, Julio de Paula (2018, 11th edition) Physical chemistry. Thomson Press (ISBN: 9780198814740).
2. Gurdeep Raj (2014, Third edition) Thermodynamics. Meerut: GOEL publishing House (ISBN: 8187224886).
3. Gurtu, J. N. Gurtu, A. (2014, Twelfth edition) Advanced Physical Chemistry. Meerut: PragatiPrakashan (ISBN: 9350060191).
4. Glasstone, Samuel. (2007) Thermodynamics for Chemists: Narahari Press (ISBN: 1406773220).
5. Barrow, Gordon M. (1996, Sixth edition) Physical Chemistry. New York: McGraw-Hill International. (ISBN: 0070051119).
6. Puri, B. R.; Sharma, L. R. & Kalia, K. C. (2010-11) *Principles of Inorganic Chemistry*. New Delhi :Milestone (ISBN No. 978-8192143330)
7. Lee, J. D. (2002, Fifth edition) *Concise Inorganic Chemistry*. Hoboken: Wiley-Blackwell Science Ltd. (ISBN: 0-632-05293-7).
8. Peter Atkins, Tina Overton, Jonarthan Rourke, Mark Weller & Fraser Armstrong (2010, Fifth edition) *Inorganic Chemistry*. Oxford: Oxford University Press (ISBN: 978-0-19-959960-8).

Pedagogic tools:

1. Chalk and Board - Power point presentation - Video
2. As per facilitator's choice

Suggested MOOCs: SWAYAM-NPTEL

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester VI

Course Category	**Major Chemistry Practical -14**
Title of the Course	**Chemistry Practical-14:** **Inorganic Qualitative Analysis Six Radicals**
Course Credit	**01**
Teaching Hours per Sem.	**30**
Total Marks	**CCE- 25**

Course Outcomes – COs

By the end of this course, the students will be able to:

CO1: Identify basic and acidic radicals through systematic and confirmatory qualitative analysis techniques.

CO2: Apply principles of solubility product, common ion effect, and group separation for the detection of cations and anions.

CO3: Develop laboratory skills in handling reagents, glassware, and performing accurate and safe chemical testing.

CO4: Record, interpret, and report observations clearly with logical inferences drawn from experimental data.

CO5: Demonstrate precision and consistency in performing qualitative analysis of complex inorganic salt mixtures containing six radicals.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skills નાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		Yes/~~No~~	Ability Enhancement Courses		Yes/~~No~~
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	~~Yes~~/No	Interdisciplinary	~~Yes~~/No
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે ?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					~~Yes~~/No
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Major Chemistry Practical -14
Inorganic Qualitative Analysis: [Minimum Ten inorganic mixtures should be analyzed and recorded by the students] Qualitative Analysis of an inorganic mixture containing Six radicals, including $PO4^{-3}$, CrO_4^{-2} , $Cr_2O_7^{-2}$, AsO_3^{-3} , AsO_4^{-3} , BO_3^{-3} and S^{-2}

Reference Books:

1. Svehla, G. (1979, 5th edition) *Textbook of macro and semi micro qualitative analysis*. London: Logman Publishing group (ISBN: 0-582-44367-9).
2. Inorganic Vogel's text book of quantitative- qualitative chemical analysis

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice
5. Laboratory Accessories

Suggested MOOCs: Swayam-NPTEL

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester VI

Course Category	**Major Chemistry-15**
Title of the Course	**Chemistry 15-Modern Analytical Techniques - MAT**
Course Credit	**03**
Teaching Hours per Sem.	**45**
Total Marks	**CCE- 25+ SEE- 50**

Course Outcomes– COs

By the end of this course, the students will be able to:

CO1: Explain the fundamental principles and instrumentation of UV, IR, NMR, and Mass Spectrometry.

CO2: Interpret UV-Vis spectra for determination of λmax and conjugated systems in organic molecules.

CO3: Analyze IR spectra to identify functional groups based on characteristic absorption bands.

CO4: Apply principles of NMR spectroscopy to elucidate the structure of organic compounds using chemical shift, splitting patterns, and integration.

CO5: Interpret mass spectra by recognizing molecular ion peaks and fragmentation patterns for molecular mass determination.

CO6: Solve combined spectral problems using integrated data from UV, IR, NMR, and MS to deduce complete molecular structures.

CO7: Describe the concept and applications of hyphenated techniques (e.g., GC-MS, LC-MS) in modern analytical chemistry.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skillsનાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		~~Yes~~/No	Ability Enhancement Courses		~~Yes~~/No
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	Yes/~~No~~	Interdisciplinary	Yes/~~No~~
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					Yes/~~No~~
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Unit No.	Topics	Hrs	Mks
1	**UNIT-1 Ultraviolate Spectroscopy** Instrumentation; types of transition in organic molecules; auxochrome; chromophore;explanation of bathochromic shift and hypsochromic shift; hyperchromic andhypochromic effects; calculation of λmax of (i) dienes and conjugated dienes; (ii)enones and dienones(iii) aromatic carbonyl system; factor affecting of UV spectralbands; application of UV.	**9**	**10**
2	**UNIT- 2: Infrared Spectroscopy** Introduction; Range of IR , theory of IR; Modes of fundamental vibration; IR active,force constant; Vibration coupling; Fermi resonance; Finger print region;Instrumentation; Application of IR; determination of structure of organic molecules from IR; Interpretation of IR for given molecules and problems.	**9**	**10**
3	**UNIT-3: Nuclear Magnetic Resonance Spectroscopy** Introduction; Principle; nuclear quantum number; equivalent and non-equivalent protons with illustrations; enantiometric and diasteriometric protons; shielding and deshielding of protons; chemical shift; paramagnetic anisotropic effect; relative intensity of signals; spin- spin coupling and coupling constant; Deuterium labeling; applications of NMR; problems based on determination of structure of organic molecules from NMR spectral data.	**9**	**10**
4	**UNIT-4:Mass Spectrometry& Introduction to Hyphenated Techniques** **Mass Spectrometry:** Introduction, Basic principle;instrumentation; General fragmentation modes,important features for the mass spectra of alkanes **Introduction to Hyphenated Techniques** :Definition, Need, Historical development and evolution, advantages over singletechniques, Classification of Hyphenated Techniques,Chromatography-Spectroscopy combinations e.g., GC-MS, LC-MS,CE-MS, LC-NMR, LC-IR **Gas Chromatography-Mass Spectrometry (GC-MS)** :Principle,Instrumentation overview, Applications and Limitations **Liquid Chromatography-Mass Spectrometry (LC-MS)** :Principle andIonization Methods (ESI, APCI), LC vs GC: Why LC is better forthermally labile compounds, Applications, Interface challenges	**9**	**10**

	andsolutions **Other Hyphenated Techniques :LC-NMR** : Principle and useinstructural analysis, LC-IR : Functional group identification, CE-MS(Capillary Electrophoresis-MS) :Used in biomolecule separation, Briefintroduction to Tandem MS (MS/MS)		
5	**UNIT-5: Interpretative Spectral Analysis** (Combined Spectral Problems solutions based on UV, IR, NMR & MS)	**9**	**10**

Reference Books:

1. Sharma, Y. R. (2013).*Elementary organic spectroscopy*. New Delhi: S. Chand Publishing (ISBN: 9788121928847).
2. Gurdeep, R., Chatwal, S., &Anand, K. (2016,7th edition). *Instrumental methods of chemical analysis*. Himalaya publishing house (ISBN: 978-9350512067).
3. Dewan, S. K. (2019, 1st edition). Organic spectroscopy. (ISBN: 9788123919065)
4. Braithwaite, A., & Smith, J. F. (2012, 5th edition). *Chromatographic methods. Springer Science & Business Media*(ISBN: 978-0751401585).
5. Dr. A. V. Kasture, Dr. S. G. Wadodkar, Dr. K. R. Mahadik, Dr. H. N. More (2008, 7th edition) *Pharmaceutical Analysis Vol.- II*.NiraliPrakashan. (ISBN: 978-8185790084).
6. Gary D. Christian, Purnendu K. Dasgupta, Kevin A. Schug (2013, 7th edition) *Analytical chemistry*. John Wiley & sons, Inc. (ISBN: 978-0-470-88757-8).
7. B. K. Sharma (2014) *Instrumental method of chemical analysis*. Meerut: Krishna Prakashan Media (P) Ltd. (ISBN: 978-8182836730).

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice

Suggested MOOCs: Swayam-NPTEL

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester VI

Course Category	**Major Chemistry Practical -15**
Title of the Course	**Chemistry Practical-15: Physicochemical Analysis**
Course Credit	**01**
Teaching Hours per Sem.	**30**
Total Marks	**CCE- 25**

Course Outcomes – COs

By the end of this course, the students will be able to:

CO1: Determine the acidity or basicity of solutions using pH-metric titrations and evaluate buffer capacity.

CO2: Apply potentiometric methods for redox and precipitation titrations by interpreting electrode potentials.

CO3: Measure the conductance of electrolytic solutions and perform conductometric titrations to determine ionic reactions.

CO4: Use colorimetric techniques to estimate the concentration of analytes using absorbance-concentration relationships.

CO5: Perform thermodynamic experiments to determine enthalpy, entropy, and equilibrium constants of reactions.

CO6: Analyze experimental data using relevant physicochemical theories and develop interpretation and problem-solving skills.

CO7: Operate instrumental techniques confidently and record accurate observations for quality chemical analysis.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skills નાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		Yes/~~No~~	Ability Enhancement Courses		Yes/~~No~~
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	~~Yes~~/No	Interdisciplinary	~~Yes~~/No
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે ?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					~~Yes~~/No
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Major Chemistry Practical-15

Exercise-: Physico chemical Exercise: (Minimum 10/12)

a) To determine the relative strength of chloroacetic acid and acetic acid by Conductometry
b) To determine the concentration of acetic acid and oxalic acid in a given mixture conductometrically
c) To determine the concentration of HCl + HAc + $CuSO_4$ in a given mixture conductometrically
d) To determine the concentration of Lactic acid in a given mixture conductometrically
e) To determine the composition of a binary mixture containing $KMnO_4$ and $K_2Cr_2O_7$ colurimetrically.
f) To study the influence of ionic strength on solubility of calcium sulphate and hence mean ionic activity coefficient
g) To determine the solubility of benzoic acid in water at different temperatures and hence its heat of solution.
h) To determine the distribution coefficient of iodine between carbon disulfide/carbon tetrachloride and water.
i) To determine concentration and dissociation of phosphoric acid by pH metry
j) To determine concentration of KI by potentiometry
k) To determine degree of hydrolysis of given NH_4Cl salt from its solution by conductometry
l) To verify Ostwald dilution law for weak acid conductometrically
m) Find out the amount of $KMnO_4$ in the given solution by colorimetry method.

Reference Books:

1. Jeffery, G. H.; Bassett, J.; Mendham, J.; Denny, R. C. (1989, 5th edition) *Vogel's Textbook of Quantitative Chemical Analysis*. Hoboken: John Willey & Sons (ISBN: 0-582-44693-7).
2. Experiments in Physical Chemistry by Dr. P H Parsania & Dr. Falguni Karia, Saurashtra University Second Ed. 2006

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice
5. Laboratory Accessories

Suggested MOOCs: SWAYAM-NPTEL

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester VI

Course Category	**Major Chemistry-16**
Title of the Course	**Chemistry-16:Advanced Organic Chemistry**
Course Credit	**03**
Teaching Hours per Sem.	**45**
Total Marks	**CCE- 25+ SEE- 50**

Course Outcomes– COs

By the end of this course, the students will be able to:

CO1: Explain the concept of molecular symmetry and apply symmetry elements and operations in organic/inorganic molecules.
CO2: Classify and describe the structure, reactivity, and synthesis of six-membered heterocycles and benzo-fused nitrogen-containing heterocyclic compounds such as pyridine, quinoline, and isoquinoline.
CO3: Illustrate the structural features, aromaticity, and reactivity of polynuclear aromatic hydrocarbons and analyze conformational isomerism in alicyclic compounds.
CO4: Recognize the chemical nature and synthetic applications of organic compounds used as perfumes, sweeteners, and pesticides (herbicides, insecticides, and fungicides).
CO5: Apply the principles of the disconnection approach for designing synthetic routes and retrosynthetic analysis of simple organic molecules.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skillsનાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		~~Yes~~/No	Ability Enhancement Courses		~~Yes~~/No
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	Yes/~~No~~	Interdisciplinary	Yes/~~No~~
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઇકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					Yes/~~No~~
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Unit No.	Topics	Hrs	Mks
1	**UNIT-1: Molecular Symmetry** Introduction; symmetry element and symmetry operations with illustrations;definition of properties of group; subgroup and classes; products of symmetryoperation; symmetry point group [C1, Cs, Ci, Cn, Cnv, Dn, Dnh, Dnd, Cv, Dαh, Td, Oh];multiplication tables for C2v, C3v and C2h point groups.	**9**	**10**
2	**UNIT-2: Heterocyclic Chemistry : Six membered compounds & Benzo fused compounds** Structure, Synthesis and Properties of: Pyridine, Pyrimidine, Pyridazine, Pyrazine, Quinolene&Isoquinolene	**9**	**10**
3	**UNIT-3: Polynuclear Aromatic Hydrocarbons & Conformational Isomerism** **Polynuclear Aromatic Hydrocarbon** : Introduction, Classification ofPolynuclear hydrocarbon, Synthesis and chemical properties: Biphenyl,Diphenyl methane, Naphthalene, Anthracene **Conformational Isomerism** : Conformation of cyclic system: CyclohexaneConformational analysis of cyclohexane: Boat form and Chair formConformation of mono-substituted and di-substituted cyclohexane	**9**	**10**
4	**UNIT-4: Perfumes, Sweetening Agents & Pesticides (Herbicides, Insecticides & Fungicides)** • Introduction to Perfumes, synthesis of Musk Xylene, Musk Ketone, Musk Ambrette • Introduction about Sweetening agent, Synthesis ofSaccharin, p-anisylurea and dulcin • Introduction to Pesticides, Classification of it, Synthesis and uses of Baygon, Carbendazim and Parathion	**9**	**10**
5	**UNIT-5:Disconnection Approach** Introduction to disconnection & retrosynthetic analysis, Synthon and Synthetic equivalent, Functional group interconversion (FGI), Functional group addition (FGA)., Simple examples of retrosynthesis of C-C bond formation (Corey House, Grignard, aldol condensation).. Retrosynthesis of monofunctionalised and Bi-functionalized (1,1 and 1,2) compounds.	**9**	**10**

Reference books :

1. R. K. Bansal (2017, 5th edition) Heterocyclic Chemistry. New Age International Private Limited (ISBN: 8122435858).
2. J. A. Joule, K. Mills (2010, 5thedition) Heterocyclic chemistry - Wiley-Blackwell (ISBN: 1405133007).
3. R. M. Acheson (2008, 3rdedition) An introduction to the chemistry of Heterocyclic compounds. Wiley India Pvt Ltd; (ISBN: 8126516607).
4. Rakesh Kumar Parashar (2014, 1stedition) Chemistry of Heterocyclic compounds- (ISBN 9781466517134).
5. R. R. Gupta, M. Kumar & V. Gupta (2009) Heterocyclic Chemistry-2 volume, Springer (ISBN: 978-3-642-72276-9 & ISBN 978-3-662-07757-3).
6. T. Eicher& S. Hauptmann (2013, 3rdCompletely Revised and Enlarged edition,)The chemistry of Heterocycles - Wiley-VCH (ISBN 3527327479).
7. A. R. Katritzky& C. W. Rees (1984, 1stedition) Comprehensive Heterocyclic chemistry - (Vols 1 - 8) Pergamon; (ISBN 0080262007).
8. T. L. Gilchrist (1997, 3rdedition) Heterocyclic chemistry - Prentice Hall; (ISBN 0582278430).
9. Clayden, Greeves, Warren &Wothers (2012, 2nd edition) *Organic Chemistry*. Oxford: Oxford University Press (ISBN: 9780199270293).
10. Sharma, B. K. (2014) *Industrial chemistry*, Goel publishing house, (ISBN; 9788187224006).
11. Paul Wyatt and Stuart Warren 2nd edition Organic Synthesis: The Disconnection Approach, Wiley Publication (ISBN 9780470712375)

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice

Suggested MOOCs: Swayam-NPTEL

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester VI

Course Category	**Major Chemistry Practical -16**
Title of the Course	**Chemistry Practical -16: Organic Synthesis**
Course Credit	**01**
Teaching Hours per Sem.	**30**
Total Marks	**CCE- 25**

Course Outcomes – COs
By the end of this course, the students will be able to: **CO1:** Perform multi-step organic synthesis with proper planning, understanding the importance of reaction sequences and intermediate purification. **CO2:** Apply suitable synthetic methods for the preparation of target compounds through two-stage synthesis using functional group transformations. **CO3:** Employ appropriate purification techniques such as recrystallization, distillation, or chromatography to isolate and purify intermediates and final products. **CO4:** Analyze and interpret the structure of synthesized compounds using classical methods (melting point/TLC) and spectral data where applicable. **CO5:** Maintain detailed laboratory records and demonstrate safe and effective handling of chemicals, glassware, and instrumentation during organic synthesis.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skills નાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		Yes/~~No~~	Ability Enhancement Courses		Yes/~~No~~
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	~~Yes~~/No	Interdisciplinary	~~Yes~~/No
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે ?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					~~Yes~~/No
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Major Chemistry Practical -16
Organic Synthesis - 2 stage (Minimum 9/10) (Percentage of yield, crystallization, melting point) **i. Acetylation / Benzoylation** 1. Acetylation of salicylic acid 2. Acelytation of aniline 3. Acelytation of phenol 4. Benzoylation of aniline 5. Benzoylation of phenol **ii. Aliphatic Electrophilic substitution** 1. Preparation of iodoform from ethanol 2. Preparation of iodoform from acetone **iii. Aromatic Electrophilic Substitution** Nitration: 1. Preparation of m-dinitrobenzene, 2. Preparation of nitro acetanilide. Halogenation: 1. Preparation of p-bromo acetanilide, 2. Preparation 2:4:6 -tribromo phenol **iv. Diazotization / Coupling** 1. Preparation of methyl orange 2. Preparation of methyl red **v. Oxidation** Preparation of benzoic acid from benzaldehyde

Reference Books:

1. Furniss, B. S. (1996, 5th edition). *Vogel's textbook of practical organic chemistry*. Pearson Education India. (ISBN: 978-0582462366).
2. Arthur I.(1974 3rd edition).A Text-Book of practical organic chemistry including Qualitative organic analysis. (ISBN: 0-582-44245-1)

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice

Suggested MOOCs: Swayam-NPTEL

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester VI

Course Category	**Minor Chemistry-6**
Title of the Course	**Minor Chemistry -6: Advanced Physical Chemistry**
Course Credit	**02**
Teaching Hours per Sem.	**27**
Total Marks	**SEE- 50**

Course Outcomes– COs
By the end of this course, the students will be able to: **CO1:** Explain the concepts of free energy and its role in determining chemical equilibrium and spontaneity of reactions. **CO2:** Apply thermodynamic principles to derive and interpret equilibrium constants and related expressions. **CO3:** Define activity and activity coefficients of electrolytes, and describe their significance in real solution behavior. **CO4:** Interpret phase diagrams using the phase rule and apply it to single / two / three-component systems. **CO5:** Describe partial molar properties and their relevance in understanding solution thermodynamics.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skillsનાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		~~Yes~~/No	Ability Enhancement Courses		~~Yes~~/No
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	Yes/~~No~~	Interdisciplinary	Yes/~~No~~
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					Yes/~~No~~
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Unit No.	Topics	Hrs	Mks
1	**UNIT-1:Free Energy & Chemical equilibrium** Work function: its physical significance and variation with V and T ΔG for ideal gases, Gibbs Helmholtz equation and its applications Free Energy: its significance & variation with P and TCriteria for chemical equilibrium, Vant Hoff reaction isotherm Law of active mass Clausius Clapeyron equation	9	10+ ≅10
2	**UNIT- 2: Activity of Electrolytes** Ionic Activity: Introduction Derivation of $a_2 = a_+^{\vartheta+} a_+^{\vartheta-}$ and $a_2 = a^+ a_-$ for 1-1 electrolyte. Mean activity and its relation with a_+ and a_- Relationship between a2 and $a_\pm$ i.e. $a_2 = at$ Mean ionic activity coefficient f_t and f_+ ,ionicstrength : Definition, explanation, equation Debye Huckel limiting law (without derivation) Derivation of $-\log f_\pm = Az_+z_-\mu^{½}$, Interpretation of equation, Graph of $-\log f_\pm \rightarrow \mu^{1/2}$ and its explanation/discussion Empirical correction of Debye Huckel limiting law of (i) Size of ion and (ii) Orientation of solvent molecules, Methods to determine Activity coefficient Solubility method Emf method (i) chemical cell with transference (ii) concentration cell without transference Examples based on theory	9	10+ ≅10
3	**UNIT-3: Phase rule & Partial Molar Properties** **Phase rule :**Three component system, ➢ Method of graphical presentation Types of partially miscible three liquid systems: (i) One partially miscible pair: Effect of adding third	9	10+ ≅10

	component,Nature of tie line, Plait point, Binodae curve, Characteristics ofdiagram, A is added to binary system, A is constant and B and C varied. (ii) Formation of two pairs of partially miscible liquid (iii)Formation of three pairs of partially miscible liquid ➢ Application of ternary liquid diagram **Partial Molar Properties :**Definition, Concept of chemical potential, Gibbs-Duhem equation Variation of chemical potential with temperature and pressure, Determination of partial molar properties by method of intercept Applications of chemical potential (Henry's law, Rault's law and Nernst's distribution law)		

Reference books:

1. Elements of physical chemistry by Samuel Glasstone and D Lewis.
2. Principles of Physical chemistry by S H Maron and C F Prutton

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice

Suggested MOOCs: SWAYAM-NPTEL

B.Sc. Honours/ Honours with Research in Chemistry

(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester V

Course Category	**Minor Chemistry Practical -06**
Title of the Course	**Minor Chemistry Practical -06: Advanced Physical Chemistry Practical**
Course Credit	**02**
Teaching Hours per Sem.	**60**
Total Marks	**CCE- 50**

Course Outcomes – COs
By the end of this course, the students will be able to: **CO1:** Determine thermodynamic parameters such as enthalpy, entropy, and free energy through experiments based on chemical equilibria. **CO2:** Apply the phase rule to interpret phase diagrams and understand phase equilibria in multi-component systems. **CO3:** Measure surface tension and viscosity to study intermolecular forces and fluid properties. **CO4:** Evaluate partial molar properties to analyze solute-solvent interactions in solutions. **CO5:** Conduct pH-metric and potentiometric titrations for the analysis of acid-base and redox systems. **CO6:** Perform conductometric experiments to investigate ionic conductivity and electrolyte behavior.

1	Employability/Entrepreneurship/Skill Development પરકેન્દ્રિતથયેલછેકેનહિ ?					Yes/~~No~~
2	Value added Courses Imparting Transferable and Life Skillsનાગુણોધરાવેછે?					Yes/~~No~~
3	Major		Yes/~~No~~	Minor		~~Yes~~/No
	Skill Enhancement Courses		Yes/~~No~~	Ability Enhancement Courses		Yes/~~No~~
	Value Added Courses		~~Yes~~/No	Exit/ Vocational Courses		~~Yes~~/No
4	Holistic Education	Yes/~~No~~	Multidisciplinary	~~Yes~~/No	Interdisciplinary	~~Yes~~/No
5	દિવ્યાંગમાટેવિષયઅંતર્ગતઆનુસાંગિકજોગવાઈકરાયેલછે ?					Yes/~~No~~
6	New India Literacy Programme (NILP) મુજબનોવિષયછે ?					Yes/~~No~~
7	Swayam પ્લેટફોર્મપરના MOOC વિષયપરઆધારિતઆવિષયછે ?					~~Yes~~/No
8	ઇન્ડીયનનોલેજસીસ્ટમ (IKS) પરઆધારિતવિષયછે ?					Yes/~~No~~

Minor Chemistry Practical-6 (Advanced Physical Chemistry Practical)

Exercise–I: pH metry

- To determine degree of hydrolysis of given NH_4Cl salt from its solution by pH metry

Potentiometry

- To determine normality of FAS solution by suing standard $K_2Cr_2O_7$.
- To determine normality of each halide by using $AgNO_3$ solution.

Phase rule

- To construct the phase diagram of two component system forming compound with congruent melting point.

Exercise-II: Thermodynamics& Surface tension

- To calculate entropy of vaporization (ΔS_v) of a Hexane by plotting a graph of log(1/time) vs (1/temperature)
- To calculate entropy of vaporization (ΔS_v) of a Benzene by plotting a graph of log(1/time) vs (1/temperature)
- To calculate entropy of vaporization (ΔS_v) of a Toluene by plotting a graph of log(1/time) vs (1/temperature)
- To calculate entropy of vaporization (ΔS_v) of a Methanol by plotting a graph of log(1/time) vs (1/temperature)
- To find the surface tension of the liquids A,B and C by drop method. From that find the value of parachor of liquid and CH_2 group.
- To study the distribution of benzoic acid between Toluene/Water.

Exercise-III: Viscometer, Partial Molar Volume & Conductometry

- To determine relative and absolute viscosity of pure liquid A,B,C,D by Ostwald's viscometer.
- Preparation three different 10%, 5%, 2.5% aqueous solution of glycerine, find viscosity of these three solutions as well as unknown concentration of solution with the help of Ostwald's viscometer.
- Preparation aqueous solution of liquid A, B, and different % of A + B ,find viscosity of these solutions as well as unknown composition of solution with the help of Ostwald's viscometer.
- To determine partial molar volume & excess volume of binary mixture of ethanol/water system.
- To determine partial molar volume & the composition of unknown mixture of ethanol/methanol + water.

Conductometry

- To determine the normality of xN $AgNO_3$ using 0.5N NaCl by conductometry.
- To determine the concentration of Ni^{+2} using 0.1 M EDTA solution.

Reference Books:

1. Vogel's Textbook of Quantitative Chemical Analysis, John Wiley & Sons, 1989.
2. Willard, H. H., Merritt, L.L., Dean, J. & Settle, F.A. Instrumental Methods of Analysis, 7thEd. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.
3. Christian, G.D; Analytical Chemistry, VI Ed. John Wiley & Sons, New York, 2004.
4. Harris, D. C. Exploring Chemical Analysis, Ed. New York, W.H. Freeman, 2001.
   Skoog, D. A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed, 2017.

Pedagogic tools:

1. Chalk and Board
2. Power point presentation
3. Video
4. As per facilitator's choice

Suggested MOOCs: Swayam-NPTEL

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Annexure to B.Sc. Honours/ Honours with Research in Chemistry
(NCrF Level- 5.5 Third Year – B.Sc. Degree in Chemistry)

Semester VI

MAJOR COURSE – INTERNSHIP – 4 Credit

CONCEPT NOTE

Concept note for **'Internship'** a 4 credit course offered in 3rd year exit semester-6 at NCrF 5.5 level to earn B.Sc. degree; in context to GoG & SU- SOP in light of NEP 2020.

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1. Background & Rationale

In line with the National Education Policy (NEP) 2020, which emphasizes work-integrated, experiential, and learner-centric education, the proposed "Internship" course is designed to bridge the gap between theoretical knowledge and practical application. This course is aimed at final-year (3rd year exit semester-6) students pursuing a B.Sc. degree. It will equip students with hands-on experience, enhance their professional skills, and improve their employability in a rapidly evolving job market.

2. Course Overview

- **Title:** Internship
- **Credit Value:** 4 Credits
- **Eligibility:** Final year (3rd year exit semester-6) students enrolled in B.Sc. programs **Mode:** On-site industry placement, research project, or institution-based internship
- **Duration:** Typically 4-6 weeks-120 Hrs. during the final semester (flexibility as per internship partner requirements)

3. Objectives

- **Integrate Theory with Practice:** Enable students to apply classroom knowledge to real-world problems.
- **Develop Professional Competencies:** Foster soft skills (communication, teamwork, problem-solving) and technical competencies.
- **Industry Exposure:** Provide direct exposure to industry practices, research environments, or applied settings.
- **Enhance Employability:** Prepare students for the job market by building relevant work experience and professional networks.
- **Promote Lifelong Learning:** Encourage self-directed learning and adaptability through practical challenges.

4. Expected Outcomes

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

- Demonstrate the application of theoretical concepts to practical scenarios.
- Analyze and solve real-world problems in their respective fields.
- Communicate effectively with industry professionals and peers.
- Develop and present a comprehensive project report reflecting their internship experience.
- Exhibit improved professional and interpersonal skills essential for future employment.

5. Alignment with NEP 2020

The course supports NEP 2020's focus on:

- **Experiential Learning:** By integrating internships into the curriculum, students gain firsthand experience in their fields.
- **Industry-Academia Collaboration:** The course fosters partnerships with industry and research organizations, creating a two-way learning environment.
- **Holistic Education:** Emphasizing practical skills alongside theoretical knowledge prepares students for diverse professional challenges.

Implementation Guidelines for the "Internship" Course

A. Internship Placement & Partnerships

1. **Establish Collaborations:**
   - Forge MOUs with relevant industries, research institutes, and laboratories in the respective fields.
   - Leverage existing industry networks and alumni connections.
2. **Internship Cell:**
   - Create a dedicated internship cell within the placement/industry relations office to coordinate opportunities and monitor progress.

B. Student Selection & Matching

Eligibility & Application:

- As per the provision made in GoG- SOP pg.71 – Table- 9.2

C. Internship Duration & Scheduling

1. **Timeline:**
   - The internship should be completed over 4-6 weeks-120 hrs. during the final semester.
   - Flexibility can be provided based on the nature and requirements of the placement.
2. **Scheduling:**
   - Coordinate with academic departments to ensure minimal disruption to ongoing academic requirements.

D. Supervision & Mentorship

1. **Dual Mentorship:**
   - Assign an on-site industry/research mentor and an internal faculty mentor for each student.
   - Conduct regular check-ins and progress reviews.
2. **Documentation:**
   - Maintain a logbook or journal where students record daily activities, challenges, and learning outcomes.

E. Assessment & Evaluation

1. **Components of Assessment:**
   - **Project Report:** Detailed documentation of tasks, learning experiences, and outcomes.
   - **Presentation:** A formal presentation summarizing the internship experience and project outcomes.
   - **Mentor Feedback:** Evaluation from both the industry and academic mentors.
2. **Grading Criteria:**
   - Define clear rubrics covering technical competence, application of knowledge, problem-solving skills, and communication.

F. Documentation & Certification

1. **Submission Guidelines:**
   - Establish standardized formats for the internship report and presentation.
   - Set submission deadlines and provide templates as needed.
2. **Certification:**
   - Issue an internship certificate upon successful completion, signed by the industry mentor and the academic coordinator.

G. Monitoring & Continuous Improvement

1. **Feedback Mechanism:**
   - Collect feedback from students, mentors, and industry partners post-internship.
   - Use insights to refine future internship placements and course structure.
2. **Periodic Review:**
   - Conduct annual reviews of the internship program to ensure alignment with academic goals and industry trends.

ASSESSMENT & EVALUATION

Below is a detailed framework for evaluating the Internship course that incorporates both continuous internal evaluation and a robust semester-end evaluation, along with a structured progress diary for ongoing monitoring.

1. Continuous Internal Evaluation Components

A. Daily/Weekly Progress Logs

- **Task Documentation:**
  • Students maintain a log of daily tasks, assignments, and activities performed at the internship site.
  • Logs should capture key actions, technical skills practiced, and challenges encountered.
- **Reflective Journal/ Diary/Report:**
  • A weekly reflective entry where students discuss learning experiences, personal growth, and adjustments made in response to challenges.
  • Encourages self-assessment and critical reflection on the work process.

B. Mentor and Faculty Check-ins

- **On-Site Mentor Feedback:**
  • Weekly feedback forms filled by the on-site industry/research mentor.
  • Evaluates aspects like punctuality, work quality, initiative, teamwork, and problem-solving ability.
- **Academic Supervisor Interaction:**
  • Bi-weekly virtual or in-person meetings between the student and a designated faculty mentor.
  • Focus on aligning internship outcomes with academic objectives and ensuring compliance with learning goals.

C. Mid-Internship Review

- **Progress Presentation:**
  • At the mid-point, students present a brief progress report (using a poster or slide deck) to both on-site and academic mentors.
  • This review is used to identify any gaps and suggest corrective measures.
- **Structured Evaluation Form:**
  • An evaluation form that captures key performance indicators (KPIs) like application of theoretical concepts, problem-solving skills, communication, and professional behavior. • The evaluation should be documented and submitted to the academic office.

Weightage:

- Continuous evaluation (including daily/weekly logs, mid-term review, and mentor check-ins) can account for **50%** of the overall internship grade.

2. Semester End Evaluation Components

A. Final Project Report

- **Detailed Documentation:**
  • A comprehensive report that covers objectives, methodologies, challenges faced, and outcomes.
  • Inclusion of data, analysis, reflections, and recommendations for future work.
- **Quality and Depth:**
  • Emphasis on clarity, analytical depth, and integration of theoretical and practical knowledge.

B. Final Presentation and Viva-Voce

- **Formal Presentation:**
  • A structured presentation (15–20 minutes) summarizing the internship experience and key learning outcomes.
  • Use of visual aids (slides, posters) to demonstrate the project work.
- **Oral Examination:**
  • A viva-voce session conducted by both academic and industry evaluators to probe deeper into the student's understanding and contributions.

C. Mentor Evaluations

- **Comprehensive Feedback:**
  • Final feedback forms from both the on-site mentor and academic supervisor covering overall performance, growth, and readiness for professional challenges.

Weightage:

- The semester-end evaluation (project report, final presentation, and mentor feedback) can account for **50%** of the total grade.

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3. Progress Diary for Monitoring

A structured progress diary should be maintained by each student. Below is a sample template:

Date	Tasks Undertaken	Learning Outcomes	Challenges/Issues	Actions Taken/Planned	Mentor Feedback (if any)
DD/MM/YYYY	- Task details- Tools used	- Skills learned- Knowledge applied	- Specific challenge- Resource gaps	- Immediate actions- Future strategy	- Comments- Suggestions

Date	Tasks Undertaken	Learning Outcomes	Challenges/Issues	Actions Taken/Planned	Mentor Feedback (if any)
DD/MM/YYYY	…	…	…	…	…

Key Features of the Diary:

- **Frequency:** Entries should be made daily or weekly, depending on the internship's intensity.
- **Reflection:** Encourage students to note personal reflections on their growth and areas for improvement.
- **Review:** The diary is reviewed during mentor check-ins and the mid-internship review to monitor progress and to provide targeted support.
- **Submission:** A compiled version of the progress diary is submitted along with the final project report as evidence of continuous learning and engagement.

Comprehensive framework that includes detailed rubrics for both overall internship evaluation and mapping of Course Outcomes (COs) to Program Outcomes (POs):

Evaluation Rubrics for the Internship Course

A. Overall Internship Evaluation Criteria

Criterion	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)	Weightage
Work Quality & Technical Skills	Work is innovative, highly accurate, and demonstrates exceptional application of theoretical concepts.	Work is well executed with minor errors; sound technical application is evident.	Meets basic requirements but shows noticeable errors or limited technical depth.	Work is below expectations; errors and gaps in applying theoretical knowledge are evident.	20%
Reflective Diary & Learning Log	Daily/weekly entries are thorough, insightful, and show deep reflection on challenges, learning outcomes, and actions.	Entries are regular and reflective, demonstrating clear learning and some critical analysis.	Entries are inconsistent with limited reflections or superficial documentation.	Few or no entries; minimal reflection and lack of documented learning are evident.	10%

Criterion	Excellent (4)	Good (3)	Satisfactory (2)	Needs Improvement (1)	Weightage
Mentor & Faculty Feedback	Consistently proactive, highly engaged with mentors; excellent teamwork, communication, and initiative are shown.	Generally meets expectations; good communication and collaboration with both mentors and faculty.	Partially meets expectations; occasional delays or gaps in communication are observed.	Rarely engages or communicates effectively; feedback consistently indicates significant issues.	10%
Project Report Quality	Report is comprehensive, analytically rigorous, well-organized, and clearly integrates theory with practice.	Report is structured and detailed with adequate analysis and clear connections between theory and practice.	Report meets minimum requirements but lacks depth, clarity, or comprehensive analysis.	Report is poorly structured, with insufficient analysis and lack of clarity in integrating theory.	30%
Final Presentation & Viva-Voce	Presentation is clear, confident, engaging, and supported by effective visual aids; excellent responses during Q&A.	Presentation is organized and clear with good use of visuals; responses are adequate.	Presentation meets basic requirements but may lack depth or clarity; Q&A responses are limited.	Presentation is unclear and poorly organized; responses during Q&A are unsatisfactory.	30%

Important: The overall grade for the internship will be a weighted sum of these components, with continuous internal evaluation contributing 50% and semester-end evaluation contributing 50%.

B. Attainment Levels for Each CO

For each CO, the following attainment levels can be used:

- **Level 4 (Excellent):**
  - **Indicators:** Student consistently demonstrates exceptional understanding and application; evidence of innovative and analytical thinking is abundant; all documentation is thorough and reflective.
- **Level 3 (Good):**
  - **Indicators:** Student demonstrates solid understanding and application with minor areas for improvement; documentation is clear and reflective; innovative elements are present but could be expanded.
- **Level 2 (Satisfactory):**
  - **Indicators:** Student meets minimum expectations; application and reflection are evident but lack depth or consistency; some areas require further development.

- **Level 1 (Needs Improvement):**
    - **Indicators:** Student shows significant gaps in understanding or application; documentation is minimal or superficial; there is limited evidence of reflective learning or innovation.

ASSESSMENT & EVALUATION

Total Engagement: For a 4-credit internship course at the NCrF 5.5 level, the total engagement is designed to be both intensive and flexible, balancing real-world exposure with academic oversight.

• **Total Engagement:**
Approximately minimum 120 hours over the internship period.

• **Duration:**
Typically 4-6 weeks.

• **Suggested Daily Breakdown Options:**

- **Option 1:** 4 hours per day for 5 days a week
- **Option 2:** 5 hours per day for 4 days a week

• **Suggested Additional Academic Activities:**
In addition to the on-site internship hours, students should allocate about 1 or 2 hours per week for:

- Meeting with academic and industry mentors
- Maintaining and reviewing progress diaries
- Working on the final project report and preparing for presentations

Assessment Weightage: CCE- 50%: SEE-50%

Total Credits: 04 **Total Marks: 100**

1. Continuous Internal Evaluation (50 Marks Total)

- **Daily/Weekly Progress Log & Reflective Diary:** 15 Marks
  Consistent, insightful entries demonstrating daily activities, reflections, and learning outcomes.
- **Mentor & Faculty Check-ins:** 10 Marks
  Regular, constructive feedback from on-site and academic mentors; demonstration of proactive engagement.
- **Mid-Internship Review (Presentation & Structured Evaluation):** 15 Marks
  Quality of interim progress presentation and performance during mid-term review.
- **Ongoing Project Updates & Feedback Implementation:** 10 Marks
  Evidence of integrating feedback and continuous improvement throughout the internship.

2. Semester-End Evaluation (50 Marks Total)

- **Final Project Report:** 20 Marks
  Comprehensive documentation covering objectives, methodology, challenges, analysis, and reflective conclusions.
- **Final Presentation & Viva-Voce:** 20 Marks
  Clarity, organization, use of visual aids, and effectiveness in communicating results during the presentation and Q&A.
- **Overall Mentor Evaluations (Industry & Academic):** 10 Marks
  Final assessment by mentors on professional conduct, technical competence, and integration of theoretical knowledge.

SN	Criteria	Max. Marks	Marks Obtained
CCE Components			
1.	Daily/ Weekly progress report	15	
2.	Mid Internship Review (after 60 hrs.)	15	
3.	Project Update & Academic Mentor feedback	10	
4.	Project Update & Internship Mentor feedback	10	
	Total CCE Marks	**50**	
SEE Components			
1	Documentation and find report	20	
2	Presentation & Viva voce	20	
3	Over all Academic & Industry Mentor Evaluation	10	
	Total SEE marks	**50**	
	Total Marks	**100**	