॥ सा विद्या या विमुक्तये ॥

स्वामी रामानंद तीर्थ मराठवाडा विद्यापीठ, नांदेड

'ज्ञानतीर्थ', विष्णुपुरी, नांदेड – ४३१ ६०६ (महाराष्ट्र राज्य) भारत

SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

'Dnyanteerth', Vishnupuri, Nanded - 431 606 (Maharashtra State) INDIA

Established on 17th September, 1994, Recognized By the UGC U/s 2(f) and 12(B), NAAC Re-accredited with'B++' grade

website: srtmun.ac.in

Fax : (02462) 215572

Phone: (02462)215542

Academic-1 (BOS) Section

E-mail: bos@srtmun.ac.in

विज्ञान व तंत्रज्ञान विद्याशाखे अंतर्गत राष्ट्रीय शैक्षणिक धोरण–२०२० नुसार पदवी तृतीय वर्षाचे अभ्यासक्रम (Syllabus) शैक्षणिक वर्ष २०२६–२७ पासून लागू करण्याबाबत.

# प रि प त्र क

या परिपत्रकान्वये सर्व संबंधितांना कळविण्यात येते की, दिनांक २२ एप्रिल २०२६ रोजी संपन्न झालेल्या मा.विद्यापरिषद बैठकीतील विषय क्र.०८/६४–२०२६ च्या ठरावानुसार विज्ञान व तंत्रज्ञान विद्याशाखेतील राष्ट्रीय शैक्षणिक धोरण–२०२० नुसार पदवी तृतीय वर्षाचे अभ्यासक्रम (Syllabus) शैक्षणिक वर्ष २०२६–२७ पासून लागू करण्यास मा.विद्यापरिषदेने मान्यता प्रदान केली आहे. त्यानुसार विज्ञान व तंत्रज्ञान विद्याशाखेतील बी.एस्सी. तृतीय वर्षाचे खालील विषयाचे अभ्यासक्रम (Syllabus) शैक्षणिक वर्ष २०२६–२७ पासून लागू करण्यात येत आहे.

| | | | |
|---|---|---|---|
| 01 | B.Sc. III Year Botany | 10 | B.Sc. III Year Biochemistry |
| 02 | B.Sc. III Year Chemistry | 11 | B.Sc. III Year Agriculture Microbiology |
| 03 | B.Sc. III Year Mathematics | 12 | B.Sc. III Year Electronics |
| 04 | B.Sc. III Year Zoology | 13 | B.Sc. III Year Seed Technology |
| 05 | B.Sc. III Year Microbiology | 14 | B.Sc. III Year Horticulture |
| 06 | B.Sc. III Year Geology | 15 | B.Sc. III Year Analytical Chemistry |
| 07 | B.Sc. III Year Enviornment & Earth Science | 16 | B.Sc. III Year Agrochemical & Fertilizers |
| 08 | B.Sc. III Year Statistics | 17 | B.Sc. III Year Industrial Chemistry |
| 09 | B.Sc. III Year Dairy Science | 18 | B.Sc. III Year Industrial Microbiology |

सदरील परिपत्रक व अभ्यासक्रम प्रस्तुत विद्यापीठाच्या www.srtmun.ac.in या संकेतस्थळावर उपलब्ध आहेत. तरी सदरील बाब ही सर्व संबंधितांच्या निदर्शनास आणून द्यावी, ही विनंती.

'ज्ञानतीर्थ' परिसर,
विष्णुपुरी, नांदेड – ४३१ ६०६.
जा.क्र.:शै–१/परिपत्रक/पदवी/बीएस्सी/२०२६–२७/60
दिनांक : १९.०६.२०२६

सहा.कुलसचिव
शैक्षणिक (१–अभ्यासमंडळे) विभाग

प्रत माहिती व पुढील कार्यवाहीस्तव :–
१) मा. कुलगुरू महोदयांचे कार्यालय, प्रस्तुत विद्यापीठ.
२) मा. प्र.कुलगुरू महोदयांचे कार्यालय, प्रस्तुत विद्यापीठ
३) मा. अधिष्ठाता, विज्ञान व तंत्रज्ञान विद्याशाखा, प्रस्तुत विद्यापीठ.
४) मा. संचालक, परिक्षा व मुल्यमापन मंडळ, प्रस्तुत विद्यापीठ.
५) मा. प्राचार्य, सर्व संबंधित संलग्नित महाविद्यालये, प्रस्तुत विद्यापीठ.

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY

**NANDED – 431 606 (MS)**

**UNDER GRADUATE PROGRAMME OF SCIENCE & TECHNOLOGY**

# B.Sc. THIRD YEAR

## SUBJECT — CHEMISTRY

With Effect from the Academic Year 2026–2027

**(As per NEP-2020)**

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# From the Desk of the Dean

## Faculty of Science and Technology

Swami Ramanand Teerth Marathwada University, Nanded, enduring to its vision statement "Enlightened Student: A Source of Immense Power", is trying hard consistently to enrich the quality of science education in its jurisdiction by implementing several quality initiatives. Revision and updating curriculum to meet the standard of the courses at national and international level, implementing innovative methods of teaching-learning, improvisation in the examination and evaluation processes are some of the important measures that enabled the University to achieve the 3Es, the equity, the efficiency and the excellence in higher education of this region. To overcome the difficulty of comparing the performances of the graduating students and also to provide mobility to them to join other institutions the University has adopted the cumulative grade point average (CGPA) system in the year 2014-2015. Further, following the suggestions by the UGC and looking at the better employability, entrepreneurship possibilities and to enhance the latent skills of the stakeholders the University has adopted the Choice Based Credit System (CBCS) in the year 2018-2019 at graduate and post-graduate level. This provided flexibility to the students to choose courses of their own interests. To encourage the students to opt the world-class courses offered on the online platforms like, NPTEL, SWAYM, and other MOOCS platforms the University has implemented the credit transfer policy approved by its Academic Council and also has made a provision of reimbursing registration fees of the successful students completing such courses. SRTM University has been producing a good number of high calibre graduates; however, it is necessary to ensure that our aspiring students are able to pursue the right education. Like the engineering students, the youngsters pursuing science education need to be equipped and trained as per the requirements of the R&D institutes and industries. This would become possible only when the students undergo studies with an updated and evolving curriculum to match global scenario. Higher education is a dynamic process and in the present era the stakeholders need to be educated and trained in view of the self-employment and self-sustaining skills like startups. Revision of the curriculum alone is not the measure for bringing reforms in the higher education, but invite several other initiatives. Establishing industry-institute linkages and initiating internship, on job training for the graduates in reputed industries are some of the important steps that the University would like to take in the coming time. As a result, revision of the curriculum was the need of the hour and such an opportunity was provided by the New Education Policy 2020. National Education Policy 2020 (NEP 2020) aims at equipping students with knowledge, skills, values, leadership qualities and initiates them for lifelong learning. As a result the students will acquire expertise in specialized areas of interest, kindle their intellectual curiosity and scientific temper, and create imaginative individuals. The curriculum given in this document has been developed following the guidelines of NEP-2020 and is crucial as well as challenging due to the reason that it is a transition from general science based to the discipline-specific-based curriculum. All the recommendations of the Sukanu Samiti given in the NEP Curriculum Framework-2023 have been followed, keeping

the disciplinary approach with rigor and depth, appropriate to the comprehension level of learners. All the Board of Studies (BoS) under the Faculty of Science and Technology of this university have put in their tremendous efforts in making this curriculum of international standard. They have taken care of maintaining logical sequencing of the subject matter with proper placement of concepts with their linkages for better understanding of the students. We take this opportunity to congratulate the Chairman(s) and all the members of various Boards of Studies for their immense contributions in preparing the revised curriculum for the benefits of the stakeholders in line with the guidelines of the Government of Maharashtra regarding NEP-2020. We also acknowledge the suggestions and contributions of the academic and industry experts of various disciplines. We are sure that the adoption of the revised curriculum will be advantageous for the students to enhance their skills and employability. Introduction of the mandatory On Job Training, Internship program for science background students is praise worthy and certainly help the students to imbibe firsthand work experience, team work management. These initiatives will also help the students to inculcate the workmanship spirit and explore the possibilities of setting up of their own enterprises.

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**Dr. M. K. Patil**
Dean Faculty of Science and Technology
Swami Ramanand Teerth Marathwada University,
Nanded

# From the Desk of Chairman

## Board of Studies in Chemistry

It gives me great pleasure to present the revised syllabus for **B.Sc. Third Year (Semester V & VI) – Chemistry**, prepared in accordance with the guidelines of the **National Education Policy (NEP) 2020** and the academic framework of **Swami Ramanand Teerth Marathwada University, Nanded**.

The present curriculum has been carefully designed to ensure a balanced integration of **fundamental concepts, practical skills, and emerging trends in chemistry**. Emphasis has been placed on **application-oriented learning, interdisciplinary approach, skill development, and employability enhancement**, which are essential in the contemporary scientific and industrial landscape.

Special features of this syllabus include the introduction of courses such as **Applications of Software in Chemistry, Green Chemistry, Industrial Chemistry components, and Field Project/On-Job Training**, which aim to bridge the gap between theoretical knowledge and real-world applications. The inclusion of **Indian Knowledge System (IKS)** further enriches the curriculum by connecting traditional scientific wisdom with modern chemistry.

The syllabus also incorporates **modern pedagogical approaches, outcome-based education (OBE), and continuous assessment methods**, ensuring that students develop critical thinking, analytical ability, and research aptitude.

I sincerely appreciate the valuable contributions of all **Board of Studies members, subject experts, and faculty colleagues** who have actively participated in designing and refining this curriculum.

I am confident that this revised syllabus will significantly contribute to the **holistic academic and professional development of students**, preparing them to meet the challenges of higher education, research, and industry.

**Dr. D. R. Munde**
Chairman
Board of Studies in Chemistry
Swami Ramanand Teerth Marathwada University, Nanded

# Details of Members of the Board of Studies in the subject Chemistry under the faculty of Science & Technology of S.R.T.M. University, Nanded.

| Sr. No. | Name | Address | Designation |
|---|---|---|---|
| **1.** | Dr. D. R. Munde | Science College, Nanded | Chairman |
| 2. | Dr. Sangeeta S. Makone | School of Chemical Sciences, SRTMU, Nanded | Member |
| 3. | Dr. Yogesh S. Nalwar | Toshniwal ACS College, Sengaon | Member |
| 4. | Dr. Anil B. Chidrawar | Degloor College, Degloor | Member |
| 5. | Dr. A. S. Bondge | Shivneri Mahavidyalaya, Shirur (Anantpal) | Member |
| 6. | Dr. B.C.Khade | D.S.M.College, Parbhani | Member |
| 7. | Dr. Suresh D. Dhage | ACS College, Gangakhed | Member |
| 8. | Dr. Krishna Chaitanya | School of Chemical Sciences, SRTMU, Nanded | Member |
| 9. | Dr. Shivraj B. Sirsat | Yeshwant Mahavidyalaya, Nanded | Member |
| 10 | Dr. Jaman Angulwar | Dayanand Science College, Latur | Member |
| 11 | Dr. Nitish Kumar S. Kaminwar | Lal Bahadur Shastri College, Dharmabad | Member |
| 12 | Dr. S. P. Hungirgekar | Shivaji University, Kolhapur | Member |
| 13 | Dr. Siddhnath V. Bhosale | Principal Scientist, CSIR–IICT, Hyderabad | Expert Member |
| 14 | Dr. P. Bhaskar Reddy | Associate Vice President, R&D Biophore Pharmaceuticals Pvt. Ltd., Hyderabad | Industry Expert |
| 15 | Mr. R. T. Sonkamble | Maharashtra Mahavidyalaya, Nilanga | Member |

# ABBREVIATIONS USED

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

# INTRODUCTION TO UNDERGRADUATE DEGREE IN CHEMISTRY

As per the guidelines of the **University Grants Commission (UGC)** and the framework adopted by **Swami Ramanand Teerth Marathwada University, Nanded**, the **Undergraduate (UG) Programme in Chemistry** is structured under the **National Education Policy (NEP)** with a flexible **Four-Year (Eight Semesters)** framework, with an option to exit after **Three Years (Six Semesters)**.

The **Teaching–Learning Process (TLP)** is designed to be **student-centric, outcome-based, and skill-oriented**, integrating theory, practical, vocational, and experiential learning components. The curriculum ensures a **strong foundation in core Chemistry subjects** along with opportunities for advanced learning and interdisciplinary exposure.

The programme includes a combination of the following course types:

- **Major (DSC/MJ – Discipline Specific Core / Major Courses)**
- **Minor (MN/DSE – Discipline Specific Electives)**
- **Vocational Skill Courses (VSC)**
- **Skill Enhancement Courses (SEC)**
- **Indian Knowledge System (IKS)**
- **Open/Generic Electives (OE/GE)**
- **Ability and Value Enhancement Courses (AEC/VEC)**
- **Field Projects, Internships (OJT), and Community Engagement Projects (CEP)**

This structure promotes a multidisciplinary and interdisciplinary approach, allowing students to explore diverse academic areas alongside their core discipline. The programme offers flexibility in course selection, credit accumulation, and academic progression, enabling students to design their learning pathway based on their interests, aptitude, and career aspirations.

Furthermore, the provision of multiple entry and exit options ensures that students can obtain Certificate, Diploma, Degree, or Honours Degree at different stages, thereby enhancing employability and supporting higher education opportunities.

Overall, the UG Programme in Chemistry under SRTMU aims to develop scientific knowledge, practical skills, critical thinking, research aptitude, and professional competence, preparing students for higher studies, research, and diverse career opportunities in industry, academia, and allied fields.

# PROGRAM DURATION AND EXIT OPTIONS

The duration of the **Undergraduate (UG) Programme in Chemistry** at **Swami Ramanand Teerth Marathwada University, Nanded** shall be **four years (Eight Semesters)** under the NEP framework. Students shall have **multiple entry and exit options** as per NEP guidelines:

- Students completing only three years (Six Semesters) will be awarded a Bachelor of Science (B.Sc.) Degree in Chemistry.
- Students exiting after the first year (Two Semesters) will be awarded an Undergraduate Certificate in Chemistry, provided they have earned the prescribed credits.
- Students exiting after the second year (Four Semesters) will be awarded an Undergraduate Diploma in Chemistry, subject to fulfilment of required credits.
- Students completing the four-year programme (Eight Semesters) will be awarded a Bachelor of Science in Chemistry (Honours / Honours with Research) as per university regulations.

Students who exit the programme at any stage (Certificate/Diploma) shall be eligible for re-entry within a maximum period of three years, subject to university rules and availability of seats.

The credit framework is designed to ensure flexibility in academic progression:

- Minimum credits per semester: 18
- Maximum credits per semester: 26
- Recommended credits per semester: 22

### Table 1: Awards and Required Credits

| Sr. No. | NCrF / NHEQF Level | Type of Award | Stage of Exit/ Programme Duration | Credits Required |
|---|---|---|---|---|
| **1** | Level 4.5 | Undergraduate Certificate in Chemistry | After successful completion of First Year (Semester I & II) | **44** |
| **2** | Level 5.0 | Undergraduate Diploma in Chemistry | After successful completion of Second Year (Semester III & IV) | **88** |
| **3** | Level 5.5 | Bachelor of Science (B.Sc.) in Chemistry | After successful completion of Third Year (Semester V & VI) | **132** |
| **4** | Level 6.0 | Bachelor of Science in Chemistry (Honours / Honours with Research) | After successful completion of Fourth Year (Semester VII & VIII) | **176** |

# OBJECTIVES OF THE PROGRAM

- To strengthen students' understanding of fundamental and advanced concepts in Physical, Organic, and Inorganic Chemistry.
- To develop the ability to apply chemical principles to solve theoretical and practical problems in chemistry.
- To enhance laboratory skills and experimental techniques required for qualitative and quantitative analysis.
- To promote critical thinking, analytical ability, and scientific reasoning among students.
- To familiarize students with the applications of chemistry in industry, environment, health, and daily life.
- To develop awareness about green chemistry, safety practices, and environmental sustainability.
- To encourage research orientation, innovation, and higher learning in the chemical sciences.

# PROGRAM OUTCOMES

After successful completion of the B.Sc. Chemistry programme, students will be able to:

### PO1: Disciplinary Knowledge

Demonstrate comprehensive knowledge of fundamental and advanced concepts in **Physical, Organic, and Inorganic Chemistry**, including theoretical and practical aspects.

### PO2: Problem Analysis

Apply chemical principles, mathematical tools, and scientific reasoning to identify, formulate, and solve complex theoretical and experimental problems.

### PO3: Critical Thinking

Develop critical thinking and analytical skills to evaluate scientific data, interpret results, and draw logical conclusions.

### PO4: Experimental Skills & Laboratory Competence

Perform qualitative and quantitative chemical analysis using standard laboratory techniques, instruments, and modern tools with accuracy and precision.

### PO5: Modern Tool Usage

Utilize contemporary chemical software, instrumentation, and ICT tools for data analysis, simulation, and research applications.

### PO6: Environment and Sustainability

Understand the role of chemistry in environmental protection and sustainable development, including principles of **green chemistry** and pollution control.

### PO7: Ethics and Safety

Follow ethical practices, laboratory safety protocols, and professional responsibilities in academic and industrial settings.

### PO8: Communication Skills

Communicate scientific information effectively through oral presentations, laboratory reports, and technical writing.

### PO9: Lifelong Learning

Recognize the need for continuous learning and professional development in the field of chemical sciences and related disciplines.

### PO10: Research and Innovation

Develop research aptitude, creativity, and innovation skills for pursuing higher studies, research, and entrepreneurship.

### PO11: Teamwork and Leadership

Work effectively as an individual and as a member or leader in multidisciplinary teams.

### PO12: Application in Society and Industry

Apply chemical knowledge in solving real-life problems related to **industry, health, agriculture, and environment**.

# PROGRAM SPECIFIC OUTCOMES

After completion of the programme, students will be able to:

### PSO1: Core Chemistry Competence

Acquire in-depth knowledge of core areas such as:

- Thermodynamics, kinetics, and quantum chemistry
- Organic reaction mechanisms and synthesis
- Coordination chemistry, spectroscopy, and materials chemistry

### PSO2: Laboratory Proficiency

Develop hands-on skills in:

- Volumetric, gravimetric, and instrumental analysis
- Organic synthesis and purification techniques
- Handling modern instruments like pH meter, conductometer, spectrophotometer, etc.

### PSO3: Application of Chemical Knowledge

Apply chemical concepts in:

- Industrial processes (fertilizers, polymers, pharmaceuticals)
- Environmental monitoring and pollution control
- Health, food chemistry, and daily life applications

### PSO4: Green Chemistry and Sustainability

Implement principles of green chemistry, waste minimization, and eco-friendly practices in laboratory and industrial contexts.

### PSO5: Research Orientation

Design and conduct basic research experiments, analyze data, and present findings scientifically.

### PSO6: Interdisciplinary Understanding

Integrate chemistry with related fields such as **biology, physics, environmental science, and material science**.

### PSO7: Employability and Skill Development

Develop skills relevant to:

- Chemical industries
- Quality control laboratories
- Teaching and academic research
- Competitive examinations and higher education

# GENERAL GUIDELINES FOR THE SELECTION OF SUBJECTS

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

# TEACHING-LEARNING PROCESS

**a.** Courses will be taught through the traditional chalk-and-talk method, laboratory work, ICT-enabled teaching–learning tools, project work, seminars, case studies, field work, internships, hands-on training, etc.

**b.** Students will be engaged in various student-centric activities including experiential learning, problem-solving methodologies, participative learning, and ICT-based teaching–learning processes.

**c.** ICT tools in Basic and Advanced Chemistry software will be used to make the teaching–learning process efficient and engaging.

**d.** Critical, analytical, and problem-solving abilities will be developed through project-based learning, internships, industrial visits, and hands-on training.

**e.** Problem-solving methodologies such as quizzes, review of books and research papers, workshops, and research-based competitions will be employed.

**f.** Vocational and skill training will be conducted through vocational and skill-based courses.

**g.** Students will be introduced to advanced laboratory instruments for hands-on training.

# METHODS OF ASSESSMENT

The primary objective of assessment is to evaluate the attainment of learning outcomes of the course in alignment with the broader goals of strengthening core theoretical knowledge, developing practical laboratory skills, and promoting research aptitude among students.

The assessment system shall be based on **Continuous Internal Evaluation (CIE)** and **End Semester University Examination (ESE)** as per the norms of **Swami Ramanand Teerth Marathwada University, Nanded**.

## Continuous Internal Evaluation (CIE)

During the semester, students' performance and mastery of the prescribed learning outcomes will be evaluated through various academic activities such as:

- Short answer tests
- Class tests
- Seminars and presentations
- Group discussions
- Quizzes and MCQs
- Assignments and tutorials
- Project work

Each theory and practical course shall carry **10 marks for internal assessment (for each-credit course)**. The internal assessment will be conducted by the respective colleges as per university guidelines.

## End Semester Examination (ESE)

The End Semester Examination will be conducted by **Swami Ramanand Teerth Marathwada University, Nanded** for both theory and practical courses. Each credit course shall carry **15 marks for the End Semester Examination (ESE)**.

## Scheme of Examination

- Total marks for 2-credit course: 50 (20 Internal + 30 ESE)
- Total marks for 4-credit course: 100 (40 Internal + 60 ESE)
- Internal examinations will be conducted by the respective colleges.
- External examinations will be conducted by SRTMU, Nanded at the end of each semester.

Marks distribution under CA (40%)

| Sr. No. | Continuous Assessment Modes | For 4 Credit (Marks) | For 2 Credit (Marks) | For 3 Credit (Marks) |
|---|---|---|---|---|
| 1 | Class Test | 20 | 10 | 15 |
| 2 | Assignment, Presentation, Viva, Quiz, Open Book, etc. | 12 | 06 | 09 |
| 3 | Attendance | 08 | 04 | 06 |
| | **Total** | **40** | **20** | **30** |
| | | | | |

# STRUCTURE OFB.Sc. Third Year — Semester V (Level 5.5)

## Teaching Scheme

| Subject | Course Code | Course Name | Credits Assigned | | | Teaching (Hrs/wk) | |
|---|---|---|---|---|---|---|---|
| | | | Theory | Practical | Total | Theory | Practical |
| Major | SCHECT1301 | Organic and Inorganic Chemistry | 03 | – | 03 | 03 | -- |
| | SCHECP1301 | Practical based on SCHECT1301 | -- | 02 | 02 | -- | 04 |
| | SCHECT1302 | Physical and Inorganic Chemistry | 03 | -- | 03 | 03 | -- |
| | SCHECP1302 | Practical based on SCHECT1302 | -- | 02 | 02 | -- | 04 |
| | SCHEIKS1301 | Subject Specific – IKS in Chemistry | 02 | -- | 02 | 02 | -- |
| Elective | SCHEET1301 OR SCHEET1302 | Organic Chemistry for Industry OR Application-Based Analytical Chemistry (Theory) | 02 | – | 02 | 02 | -- |
| | SCHEEP1301 OR SCHEEP1302 | Practical Course in Organic Chemistry for Industry OR Application-Based Analytical Chemistry (Practical) | – | 02 | 02 | – | 04 |
| Vocational Course | SCHEVC1301 | Vocational Skill Course- Green Chemistry | – | 02 | 02 | – | 04 |
| Field Project | SCHEFP1301 | Field Project in Chemistry SCHEFP-1301 | – | 04 | 04 | – | 08 |
| **Total Credits** | | | 10 | 12 | **22** | **10** | **24** |

# B.Sc. Third Year — Semester V

## Examination Scheme

| Subject (1) | Course Code (2) | Course Name (3) | Theory/ Practical | | | | | Total Col(7) /Col(8) (09) |
|---|---|---|---|---|---|---|---|---|
| | | | Continuous Assessment (CA) | | | (4+5+6) = 7 | ESA (8) | |
| | | | Test (4) | Assignment (5) | Attendance (6) | | | |
| **Major** | SCHECT1301 | Organic and Inorganic Chemistry | 15 | 09 | 06 | 30 | 45 | 75 |
| | SCHECP1301 | Practical based on SCHECT1301 | 10 | 06 | 04 | 20 | 30 | 50 |
| | SCHECT1302 | Physical and Inorganic Chemistry | 15 | 09 | 06 | 30 | 45 | 75 |
| | SCHECP1302 | Practical based on SCHECT1302 | 10 | 06 | 04 | 20 | 30 | 50 |
| | SCHEIKS1301 | Subject Specific – IKS in Chemistry | 10 | 06 | 04 | 20 | 30 | 50 |
| **Elective** | SCHEET1301 OR SCHEET1302 | Organic Chemistry for Industry OR Application-Based Analytical Chemistry (Theory) | 10 | 06 | 04 | 20 | 30 | 50 |
| | SCHEEP1301 OR SCHEEP1302 | Practical Course in Organic Chemistry for Industry (SCHEEP1301) OR Application-Based Analytical Chemistry (Practical) (SCHEEP1302) | 10 | 06 | 04 | 20 | 30 | 50 |
| **Vocational Course** | SCHEVC1301 | Vocational Skill Course- Green Chemistry | 10 | 06 | 04 | 20 | 30 | 50 |
| **Field Project** | SCHEFP1301 | Field Project in Chemistry SCHEFP-1301 | 20 | 12 | 08 | 40 | 60 | 100 |

# B.Sc. Third Year — Semester VI (Level 5.5)

## Teaching Scheme

| Subject | Course Code | Course Name | Credits Assigned | | | Teaching (Hrs/wk) | |
|---|---|---|---|---|---|---|---|
| | | | Theory | Practical | Total | Theory | Practical |
| **Major** | SCHECT1351 | Organic Chemistry | 03 | – | 03 | 03 | -- |
| | SCHECT1352 | Physical Chemistry | 03 | -- | 03 | 03 | -- |
| | SCHECT1353 | Inorganic Chemistry | 02 | -- | 02 | 02 | -- |
| | SCHECP1351 | Practical based on SCHECT1351 + SCHECT1353 | -- | 02 | 02 | – | 04 |
| | SCHECP1352 | Practical based on SCHECT1352 + SCHECT1353 | -- | 02 | 02 | – | 04 |
| **Elective** | SCHEET1351 OR SCHEET1352 | Advanced Organic Synthesis and Reaction Mechanisms OR Fundamentals of Phase Equilibria and Solution Chemistry | 02 | – | 02 | 02 | – |
| | SCHEEP1351 OR SCHEEP1352 | Practical Course in Advanced Organic Synthesis and Reaction Mechanisms OR Practical Course in Fundamentals of Phase Equilibria and Solution Chemistry | – | 02 | 02 | – | 04 |
| **Vocational Course** | SCHEVC1351 | Applications of Software in Chemistry | – | 02 | 02 | – | 04 |
| OJT | SCHEOJT1351 | On-Job Training (OJT) in Chemistry | – | 04 | 04 | – | 08 |
| Total Credits | | | 10 | 12 | 22 | 10 | 24 |

# B.Sc. Third Year — Semester VI

## Examination Scheme

| Subject (1) | Course Code (2) | Course Name (3) | Theory/ Practical | | | | | Total Col(7) /Col(8) =(09) |
|---|---|---|---|---|---|---|---|---|
| | | | Continuous Assessment (CA) | | | (4+5+6) = 7 | ESA (8) | |
| | | | Test (4) | Assignment (5) | Attendance (6) | | | |
| **Major** | SCHECT1351 | Organic Chemistry | 15 | 09 | 06 | 30 | 45 | 75 |
| | SCHECT1352 | Physical Chemistry | 15 | 09 | 06 | 30 | 45 | 75 |
| | SCHECT1353 | Inorganic Chemistry | 10 | 06 | 04 | 20 | 30 | 50 |
| | SCHECP1351 | Practical based on SCHECT1351 + SCHECT1353 | 10 | 06 | 04 | 20 | 30 | 50 |
| | SCHECP1352 | Practical based on SCHECT1352 + SCHECT1353 | 10 | 06 | 04 | 20 | 30 | 50 |
| **Elective** | SCHEET1351 OR SCHEET1352 | Advanced Organic Synthesis and Reaction Mechanisms OR Physical Chemistry of Liquids and Thermodynamics | 10 | 06 | 04 | 20 | 30 | 50 |
| | SCHEEP1351 OR SCHEEP1352 | Practical Course in Advanced Organic Synthesis and Reaction Mechanisms OR Practical Course in Physical Chemistry of Liquids and Thermodynamics | 10 | 06 | 04 | 20 | 30 | 50 |
| **Vocational Course** | SCHEVC1351 | Applications of Software in Chemistry | 10 | 06 | 04 | 20 | 30 | 50 |
| **OJT** | SCHEOJT1351 | On-Job Training (OJT) in Chemistry | 20 | 12 | 08 | 40 | 60 | 100 |

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

**Faculty of Science & Technology**

| | |
|---|---|
| **Name of the Program** | B.Sc. Third Year (Chemistry) |
| **Title of the Paper/Course** | Organic and Inorganic Chemistry (Theory) [SCHECT-1301] |
| **Semester** | V |
| **Paper Type** | DSC (Major Core) |
| **Credits** | 03 |
| **Total Hours** | 45 Hours |
| **Formative Assessment Marks** | 30 |
| **Summative Assessment Marks** | 45 |
| **Total Marks** | 75 |

## Course Objectives (CO):

1. To develop a comprehensive understanding of **stereochemistry**, including structural and stereoisomerism, optical activity, and stereochemical configurations.
2. To impart knowledge of **synthetic drugs and dyes**, their classification, synthesis, and applications in medicinal and industrial chemistry.
3. To explain various types of **molecular rearrangements** and their mechanistic pathways.
4. Gain fundamental and applied knowledge of f-block elements (lanthanides and actinides), including their properties, separation techniques, and industrial applications.
5. Apply theoretical concepts to solve numerical problems, reaction mechanisms, and structure–property relationships in chemistry.

## Course Outcomes (COs):

| CO No. | Upon completion of this course, students will be able to: | Bloom's Level | PO Mapped |
|---|---|---|---|
| CO1 | Explain structural and stereoisomerism and assign **R/S and E/Z configurations**. | Understand / Apply | PO1, PO2 |
| CO2 | Analyze stereochemical concepts such as **chirality, symmetry, enantiomers, and conformations**. | Analyze | PO2, PO4 |
| CO3 | Describe synthesis, classification, and applications of **synthetic drugs and dyes**. | Understand / Apply | PO1, PO3 |
| CO4 | Explain mechanisms of **molecular rearrangements** (electrophilic, nucleophilic, free radical). | Analyze | PO2, PO4 |
| CO5 | Explain properties and applications of **d- and f-block elements** including magnetic behavior. | Understand / Apply | PO1, PO2 |
| CO6 | Describe occurrence, extraction, properties, and uses of uranium in nuclear applications. | Understand | PO1, PO6 |

## Detailed Syllabus

| Module No. | Title | Topics | Hours |
|---|---|---|---|
| **I** | **Stereochemistry** | **1.1** Introduction, Concept and Types of isomerism<br>(a) Structural isomerism: Types of Structural isomerism: Chain isomerism, Position isomerism, Functional isomerism, Metamerism, Tautomerism<br>(b) Stereoisomerism: Types of Stereoisomerism:<br>i) Configurational isomerism (Geometrical & Optical isomerism) ii) Conformational isomerism Ex: Ethane & Butane<br>**1.2** Optical Isomerism: a) Concept of Asymmetric Carbon atom (Chiral centre) b) Optical Activity (Plane polarized light, dextro and laevo forms, racemic mixture)<br>c) Element of Symmetry [Plane, Centre, and Axis]<br>d) Concept of Enantiomerse) Concept of Diastereomers<br>f) Racemic Modification, Resolution<br>**1.3** Relative configuration (D and L Notations) & Absolute configuration (R and S Notations)<br>**Examples:** i) Lactic acid, ii) Glyceraldehyde, iii) Bromochloroiod omethane, iv) 2-Chlorobutane, v) 1-Bromo-1-Chloro ethanol, vi) 1-Chloro ethylamine, vii) 1-Chloro-1-propanol, viii) Glyceric acid, ix) α-Deutero ethyl bromide, x) 1-Phenyl ethanol, xi) Mendelic acid, xii) 1-Phenyl ethylchloride, xiii) Lactonitrile, xiv) α -Bromopropanoic acid, xv) 2-Iodo octane xvi) Cinnamic acid dibromide.<br>**1.4** Geometrical Isomerism (Cis-trans isomerism), E and Z System of nomenclature **Examples:** i) Maleic acid, ii) 1-Chloro-2-bromo-2-iodoethene, iii) 3-Hexene, iv) 1,2-Diphenylethene, v) 2-Pentene, vi) 1-Deuterium hexene, vii) 3-Methyl-3-haxene, viii) Phenyl oxime, ix) 1-Bromo-1,2-dichloroethene, x) 2-Chloro-3-methyl-2-pentenoic acid, xi) Cinnamic acid xii) Crotonic acid. | **10** |
| **II** | **Synthetic Drugs and Dyes** | **2.1** Introduction, Definition of drugs, qualities of good drug,<br>**2.2** Classification of drugs based on therapeutic action.<br>a) Pharmacodynamic agents: Antipyretics, Analgesics, Anesthetics, Antidiabetics, Anti-inflammatory, sedatives, hypnotics and tranquillizers.<br>b) Chemotherapeutic agents: Antimalarials, Antibacterials, Antifungals, Antituberculars, Antibiotics, Anticancer drugs.<br>**2.3 Synthesis and uses of the following drugs:**<br>i) Antimalerials: Paludrin ii) Antituberculars: Isoniazide<br>iii) CNS drugs: Phenobarbitone iv) Antidiabetics: Tolbutamide<br>v) Anti-inflammatory drugs: Ibuprofen | **10** |

| | | | |
|---|---|---|---|
| | | vi) Antibiotics: Chloromycetin vii) Anticancer drugs: Chlorambucil (Leukeran)<br>**2.4 Synthetic Dyes**: Introduction, Definition of dyes qualities of good dye, Classification of dyes based on methods of applications. Colour and Chemical constitution: a) Witt's theory b) Armstrong's theory.<br>**2.5 Synthesis and applications of following dyes**:<br>Azo dyes: Methyl orange and Congo red.<br>Triphenylmethane dyes: Malachite green and Crystal violet.<br>Phthalein dyes: Phenolphthalein and Fluorescein dye. | |
| **III** | **Molecular Rearrangements** | 3.1.1 Introduction and classification of rearrangements (based on migratory group)<br>3.2 Types of Rearrangements<br>**Electrophilic Rearrangement**<br>3.2.1 Pinacol–Pinacolone rearrangement<br>3.2.2 Wolff rearrangement<br>**Nucleophilic Rearrangement**<br>3.2.3 Favorskii rearrangement<br>3.2.4 Hofmann rearrangement<br>3.2.5 Benzilic acid rearrangement<br>**Free Radical Rearrangement**<br>3.2.6 Photo-Fries rearrangement<br>**Aromatic Rearrangement**<br>3.2.7 Stevens rearrangement | **10** |
| **IV** | **A. Chemistry of d- Block Elements** | 4.1.1 Introduction and Position in Periodic Table<br>4.1.2 Electronic Configuration<br>• Electronic configuration of first, second and third transition series elements<br>4.1.3 General Properties of d-Block Elements<br>• Atomic size<br>• Metallic character<br>• Melting and boiling points<br>4.1.4 Characteristic Properties<br>• Oxidation states<br>• Colour formation<br>• Catalytic properties<br>• Complex formation<br>• Magnetic properties:<br>o Paramagnetic nature<br>o Diamagnetic nature<br>4.1.5 Numerical Problems<br>• Calculation of magnetic moment of first transition metal ions | **05** |
| | **B. Chemistry of f-Block Elements**<br><br>***(Lanthanides*** | **4.2. Lanthanides**<br>**4.2.1. Introduction**<br>• Definition and position in the periodic table<br>• Electronic configuration:<br>**4.2.2. General Properties** | 10 |

| | | | |
|---|---|---|---|
| | ***and Actinides)*** | • Oxidation states (mainly +3)<br>• Colour and spectral characteristics<br>• Magnetic properties (paramagnetism, diamagnetism)<br>• Numerical problems on calculation of magnetic moment<br>**4.2.3. Lanthanide Contraction**<br>• Definition and cause<br>• Consequences (similarity in properties, separation difficulty, effect on transition elements)<br>**4.2.4. Separation Techniques**<br>• Ion-exchange method for separation of lanthanides<br>**4.2.5. Spectral Properties**<br>• Sharp absorption spectra<br>• f–f transitions<br>**4.2.6. Special Applications**<br>• Lanthanides as shift reagents<br>• Industrial and technological uses<br>**4.3 Actinides**<br>**4.3.1. Introduction**<br>• Definition and position in the periodic table<br>• Electronic configuration<br>**4.3.2. General Properties**<br>• Variable oxidation states<br>**4.3.3. Chemistry of Uranium**<br>• Occurrence of uranium ores<br>• Extraction and purification<br>• Important properties<br>• Uses (energy production, nuclear applications)<br>**4.4. Comparative Study**<br>• Comparison between lanthanides and actinides based on:<br>o Electronic configuration<br>o Oxidation states<br>o Magnetic properties<br>o Chemical reactivity<br>o Complex formation | |

**Total Hours: 45**

**Recommended Textbooks**

1. S.M. Mukherji, S.P. Singh, R.P. Kapoor – Organic Chemistry
2. P.S. Kalsi – Stereochemistry, Conformation and Mechanism
3. Morrison and Boyd – Organic Chemistry
4. Puri, Sharma and Kalia – Inorganic Chemistry
5. Clayden, Greeves, Warren – Organic Chemistry
6. Jerry March – Advanced Organic Chemistry
7. AshutoshKar – Medicinal Chemistry
8. G.R. Chatwal – Synthetic Drugs and Dyes
9. R.L. Madan – Chemistry for Degree Student

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science and Technology

| | |
|---|---|
| **Name of the Program** | B.Sc. (Chemistry) |
| **Title of the Paper/Course** | Organic and Inorganic Chemistry (Practical) [SCHECP1301] |
| **Semester** | V |
| **Paper Type** | DSC (Practical) |
| **Credits** | 02 |
| **Total Hours** | 60 Hours |
| **Formative Assessment Marks** | 20 |
| **Summative Assessment Marks** | 30 |
| **Total Marks** | 50 |

### Course Objectives

1. **To develop systematic skills** in separation and identification of organic compounds present in binary mixtures.
2. **To impart knowledge of functional group analysis** using chemical tests and confirmatory reactions.
3. **To train students in qualitative analysis techniques**, including acid-base extraction and purification methods.
4. **To enhance analytical thinking** in identifying unknown organic compounds based on physical and chemical properties.
5. **To develop laboratory skills** such as observation, recording, and interpretation of experimental results.
6. **To promote safety practices, accuracy, and scientific reporting** in laboratory work.

### Course Outcomes (COs)

After completing this course, students will be able to:

| CO No. | Upon completion of this course, students will be able to: | Bloom's Level | PO Mapped |
|---|---|---|---|
| **CO1** | Separate components of binary organic mixtures using appropriate chemical methods such as acid-base extraction. | Apply | PO3, PO4 |
| **CO2** | Identify functional groups present in organic compounds using systematic qualitative analysis. | Understand / Analyze | PO1, PO2 |
| **CO3** | Perform confirmatory tests and classify compounds as acids, bases, phenols, or neutral substances. | Apply / Analyze | PO3, PO4 |
| **CO4** | Analyze unknown organic compounds based on experimental observations and chemical behavior. | Analyze | PO2, PO4 |
| **CO5** | Record experimental data accurately and present results with proper interpretation and conclusions. | Analyze / Evaluate | PO4, PO5 |

| | | | |
|---|---|---|---|
| **CO6** | Demonstrate safe laboratory practices, proper handling of chemicals, and teamwork in experimental work. | Apply / Create | PO6, PO7 |

## Detailed Syllabus

### 01. Organic Qualitative Analysis: At least 08 mixtures are to be separated.

Separation of organic binary mixture containing two solid components and analysis of (both/one) components.

**Nature 01) Solid-Solid: 06 mixtures**

One mixture from each of the following types should be given:

a) Acid + Phenol b) Acid + Base

c) Acid + Neutral d) Phenol + Base

e) Phenol + Neutral f) Base + Neutral

Separation of organic binary mixture containing one solid and one liquid components and analysis of (both/one) components.

**Nature 02) Solid-Liquid: 02 mixtures**

One mixture of type Acid + Neutral should be given.

Following compounds should be used for preparation of mixtures:

**Acids:** Benzoic acid, Phthalic acid, Salicylic acid, Cinnamic acid, o-Chlorobenzoic acid, Aspirin, m-Cholorobenzoic acid.

**Phenols:** α -Naphthol, β –Naphthol, P-nitrophenol.

**Bases:** o-Nitroaniline, m-Nitroaniline, p-Nitroaniline, p-Anisidine, Aniline, p-Toluidine, p-Chloroaniline, N, N-Dimethyl aniline.

**Neutrals:** Naphthalene, Acetanilide, Anthracene, Benzamide, Benzophenone, Carbon tetrachloride, Acetone, Nitrobenzene, Acetophenone, m-Dinitrobenzene, p-Dichloro benzene.

### 02. (Inorganic chemistry)

i) To Determine percentage of iron from haematite ore by volumetrically.

ii) To Determine percentage Silica and manganese from pyrolusite ore by volumetrically.

iii) To Determine percentage of Calcium and Magnesium in dolomite ore by volumetrically.

iv) To determine percentage of copper and iron from Chalcopyrite.

v) To determine of percentage of Aluminium from Bauxite

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

| | |
|---|---|
| **Name of the Program** | B.Sc. Third Year (Chemistry) |
| **Title of the Paper/Course** | Physical and Inorganic Chemistry (Theory) [SCHECT-1302] |
| **Semester** | V |
| **Paper Type** | DSC (Major Core) |
| **Credits** | 03 |
| **Total Hours** | 45 Hours |
| **Formative Assessment Marks** | 30 |
| **Summative Assessment Marks** | 45 |
| **Total Marks** | 75 |

## Course Objectives

1. To develop a **fundamental understanding of molecular spectroscopy** including rotational, vibrational, Raman, and electronic spectra, and their role in molecular structure determination.
2. To introduce the principles of **photochemistry**, including light absorption, photochemical laws, quantum yield, and photophysical processes such as fluorescence and phosphorescence.
3. To enable students to understand and analyze **chemical kinetics**, including third-order reactions, complex reactions, and photochemical reaction mechanisms.
4. To impart knowledge of **coordination chemistry**, including structure, bonding, nomenclature, isomerism, and classical theories such as Werner's theory.
5. To familiarize students with the **concept and applications of medicinal coordination chemistry**, including chelation therapy and metal-based drugs.
6. To develop **analytical and problem-solving skills** through numerical treatment and interpretation of concepts in spectroscopy, photochemistry, and kinetics.
7. To correlate theoretical concepts with **practical, industrial, and medicinal applications** in modern chemistry.

## Course Outcomes (COs)

| CO No. | Course Outcomes | Bloom's Level | PO Mapping |
|---|---|---|---|
| **CO1** | Explain the principles of **rotational, vibrational, Raman, and electronic spectroscopy**, including energy levels, selection rules, and spectral interpretation. | Understand | PO1 |
| **CO2** | Apply spectroscopic concepts to **solve numerical** | Apply | PO2, PO3 |

| | | | |
|---|---|---|---|
| | **problems** related to moment of inertia, force constant, and spectral transitions. | | |
| **CO3** | Describe and analyze **photochemical processes**, including Lambert-Beer law, photochemical laws, quantum yield, fluorescence, and phosphorescence. | Understand / Analyze | PO1, PO2 |
| **CO4** | Analyze the kinetics of **third-order, opposing, consecutive, and photochemical reactions**, and interpret reaction mechanisms and rate equations. | Analyze | PO2, PO4 |
| **CO5** | Explain the concepts of **coordination chemistry**, including nomenclature, Werner's theory, bonding, and various types of isomerism. | Understand | PO1 |
| **CO6** | Apply knowledge of coordination chemistry to **interpret structures, EAN rule, and properties of metal complexes**. | Apply / Analyze | PO2, PO3 |
| **CO7** | Evaluate the **applications of coordination compounds in medicinal chemistry**, such as chelation therapy, anticancer drugs, and diagnostic agents. | Analyze / Evaluate | PO6, PO12 |

## Detailed Syllabus

| Module No. | Title | Topics | Hours |
|---|---|---|---|
| I | **Spectroscopy** | 1. Brief introduction to molecular Spectroscopy.<br>2. Rotational spectra: Rotational spectra of diatomic molecules.(Rigid rotator model) Moment of inertia, energy levels of rigid rotator, selection rule, spacing between spectral lines of diatomic rigid rotator, isotopic effect. Numericals on bond length.<br>3. Vibrational Spectra: Infrared spectrum, simple harmonic oscillator model, energy levels of simple harmonic oscillator, selection rule, pure vibrational spectrum, intensity, determination of force constant, Numerical on force constant.<br>4. Raman spectra: Raman Effect, Classical and quantum theory of Raman scattering, Rotational Raman spectrum of a diatomic molecule.<br>5. Electronic spectra: Franck-Condon Principle, Types of electronic transitions. | 12 |
| II | **Photochemistry** | 1. Introduction to photochemistry, types of chemical reactions, difference between thermal and photochemical reactions. | 10 |

| | | | |
|---|---|---|---|
| | | 2. Lambert-Beer Law: Light absorption by solution, molar extinction coefficient.<br>3. Laws of photochemistry: Grothus - Drapper law, Stark-Einstein law of photochemical equivalence.<br>4. Quantum yield, experimental determination of quantum yield. High and low quantum yields reactions.<br>5. Fluorescence, phosphorescence, Photosensitized reactions. Chemiluminescence.<br>6. Numerical on quantum yield. | |
| III | **Chemical Kinetics** | 1. Introduction, Kinetics of Third order reaction with equal concentration of all reactants, characteristics of third order reaction.<br>2. Kinetics of complex reaction: i) Opposing reaction; ii) Consecutive reaction.<br>3. Kinetics of Photochemical reaction: i) Hydrogen-chlorine reaction; ii) Decomposition of HI;<br>4. iii) Dimerization of anthracene. | 08 |
| IV | **A. Introduction to Coordination Chemistry** | 1. **Introduction**: Addition or molecular compound, double salt, coordination compound. Comparison of double salt and coordination compound.<br>2. **Terminology**: complex ion, central metal atom, ligand, types of ligands, coordination number and coordination sphere.<br>3. **Nomenclature**: Rules of nomenclature of coordination compound, and its applications tonomenclature of simple and bridging complex compounds.<br>4. **Werner's theory of coordination compound**: Postulates, applications with reference to $CoCl_3.6NH_3$, $CoCl_3.5NH_3$, $CoCl_3.4NH_3$, $CoCl_3.3NH_3$. Chelating agents: Definition and classification, difference between metal complex and metal chelate complex.<br>5. **Isomerism in coordination compounds**: Structural isomerism, ionization, hydrate, linkage, coordination isomerism, Geometrical isomerism, optical isomerism in 4 and 6 coordination complexes.<br>6. E. A. N. of metal complexes. | 10 |
| | **B. Medicinal coordination chemistry.** | **1.** Introduction, Chelation Therapy, Cancer Treatment, Anti-arthritis drugs and Imaging agents. | 05 |

**Total Hours: 45**

## Recommended books


1. G. M. Barrow, *Physical Chemistry*, Tata McGraw-Hill Publishing Co. Ltd.
2. S. Glasstone and D. Lewis, *Elements of Physical Chemistry*, D. Van Nostrand Co. Inc.
3. W. J. Moore, *Physical Chemistry*, Orient Longman.
4. S. H. Maron and C. F. Prutton, *Principles of Physical Chemistry*.
5. C. N. R. Rao, *University General Chemistry*, McMillan.
6. P. W. Atkins, *Elements of Physical Chemistry*, Oxford University Press.
7. R. A. Alberty, *Physical Chemistry*, Wiley Eastern Ltd.
8. S. K. Dogra and D. Dogra, *Physical Chemistry through Problems*, Wiley Eastern Ltd.
9. Puri, Sharma and Pathania, *Principles of Physical Chemistry*, Vishal Publishing Co.
10. A. J. Mee, *Physical Chemistry*, ELBS and Heinemann Educational Books Ltd.
11. B. S. Bahl, ArunBahl and G. D. Tuli, *Essentials of Physical Chemistry*, S. Chand.
12. K. J. Laidler, *Kinetics*, Tata McGraw-Hill Publishing Co. Ltd.
13. Soni and Dharmarha, *Text Book of Physical Chemistry*.
14. S. Glasstone, *A Text Book of Physical Chemistry*, Macmillan.
15. D. N. Bajpai,*Advanced Physical Chemistry*, S. Chand.
16. GurdeepRaj,*Advanced Physical Chemistry*, Goel Publishing House, Meerut.
17. Ira N. Levine, *Physical Chemistry*, McGraw-Hill.
18. Peter Atkins and Julio de Paula, *Atkins' Physical Chemistry*, Oxford University Press.
19. Donald A. McQuarrie and John D. Simon, *Physical Chemistry: A Molecular Approach*, Viva Books / University Science Books.
20. J. Rajaram and J. C. Kuriacose, *Chemical Thermodynamics*, Pearson.
21. Principles of inorganic chemistry by Puri, Sharma and Kalia, Milestone Publication.
22. Inorganic chemistry by Shriver and Atkins, fifth edition, Oxford Publication.
23. Inorganic chemistry, Principles of Structure and Reactivity by James E. Huhhey, Ellen Keiter, RicherdKeiter, OkhilMedhi, forth edition, Pearson Publication.


## E-Resources / MOOCs

1. NPTEL Courses on Physical Chemistry and Molecular Spectroscopy
2. SWAYAM undergraduate chemistry resources
3. e-PG Pathshala resources in Physical Chemistry
4. Virtual Labs in spectroscopy and kinetics

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

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|---|---|
| **Name of the Program** | B.Sc. Third Year (Chemistry) |
| **Title of the Paper/Course** | Physical and Inorganic Chemistry Practical based on SCHECT1302 [SCHECP1302] |
| **Semester** | V |
| **Paper Type** | DSC (Practical) |
| **Credits** | 02 |
| **Total Hours** | 60 Hours |
| **Formative Assessment Marks** | 20 |
| **Summative Assessment Marks** | 30 |
| **Total Marks** | 50 |

### Course Objectives

1. **To develop experimental proficiency** in physical chemistry techniques, including both instrumental and non-instrumental methods.
2. **To familiarize students with modern analytical instruments** such as conductometers, potentiometers, and pH meters, and their practical applications.
3. **To enhance analytical and problem-solving abilities** through interpretation of experimental data and calculation of physicochemical parameters.
4. **To strengthen understanding of chemical kinetics, thermodynamics, and solution behavior** through laboratory experimentation.
5. **To develop competence in quantitative analysis** of inorganic substances and alloys.
6. **To promote safe laboratory practices, accuracy, teamwork, and systematic scientific record keeping.**

### Course Outcomes (COs)

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

| CO No. | Upon completion of this course, students will be able to: | Bloom's Level | PO Mapped |
|---|---|---|---|
| **CO1** | Perform conductometric, potentiometric, and pH-metric experiments using appropriate instruments with accuracy and precision. | Apply | PO3, PO4 |
| **CO2** | Analyze experimental data to determine physicochemical parameters such as rate constants, dissociation constants, and thermodynamic quantities. | Analyze | PO4, PO5 |
| **CO3** | Apply principles of chemical kinetics, thermodynamics, and solution chemistry to interpret experimental observations. | Apply / Analyze | PO2, PO4 |
| **CO4** | Conduct quantitative analysis of inorganic substances and alloys using volumetric and instrumental methods. | Apply | PO3, PO5 |

| | | | |
|---|---|---|---|
| **CO5** | Record, organize, and present experimental results systematically with proper calculations, graphs, and conclusions. | Analyze / Evaluate | PO4, PO6 |
| **CO6** | Demonstrate safe handling of chemicals and instruments, and follow ethical laboratory practices and teamwork. | Apply / Create | PO6, PO7 |

## List of Experiments

### (A) Instrumental Methods

1. Determine the normality and strength of oxalic acid conductometrically using standard solution of strong base (NaOH/KOH).
2. Determine the equivalent conductance of a strong electrolyte at several concentrations and hence verify the Onsager's equation.
3. Determine the normality and strength of acids in mixture of strong acid ($HCl/HNO_3$) and weak acid ($CH_3COOH/HCOOH$)] potentiomertrically using standard solution of strong base (NaOH/KOH).
4. Determination of empirical formula of a complex between $Fe^{+3}$ and 5-sulphosalicylic acid by Job's method calorimetrically.
5. Determination of dissociation constant of an organic acid ($CH_3COOH$) using various buffers ($CH_3COOH + CH_3COONa$) pH metrically.

### (B) Non-Instrumental Methods

1. Determine the rate constant of the reaction between potassium persulphate and potassium iodide having equal concentrations of reacting species (a=b).
2. Determine enthalpy change of neutralization of a strong acid by a strong base.
3. To determine the kinetics of saponification reaction between sodium hydroxide and ethyl acetate.
4. To determine the percentage composition of a given mixture of two liquids by Stalagmometer.
5. Determine the radius of glycerol molecule from viscosity measurement.

### (C) Inorganic Chemistry

1. Determination of tin or lead from solder alloy.
2. Determination of Iron or chromium from stainless steel.
3. To determine the percentage of copper in Copper sulphate by iodometric method.
4. To estimate the amount of tin in stannous chloride by iodimetric method
5. To determine the percentage of Zinc in $ZnSO_4.7H_2O$ by using the diphenylamine indicator.
6. To estimate the amount of ammonia in a given sample of ammonium salt ($(NH_4)_2SO_4$).
7. To determine the percentage purity of commercial sample of nitrite ($NaNO_2$).
8. Determination of chlorine in water sample /waste water.
9. To determine the equivalent weight and basicity of Citric acid /Oxalic acid.

## Reference Books (Laboratory Work)


1. S. W. Rajbhoj and T. K. Chondekar, *Systematic Experimental Physical Chemistry*, Anjali Publication, Aurangabad.
2. J. B. Yadav,*Advanced Practical Physical Chemistry*, Goel Publication, Meerut.
3. O. P. Pandey, D. N. Bajpai and S. Giri, *Practical Chemistry*, S. Chand Publications.
4. D. V. Jahagirdar, *Experiments in Chemistry*, Himalaya Publishing House.
5. Gurtu and Gurtu,*Advanced Physical Chemistry Experiments*, Pragati Publication.
6. B. D. Khosla, V. C. Garg and A. Galati, *Senior Practical Physical Chemistry*, R. Chand & Company.
7. R. C. Das and B. Behra, *Experiments in Physical Chemistry*, Tata McGraw Hill.
8. C. W. Garland, J. W. Nibler and D. O. Shoemaker, *Experiments in Physical Chemistry*, McGraw Hill (2003).
9. A. Findlay and T. A. Kitchener, *Practical Physical Chemistry*, Longmans.
10. Vishwanathan and Raghwan, *Practical Physical Chemistry*, Viva Books.
11. Inorganic Chemistry practical by Nadkarni Kothari.

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

**Faculty of Science & Technology**

**Subject Specific - IKS**

| | |
|---|---|
| **Name of the Programme** | B.Sc. Third Year (Chemistry) (Theory) |
| **Title of the Course** | Indian Knowledge System in Chemistry (SCHEIKS1301) |
| **Semester** | V |
| **Paper Type** | IKS (Indian Knowledge System) |
| **Credits** | 2 |
| **Total Hours** | 30 Hours |
| **Formative Assessment** | 20 Marks (Internal Assessment) |
| **Summative Assessment** | 30 Marks (Semester End Examination) |
| **Total Marks** | 50 Marks |

## Course Objectives (CO)

1. To introduce students to the rich chemical heritage of India from prehistoric to ancient periods.
2. To develop an understanding of Indian philosophical concepts of matter and atomic theories.
3. To explore the applications of chemistry in ancient Indian medicine, textiles, metallurgy, and daily life.
4. To examine traditional chemical techniques such as distillation, calcination, and fermentation from a modern scientific perspective.

## Course Outcomes (COs)

| CO No. | Course Outcomes | Bloom's Level | PO Mapping |
|---|---|---|---|
| CO1 | Explain early chemical traditions and material advancements from prehistoric to Harappan India. | Understand | PO1, PO3, PO9 |
| CO2 | Analyze Vedic and philosophical concepts of matter, including Vaisheshika and Jain atomic theories. | Analyze | PO2, PO3, PO10 |
| CO3 | Evaluate applications of chemical knowledge in ancient Indian medicine, textiles, and household materials. | Evaluate | PO6, PO8, PO12 |
| CO4 | Apply knowledge of ancient chemical techniques such as metallurgy, distillation, sublimation, and fermentation. | Apply | PO4, PO5, PO7, PO11 |

## Detailed Syllabus (Four Modules – 30 Hours)

| Module No. | Title | Topics | Hours |
|---|---|---|---|
| **I** | **Early Chemical Traditions – Prehistoric to Harappan India** | 1.1 Pre-Harappan developments: early settlements, pottery techniques, coloured ceramics, copper extraction and fabrication.<br>1.2 Harappan advancements: ceramic technology, faience, pigments (ferric oxide, manganese oxide), glazed pottery, construction materials (gypsum, lime, sand).<br>1.3 Metals and minerals: copper, bronze alloys, gold, silver, semi-precious stones, galena, natural dyes (madder). | 07 |

| | | | |
|---|---|---|---|
| | | 1.4 Post-Harappan phase: cultural transition and spread of metallurgical practices. | |
| **II** | **Vedic Knowledge and Philosophical Concepts of Matter** | 2.1 Chemical knowledge in Vedic texts: metals, alloys, fermentation (soma, sura), natural dyes, medicinal plant use.<br>2.2 Atomic theories: Vaisheshika (Kanada) – paramanu, atomic combinations, molecular structures; Jain theory – atomic forces and chemical affinity.<br>2.3 Samkhya and Nyaya perspectives: evolution of matter, tanmatras, sensory properties, concept of akasha. | 07 |
| **III** | **Applications of Chemistry in Ancient India** | 3.1 Medicine (Ayurveda): Rasashastra, herbal and mineral-based preparations.<br>3.2 Textiles: natural dyes (indigo, madder, turmeric), mordants, dyeing techniques.<br>3.3 Tools and weapons: metal crafting and hardening techniques.<br>3.4 Ceramics and household materials: glazed pottery, terracotta, soaps, oils, and cosmetics.<br>3.5 Construction materials: gypsum, lime, and sand-based binders and plasters. | 08 |
| **IV** | **Ancient Chemical Techniques and Processes** | 4.1 Metallurgy: extraction, purification, and alloy formation (brass, bronze, wootz steel).<br>4.2 Distillation: preparation of perfumes, essential oils, and medicines.<br>4.3 Other techniques: sublimation, calcination, and fermentation processes in beverages and medicinal formulations. | 08 |

**Total: 30 Hours**

## Recommended Textbooks

1. Pakrashi, B. C., & Ghosh, S. (Eds.). *History of Science in India, Vol. III: Chemical Sciences*. The National Academy of Sciences, India (NASI) & Ramakrishna Mission Institute of Culture, Kolkata.
2. S. Mahdihassan, *Indian Alchemy: Its Origin and Ramifications*, Motilal Banarsidass, 1991.
3. B. V. Subbarayappa, *Chemistry in Ancient and Medieval India*, INSA, 1999.
4. P. C. Ray, *History of Chemistry in Ancient and Medieval India*, Indian Chemical Society, 1956.
5. O. P. Jaggi, *History of Science and Technology in India (Vol. 1–12)*, Atma Ram & Sons, 1970.
6. Debiprasad Chattopadhyaya, *History of Science and Technology in Ancient India*, Firma KLM, 1986.

## E-Resources / MOOCs

1. NPTEL: Indian Knowledge System – IIT Kharagpur (https://nptel.ac.in)
2. SWAYAM: History of Science and Technology in India – UGC

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

| | |
|---|---|
| **Name of the Programme** | B.Sc. (Chemistry), Third Year (Theory) |
| **Title of the Course** | Organic Chemistry for Industry (SCHEET-1301) |
| **Semester** | V |
| **Paper Type** | Elective Core |
| **Credits** | 02 |
| **Total Hours** | 30 Hours |
| **Formative Assessment** | 20 |
| **Summative Assessment** | 30 |
| **Total Marks** | 50 |

### Course Objectives

1. To develop understanding of qualitative analysis of organic compounds including detection of elements and functional groups.
2. To impart knowledge of quantitative estimation methods for elements present in organic compounds.
3. To familiarize students with principles and applications of separation techniques such as TLC and column chromatography.
4. To understand the formation of carbon–carbon and carbon–heteroatom bonds through important organic reactions.
5. To introduce stereochemical aspects of organic reactions including stereospecific and stereoselective reactions.
6. To provide knowledge of structure, classification, and reactions of carbohydrates.
7. To understand the chemistry of enolates and enamines and their role in organic synthesis.
8. To develop problem-solving skills related to reaction mechanisms and structure determination.

### Course Outcomes (COs)

| CO No. | Course Outcome | Bloom's Level | PO Mapping |
|---|---|---|---|
| CO1 | Identify organic compounds using preliminary and functional group analysis. | Understand | PO1, PO2 |
| CO2 | Perform qualitative and quantitative analysis of organic compounds. | Apply | PO2, PO4 |
| CO3 | Explain mechanisms of carbon–carbon and carbon–heteroatom bond formation. | Analyze | PO3, PO10 |
| CO4 | Apply chromatographic and stereochemical concepts in | Apply | PO4, PO5 |

| | | | |
|---|---|---|---|
| | organic chemistry. | | |
| CO5 | Describe structure and reactions of carbohydrates. | Understand | PO1, PO3 |
| CO6 | Analyze stereochemical aspects of organic reactions. | Analyze | PO3, PO10 |
| CO7 | Apply enolate and enamine chemistry in organic synthesis. | Apply | PO2, PO10 |
| CO8 | Solve problems related to reaction mechanisms and structure determination. | Analyze | PO2, PO3 |

## Detailed Syllabus

| Module No. | Title | Topics | Hours |
|---|---|---|---|
| **I** | **Organic Qualitative & Quantitative Analysis** | **1.1 Preliminary Examination and Qualitative Analysis** Physical state, colour, odour. Detection of elements by Lassaigne's test (Nitrogen, Sulphur, Halogens). Functional group identification: Unsaturation (Baeyer's test), Phenols (Ferric chloride test), Carboxylic acids (Sodium bicarbonate test), Carbonyl compounds (Aldehydes and ketones: 2,4-DNP, Tollens', Fehling's tests), Amines (Carbylamine and Hinsberg tests), Alcohols (Lucas test, oxidation test). **1.2 Organic Quantitative Analysis** Estimation of elements: Carbon and Hydrogen (Liebig's method), Nitrogen (Dumas and Kjeldahl's methods), Halogens (Carius method), Sulphur (Carius method), Phosphorus (as ammonium phosphomolybdate). Determination of empirical and molecular formula based on percentage composition, calculation of percentage yield of synthesized organic compounds. **1.3 Principles and Techniques** Principles of Lassaigne's test, Carius method, and functional group identification based on characteristic chemical reactions. **1.4 Separation Techniques** Principles of separation techniques; Thin Layer Chromatography (Rf value, applications); Column Chromatography (adsorption, stationary phases, industrial applications). | 08 |
| **II** | **Carbon–Carbon & Carbon–Heteroatom Bond Formation** | **2.1 Named Reactions:** Wurtz reaction, Wurtz–Fittig reaction, Simmons–Smith reaction. **2.2 Reaction Mechanisms and Reagents:** Free radical substitution reactions; Elimination reactions (Saytzeff and Hofmann rules); Reagents of phosphorus, sulphur, and boranes. **2.3 Stereochemical Aspects:** Stereospecific and stereoselective reactions. **2.4 Reactions of Alkenes:** Epoxidation of alkenes using mCPBA. | 08 |

| | | | |
|---|---|---|---|
| **III** | **Carbohydrate Chemistry** | **3.1** Classification of monosaccharides; Absolute configuration of glucose and fructose; Epimers and anomers; Mutarotation;<br>**3.2** Determination of ring size of glucose and fructose; Conformations of glucose (Fischer, Haworth, and stereoscopic projections); Interconversion of aldoses and ketoses; Killiani–Fischer synthesis and Ruff degradation;<br>**3.3** Structure elucidation of disaccharides (maltose, lactose, sucrose); Structure of polysaccharides (starch, cellulose, glycogen). | 07 |
| **IV** | **Chemistry of Enolates & Enamines** | **4.1. Formation and Structure:** Generation of enolates from carbonyl compounds; kinetic and thermodynamic enolates; formation of enamines from aldehydes and ketones using secondary amines; introduction to azaenolates (imine/enamine analogues).<br>**4.2. Alkylation Reactions:** Alkylation of enolates with alkyl halides (SN2 mechanism); regioselectivity in enolate alkylation; alkylation of enamines; alkylation of azaenolates.<br>**4.3. Acylation Reactions:** Acylation of enolates using acid chlorides and esters; carbon–carbon bond formation through acylation; acylation using enamines; acylation of azaenolates.<br>**4.4. Synthetic Applications and Named Reactions:** Role of enolates and enamines in organic synthesis; functional group interconversions; application in multistep synthesis.<br>**Named Reactions:** Stork Enamine Reaction, Dieckmann Condensation, Robinson Annulation | 07 |

**Total Hours: 30**

## Recommended Textbooks

**References**


1. Organic Chemistry, Jonathan Clayden, Nick Greeves, Stuart Warren, 2nd Edition.
2. Principles of Organic Synthesis, R. O. C. Norman, J. M. Coxon, 3rd Edition.
3. Advanced Organic Chemistry, R. Bruckner.
4. Organic Chemistry, G. M. Loudon, 4th Edition.
5. Organic Chemistry, R. T. Morrison, R. N. Boyd, S. K. Bhattacharjee, 7th Edition.
6. Organic Chemistry Volume 2, I. L. Finar, 5th Edition.
7. Vogel's Textbook of Practical Organic Chemistry, B. S. Furniss, A. J. Hannaford, P. W. G. Smith, Pearson, 2012.
8. Comprehensive Practical Organic Chemistry, V. K. Ahluwalia, S. Dhingra, University Press.
9. Practical Organic Chemistry, F. G. Mann, B. C. Saunders, 3rd Edition, Longman, 197

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

| | |
|---|---|
| **Name of the Programme** | B.Sc. (Chemistry), Third Year (Practical) |
| **Title of the Course** | Practical Course in Organic Chemistry for Industry (SCHEEP-1301) |
| **Semester** | V |
| **Paper Type** | Elective Core Practical |
| **Credits** | 02 |
| **Total Hours** | 60 Hours |
| **Formative Assessment** | 20 |
| **Summative Assessment** | 30 |
| **Total Marks** | 50 |

### Course Objectives

1. **To develop practical skills in systematic qualitative analysis** of organic compounds, including detection of elements and functional groups.
2. **To impart hands-on training in chromatographic techniques** such as Thin Layer Chromatography (TLC) and Column Chromatography for separation and identification of organic compounds.
3. **To enable students to perform organic synthesis reactions** and understand reaction mechanisms involved in the preparation of compounds like acetanilide, chalcone, and dibenzalacetone.
4. **To familiarize students with purification techniques** such as distillation and extraction used in organic chemistry laboratories and industries.
5. **To develop analytical skills for quantitative estimation**, including glucose estimation and interpretation of experimental results.
6. **To provide knowledge of classical organic reactions and transformations**, such as dehydration, condensation, and epoxidation reactions.
7. **To enhance experimental accuracy, observation, and reporting skills** through systematic laboratory work.
8. **To prepare students for industrial applications and competitive examinations** by strengthening laboratory competence and problem-solving ability in organic chemistry.

### Course Outcomes

| CO No. | Course Outcome | Bloom's Level | PO Mapping |
|---|---|---|---|
| CO1 | Perform systematic qualitative analysis of organic compounds. | Apply | PO3, PO4 |
| CO2 | Apply chromatographic techniques for separation and identification. | Apply | PO4, PO5 |
| CO3 | Carry out organic synthesis reactions and purification techniques. | Apply | PO3, PO4 |

| | | | |
|---|---|---|---|
| CO4 | Analyze experimental results and interpret chemical behavior. | Analyze | PO3, PO4 |

## List of Experiments

1. To systematically analyze the given organic compound and identify its nature, class, and functional group(s) by performing preliminary tests, detection of elements (Lassaigne's test), and confirmatory tests, thereby determining its probable structure.
2. To separate and identify the components of a mixture using thin layer chromatography and to determine their Rf values for qualitative analysis and purity assessment.
3. To separate a given binary mixture of organic compounds into its individual components using suitable separation techniques such as solvent extraction or chemical methods, followed by purification and identification of each component.
4. To prepare cyclohexene by dehydration of cyclohexanol using an acid catalyst and to purify the product by distillation, followed by determination of its yield.
5. To synthesize acetanilide by acetylation of aniline using acetic anhydride or acetyl chloride, and to purify the product by recrystallization and determine its melting point.
6. To estimate the amount of glucose present in the given sample by a suitable titrimetric method (e.g., Fehling's or Benedict's method) based on its reducing property.
7. To prepare osazone derivative of a carbohydrate (such as glucose or fructose) and to identify the sugar based on the characteristic crystalline structure and melting point of the osazone formed.
8. To synthesize dibenzalacetone by Claisen–Schmidt condensation between benzaldehyde and acetone in the presence of a base, and to purify and characterize the product.
9. To prepare chalcone by condensation of benzaldehyde with acetophenone under basic conditions and to purify the product by recrystallization.
10. To separate and purify a liquid mixture based on differences in boiling points using simple or fractional distillation techniques.
11. To separate and purify the components of a mixture using column chromatography based on differences in adsorption and polarity.
12. To identify the functional group(s) present in the given organic compound by performing specific chemical tests and confirming the results through characteristic reactions.
13. To synthesize an epoxide from an alkene using an oxidizing agent and to study the reaction mechanism and yield of the product.

## Recommended Books

1. Vogel's Textbook of Practical Organic Chemistry — Author: Arthur I. Vogel; Publisher: Pearson Education
2. Practical Organic Chemistry — Authors: F.G. Mann & B.C. Saunders; Publisher: Orient Longman
3. Advanced Practical Organic Chemistry — Author: N.K. Vishnoi; Publisher: Vikas Publishing House.
4. Chromatography: Concepts and Contrasts — Author: James M. Miller; Publisher: Wiley-Interscience
5. Experimental Organic Chemistry — Authors: Louis F. Fieser & Kenneth L. Williamson; Publisher: D.C. Heath & Co.
6. Practical Organic Chemistry — Author: Arthur I. Vogel; Publisher: Pearson Education

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

| | |
|---|---|
| **Name of the Program** | B.Sc. (Chemistry), Third Year (Theory) |
| **Title of the Paper/Course** | Application-Based Analytical Chemistry **[**SCHEET1302] |
| **Semester** | V |
| **Paper Type** | Elective |
| **Credits** | 2 |
| **Total Hours** | 30 |
| **Formative Assessment Marks** | 20 |
| **Summative Assessment Marks** | 30 |
| **Total Marks** | 50 |

### Course Objectives

1. To provide fundamental knowledge of analytical techniques used in real-life applications.
2. To develop skills in chemical analysis of environmental, pharmaceutical, food, and industrial samples.
3. To understand the principles and applications of modern instrumental methods in analytical chemistry.
4. To enhance problem-solving ability and research-oriented thinking among students.

### Course Outcomes (COs)

After completing this course, students will be able to:

| CO No. | Course Outcome | Bloom's Level | PO Mapped |
|---|---|---|---|
| **CO1** | Explain the principles and types of analytical techniques used in environmental and industrial analysis. | Understand | PO1, PO2 |
| **CO2** | Apply qualitative and quantitative analytical methods for real sample analysis. | Apply / Analyze | PO3, PO4 |
| **CO3** | Describe the working principles and applications of modern analytical instruments. | Understand / Analyze | PO2, PO4 |
| **CO4** | Interpret analytical data and prepare systematic laboratory reports. | Analyze / Evaluate | PO5, PO6 |

## Detailed Syllabus

| Module No. | Title | Topics | Hours |
|---|---|---|---|
| **I** | **Fundamentals of Analytical Chemistry (Application Perspective)** | **1.1** Types of analysis: qualitative and quantitative<br>**1.2** Sampling techniques and sample preparation<br>**1.3** Errors in analysis (types, accuracy, precision)<br>**1.4** Calibration and standardization<br>**1.5** Quality assurance and quality control (QA/QC) | **07** |
| **II** | **Environmental Analysis** | **2.1** Analysis of water: pH, hardness, alkalinity, DO, COD, BOD<br>**2.2** Soil analysis: pH, nutrients (NPK), organic matter<br>**2.3** Air pollution analysis: particulate matter and gaseous pollutants<br>**2.4** Wastewater treatment and analysis | **08** |
| **III** | **Food and Pharmaceutical Analysis** | **3.1** Food adulteration and its detection<br>**3.2** Analysis of milk, oils, sugar, and spices<br>**3.3** Basic concepts of drug analysis<br>**3.4** Chromatographic techniques in pharmaceuticals (TLC, HPLC basics)<br>**3.5** Quality control in food and drug industries | **07** |
| **IV** | **Instrumental Methods in Analytical Chemistry** | **4.1** UV-Visible spectroscopy: principle and applications<br>**4.2** Flame photometry<br>**4.3** Atomic absorption spectroscopy (AAS): basic concept<br>**4.4** Chromatography: TLC, GC, HPLC (principles and applications)<br>**4.5** Electroanalytical methods: pH-metry and potentiometry | **08** |

**Total Hours: 30**

## Recommended Textbooks

1. Vogel, *Textbook of Quantitative Chemical Analysis*, Pearson.
2. Skoog, Holler & Crouch, *Principles of Instrumental Analysis*, Cengage Learning.
3. Willard, Merritt & Dean, *Instrumental Methods of Analysis*.
4. R. D. Braun, *Introduction to Instrumental Analysis*.
5. A. K. De, *Environmental Chemistry*, New Age International.

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

| | |
|---|---|
| **Name of the Program** | B.Sc. (Chemistry), Third year (Practical) |
| **Title of the Paper/Course** | Application-Based Analytical Chemistry [SCHEEP1302] |
| **Semester** | V |
| **Paper Type** | Elective |
| **Credits** | 2 |
| **Total Hours** | 60 |
| **Formative Assessment Marks** | 20 |
| **Summative Assessment Marks** | 30 |
| **Total Marks** | 50 |

### Course Outcomes (COs)

After completing this course, students will be able to:

| CO No. | Course Outcome | Bloom's Level | PO Mapped |
|---|---|---|---|
| **CO1** | Perform basic environmental analysis such as hardness, DO, BOD, and ion estimation in water samples. | Apply | PO3, PO4 |
| **CO2** | Analyze food samples for adulterants, vitamin content, and sugar estimation using standard methods. | Apply / Analyze | PO3, PO4 |
| **CO3** | Operate and calibrate analytical instruments such as pH meter and perform colorimetric analysis. | Apply | PO4, PO5 |
| **CO4** | Apply chromatographic and conductometric techniques for qualitative and quantitative analysis. | Analyze / Apply | PO4, PO6 |

### List of Experiments (Any 10)

1. To determine the total hardness of the given water sample.
2. To determine the dissolved oxygen (DO) and biological oxygen demand (BOD) of the given water sample.
3. To estimate the chloride and sulphate content in the given water sample.
4. To determine the pH and nutrient status of the given soil sample.
5. To detect common adulterants in milk, ghee, and edible oil samples.
6. To estimate the vitamin C content in the given fruit juice sample.
7. To determine the sugar content in the given sample.
8. To calibrate the pH meter using standard buffer solutions.
9. To estimate the concentration of iron/phosphate in the given sample by colorimetric method.

10. To separate organic compounds by thin layer chromatography (TLC).
11. To determine the concentration of the given solution by conductometric titration.

**Total Hours: 60**

## Recommended Textbooks

1. Vogel, *Textbook of Quantitative Chemical Analysis*
2. Skoog, Holler & Crouch, *Principles of Instrumental Analysis*
3. Willard, Merritt & Dean, *Instrumental Methods of Analysis*
4. R. D. Braun, *Introduction to Instrumental Analysis*
5. A. K. De, *Environmental Chemistry*

## E-Resources / MOOCs

1. **SWAYAM / NPTEL** – Analytical Chemistry Courses
2. **e-PG Pathshala** – Environmental and Instrumental Analysis Modules

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science and Technology

| | |
|---|---|
| **Name of the Program** | B.Sc. (Chemistry) |
| **Title of the Paper/Course** | Green Chemistry [SCHEVSC-1201] |
| **Semester** | V |
| **Paper Type** | Practical based VSC |
| **Credits** | 02 |
| **Total Hours** | 60 |
| **Formative Assessment Marks** | 20 |
| **Summative Assessment Marks** | 30 |
| **Total Marks** | 50 |

### Course Objectives

1. **Knowledge-based:**
   To develop a comprehensive understanding of the fundamental principles and concepts of **Green Chemistry** and sustainable chemical processes.
2. **Skill-based:**
   To enhance practical and laboratory skills through the application of **green chemistry techniques** and environmentally benign methodologies.
3. **Application-based:**
   To apply the principles of Green Chemistry in the **design and development of safer, sustainable, and eco-friendly chemical processes**.
4. **Research-oriented:**
   To foster analytical thinking, problem-solving ability, and innovation in the field of **sustainable chemical synthesis and environmental protection**.

### Course Outcomes (COs)

| CO No. | Course Outcome Statement | Bloom's Level | PO Mapped |
|---|---|---|---|
| CO1 | Describe the fundamental principles and concepts of Green Chemistry. | Remember / Understand | PO1 |
| CO2 | Explain various green synthetic methods and environmentally benign chemical processes. | Understand | PO2 |
| CO3 | Apply green chemistry principles in laboratory and industrial practices. | Apply | PO3 |
| CO4 | Analyze chemical processes in terms of sustainability, safety, and environmental impact. | Analyze | PO4 |
| CO5 | Design environmentally safer chemical processes using green synthesis approaches. | Create | PO5 |
| CO6 | Perform green chemistry experiments and interpret experimental results effectively. | Apply | PO6 |

## Detailed Syllabus (Theory)

| Module No. | Topic |
|---|---|
| **1.0** | **1.0 Green Chemistry**<br>1.1 Introduction: Definition of green chemistry, need of green chemistry, Twelve principles of Green Chemistry with their explanations and examples<br>1.2 Green synthesis – Maximum utilization of reactants and reagents (atom economy)<br>1.3 Selection of solvent: Aqueous phase reactions, reactions in ionic liquids, solid supported synthesis, solvent-free reactions (solid phase reactions)<br>1.4 Green catalysts: Phase transfer catalysts (PTC) and biocatalysts<br>1.5 Green synthesis of the following compounds: Styrene, Adipic acid, Catechol, BHT, Methyl methacrylate, Urethane, 4-aminodiphenylamine, Benzyl bromide, Acetaldehyde, Furfural, Ibuprofen, Paracetamol, Citral |

## List of Experiments:

| Sr. No. | Detailed Aim of the Experiment |
|---|---|
| 1 | To synthesize benzoin from benzaldehyde using **thiamine hydrochloride as a non-toxic catalyst**, demonstrating safer alternatives to hazardous cyanide catalysts and principles of green catalysis. |
| 2 | To prepare chalcone via **Claisen–Schmidt condensation under solvent-free or eco-friendly conditions**, illustrating reduction in solvent usage and waste minimization. |
| 3 | To synthesize aspirin using **microwave irradiation** for faster and energy-efficient reaction, demonstrating green chemistry principles of energy conservation and improved yield. |
| 4 | To prepare TBATB as a **safer brominating agent**, replacing hazardous liquid bromine and reducing risks associated with toxic reagents. |
| 5 | To synthesize dibenzalacetone using **mild reaction conditions and minimal solvent**, emphasizing waste reduction and environmentally benign synthesis. |
| 6 | To produce biodiesel from vegetable oil through **transesterification**, demonstrating the use of renewable resources and sustainable fuel production. |
| 7 | To synthesize an ester under **solvent-free conditions**, highlighting reduction in solvent usage and greener reaction pathways. |
| 8 | To oxidize alcohol to aldehyde/ketone using **environmentally benign oxidizing agents** (e.g., $H_2O_2$), avoiding toxic chromium-based reagents. |
| 9 | To prepare soap using **natural oils and alkali**, demonstrating biodegradable product formation and green industrial chemistry concepts. |
| 10 | To synthesize paracetamol using **safer reagents and improved reaction conditions**, illustrating industrial relevance of green chemistry in pharmaceuticals. |

**Total Hours: 60**

## Recommended Text Books / Reference Books:

1. A.I. Vogel – *Practical Organic Chemistry*
2. R.K. Bansal – *Laboratory Manual of Organic Chemistry*
3. N.K. Vishnoi – *Advanced Practical Organic Chemistry*
4. Lancaster – *Green Chemistry: An Introductory Text*
5. Cann & Connelly – *Real World Cases in Green Chemistry*

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

| | |
|---|---|
| Name of the Program | B.Sc. (Chemistry), Third Year |
| Title of the Paper / Course | Field Project in Chemistry SCHEFP-1301 |
| Semester | V |
| Paper Type | Field Project |
| Credits | 4 |
| Total Hours | 120 |
| Formative Assessment Marks | 40 |
| Summative Assessment Marks | 60 |
| Total Marks | 100 |

### Course Description:

The **Field Project (FP)** provides practical exposure to **chemical industries, laboratories, water treatment plants, pharmaceutical units, and environmental monitoring sites**. Students study **industrial chemical processes, analytical techniques, environmental aspects, and safety practices** under real working conditions, thereby bridging the gap between theoretical knowledge and industrial applications.

### Course Outcomes (COs):

After completing this course, students will be able to:

| CO No. | Upon completion of this course, students will be able to: | Bloom's Level | PO Mapped |
|---|---|---|---|
| CO1 | Describe industrial chemical processes and operations in real environments. | Remember /Understand | PO1, PO2 |
| CO2 | Apply sampling and analytical techniques for chemical analysis of water, soil, and industrial samples. | Apply/Analyze | PO3, PO4 |
| CO3 | Analyze data related to chemical composition, process parameters, and environmental impact. | Evaluate | PO5 |
| CO4 | Prepare and present scientific reports based on field observations and analytical findings. | Apply/Create | PO6, PO7 |

### Detailed Syllabus:

| Module No. | Title | Topics | Hours |
|---|---|---|---|
| I | Field Visit & Industrial Exposure | **1.1** Study of chemical industries, laboratories, water treatment plants, and environmental sites<br>**1.2** Understanding raw materials, processes, safety measures, and industrial operations | 15 |
| II | Data Collection & | **2.1** Recording observations on raw materials | 15 |

| | | | |
|---|---|---|---|
| | Process Study | **2.2** Chemical reactions and process conditions<br>**2.3** Instrumentation and environmental parameters | |
| III | Sampling & Chemical Analysis | **3.1** Collection of samples such as water, soil, effluents, and industrial products<br>**3.2** Analysis using standard analytical methods | 15 |
| IV | Project Work & Report Writing | **4.1** Data interpretation and process evaluation<br>**4.2** Problem identification<br>**4.3** Preparation of a detailed scientific report including methodology, results, and conclusions | 15 |

**Total Hours: 60**

## Recommended Textbooks:

1. Austin, G. T., *Shreve's Chemical Process Industries*, McGraw Hill.
2. Rao, G. N., *Outlines of Chemical Technology*, East-West Press.

## E-Resources / MOOCs:

1. NPTEL – Industrial Chemistry & Chemical Technology
2. SWAYAM – Environmental Chemistry & Analytical Techniques

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

| | |
|---|---|
| **Name of the Program** | B.Sc. (Chemistry), Third Year (THEORY) |
| **Title of the Paper/Course** | Organic Chemistry SCHECT-1351 |
| **Semester** | VI |
| **Paper Type** | Core Major |
| **Credits** | 03 |
| **Total Hours** | 45 |
| **Formative Assessment Marks** | 30 |
| **Summative Assessment Marks** | 45 |
| **Total Marks** | 75 |

### Course Objectives

**1.** To develop conceptual understanding of UV, IR and $^1H$ NMR spectroscopy and their role in structural elucidation of organic molecules.

**2.** To familiarize students with spectral terminology, electronic transitions, vibrational modes, chemical shift, spin–spin splitting, and interpretation of spectral data.

**3.** To introduce important organic reagents such as DDQ, DCC, $NaBH_4$, $LiAlH_4$ and Birch reduction, along with their synthetic applications.

**4.** To develop understanding of selected named reactions and their mechanistic significance in organic synthesis.

### Course Outcomes (COs)

After completing this course, students will be able to:

| CO No. | Upon completion of this course, students will be able to: | Bloom's Level | PO Mapped |
|---|---|---|---|
| CO1 | Explain the principles, terminology and spectral features of UV, IR and $^1H$ NMR spectroscopy used in organic chemistry. | Remember/ Understand | PO1, PO2 |
| CO2 | Interpret spectral data and apply UV, IR and $^1H$ NMR techniques for identification of simple organic molecules. | Apply/ Analyze | PO3, PO4 |
| CO3 | Describe the functions and synthetic applications of important organic reagents such as DDQ, DCC, $NaBH_4$, $LiAlH_4$ and Birch reduction. | Understand/ Apply | PO2, PO5 |
| CO4 | Explain and apply the mechanisms of selected named reactions including Darzens, Wittig, McMurry, Simmons–Smith and Michael reactions. | Apply /Create | PO3, PO6, PO7 |

### Detailed Syllabus

| Module No. | Title | Topics | Hours |
|---|---|---|---|
| I | **UV Spectroscopy** | **1.1** Electromagnetic radiations, Electromagnetic spectrum, Characteristics of EMR: a) Wave length b) Wave number, c) Frequency, d) Energy of EMR.<br>Intoduction of Spectroscopy: Meaning of Spectroscopy, types of Spectroscopy and advantages of Spectroscopic methods.<br>**1.2** Ultraviolet Spectroscopy: Introduction, Types of Electronic Transitions.<br>Terms used in UV Spectroscopy: Chromophore, Auxochrome, Bathochromic Shift, Hypsochromic Shift, Hypochromic and Hyperchromic effects. Effect of conjugation on position of UV and Visible bands.<br>**1.3** Calculation of λmax by Woodward-Fieser rules for conjugated dienes and enones.<br>**1.4** Spectral problems based on UV spectroscopy. | 10 |
| II | **IR Spectroscopy** | **2.1** Introduction of IR Spectroscopy, Principle of IR Spectroscopy<br>Types of Vibrations: a) Stretching Vibrations b) Bending Vibrations<br>**2.2** Functional group region and Finger print region.<br>**2.3** Characteristic absorption of various functional groups.<br>**2.4** Interpretation of IR spectra of following organic compounds:<br>a) Ethane, b) Ethene, c) Ethyne, d) Benzene, e) 1-Propanol, f) 2-Propanol, g) t-Butyl alcohol, h) Phenol, i) Acetone, j) Acetophenone, k) Acetaldehyde, l) Benzaldehyde, m) Benzoic acid, n) Methyl benzoate o) Phenyl cyanide. | 10 |
| III | **Nuclear Magnetic Resonance (NMR) Spectroscopy** | 3.1 Proton Magnetic Resonance (PMR) Spectroscopy<br>3.1.1 Introduction<br>• Introduction to NMR Spectroscopy<br>• Magnetic and non-magnetic nuclei<br>3.1.2 PMR Spectroscopy<br>• Introduction to PMR Spectroscopy<br>• Equivalent and non-equivalent protons<br>3.1.3 Number of Absorption Signals (PMR Signals) in the Following Compounds<br>a) Acetone b) Cyclobutane c) Methanol d) Ethylbenzene e) Ethylamine f) Mesitylene g) Diethyl ether<br>3.2 Chemical Shift and Spin–Spin Splitting<br>3.2.1 Shielding and Deshielding Effects<br>• Shielding effect<br>• Deshielding effect<br>• Examples:<br>o Acetylene, Benzene<br>3.2.2 Chemical Shift | 15 |

| Module No. | Title | Topics | Hours |
|---|---|---|---|
| | | • Chemical shift<br>• Measurement of chemical shift by:<br>  ○ Delta (δ) scale<br>  ○ Tau (τ) scale<br>• TMS as reference compound<br>• Advantages of TMS<br>3.2.3 Spin–Spin Splitting<br>• Spin–spin splitting<br>• n + 1 rule<br>• Peak area (integration)<br>3.3 Interpretation of PMR Spectra<br>3.3.1 Interpretation of PMR Spectra of the Following Compounds<br>a) Ethyl bromide b) Ethyl alcohol c) Acetaldehyde<br>d) 1,1,2-Tribromoethane e) Ethyl acetate f) Toluene<br>g) Acetophenone h) Ethylamine i) Acetic acid j) Benzoic acid<br>3.4 Applications of IR, UV and NMR Spectroscopy<br>3.4.1 Identification of Simple Organic Molecules Using IR, UV and NMR Spectroscopy<br>a) n-Propyl alcohol b) iso-Propyl alcohol c) tert-Butyl alcohol<br>d) Acetic acid e) Ethylamine f) Ethyl cyanide g) Ethyl methyl ketone h) Ethyl acetate i) Ethylbenzene j) Phenyl acetaldehyde<br>k) Phenol l) Ethyl methyl ether m) Ethylene glycol<br>n) Propionamide o) Propionaldehyde | |
| IV | **Organic Reagents and Named Reactions** | **4.1** Reagents:DDQ, DCC, $NaBH_4$, $LiAlH_4$, Birch Reduction,<br>**4.2** Named Reactions: Darzen reaction, Wittig reaction and Mc Murry reactions, Simmons- Smith reaction, Michael reaction | 10 |

**Total Hours: 45**

## Recommended Textbooks

1. P. S. Kalsi, Spectroscopy of Organic Compounds.
2. Y. R. Sharma, Elementary Organic Spectroscopy.
3. Colin N. Banwell and Elaine M. McCash, Fundamentals of Molecular Spectroscopy.
4. V. M. Parikh, Absorption Spectroscopy of Organic Molecules.
5. Clayden, Greeves and Warren, Organic Chemistry.
6. Jie Jack Li, Name Reactions: A Collection of Detailed Mechanisms and Synthetic Applications.
7. Bradford P. Mundy, Michael G. Ellerd and Frank G. Favaloro Jr., Name Reactions and Reagents in Organic Synthesis.

## E-Resources / MOOCs

1. NPTEL courses on Organic Spectroscopy and Organic Reaction Mechanisms.
2. SWAYAM undergraduate chemistry courses.

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

| | |
|---|---|
| Name of the Program | B.Sc. (Chemistry), Third Year |
| Title of the Paper/Course | Physical Chemistry (Theory) SCHECT-1352 |
| Semester | VI |
| Paper Type | Core Major |
| Credits | 03 |
| Total Hours | 45 |
| Formative Assessment Marks | 30 |
| Summative Assessment Marks | 45 |
| Total Marks | 75 |

### Course Objectives

1. To develop a fundamental understanding of electrochemical principles, electrode potentials, and their applications.
2. To explain thermodynamic concepts including free energy, chemical potential, and laws of thermodynamics.
3. To analyze equilibrium systems using thermodynamic relationships such as Van't Hoff equation and Clausius–Clapeyron equation.
4. To introduce magnetic properties of substances and their measurement techniques.
5. To enhance problem-solving ability through numerical applications in electrochemistry and thermodynamics.

### Course Outcomes (COs)

After completing this course, students will be able to:

| CO No. | Course Outcome | Bloom's Level | PO Mapped |
|---|---|---|---|
| CO1 | Explain concepts of electrode potential, EMF, and electrochemical cells. | Remember/ Understand | PO1, PO2 |
| CO2 | Apply Nernst equation and electrochemical principles to solve numerical problems and pH determination. | Apply/Analyze | PO3, PO4 |
| CO3 | Analyze thermodynamic functions, chemical potential, and equilibrium relationships. | Analyze | PO2, PO4 |
| CO4 | Evaluate thermodynamic equations such as Van't Hoff and Clausius–Clapeyron in real systems. | Evaluate | PO5 |
| CO5 | Explain magnetic properties and measurement techniques of substances. | Understand | PO1, PO2 |
| CO6 | Apply theoretical concepts to interpret experimental and real-life chemical systems. | Apply/Create | PO6, PO7 |

## Detailed Syllabus

| Module No. | Title | Topics | Hours |
|---|---|---|---|
| **I** | **Electrochemistry** | 1. Introduction, Concept of electrode potential, Nernst theory of electrode potential, single electrode potential, standard electrode potential, standard oxidation and reduction potential.<br>2. Electrolytic and electrochemical cells, reversible and irreversible cells, conventional representation of electrochemical cells.<br>3. EMF of cell, Reference electrodes , standard Hydrogen electrode (SHE) and calomel electrodes,<br>4. Derivation of Nernst equation, application of Nernst equation to oxidation half-cell and reduction half-cell.<br>5. Application of EMF measurement in determination of pH by using a) Quinhydrone electrode b) Glass electrode.<br>6. Numerical on Nernst Equation. | **15** |
| **II** | **Thermodynamics – I** | 1. Introduction.<br>2. Work function(A) and free energy function(G), Change of work function and Gibb's free energy function at constant temperature, relation between G and A, variation of work function with temperature and volume, variation of free energy function with temperature and pressure, Gibb's-Helmholtz equation.<br>3. Nernst heat theorem. Third law of thermodynamics.<br>**4.** Thermodynamics of open system: partial molar properties, concept of chemical potential, partial molar free energy. Gibb's Duhem equation. Variation of chemical potential with temperature and pressure. . | **12** |
| **III** | **Thermodynamics – II** | 1. Thermodynamic derivation of law of mass action.<br>2. Vant-Hoff's Isotherm, Relation between $K_p$, $K_c$ and $K_x$<br>3. Vant-Hoff's reaction isochore. Integrated form of Vant-Hoff's equation.<br>4. Clausius-Clapeyron equation and its applications. | **10** |

| | | | |
|---|---|---|---|
| | | 5. Numerical on Integrated form of Vant-Hoff's equation. | |
| **IV** | **Magnetochemistry** | 1. Introduction, Magnetic susceptibility, Specific susceptibility, unit of measurement.<br>2. Types of substances: Paramagnetic, diamagnetic and ferromagnetic.<br>3. Effect of temperature on Paramagnetic, diamagnetic, ferromagnetic substances.<br>4. Measurement of magnetic susceptibility: Gouy's method. | **08** |

**Total Hours: 45**

## Recommended Textbooks


1. Physical Chemistry by G. M. Barrow (Tata Mc-Graw Hill publishing Co., Ltd.)
2. Elements of Physical Chemistry by S. Gladstone & D. Lewis (D.vannostrand co. inc.)
3. Physical Chemistry by W. J. Moore (Orient Longman).
4. Principles of Physical Chemistry by S. H. Maron and C. F. Prutton.
5. University General Chemistry by C. N. R. Rao (McMillan).
6. Elements of Physical Chemistry by P. W. Atkins. (Oxford University Press).
7. Physical Chemistry by R. A. Alberty (Wiley Eastern Ltd.).
8. Physical Chemistry through problems by S. K. Dogra, D. Dogra(Wiley Eastern Ltd)
9. Principles of Physical Chemistry by Puri, Sharma and Pathania (Vishal Publication Jalandhar, Delhi)
10. Physical Chemistry by A. J. Mee. ELBS & Heinemann Educational Books Ltd.
11. Essentials of Physical Chemistry by ArunBhal, B. S. Bahl and G. D. Tuli. (S. Chand )
12. Kinetics by K. J. Laidler (Tata Mc-Graw Hill Publishing Co. Ltd).
13. Text Book of Physical Chemistry by Soni-Dharmarha.
14. A Text Book Physical Chemistry by S. Glasstone, (Mac Millan.)
15. Advanced Physical Chemistry by D. N. Bajpai. (S. Chand)
16. Advanced Physical Chemistry by Gurdeep Raj. (Goel publishing house, Meerut).

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

| | |
|---|---|
| **Name of the Program** | B.Sc. (Chemistry) |
| **Title of the Paper/Course** | Inorganic Chemistry [SCHECT-1353] |
| **Semester** | VI |
| **Paper Type** | DSC (Major Core) |
| **Credits** | 02 |
| **Total Hours** | 30 |
| **Formative Assessment Marks** | 20 |
| **Summative Assessment Marks** | 30 |
| **Total Marks** | 50 |

### Course Objectives

1. To develop conceptual understanding of bonding theories in coordination compounds using VBT and CFT. *(Knowledge)*
2. To enhance analytical skills in interpreting electronic spectra and magnetic behavior of transition metal complexes. *(Skill)*
3. To introduce structural and bonding aspects of metal clusters including boranes and carboranes. *(Application)*
4. To explain the role of metal ions in biological systems through bioinorganic chemistry. *(Application)*
5. To promote understanding of structure, bonding, and reactivity in metal carbonyls and organometallic compounds. *(Research-oriented)*

### Course Outcomes (COs)

| CO No. | Upon completion of this course, students will be able to: | Bloom's Level | PO Mapped |
|---|---|---|---|
| CO1 | Explain bonding theories of coordination compounds including VBT and CFT and evaluate CFSE. | Understand / Apply | PO1, PO2 |
| CO2 | Analyze electronic spectra, selection rules, and Orgel diagrams of transition metal complexes. | Analyze | PO2, PO4 |
| CO3 | Describe structure, bonding, and properties of boranes and carboranes including STYX concept. | Understand / Analyze | PO1, PO2 |
| CO4 | Explain the biological role of metal ions including hemoglobin, myoglobin, and nitrogen fixation. | Understand | PO1, PO6 |
| CO5 | Describe preparation, structure, and bonding in metal carbonyls and explain metal–carbon bonding. | Understand / Apply | PO1, PO2 |
| CO6 | Analyze structure, bonding, and reactions of organometallic compounds such as ferrocene. | Analyze | PO2, PO4 |

## Detailed Syllabus

| Module No. | Title | Topics | Hours |
|---|---|---|---|
| **I** | **Coordination Chemistry and Electronic Spectra** | **1.1 Theories of Coordination Chemistry**<br>1.1.1 Valence Bond Theory: postulates, inner and outer orbital complexes (CN 4 & 6), limitations<br>1.1.2 Crystal Field Theory: d-orbitals, splitting in octahedral, tetrahedral, tetragonal and square planar complexes.<br>1.1.3 CFSE and its calculations<br>1.1.4 Factors affecting crystal field splitting (10 Dq)<br>1.1.5 Applications of CFT, Jahn–Teller effect<br><br>**1.2 Electronic Spectra**<br>1.2.1 Types of electronic transitions<br>1.2.2 Selection rules for d–d transitions<br>1.2.3 Spectrochemical series and ground states<br>1.2.4 Orgel diagrams ($d^1$, $d^9$)<br>1.2.5 Spectrum of $[Ti(H_2O)_6]^{3+}$ | **10** |
| **II** | **Metal Clusters (Boranes and Carboranes)** | 2.1 Introduction, classification and nomenclature of boranes<br>2.2 Diborane: preparation and properties (heat, water, acids, alkali, ammonia)<br>2.3 Structure, bonding and STYX number<br>2.4 Carboranes: classification, preparation and structure | **06** |
| **III** | **Bioinorganic Chemistry** | 3.1 Introduction<br>3.2 Essential and trace elements<br>3.3 Metalloporphyrins<br>3.4 Structure and functions of hemoglobin and myoglobin<br>3.5 Nitrogen fixation | **04** |
| **IV** | **A. Metal Carbonyls** | 4.1 Definition and classification<br>4.2 Preparation and properties of $Ni(CO)_4$<br>4.3 Structure of $Ni(CO)_4$<br>4.4 Nature of metal–carbon bond | **04** |
| | B. **Organometallic Compounds** | 4.5 Introduction, classification and nomenclature<br>4.6 Metallocenes<br>4.7 Ferrocene: preparation and reactions<br>4.8 Aromatic nature<br>4.9 Structure and bonding | **06** |

**Total Hours: 30**

## Recommended Textbooks

1. Puri, Sharma &Kalia – *Principles of Inorganic Chemistry*, Milestone Publication
2. Huheey, Keiter&Keiter – *Inorganic Chemistry: Principles of Structure and Reactivity*, Pearson.
3. Cotton & Wilkinson – *Advanced Inorganic Chemistry*
4. J.E. Huheey – *Inorganic Chemistry*
5. Miessler&Tarr – *Inorganic Chemistry*

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## E-Resources / MOOCs

- NPTEL: Coordination Chemistry
- SWAYAM: Inorganic Chemistry Courses

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# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science and Technology

| | |
|---|---|
| **Name of the Program** | B.Sc. (Chemistry) |
| **Title of the Paper/Course** | Organic and Inorganic Chemistry (Practical) [SCHECP1351] |
| **Semester** | VI |
| **Paper Type** | DSC (Practical) based on SCHECT1351+ SCHECT1353 |
| **Credits** | 02 |
| **Total Hours** | 60 |
| **Formative Assessment Marks** | 20 |
| **Summative Assessment Marks** | 30 |
| **Total Marks** | 50 |

### Course Objectives

1. **To develop practical skills** in green organic synthesis using environmentally friendly reagents and techniques.
2. **To understand reaction mechanisms** and perform organic preparations such as acetylation, nitration, bromination, condensation, and rearrangement reactions.
3. **To train students in purification and characterization techniques**, including recrystallization, melting point determination, and Thin Layer Chromatography (TLC).
4. **To develop analytical skills** in preparation of organic derivatives for identification of unknown compounds.
5. **To enhance volumetric analysis skills** for quantitative estimation of metals in ores and minerals.
6. **To promote laboratory safety, accuracy, and scientific reporting**, encouraging research-oriented thinking and data interpretation.

### Course Outcomes (COs)

After completing this course, students will be able to:

| CO No. | Upon completion of this course, students will be able to: | Bloom's Level | PO Mapped |
|---|---|---|---|
| **CO1** | Perform green organic synthesis reactions such as acetylation, nitration, bromination, and condensation using eco-friendly methods. | Apply | PO3, PO4 |
| **CO2** | Purify and characterize organic compounds using recrystallization, melting point determination, and TLC techniques. | Apply / Analyze | PO3, PO4 |
| **CO3** | Prepare and identify organic derivatives for unknown compounds through systematic laboratory procedures. | Analyze | PO2, PO4 |

| | | | |
|---|---|---|---|
| **CO4** | Carry out volumetric analysis for estimation of metals such as iron, manganese, calcium, magnesium, copper, and aluminium from ores. | Apply | PO3, PO5 |
| **CO5** | Interpret experimental data, calculate percentage yield/composition, and present results with accuracy and scientific reasoning. | Analyze / Evaluate | PO4, PO5 |
| **CO6** | Demonstrate safe laboratory practices, teamwork, and professional ethics in chemical experimentation. | | |

### 01) Organic Preparations by Green Approach:

N.B.: a) Calculation of percentage practical yield.
b) Recrystallization of crude product and its melting point.
c) The purity of the product may be confirmed by TLC.

01) Preparation of acetanilide from aniline using zinc dust (Acetylation reaction).
02) Preparation of 1,5-diphenylpenta-1,4-dien-3-one from benzaldehyde using lithium hydroxide. (Aldol condensation reaction).
03) Preparation of p-bromoacetanilide from acetanilide using ceric ammonium nitrate (Bromination reaction).
04) Preparation of Benzilic acid from benzilin solid state under solvent free condition. (BenzilBenzilic acid rearrangement).
05) Nitration of Salicylic acid using ceric ammonium nitrate (Nitration Reaction).
06) Preparation of dihydropyrimidinone benzaldehyde (Three component coupling reaction).

### 02) Preparation of Derivatives:

N.B.: During practical course, name of the organic compound should not to be given.
1) Bromo derivative of aniline and cinnamic acid.
2) Nitro derivative of salicylic acid and nitrobenzene.
3) Benzoyl derivative of β-naphthol and aniline
4) Picrate derivative of anthracene and β-naphthol.
5) Oxalate and nitro derivatives of urea.
6) Anhydride derivative of phthalic acid.
7) Oxime derivatives of Ketones: Acetone and acetophenone.
8) 2: 4 DNP of acetophenone.

### Inorganic Section

**A) Preparation of Complexes**

1. **Prussian Blue** – $Fe_4[Fe(CN)_6]_3$
2. **Potassium Trioxalatochromate** (III) – $K_3[Cr(C_2O_4)_3]$
3. **Hexaureachromium (III) Chloride** – $[Cr(CON_2H_4)_6]Cl_3 \cdot 3H_2O$
4. **Reinecke's Salt** – $NH_4[Cr(NH_3)_2(SCN)_4] \cdot H_2O$

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

| | |
|---|---|
| **Name of the Program** | B.Sc. (Chemistry) |
| **Title of the Paper/Course** | Physical and Inorganic Chemistry (Practical) [SCHECP1352] |
| **Semester** | VI |
| **Paper Type** | Core Major Practical based on SCHECT1352+ SCHECT1353 |
| **Credits** | 02 |
| **Total Hours** | 60 |
| **Formative Assessment Marks** | 20 |
| **Summative Assessment Marks** | 30 |
| **Total Marks** | 50 |

### Course Objectives

1. **To develop practical skills** in the synthesis of coordination compounds using appropriate laboratory techniques.
2. **To understand the principles of coordination chemistry**, including ligand behavior, coordination number, and complex formation.
3. **To train students in purification and characterization** of inorganic complexes through crystallization and analytical methods.
4. **To determine the percentage purity** of synthesized complexes using quantitative analysis.
5. **To introduce Schiff's base complexes** and their significance in coordination chemistry and industrial applications.
6. **To enhance laboratory skills**, accuracy, safety practices, and scientific reporting in inorganic experimental work.

### Course Outcomes (COs)

After completing this course, students will be able to:

| CO No. | Upon completion of this course, students will be able to: | Bloom's Level | PO Mapped |
|---|---|---|---|
| **CO1** | Synthesize coordination compounds such as Prussian blue, oxalato, ammine, and thiourea complexes using standard laboratory procedures. | Apply | PO3, PO4 |
| **CO2** | Explain the principles of coordination chemistry involved in complex formation, including ligand coordination and geometry. | Understand | PO1, PO2 |
| **CO3** | Purify and characterize inorganic complexes using crystallization and observational techniques. | Apply / Analyze | PO3, PO4 |
| **CO4** | Perform quantitative estimation to determine percentage purity of synthesized complexes. | Apply / Analyze | PO3, PO5 |
| **CO5** | Analyze experimental results and correlate them with theoretical concepts of coordination chemistry. | Analyze / Evaluate | PO4, PO5 |

| | | | |
|---|---|---|---|
| **CO6** | Demonstrate safe laboratory practices, proper handling of chemicals, and professional ethics in experimental work. | Apply / Create | PO6, PO7 |

## Detailed Syllabus (Practical Work)

### (A) Instrumental

1. Determine the concentration of KCl solution by titrating it with standard solution of $AgNO_3$conductometrically.
2. Determine the dissociation constant of a weak acid ($CH_3COOH$/HCOOH) potentiometrically using standard solution of strong base (NaOH/KOH).
3. To determine the order of reaction for the oxidation of alcohol by potassium dichromate and potassium permanganate in acidic medium colorimetrically
4. To determine the hydrolysis constant of aniline hydrochroride by pH measurements.
5. To study inversion of cane sugar by polarimetrically.

### (B) Non-Instrumental

6. Determine energy of activation of hydrolysis of an ester by acid/base.
7. Investigate the reaction between bromic acid and hydroiodic acid.
8. Determine molecular weight of a polymer by viscosity measurement.
9. To Study the kinetics of Iodination of acetone.
10. To determine the solubility of a salt (e.g. KCl) in water at room temperature

### A) Preparation of Complexes and Determination of Percentage Purity

1. Tetraammine Copper (II) Sulphate – $[Cu(NH_3)_4]SO_4$
2. Hexaammine Nickel (II) Chloride – $[Ni(NH_3)_6]Cl_2$
3. Sodium/Potassium Trioxalatoferrate (III) – $Na_3[Fe(C_2O_4)_3]\cdot 9H_2O$
4. Tris(thiourea) Copper (I) Sulphate Hydrate – $[Cu(NH_2CSNH_2)_3]SO_4\cdot 2H_2O$
5. Chloropentaammine Cobalt (III) Chloride – $[Co(NH_3)_5Cl]Cl_2$
6. Hexaaquonickel (II) Chloride – $[Ni(H_2O)_6]Cl_2$

### Reference Books (Laboratory work):


1. Systematic Experimental Physical Chemistry by S. W. Rajbhoj, T. K. Chondekar (Anjali publication, Aurangabad)
2. Advanced Practical Physical Chemistry by J. B. Yadav (Goel Publication, Meerut)
3. Practical Chemistry by O. P. Pandey, D. N. Bajpai and Dr. S. Giri (S. Chand Publications)
4. Experiments in Chemistry, D. V. Jahagirdar (Himalaya Publishing House)
5. Advanced Physical Chemistry experiments by Gurtu and Gurtu (Pragati Publication, Meerut)
6. Senior Practical Physical Chemistry by B. D. Khosla, V. C. Garg and A. Galati (R. Chand and Company, New Delhi)
7. Experiments in Physical Chemistry by R. C. Das and B. Behra (Tata McGraw Hill)

8. Experiments in Physical Chemistry ($8^{th}$Edn) by C.W. Garland, J.W. Nibler and D. O. Shoemaker ( McGraw Hill, New York, 2003)
9. Practical Physical Chemistry by A. Findlay, T. A. Kitchner (Longmans, Green and Co.)
10. Practical Physical Chemistry, Vishwanathan and Raghwan, Viva book.

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

| | |
|---|---|
| **Name of the Programme** | B.Sc. (Chemistry), Third Year (Theory) |
| **Title of the Paper/Course** | Advanced Organic Synthesis and Reaction Mechanisms (SCHEET1351) |
| **Semester** | VI |
| **Paper Type** | Elective Core |
| **Credits** | 02 |
| **Total Hours** | 30 |
| **Formative Assessment Marks** | 20 |
| **Summative Assessment Marks** | 30 |
| **Total Marks** | 50 |

### Course Outcomes (COs)

**After completing this course, students will be able to:**

| CO No. | Course Outcome | Bloom's Level | PO Mapping |
|---|---|---|---|
| **CO1** | Explain and apply various oxidation reactions for functional group transformations. | Understand | PO1, PO2 |
| **CO2** | Select and apply suitable reduction methods and reagents in organic synthesis. | Apply | PO2, PO4 |
| **CO3** | Design synthetic routes using retrosynthetic analysis and disconnection approach. | Analyze | PO3, PO10 |
| **CO4** | Apply concepts of photochemistry and pericyclic reactions in organic transformations. | Apply | PO4, PO5 |
| **CO5** | Interpret reaction mechanisms and solve problems related to oxidation and reduction reactions. | Analyze | PO2, PO3 |
| **CO6** | Demonstrate understanding of synthetic strategies involving synthons and functional group inter conversions. | Apply | PO3, PO10 |

### Detailed Syllabus

| Module No. | Title | Topics | Hours |
|---|---|---|---|
| **I** | **Oxidation Reactions** | 1.1 Oxidation of Alcohols: Conversion of alcohols to carbonyl compounds; Chromium (VI) oxidants; Swern oxidation (DMSO-based); $MnO_2$; Silver carbonate; Dess–Martin periodinane (DMP); Ceric Ammonium Nitrate (CAN).<br>1.2 Oxidation of Alkenes: Dihydroxylation using | 08 |

| | | | |
|---|---|---|---|
| | | $KMnO_4$ and $OsO_4$ (stereochemical aspects); Prevost oxidation and Woodward modification.<br>1.3 Oxidative Cleavage: Cleavage of 1,2-diols using periodic acid and lead tetraacetate.<br>1.4 Oxidation of C–H Bonds: Allylic and benzylic oxidation using NBS, DDQ, Chloranil, $SeO_2$. | |
| **II** | **Reduction Reactions** | 2.1 Metal Hydride Reductions: $NaBH_4$; Sodium cyanoborohydride; STAB; $LiAlH_4$; $BH_3$; Red-Al.<br>2.2 Hydrogenolysis: Tri-n-butyl tin hydride; Pd/C; $BBr_3$; HX.<br>2.3 Important Reduction Reactions: Birch reduction; Clemmensen reduction; Wolff–Kishner reduction; Diimide reduction.<br>2.4 Applications: Structural problems based on oxidation and reduction reactions. | 08 |
| **III** | **Retrosynthesis and Synthetic Strategy** | 3.1 Introduction to Retrosynthesis: Concept, importance, and basics.<br>3.2 Retrosynthetic Analysis: Design and planning of synthesis; disconnection approach.<br>3.3 Synthons and Synthetic Equivalents; Functional Group Interconversions (FGI).<br>3.4 Strategy in Synthesis: Order of reactions; reagent selection; applications. | 07 |
| **IV** | **Organic Photochemistry and Pericyclic Reactions** | 4.1 Organic Photochemistry: Basic principles; excitation and energy transfer.<br>4.2 Pericyclic Reactions: General characteristics and classification.<br>4.3 Cycloaddition Reactions: Diels–Alder reaction.<br>4.4 Electrocyclic and Sigmatropic Reactions. | 07 |

**Total Hours: 30**

## Recommended Textbooks


1. Stuart Warren, *Organic Synthesis: The Disconnection Approach*
2. Stuart Warren, *Designing Organic Synthesis*
3. Paul Wyatt & Stuart Warren, *Organic Synthesis Strategy and Control*
4. Corey & Cheng, *The Logic of Chemical Synthesis*
5. Nicolaou et al., *Classics in Total Synthesis*
6. J. Fuhrhop & G. Penzlin, *Organic Synthesis Concepts*
7. W. Carruthers, *Modern Methods of Organic Synthesis*

8. Clayden et al., *Organic Chemistry*
9. March, *Advanced Organic Chemistry*
10. Carey & Sundberg, *Advanced Organic Chemistry Part B*

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

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|---|---|
| **Name of the Programme** | B.Sc. (Chemistry), Third Year |
| **Title of the Paper/Course** | Practical Course in Advanced Organic Synthesis and Reaction Mechanisms (SCHEEP-1351) |
| **Semester** | VI |
| **Paper Type** | Elective Core Practical |
| **Credits** | 02 |
| **Total Hours** | 60 |
| **Formative Assessment Marks** | 20 |
| **Summative Assessment Marks** | 30 |
| **Total Marks** | 50 |

### Course Objectives

| Sr. No. | Course Objectives |
|---|---|
| **1** | To develop practical skills in performing oxidation reactions for transformation of organic functional groups. |
| **2** | To impart hands-on training in reduction reactions using various reducing agents such as $NaBH_4$ and metal-acid systems. |
| **3** | To enable students to carry out organic synthesis reactions such as condensation and cycloaddition. |
| **4** | To familiarize students with reaction conditions, reagents, and mechanisms involved in organic transformations. |
| **5** | To develop skills in observation, analysis, and interpretation of experimental results. |
| **6** | To enhance laboratory competence, safety practices, and accuracy in organic chemistry experiments. |
| **7** | To strengthen problem-solving ability related to organic reactions and transformations. |
| **8** | To prepare students for industrial applications and competitive examinations through practical exposure. |

### Course Outcomes (COs)

**After completing this course, students will be able to:**

| CO No. | Course Outcome | Bloom's Level | PO Mapping |
|---|---|---|---|
| **CO1** | Perform oxidation reactions for transformation of organic functional groups. | Apply | PO3, PO4 |
| **CO2** | Carry out reduction reactions using suitable reducing agents. | Apply | PO3, PO4 |
| **CO3** | Perform organic synthesis reactions and understand reaction | Apply | PO3, PO4 |

| | | | |
|---|---|---|---|
| | mechanisms. | | |
| **CO4** | Analyze experimental results and interpret chemical transformations. | Analyze | PO3, PO4 |

## Detailed Syllabus / List of Experiments

1. Oxidation of Benzyl Alcohol to Benzaldehyde
   ($MnO_2$ Oxidation; Starting material: Benzyl alcohol; Reagent: $MnO_2$)
2. Oxidation of Cyclohexanol to Cyclohexanone
3. (Chromium (VI) Oxidation; Starting material: Cyclohexanol; Reagent: $K_2Cr_2O_7$ / $H_2SO_4$)
4. Baeyer's Oxidation of Alkene to Glycol
   ($KMnO_4$ Dihydroxylation; Starting material: Alkene; Reagent: Cold dilute $KMnO_4$)
5. Oxidative Cleavage of Glycol
   (Periodic Acid Cleavage; Starting material: Vicinal diol; Reagent: $HIO_4$)
6. Reduction of Benzaldehyde to Benzyl Alcohol
   ($NaBH_4$ Reduction; Starting material: Benzaldehyde; Reagent: $NaBH_4$)
7. Reduction of Acetophenone to 1-Phenylethanol
   ($NaBH_4$ Reduction; Starting material: Acetophenone; Reagent: $NaBH_4$)
8. Reduction of Nitrobenzene to Aniline
   (Chemical Reduction; Starting material: Nitrobenzene; Reagent: Sn/HCl or Fe/HCl)
9. Wolff–Kishner Reduction of Cyclohexanone
   (Reduction Reaction; Starting material: Cyclohexanone; Reagent: $NH_2NH_2$ / KOH)
10. Synthesis of Dibenzalacetone
    (Claisen–Schmidt Condensation; Starting materials: Benzaldehyde + Acetone; Reagent: NaOH)
11. Diels–Alder Reaction
    (Cycloaddition; Starting materials: Cyclopentadiene + Maleic anhydride; Condition: Mild heating)

**Total Hours: 60**

## Reference Books


1. Vogel's Textbook of Practical Organic Chemistry — Author: Arthur I. Vogel; Publisher: Pearson Education
2. Experimental Organic Chemistry — Author: Louis F. Fieser; Publisher: D.C. Heath & Co.
3. Experimental Organic Chemistry — Authors: Louis F. Fieser & Kenneth L. Williamson; Publisher: D.C. Heath & Co.
4. Practical Organic Chemistry — Author: Arthur I. Vogel; Publisher: Pearson Education.
5. Organic Chemistry — Authors: Clayden, Greeves & Warren; Publisher: Oxford University Press
6. Advanced Organic Chemistry — Author: Jerry March; Publisher: Wiley

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

| | |
|---|---|
| Name of the Program | B.Sc. (Chemistry), Third Year |
| Title of the Paper/Course | Fundamentals of Phase Equilibria and Solution Chemistry SCHEET-1352 |
| Semester | VI |
| Paper Type | Elective |
| Credits | 02 |
| Total Hours | 30 |
| Formative Assessment Marks | 20 |
| Summative Assessment Marks | 30 |
| Total Marks | 50 |

### Course Objectives

1. To understand and define phases, components and degree of freedom in heterogeneous systems**.**
2. To utilize the Gibb's phase rule to calculate degree of freedom and interpret the behaviour of single and multi-component systems.
3. To understand how the concentration of solute particles affects the physical properties of solution
4. To understand these colligative properties depend solely on the ratio of number of solvent molecules in a solution.
5. To impart knowledge of the distribution law and its applications in solvent extraction, separation techniques, and analytical chemistry.

### Course Outcomes (COs)

After completing this course, students will be able to:

| CO No. | Upon completion of this course, students will be able to: | Bloom's Level | PO Mapped |
|---|---|---|---|
| CO1 | Students will able to define, calculate and apply concepts such as phases, components, and degree of freedom to various systems. | Understand / Apply | PO1, PO2 |
| CO2 | Students will learn to derive and apply Gibb's phase rule to non-reactive and reactive systems. | Apply | PO2. PO4, |
| CO3 | Apply the Nernst distribution law to problems involving association, dissociation and solvent extractionetc. | Apply | PO2, PO3 |
| CO4 | Solve numerical problems related to depression in freezing point, elevation in boiling point and distribution law, and interpret the results in chemical and industrial contexts. | Apply / Analyse | PO2, PO3 |
| CO5 | Explain intermolecular forces and physical properties of liquids | Apply / Analyse | PO2, PO3 |
| CO6 | Apply concepts of viscosity and surface tension to molecular structure of liquids. | Apply / Analyse | PO2, PO3 |

## Detailed Syllabus (Theory)

| Module No. | Title | Topics | Hours |
|---|---|---|---|
| **I** | **Phase Equilibrium** | 1. Phase rule, Statement and explanation of the terms-phase, component and degree of freedom.<br>2. Phase equilibria of one component system: Water system, Sulphur system.<br>3. Phase equilibria of two component system: Pb-Ag system<br>4. Solubility of partially miscible liquids: Critical solution temperature (CST) Or Consulate temperature, upper critical solution temperature (UCST), lower critical solution temperature (LCST), Phenol water system. Effect of impurities on critical solution temperature | 10 |
| **II** | **Colligative Properties** | 1. Relative lowering of vapour pressure.<br>2. Elevation in boiling point.<br>3. Depression in freezing point and relation of these properties with molecular weight.<br>4. Osmotic pressure.<br>5. Numerical on depression in freezing point and Elevation in boiling point.. | 08 |
| **III** | **Distribution Law** | 1. Introduction, Nernst Distribution law, Solubility and distribution law, Limitations of law.<br>2. Association and dissociation of solute in solvent.<br>3. Henry's law.<br>4. Extraction of solvent.<br>5. Applications of distribution law.<br>6. Numerical on distribution law.. | 06 |
| **IV** | **Liquid State** | 1. Intermolecular Forces in Liquids: i) Dipole-dipole attractions; ii) London forces; iii) Hydrogen bonding.<br>2. Surface tension: Units of surface tension, Determination of surface tension by drop formation Method.<br>3. Viscosity: Units of viscosity, Effect of temperature on viscosity of a liquid. Determination of viscosity by Ostwald viscometer method.<br>4. Numerical on surface tension and viscosity. | 06 |

**Total Hours: 30**

## Reference Books:


1. Physical Chemistry by G. M. Barrow (Tata Mc-Graw Hill publishing Co., Ltd.)
2. Elements of Physical Chemistry by S. Gladstone & D. Lewis (D.vannostrand co. inc.)
3. Physical Chemistry by W. J. Moore (Orient Longman).
4. Principles of Physical Chemistry by S. H. Maron and C. F. Prutton.
5. University General Chemistry by C. N. R. Rao (McMillan).
6. Elements of Physical Chemistry by P. W. Atkins. (Oxford University Press).
7. Physical Chemistry by R. A. Alberty (Wiley Eastern Ltd.).
8. Physical Chemistry through problems by S. K. Dogra, D. Dogra(Wiley Eastern Ltd)
9. Principles of Physical Chemistry by Puri, Sharma and Pathania (Vishal Publication Jalandhar, Delhi)
10. Physical Chemistry by A. J. Mee. ELBS & Heinemann Educational Books Ltd.
11. Essentials of Physical Chemistry by ArunBhal, B. S. Bahl and G. D. Tuli. (S. Chand )
12. Kinetics by K. J. Laidler (Tata Mc-Graw Hill Publishing Co. Ltd).
13. Text Book of Physical Chemistry by Soni-Dharmarha.
14. A Text Book Physical Chemistry by S. Glasstone, (Mac Millan.)
15. Advanced Physical Chemistry by D. N. Bajpai. (S. Chand)
16. Advanced Physical Chemistry by Gurdeep Raj. (Goel publishing house, Meerut).

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

| | |
|---|---|
| Name of the Program | B.Sc. (Chemistry), Third Year |
| Title of the Paper/Course | Practical Course in Fundamentals of Phase Equilibria and Solution Chemistry (SCHEEP-1352) |
| Semester | VI |
| Paper Type | Elective |
| Credits | 02 |
| Total Hours | 60 |
| Formative Assessment Marks | 20 |
| Summative Assessment Marks | 30 |
| Total Marks | 50 |

### Course Objectives (Practical)

- To develop a clear understanding of **analytical and physical chemistry principles** through laboratory-based experiments involving instrumental and non-instrumental techniques.
- To train students in the use of **modern analytical instruments** such as conductometer, potentiometer, pH meter, colorimeter, and spectrophotometer for quantitative analysis.
- To enhance practical skills in performing **titrimetric, electrochemical, spectroscopic, and kinetic experiments** with accuracy and precision.
- To develop the ability to **analyze experimental data**, perform calculations, and interpret results in a scientific manner.
- To provide hands-on experience in studying **reaction kinetics, thermodynamic parameters, and physicochemical properties** such as density, viscosity, and surface tension.
- To promote safe laboratory practices, **proper handling of chemicals and instruments**, and systematic record keeping.

### Course Outcomes (COs)

| CO No. | Course Outcomes | Bloom's Level | PO Mapping |
|---|---|---|---|
| **CO1** | Perform conductometric, potentiometric, pH-metric, and spectrophotometric experiments to determine concentration, strength, and λmax of chemical systems. | Apply | PO3, PO4 |
| **CO2** | Analyze titration data and interpret electrochemical and spectroscopic results for quantitative chemical analysis. | Analyze | PO2, PO4 |
| **CO3** | Determine physicochemical parameters such as **density, viscosity, surface tension, and distribution coefficient** using appropriate experimental methods. | Apply | PO3, PO5 |
| **CO4** | Investigate reaction kinetics, including **order of reaction** | Analyze | PO2, PO4 |

| | | | |
|---|---|---|---|
| | **and hydrolysis reactions**, and evaluate rate constants using experimental data. | | |
| **CO5** | Evaluate thermodynamic properties such as **enthalpy of ionization and hydration** through laboratory experiments. | Analyze / Evaluate | PO4, PO5 |
| **CO6** | Demonstrate proficiency in **laboratory techniques, safety practices, and scientific documentation**, and present results systematically. | Apply | PO6, PO7 |

## List of Experiments

**(A) Instrumental**

1. To determine the relative strength of monochloroacetic acid and acetic acid conductometrically.
2. To determine the normality of citric acid in given fruit by titrating it against standard NaOH solution by conductometric method
3. To determine the amount of NaCl in the given solution by potentiometric titration against silver nitrate.
4. To find out the strength of the given hydrochloric acid solution by titrating it against NaOH by using $p^H$ meter.
5. To find out the strength of HCl and $CH_3COOH$ in a mixture of both by titrating it against NaOH by using $p^H$ meter.
6. To determine the λmaxof unknown $KMnO_4/K_2Cr_2O_7$ solution by colorimetric measurements.
7. To measure the pH of different solutions like aerated drinks, fruit juices, shampoos and soap using pH-meter.
8. Determine the concentration of HCl against 0.1 N NaOH spectrophotometrically

**(B) Non-Instrumental**

9. To study the kinetics of acid hydrolysis of methyl acetate with hydrochloric acid.
10. To study distribution of benzoic acid between water and toluene.
11. Determination of enthalpy of ionization of acetic acid.
12. To determine the density of different liquids (e.g. ethanol, toluene, carbon tetrachloride, etc.) by using Pyknometer or relative density bottle.
13. To determine the order of reaction between $K_2S_2O_8$ and KI by half-life method.
14. Determination of enthalpy of hydration of copper sulphate.
15. To determine the parachor of p-chlorobenzene by stalagmometer.
16. To find out the temperature coefficient of the given liquid by using viscometer.

## Recommended Textbooks (Theory)

1. P. W. Atkins – *Elements of Physical Chemistry*
2. G. M. Barrow – *Physical Chemistry*
3. S. Glasstone & D. Lewis – *Elements of Physical Chemistry*
4. W. J. Moore – *Physical Chemistry*

5. S. K. Dogra & D. Dogra – *Physical Chemistry through Problems*.
6. Rajbhoj & Chondekar – *Systematic Experimental Physical Chemistry*
7. J. B. Yadav – *Advanced Practical Physical Chemistry*
8. O. P. Pandey et al. – *Practical Chemistry*
9. D. V. Jahagirdar – *Experiments in Chemistry*
10. Gurtu & Gurtu – *Advanced Physical Chemistry Experiments*

## E-Resources / MOOCs

1. NPTEL – Physical Chemistry Courses
2. SWAYAM – Undergraduate Chemistry Courses
3. e-PG Pathshala – Physical Chemistry Modules
4. Virtual Labs – Physical Chemistry Experiments

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

| | |
|---|---|
| Name of the Program | B.Sc. (Chemistry), Third Year |
| Title of the Paper/Course | Applications of Software in Chemistry, SCHEVSC-1351 |
| Semester | VI |
| Paper Type | Skill Enhancement course (VSC) |
| Credits | 02 (Practical based) |
| Total Hours | 60 |
| Formative Assessment Marks | 20 |
| Summative Assessment Marks | 30 |
| Total Marks | 50 |

### Course Objectives

1. To train students in the use of modern ICT tools and software relevant to chemistry.
2. To develop proficiency in MS Word and MS Excel for scientific documentation and data analysis.
3. To introduce students to chemical drawing and analysis software such as ChemDraw and ChemSketch.
4. To enable students to use online platforms for literature survey and scientific research.
5. To develop skills in graphical data representation and interpretation using software tools like Origin.

### Course Outcomes (COs)

After completing this course, students will be able to:

| CO No. | Course Outcome | Bloom's Level | PO Mapped |
|---|---|---|---|
| CO1 | Use MS Word and Excel for writing chemical equations, handling data, and graphical representation. | Remember/ Understand | PO1, PO2 |
| CO2 | Apply chemical software tools (Chem Draw/ Chem Sketch) for drawing structures and predicting properties. | Apply/Analyze | PO3, PO4 |
| CO3 | Utilize online databases for literature survey and scientific information retrieval. | Apply | PO3, PO6 |
| CO4 | Analyze and interpret experimental data using software such as Origin. | Analyze | PO4, PO5 |
| CO5 | Predict NMR spectra and convert chemical structures to names and vice versa using software tools. | Evaluate/Create | PO5 |
| CO6 | Demonstrate digital competency and scientific communication skills using ICT tools. | Apply/Create | PO6, PO7 |

## Detailed Syllabus

| Module No. | Title | Topics | Hours |
|---|---|---|---|
| **I** | **ICT Tools in Chemistry** | **1.1** Use of MS Word for writing chemical formulae and equations<br>**1.2** Use of MS Excel for data analysis: basic functions, calculations, charts, and graphs | **20** |
| **II** | **Online Platforms for Literature Survey** | **2.1** Introduction to scientific databases: Google Scholar, SciFinder, Scopus, Web of Science<br>**2.2** Literature search techniques and referencing | **10** |
| **III** | **Chemistry Software Tools** | **3.1** ChemDraw / ChemSketch: drawing structures, reaction schemes, name ↔ structure conversion<br>**3.2** Origin software: plotting graphs, 2D/3D visualization, data analysis | **10** |
| **IV** | **Practical Applications using Software** | **4.1** Writing equations in Word<br>**4.2** Excel calculations and plotting kinetics graphs<br>**4.3** Drawing organic structures<br>**4.4** Plotting titration curves (conductometric and pH-metric)<br>**4.5** Determination of pKa<br>**4.6** Use of Origin software<br>**4.7** Prediction of NMR spectra<br>**4.8** Structure–name interconversion<br>**4.9** Drawing laboratory apparatus<br>**4.10** Virtual lab simulations (minimum 3 experiments) | **20** |

**Total Hours: 60**

## Recommended Textbooks

1. C. R. Kothari – *Research Methodology: Methods and Techniques*
2. M. L. Humphrey – *Excel 2019 Charts*
3. Juhn Morton – *Tutorial to ChemDraw for Beginners*
4. Levie, R. – *How to Use Excel in Analytical Chemistry*
5. Cramer, C. J. – *Essentials of Computational Chemistry*

## E-Resources / MOOCs

1. NPTEL – Computational Chemistry / Data Analysis Courses
2. SWAYAM – ICT and Research Methodology Courses
3. Chem Collective Virtual Lab – http://www.chemcollective.org/vlab/vlab.php
4. Origin Software Documentation Resources

# SWAMI RAMANAND TEERTH MARATHWADA UNIVERSITY, NANDED

## Faculty of Science & Technology

| | |
|---|---|
| Name of the Program | B.Sc. (Chemistry), Third Year |
| Title of the Paper / Course | On-Job Training (OJT) in Chemistry, SCHEOJT-1351 |
| Semester | VI |
| Paper Type | Skill-Based / Internship / OJT |
| Credits | 4 |
| Total Hours | 120 (Minimum 2-3 Weeks) |
| Formative Assessment Marks | 40 |
| Summative Assessment Marks | 60 |
| Total Marks | 100 |

### Course Description:

The **On-Job Training (OJT)** programme provides students with **hands-on industrial experience** in chemical industries such as pharmaceuticals, petrochemicals, polymers, dyes, fertilizers, food processing, and environmental sectors. Students will gain exposure to **industrial operations, process control, quality assurance, safety practices, and analytical techniques**, enabling them to bridge the gap between academic knowledge and industrial applications.

### Course Objectives:

- To provide real-time exposure to **industrial chemical processes and plant operations**.
- To develop skills in **handling instruments, quality control techniques, and industrial analysis**.
- To understand **industrial safety, environmental regulations, and waste management practices**.
- To enhance **professional skills, teamwork, and problem-solving abilities** in industrial environments.

### Course Outcomes (COs):

| CO No. | Upon completion of this course, students will be able to: | Bloom's Level | PO Mapped |
|---|---|---|---|
| CO1 | Describe industrial processes, plant layout, and operational workflow. | Remember/ Understand | PO1, PO2 |
| CO2 | Apply analytical and quality control techniques in industrial settings. | Apply | PO3 |
| CO3 | Analyze process parameters, efficiency, and product quality. | Analyze | PO4 |
| CO4 | Evaluate industrial safety practices and environmental management systems. | Evaluate | PO5 |

| | | | |
|---|---|---|---|
| CO5 | Demonstrate professional skills including teamwork, communication, and documentation. | Apply /Create | PO6 |
| CO6 | Prepare and present a comprehensive industrial training report. | Create | PO7 |

## Detailed Syllabus / Training Components

| Module No. | Title | Topics / Activities | Hours |
|---|---|---|---|
| I | Industrial Orientation | **1.1** Introduction to industry<br>**1.2** Plant layout<br>**1.3** Raw materials<br>**1.4** Product line<br>**1.5** Safety rules<br>**1.6** Standard Operating Procedures (SOPs) | 40 |
| II | Process & Production Training | **2.1** Study of manufacturing processes<br>**2.2** Reaction conditions<br>**2.3** Process flow diagrams<br>**2.4** Production techniques | 50 |
| III | Quality Control & Analytical Techniques | **3.1** Exposure to laboratory instruments<br>**3.2** Sampling techniques<br>**3.3** Testing procedures<br>**3.4** Quality assurance practices | 40 |
| IV | Environmental & Safety Practices | **4.1** Waste management<br>**4.2** Effluent treatment<br>**4.3** Pollution control<br>**4.4** Industrial safety measures<br>**4.5** Regulatory compliance | 25 |
| V | Project Work & Report Preparation | **5.1** Data collection<br>**5.2** Analysis<br>**5.3** Industrial problem identification<br>**5.4** Report writing<br>**5.5** Presentation<br>**5.6** Viva | 25 |

**Total Hours: 120**

## Recommended Textbooks:

1. Austin, G. T., *Shreve's Chemical Process Industries*, McGraw Hill.
2. Rao, G. N., *Outlines of Chemical Technology*, East-West Press.
3. Sawyer, C. N., *Chemistry for Environmental Engineering*, McGraw Hill.