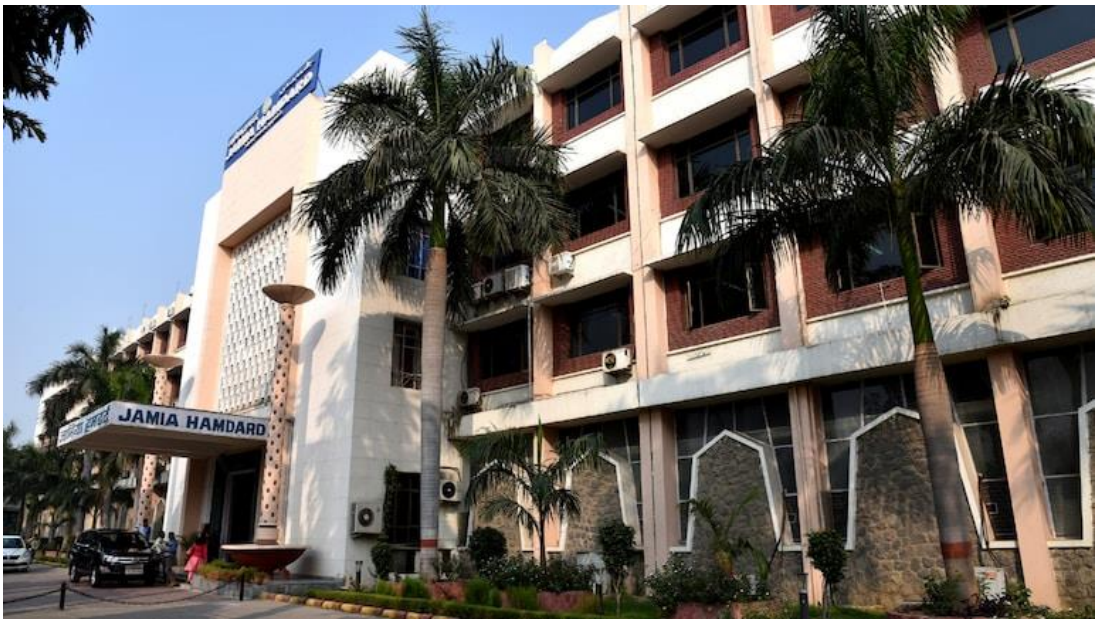
# JAMIA HAMDARD
# (Deemed to be University)
# HAMDARD NAGAR, NEW DELHI

## Bachelor of Science (Hons.) Chemistry
THREE YEARS FULL-TIME PROGRAMME

**Programme Code: 339**

Programme Brochure




**SCHOOL OF CHEMICAL AND LIFE SCIENCES**
**Department of Chemistry**

**Revised on : Nov 22, 2021**
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# DEPARTMENT OF CHEMISTRY

http://jamiahamdard.edu/Department/Deptindex.aspx?page=a&ItemID=ic&nDeptID=gm

The objective of any programme at Jamia Hamdard is to prepare their students for society at large. Jamia Hamdard envisages all the programmes of study in the best interest of their students and in this endeavour. Jamia Hamdard has adopted Learning Outcome-based Curriculum Framework (LOCF) for all its Under Graduate programmes. The LOCF approach provides a focused,outcome-based curriculum at the undergraduate level with an aim to structure the teaching-learning experiences in a more student-centric manner.

The Department of Chemistry is well known for its excellence in teaching and research. The faculty members of the department are engaged in state-of-the-art research as well as guiding the Ph.D., M. Sc. and Post Doctoral Students. The mission of the Department is to provide knowledge in Chemistry that offers opportunities forhigh quality and comprehensive learning experience for students. The Department offers an M.Sc. programme in Chemistry with the option of specialization in Organic Chemistry in addition to B.Sc. (Hons.) programme and these courses are taught semester wise. The students are assigned intensive project assignments on topics of current research interest and are exposed to sophisticated instrumental techniques in their budding stage itself. Advanced level optional courses are also offered at the Ph.D. levels. C0ollaborative research programmes with many research laboratories and research institutes in Delhi and outside India are also operating very successfully with mutual benefit. The Department has distinguished itself as a centre for innovative and pioneering research in a wide range of areas in chemistry and chemistry interfacing with physical and biological sciences. Department has funding from the Department of Science and Technology,the Department of Biotechnology (DBT), Defence Research & Development Organisation (DRDO) and the University Grant Commission (UGC). The University is also funding the faculty through Research Promotion Grants for beginners.

The Under-Graduate Programme of the department will prepare the students for both, academia and employability. The graduate attributes encompass values related to well-being, emotional stability, critical thinking, social justice and also skills for employability.

**Vision and Mission of the Department**

Department aspires to attain global recognition in chemistry education, research and training for meeting the growing needs of industry and society.
The mission of the Department includes:

- M1. To make the department a growing center of excellence in teaching, cutting-edge research, curriculum development and popularizing Chemistry.
- M2. To impart education through a well-defined curriculum driven by the needs of the students, the mission of the institution and the program, the standards of the discipline, and the needs of the partners.
- M3. To provide state of art research facilities to generate new knowledge and develop new technologies in the thrust areas of chemistry.
- M4. To develop linkages and collaborations in order to strengthen industry-academia relations for mutual benefit and address problems of societal importance
- M5. To outreach in the form of books, online courses, and other Chemistry education activities that showcase the role of Chemistry as a central science.

## 1. CBCS (CHOICE BASED CREDIT SYSTEM)

CBCS provides an opportunity for the students to learn core subjects but also at the same time explore additional avenues of learning beyond the core subjects for holistic development. It envisages a shift in focus from the teacher-centric to student-centric education allowing students to choose inter-disciplinary, intra-disciplinary courses, skill-oriented papers (even from other disciplines according to their learning needs, interests and aptitude) and more flexibility for students. The courses are evaluated following the grading system involving computation of Cumulative Grade Point Average (CGPA) based on student's performance in examinations to enable the student. It provides uniformity in the evaluation which enables the students to move across institutions of higher learning and enables the potential employers in assessing the performance of the candidates uniformly.

## 2. Definitions of Key concepts

1. **'Academic Programme'** means an entire course of study comprising its programme structure, course details, evaluation schemes etc. designed to be taught and evaluated in a teaching Department/Centre or jointly under more than one such Department/ Centre.
2. **'Course'** means a segment of a subject that is part of an Academic Programme.
3. **'Programme Structure'** means a list of courses (Core, Elective, Open Elective) that makes up an Academic Programme, specifying the syllabus, Credits, hours of teaching, evaluation and examination schemes, the minimum number of credits required for successful completion of the programme etc. prepared in conformity to University Rules, eligibility criteria for admission.
4. The Courses offered under a Programme of Study are designated as **Core courses**,**Ability Enhancement Courses (AEC) and elective courses.**
    - **Core Course**: A course designated as a **Core course** must be completed by students to receive the degree in a Programme.
    - **Ability Enhancement Courses (AEC):**These courses are of two types:
        - ❖**Ability Enhancement Compulsory Courses (AECC):** These courses are based on the contents that lead to knowledge enhancement. Two credit AECCs that are mandatory to all disciplines of UG programmes are:
            (i) Environmental Science, (ii) English/MIL Communication)
        - ❖**Skill Enhancement Courses** (SEC): These two-creditcourses are chosen from a pool of courses designed to provide value-based and/ or skill-based knowledge.
    - **Elective courses** can be chosen from:
        - ❖ A list of courses which are very specific/advanced chemistry courses and are prescribed by the Department of chemistry as **Discipline Specific Elective Papers** (DSE) and.
        - ❖ Any course which provides an extended exposure to some other discipline/subject/domain and is offered by a Centre/Department/School of Jamia Hamdard under CBCS as a **Generic elective. An option is also available for credit transfers from MOOCs/SWAYAM platforms.**

    All of the above-mentioned courses will be audit courses, i.e., for all the papers including elective courses and the courses completed through MOOCs/SWAYAM platforms, credits

earned will be taken into consideration for the calculation of CGPA and declaration of results.

A student will be permitted to pursue audit courses online up to a maximum of 18 credits. However, during one semester a student will not be permitted to transfer more than 06 credits of online courses.

SWAYAM Counsellor of the department shall facilitate online courses through the SWAYAM platform and shall obtain marks from the host institution.

**Additional Credit courses:** (Non-audit courses or Credits under Non-CGPA)

**Interested candidates may enroll in various co extracurricular activities. At least 02 credits each will be given in an activity for one year. An option is also available for credit transfers from MOOCs/SWAYAM platforms. Additional credits will be shown in the transcripts of the student**

3. **B.Sc. (Hons.) Chemistry Programme:**
The B.Sc. (Hons.) Chemistry course is spread over three academic years and comprises of six-semesters. The student-centered,teaching-learning process involves theory and practical classes. Apart from the conventional chalk and talk method,technology-enriched teaching pedagogy including PowerPoint presentations, audio-video tools, class discussions, seminars, simulations and virtual labs (wherever possible) will be adopted. Students will be encouraged to carry out short term projects and participate in industrial and institutional visitsand workshops. Schemes of holistic assessment including continuous evaluation (class test, presentation, group discussion, quiz, assignment etc.) and end of semester examination will be employed. Each theory paper will be of 100 marks out of which 25% marks are for internal assessment while a practical paper will be of 50 marks comprising 25% of internal assessment.

4. **Duration of the course:** Three years spread over 06 semesters
B.Sc. Chemistry (Hons) is a three-yearfull-time academic program of study spread over 06 semesters. Each year, new session will start in July, and the 06 semesters will be as under,

| | | |
|---|---|---|
| Semester I | (1st year) | July-Dec (Odd Semester) |
| Semester II | (1st year) | Jan-May (Even Semester) |
| Semester III | (2nd year) | July-Dec (Odd Semester) |
| Semester IV | (2nd year) | Jan-May (Even Semester) |
| Semester V | (3rd year) | July-Dec (Odd Semester) |
| Semester VI | (3rd year) | Jan-May (Even Semester) |

The number of teaching days in each semester shall not be less than 90 days.

5. **Medium of instruction and examination:** English

6. **Eligibility for admission:** A candidate seeking admission to the BSc program must have passed Senior Secondary (12th / Intermediate) examination with Biology /Mathematics from CBSE or any other Board recognized by Jamia Hamdard (JH) as equivalent thereto, securing at least 50% marks or equivalent CGPA in aggregate.

## 7. Qualification Descriptors (QDs):

QD1. Development of the appreciation of the uses of chemistry in daily life and awareness of the role of chemistry in contemporary societal and global issues, including areas such as sustainability and green chemistry.

QD2. To demonstrate comprehensive knowledge of broad concepts, principles and theories of chemistry as well as advanced and emerging topics that stress scientific reasoning and analytical problem-solving perspective.

QD3. Development of competence in intellectual, practical and transferable skills (communication skills, IT skills, Interpersonal skills) necessary for a chemist

QD4. Demonstration of an ability to apply underlying concepts and principles outside the context in which they were first studied in interdisciplinary scenarios.

## 8. Mapping of Qualification descriptors (QDS) with Mission Statements (MS)

| MS1 | MS2 | MS3 | MS4 | MS5 |
|---|---|---|---|---|
| **QD1** | **2** | **2** | **2** | **2** |
| **QD2** | **3** | **2** | **2** | **2** |
| **QD3** | **3** | **3** | **3** | **3** |
| **QD4** | **3** | **3** | **3** | **3** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

## 9. Programme Learning Outcomes (PLOs):

**PLO1.** To acquire comprehensive knowledge of concepts, principles and theories of chemistry as well as advanced and emerging topics that stress scientific reasoning and analytical problem-solving perspective.

**PLO2.** Competence in understanding intellectual, practical and transferable skills (communication skills, IT skills, Interpersonal skills) necessary for a chemist

**PLO3.** Demonstration of an ability to apply underlying concepts and principles outside the context in which they were first studied in interdisciplinary scenarios.

**PLO4.** Acquisition of competence in the operation of standard chemical instrumentation and techniques, for conducting the documented laboratory procedures and other practices of chemistry.

**PLO5.** Apply skills for gathering, evaluation, analysis and presentation of information, ideas, concepts and quantitative and/or qualitative data.

**PLO6.** Evaluate the impact of chemical processes and materials in societal and environmental contexts and demonstrate the knowledge of, and need for sustainable development.

**PLO7.** Design and develop small projects forapplications in science and technology, that meet specified needs with appropriate significance for public health and safety, cultural, societal and environmental considerations

## 10. Programme Specific Outcomes (PSOs):

The B.Sc.(Hons.) programme in Chemistry is designed to develop in students anin-depth knowledge of thecore concepts and principles that are central to the understanding of this core science discipline.

On the completion of this programme, the students will be able to:

**PSO 1.** Have a familiarity with the theoretical knowledge and understanding of the fundamental concepts, principles and processes in main branches of chemistry, namely, organic chemistry, inorganic chemistry, physical chemistry, analytical chemistry and biochemistry.

**PSO 2.** Understand the background of organic reaction mechanisms, complex chemical structures, and instrumental methods of chemical analysis, molecular rearrangements and separation techniques.

**PSO 3.** Developquantitative and qualitative practical skills through hands-on training in handling basic chemical laboratory instruments.

**PSO 4.** Able to synthesize, separate, purify and characterize compounds using laboratory and instrumentation techniques.

**PSO 5.** Carry out experiments in the area of organic analysis, estimation, separation, derivative process, and inorganic semi microanalysis, and preparation, conductometric and potentiometric analysis.

**PSO 6.** Analyze the data obtained from sophisticated instruments (like FTIR, NMR, GCMS, HPLC, GCMS UV-Vis, Fluorescence, and TGA) for structure determination and chemical analysis.

**PSO 7.** Work in the interdisciplinary and multidisciplinary areas of sciences

**PSO 8.** Apply green/sustainable chemistry approach towards planning and doing experiments andunderstanding the causes of environmental pollution and methods of pollution control.

**PSO 9.** Design and develop small projects for applications in science and technology, that meet specified needs with appropriate significance for public health and safety, cultural, societal and environmental considerations

**Mapping of PLOs with QDs**

| | PLO-1 | PLO-2 | PLO-3 | PLO-4 | PLO-5 | PLO-6 | PLO-7 | PSO-1 | PSO-2 | PSO-3 | PSO-4 | PSO-5 | PSO-6 | PSO-7 | PSO-8 | PSO-9 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| QD1 | 3 | 3 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| QD2 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 2 |
| QD3 | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| QD4 | 1 | 1 | 2 | 2 | 3 | 2 | 3 | 1 | 1 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

## 11. Structure of the Programme in B.Sc. (Hons.) Chemistry:

**Course Structure:**

**(a)** The course, as approved by the Board of Studies of the Department of chemistry and reviewed regularly, shall be divided into not less than 14 theory and practical core courses having 04 and 02 credits each. The course will have two ability enhancement courses of 2 credits each. The student will have to undertake two Skill enhancement elective courses of 02 credits each along with 04 discipline-specific 04 generic electives of 06 credits each in the first six semesters. Each discipline-specific generic elective will have 04 credits assigned to the theory component and two credits to either tutorial or practical component

**(b)** In Semester I and II there will be common courses in basic subject areas like physics, mathematics, statistics, computer science, biology, and chemistry.

**(c)** A minimum of 02 credits and a maximum of 04 credits shall be assigned for each theory paper and 02 credits for each practical course. The lab work may also include a report or industrial visit.

**(d)** One theory credit will be counted as 1 h of contact per week, and two practical credits will be counted as 1 h of contact per week.

**(e)** There shall be no less than 20 credits and no more than 26 credits for each semester. This includes the lab work also.

**(f)** The contents of each theory course shall be divided into four units. Each unit shall preferably have equal teaching hours

**(g)** 04 credit papers will have a weightage of 100 marks with a 25% weightage for

Continuous evaluation and 75 % for end semester examination.

**(h)** 02 credit paper will have a weightage of 50 marks with a 25% weightage for Continuous evaluation and 75 % for end semester examination.

To acquire a B.Sc. (Hons.) Chemistry degree, the student will study **fourteen Core Courses**,**two Ability Enhancement compulsory courses**, **two Skill Enhancement Courses**, **fourDiscipline Specific ElectiveCourses,** and **four Generic Elective Courses**. The Core, DSE, and GE Courses are six credit courses; the SEC, AEC are two-credit courses.

A student will be permitted to pursue audit courses online up to a maximum of 18 credits. However, during one semester a student will not be permitted to transfer more than 06 credits of online courses.

SWAYAM Counsellor of the department shall facilitate online courses through the SWAYAM platform and shall obtain marks from the host institution.

**Additional Credit courses:** (Non-audit courses or Credits under Non-CGPA)

**Interested candidates may enroll in various co extracurricular activities. At least 02 credits each will be given in an activity for one year. An option is also available for credit transfers from MOOCs/SWAYAM platforms. Additional credits will be shown in the transcripts of the student**

The Department of Chemistry offers eight Generic elective courses to students of other disciplines with a minimum of 30 % reservation for students of other programs of the university

## 12. Overview of B.Sc (Hons.) Chemistry Curriculum

**Total No. of Semesters: 06** **Total No. of Credits: 140**

| S.No. | Course Type | No. | Credits |
|---|---|---|---|
| 1 | Core Courses | 14 | 14×06 =84 |
| 2 | Ability enhancement courses | 02 | 02×02 = 04 |
| 3 | Chemistry Elective Courses<br>[DSE + SEC] | DSE 04 {06}<br>SEC 02 {02} | 04×06 =24<br>02×02 = 04 |
| 4 | Generic elective Course (GE I) | 01 | 06 |
| 5 | Generic elective Courses (GE 2-GE 4)<br>The option is available for credit transfer from MOOCs/SWAYAM platforms | 03 | 03×06 = 18 |

## 13. Semester-wise scheme of B.Sc. (Hons.) Chemistry Programmeas proposed for Jamia Hamdard:

| Semester | CORE COURSES (CC) (14)* Credits: Th:4, PR:2 | Ability Enhancement Compulsory Courses (AEC) (2)* Credits: Th:2 | Skill Enhancement Courses (SEC) (2)* Credits: Th:2 | Discipline-Specific Elective (DSE) (4)* Credits: Th:4, PR:2 | Generic Electives (GE) (4)* Credits: Th:4, PR:2 | Total Credits 140 |
|---|---|---|---|---|---|---|
| I | BCH-CC1 TH (4 C)<br>BCH-CC1-TU (2 C) | BCH-AEC1: English Communication (2 C) | | | GE1TH (4C) | 22 |
| | BCH-CC2 TH (4 C)<br>BCH-CC2 PR (2 C) | BCH-AEC2: Environment Studies (2 C) | | | GE1-TU (2C) | |
| II | BCH-CC3 TH (4 C)<br>BCH-CC3 PR (2 C) | | | | GE2(6 C) ( may be chosen from the papers offered by other departments, Option is available for 06 credit transfers from MOOC platforms) | 24 |
| | BCH-CC4TH (4 C)<br>BCH-CC4 PR (2 C) | | | | | |
| | BCH-CC5 TH (4 C)<br>BCH-CC5 PR (2 C) | | | | | |
| III | BCH-CC6 TH (4 C)<br>BCH-CC6 PR (2 C) | | SEC (2 C) + (2 C)<br>*(Any two from SEC-1 to SEC-6*) | | GE3 (6 C) ( may be chosen from the papers offered by other departments, Option is available for 06 credit transfers from MOOC platforms) | 22 |
| | BCH-CC7 TH (4 C)<br>BCH-CC7 PR (2 C) | | | | | |
| IV | BCH-CC8 TH (4 C)<br>BCH-CC8 PR (2 C) | | | BCH-DSETH (4 C)<br>BCH-DSE PR (2 C)<br>(Anyone from DSE I-IX) | GE4 (6 C) ( t may be chosen from the papers offered by other departments, Option is available for 06 credit transfers from MOOC platforms) | 24 |
| | BCH-CC9 TH (4 C)<br>BCH-CC9 PR (2 C) | | | | | |
| V | BCH-CC10 TH (4 C)<br>BCH-CC10 PR (2 C) | | | BCH-DSETH (4 C)<br>BCH-DSE PR (2 C)<br>BCH-DSETH (4 C) X 2<br>BCH-DSE PR (2 C) X 2 | | 24 |
| | BCH-CC11 TH (4 C)<br>BCH-CC11 PR (2 C) | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | (Any two from DSE I-IX) | | |
| VI | BCH-CC12 TH (4 C)<br>BCH-CC12 PR (2 C)<br>BCH-CC13 TH (4 C)<br>BCH-CC13 PR (2 C)<br>BCH-CC14 TH (4 C)<br>BCH-CC14 PR (2 C) | | | BCH-DSE4 TH (4C)<br>BCH-DSE4 PR (2C)<br>*(Anyone from DSE I-IX)* | | 24 |

*** Number of courses student has to study, TH-Theory; PR-Practical; Tu-Tutorial; C-Credit**

A student will be permitted to pursue online audit courses of up to a maximum of 18 credits. However, during one semester a student will not be permitted to transfer more than 06 credits of online courses.

SWAYAM Counsellor of the department shall facilitate online courses through the SWAYAM platform and shall obtain marks from the host institution.

**Additional Credit courses:** (Non-audit courses or Credits under Non-CGPA)

**Interested candidates may enrol in various co extracurricular activities. At least 02 credits each will be given in an activity for one year. An option is also available for credit transfers from MOOCs/SWAYAM platforms. Additional credits will be shown in the transcripts of the student**

**For students selected for taking NCC course, the option is available for transfer of 24 credits of generic electives from NCC as per the schedule of NCC courses being offered**

## 14. Semester-wise marks of B.Sc. Programme as proposed for Jamia Hamdard:

| Semester | COURSES | Total Credits 140 | Total Continuous evaluation marks: 888 | Total External Evaluation marks:2612 | Total marks: 3500 |
|---|---|---|---|---|---|
| | | Credits/semester | Continuous evaluation Marks/semester | External Evaluation Marks/semester | Marks/ semester |
| I | BCH-CC1 TH | 04 | 25 | 75 | 100 |
| | BCH-CC1-TU | 02 | 13 | 37 | 50 |
| | BCH-CC2 TH | 04 | 25 | 75 | 100 |
| | BCH-CC2 PR | 02 | 13 | 37 | 50 |
| | BCH-AEC1: English Communication | 02 | 13 | 37 | 50 |
| | BCH-AEC2: Environment Studies | 02 | 13 | 37 | 50 |
| | GE1-TH | 04 | 25 | 75 | 100 |
| | GE1-TU | 02 | 13 | 37 | 50 |
| | **Total Semester I** | **22** | **140** | **410** | **550** |
| II | BCH-CC3 TH | 04 | 25 | 75 | 100 |
| | BCH-CC3 PR | 02 | 13 | 37 | 50 |
| | BCH-CC4 TH | 04 | 25 | 75 | 100 |
| | BCH-CC4 PR | 02 | 13 | 37 | 50 |
| | BCH-CC5 TH | 04 | 25 | 75 | 100 |
| | BCH-CC5 PR | 02 | 13 | 37 | 50 |
| | GE2 TH<br>(maybe chosen from the papers offered by other departments, Option is available for 06 credit transfers from MOOC platforms) | 04 | 25 | 75 | 100 |
| | GE2 PR<br>(maybe chosen from the papers offered by | 02 | 13 | 37 | 50 |

| | | | | | |
|---|---|---|---|---|---|
| | other departments, Option is available for 06 credit transfers from MOOC platforms) | | | | |
| | **Total Semester II** | **24** | **152** | **448** | **600** |
| **III** | BCH-CC6 TH (4 C) | 04 | 25 | 75 | 100 |
| | BCH-CC6 PR (2 C) | 02 | 13 | 37 | 50 |
| | BCH-CC7 TH (4 C) | 04 | 25 | 75 | 100 |
| | BCH-CC7 PR (2 C) | 02 | 13 | 37 | 50 |
| | SEC (Any from SEC-1 to SEC-6) | 02 | 13 | 37 | 50 |
| | SEC (Any from SEC-1 to SEC-6) | 02 | 13 | 37 | 50 |
| | GE3TH (Both TH and related PR maybe chosen from the papers offered by other departments, Option is available for 06 credit transfers from MOOC platforms) | 04 | 25 | 75 | 100 |
| | GE3 PR | 02 | 13 | 37 | 50 |
| | **Total Semester III** | **22** | **140** | **410** | **550** |
| **IV** | BCH-CC8 TH (4 C) | 04 | 25 | 75 | 100 |
| | BCH-CC8 PR (2 C) | 02 | 13 | 37 | 50 |
| | BCH-CC9 TH (4 C) | 04 | 25 | 75 | 100 |
| | BCH-CC9 PR (2 C) | 02 | 13 | 37 | 50 |
| | BCH-DSE TH Anyone from DSE I-IX | 04 | 25 | 75 | 100 |
| | BCH-DSE PR | 02 | 13 | 37 | 50 |
| | GE4TH (Both TH and related PR maybe chosen from the papers offered by other departments, Option is available for 06 credit transfers from MOOC platforms) | 04 | 25 | 75 | 100 |
| | GE4 PR | 02 | 13 | 37 | 50 |
| | **Total Semester IV** | **24** | **152** | **448** | **600** |
| **V** | BCH-CC10 TH (4 C) | 04 | 25 | 75 | 100 |
| | BCH-CC10 PR (2 C) | 02 | 13 | 37 | 50 |
| | BCH-CC11 TH (4 C) | 04 | 25 | 75 | 100 |
| | BCH-CC11 PR (2 C) | 02 | 13 | 37 | 50 |
| | BCH-DSE TH (Any from DSE I-IX) | 04 | 25 | 75 | 100 |
| | BCH-DSE PR | 02 | 13 | 37 | 50 |
| | BCH-DSE TH (Any from DSE I-IX) | 04 | 25 | 75 | 100 |
| | BCH-DSE PR | 02 | 13 | 37 | 50 |
| | **Total Semester V** | **24** | **152** | **448** | **600** |
| **VI** | BCH-CC12 TH (4 C) | 04 | 25 | 75 | 100 |
| | BCH-CC12 PR (2 C) | 02 | 13 | 37 | 50 |
| | BCH-CC13 TH (4 C) | 04 | 25 | 75 | 100 |
| | BCH-CC13 PR (2 C) | 02 | 13 | 37 | 50 |
| | BCH-CC14 TH (4 C) | 04 | 25 | 75 | 100 |
| | BCH-CC14 PR (2 C) | 02 | 13 | 37 | 50 |
| | BCH-DSE TH*(Anyone from DSE I-IX* | 04 | 25 | 75 | 100 |
| | BCH-DSE PR | 02 | 13 | 37 | 50 |
| | **Total Semester VI** | 24 | **152** | **448** | **600** |
| | **Total Semester I-VI** | **140** | | | **3500** |

## 16. List of Papers

- **List of Core Papers (CC) (Credit: 06 each-** (4 periods/week for theory and practicals)

| S.No | Course code | Name of the course | Credits |
|---|---|---|---|
| 1. | BCH-CC1 | Basics of computer science and statistics | 06 (TH:04, PR:02) |
| 2. | BCH-CC2 | Basics of chemistry | 06 (TH:04, PR:02) |
| 3. | BCH-CC3 | Inorganic Chemistry I: Chemistry of s- and p-block Elements | 06 (TH:04, PR:02) |
| 4. | BCH-CC4 | Physical Chemistry I: States of Matter & Ionic Equilibrium | 06 (TH:04, PR:02) |
| 5. | BCH-CC5 | Organic Chemistry I: Hydrocarbons | 06 (TH:04, PR:02) |
| 6. | BCH-CC6 | Physical Chemistry II: Phase Equilibria and Chemical Kinetics | 06 (TH:04, PR:02) |
| 7. | BCH-CC7 | Organic Chemistry II: Halogens, Oxygen and Nitrogen Containing Functional Groups | 06 (TH:04, PR:02) |
| 8. | BCH-CC8 | Inorganic Chemistry II: Coordination Chemistry | 06 (TH:04, PR:02) |
| 9. | BCH-CC9 | Organic Chemistry III: Heterocyclic and Natural Product Chemistry | 06 (TH:04, PR:02) |
| 10. | BCH-CC10 | Physical Chemistry III Electrochemistry | 06 (TH:04, PR:02) |
| 11. | BCH-CC11 | Organic Chemistry IV: Biomolecules | 06 (TH:04, PR:02) |
| 12. | BCH-CC12 | Physical Chemistry IV: Quantum Chemistry & Spectroscopy | 06 (TH:04, PR:02) |
| 13. | BCH-CC13 | Inorganic Chemistry IV: Organometallic Chemistry | 06 (TH:04, PR:02) |
| 14. | BCH-CC14 | Organic Chemistry IV: Spectroscopy and Polymers | 06 (TH:04, PR:02) |

- **List of Ability Enhancement Courses (AEC) (Credit: 02 each-**2 periods/week**)**

| S.No | Course code | Name of the course | Credits |
|---|---|---|---|
| 1. | BCH AEC1 | English Communication (2) | 02 TH |
| 2. | BCH AEC2 | Environment Studies (2) | 02 TH |

- **Discipline Specific Elective Papers: (Credit-06 each-**4 periods/week for theory and practical)
  **(Four courses to be chosen)**

| S.No | Course code | Name of the course | Credits |
|---|---|---|---|
| 1. | BCH-DSE-I. | Analytical Methods in Chemistry (4) + Lab (2) | 06 (TH:04, PR:02) |
| 2. | BCH-DSE-II | Molecular Modelling & Drug Design (4) + Lab (2) | 06 (TH:04, PR:02) |
| 3. | BCH-DSE-III | Novel Inorganic Solids (4) + Lab (2) | 06 (TH:04, PR:02) |
| 4. | BCH-DSE-IV | Polymer Chemistry (4) + Lab (2) | 06 (TH:04, PR:02) |
| 5. | BCH-DSE-V | Green Chemistry (4) + Lab (2) | 06 (TH:04, PR:02) |
| 6. | BCH-DSE-VI | Industrial Chemicals & Environment (4) + Lab (2) | 06 (TH:04, PR:02) |
| 7. | BCH-DSE-VII | Inorganic Materials of Industrial Importance (4) + Lab (2) | 06 (TH:04, PR:02) |
| 8. | BCH-DSE-VIII. | Instrumental Methods of Analysis (4) + Lab (2) | 06 (TH:04, PR:02) |
| 9. | BCH-DSE-IX | Dissertation (4) + Research Methodology (2) | 06 |

- **Skill Enhancement Courses (Credit: 02 each**--2 periods/week**) (<u>Two courses to be chosen</u>)**

| S.No | Course code | Name of the course | Credits |
|---|---|---|---|
| 1. | BCH-SEC1. | Chemoinformatics | 02 TH |
| 2. | BCH-SEC2. | Intellectual Property Rights | 02 TH |
| 3. | BCH-SEC3. | Pharmaceutical Chemistry | 02 TH |
| 4. | BCH-SEC4. | Chemistry of Cosmetics & Perfumes | 02 TH |
| 5. | BCH-SEC5. | Pesticide Chemistry | 02 TH |
| 6. | BCH-SEC6. | Fuel Chemistry | 02 TH |

- **Generic Electives (Credit-06 each) (**4 periods/week for theory and practical or 02 periods /week for tutorial)

  - **GE-01: Any <u>one</u> of the following in Semester I as per the subjects studied in Higher secondary**
    BCH GE1A: for students with Maths in Higher secondary
    BCH GE1B: for students with Biology in Higher secondary

| S.No | Course code | Nsme of the course | Credits |
|---|---|---|---|
| 1. | BCH GE1A | Basics of Physics and Biology | 06 (TH:04, TU:02) |
| 2. | BCH GE1B | Basics of Physics and Maths | 06 (TH:04, TU:02) |

  - **GE 02 to GE 04 (Credit: 06 each; TH:04, PR:02/TU: 02)** (4 periods/week for theory and practical or 02 periods /week for tutorial)

    - Any <u>three</u>Generic Elective papers may be chosen from the papers offered by other departments.An option is available for credit transfer from MOOCs/SWAYAM platforms.
    - The Course codes of the generic elective courses will be designated by adding Suffixes to BCH -GE 2, BCH -GE 3 and BCH -GE 4

**<u>Someappropriate generic elective courses offered offline in different departments for undergraduate programmes of Sciences are</u>**

| BIOLOGICAL SCIENCES (Any Three) | <u>Maths</u> (Any Three) | <u>Computer Science</u> (Any Three) |
|---|---|---|
| Any three papers could be chosen from the generic elective papers offered by other departments of SCLS | 1. Calculus and Differential equations<br>2. Probability and Statistics<br>3. Object-Oriented Programming in C++<br>4. Finite Element Methods<br>5. Mathematical Finance<br>6. Econometrics<br>7. Cryptography and Network Security<br>8. Information Security<br>9. Applications of Algebra<br>10. Combinatorial Mathematics | 1. Computer Fundamentals<br>2. Introduction to Database Systems<br>3. Introduction to Programming<br>4. Computer Networks and Internet Technologies<br>5. Multimedia and Applications<br>6. Programming in Visual Basic / Gambas<br>7. Information Security and Cyber Laws<br>8. Web and E-Commerce Technologies |

- **List of Generic Elective Papers (GE) open for other Departments/Disciplines: (Credit: 06 each)**

| S.No | Name of the course | Semester |
|---|---|---|

| | | |
|---|---|---|
| **1.** | **CHG-A TH** Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons (04 credits)<br>**CHG-A PR** Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons (02 credits) | **Semester I** |
| **2.** | **CHG-B TH** Chemical Energetics, Equilibria & Functional Group Organic Chemistry-I (04 credits)<br>**CHG-B PR** Chemical Energetics, Equilibria & Functional Group Organic Chemistry-I (02 credits) | **Semester I** |
| **3.** | **CHG-C TH** Chemical Energetics, Equilibria & Functional Group Organic Chemistry-I (04 credits)<br>**CHG-C PR** Chemical Energetics, Equilibria & Functional Group Organic Chemistry-I (02 credits) | **Semester II** |
| **4.** | **CHG-D TH** Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional Group Organic Chemistry-II (04 credits)<br>**CHG-D PR** Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional Group Organic Chemistry-II (02 credits) | **Semester II** |
| **5.** | **CHG-E TH** Chemistry of s- and p-block elements, States of matter and Chemical Kinetics (04 credits)<br>**CHG-E PR** Chemistry of s- and p-block elements, States of matter and Chemical Kinetics (02 credits) | **Semester III** |
| **6.** | **CHG-F TH** Chemistry of d-block elements, Quantum Chemistry, Spectroscopy (04 credits)<br>**CHG-F PR** Chemistry of d-block elements, Quantum Chemistry, Spectroscopy (02 credits) | **Semester III** |
| **7.** | **CHG-G TH** Organometallics, Bioinorganic chemistry, Polynuclear hydrocarbons and UV, IR Spectroscopy (04 credits)<br>**CHG-G PR** Organometallics, Bioinorganic chemistry, Polynuclear hydrocarbons and UV, IR Spectroscopy (02 credits) | **Semester IV** |
| **8.** | **CHG-H TH** Molecules of life (04 credits)<br>**CHG-H PR** Molecules of life (02 credits) | **Semester IV** |

**Courses will be taught only on minimum enrollment of 5 students**

## 17. Attendance

1. 100% attendance is desirable, but 75% attendance is mandatory in each paper for a student to enable him to appear in the Semester examination. In unforeseen contingencies, on the recommendation of the Dean of the School, 5% relaxation in attendance may be considered. This 5% shortage condoning may be on account of sickness, provided the medical certificate, duly certified by a Registered Medical Practitioner/Public Hospital had been submitted in the office of the Head of the Department at the time of rejoining the classes immediately after the recovery from illness. The Head of the Department shall forward such cases along with all related documentsto the Dean. The relaxation may not be considered as the right of the student.
2. In order to maintain the attendance record of a particular course, a roll call will be taken by the teacher in every scheduled lecture and practical class. For the purpose of attendance, each practical class will count as one attendance unit, irrespective of the number of contact hours. Attendance on account of participation in the prescribed and notified activities such as, NCC, NSS, Inter-university sports, educational tours/fieldwork, shall be granted provided the participation of the student is duly verified by the officer-in-charge and is sent to the Head of the Department within two weeks of the function/activity etc.
3. The subject teacher shall consolidate the attendance record for lectures and practicals the end of each month and submit to the Head of the Department. At the end of the semester, the teacher shall consolidate the attendance record for the whole semester and submit it to the Head of the Department. The statement of attendance of students shall be displayed by the Head of the Department on the Notice Board/University Website. A copy of the same shall be preserved as the record. Attendance record displayed on the Notice Board/University Website shall deem to be a proper notification for the students and no individual notice shall be sent to any student.
4. If a student is found to be continuously absent from the classes without any information for

a period of 30 days, the concerned teacher shall report the matter to the Head of the Department will report the matter to the Dean for appropriate action that may include striking off the name of such student(s) from the roll. Such a student may, however, apply for re-admission within 7 days from the date of issue of the notice of striking off the name from the rolls. The request for re-admission may be considered by the Dean of the School. Such a student shall not be eligible for re-admission after the prescribed period of 7 days. The re-admission shall be effected only after the payment of the prescribed re-admission fee.

5. The cases of students with less than 70% attendance may be forwarded to the Vice-Chancellor through Dean for considering these cases to further condone the attendance shortage as a special case.
6. A student detained on account of a shortage of attendance in any semester shall be re-admitted to the same class in the subsequent academic year on payment of prescribed fees applicable in that year to complete the attendance requirement of that course.

**18. Internal assessment**

The performance of the student in each paper will be evaluated both continuously (Internal Assessment) and at the end of the semester (Semester Examination). 25% marks for each theory paper will be allocated for internal assessment and 75% marks will be kept for semester examination at the end of each semester. For example, for a paper carrying 100 marks, 25% marks (= 25 marks) allocated for internal assessment will be divided as follows: There will be (i) three sessional tests for each paper, each of 5 marks, totalling 15 marks, (ii) an assignment of 5 marks, and (iii) 5 marks will be allocated to attendance as per the guidelines provided by the Office of the Controller of Examination. For a practical course, for example, of 50 marks, 13 marks will be allocated for the internal assessment and 37 marks will be assigned for the semester examination at the end of each semester.

For the evaluation of the lab work, laboratory notebook, practical test/viva-voce shall be taken into account. The marks shall be awarded by the respective teacher conducting the practical course. For sessional tests, discontinuance of classes will not be permitted and the teacher may take the test in his/her scheduled class. Under compelling circumstances such as sickness of the student or mourning in the family, the candidate may be given another chance. For sickness, only a credible medical certificate issued by a hospital shall be considered. In case of causalities, a letter from the parents would be required.

| | |
|---|---|
| 100% attendance | 05 Marks |
| 80 - 99.9% attendance | 04 Marks |
| 75 - 80% attendance | 03 Marks |

Evaluation of tutorials will be done by conducting two written tests and a viva, weightage shall also be given to the attendance in the tutorials.

**19. Semester examination:**

a) Semester examination shall be held at the end of each semester as per schedule given in the Academic Calendar of the School.
b) Upto a maximum of seven days preparatory holidays may be given to the examinees before the start of the semester examinations.
c) There shall be no less than two theory courses and one lab course in each semester, except

the 4th Semester. The detailed contents of the courses of studies shall be prescribed by the respective Board of Studies and shall be reviewed regularly.

d) Each theory paper having 04 credits shall be of 100 marks out of which 75% marks shall be for semester examination and 25% marks for internal assessment.
e) Each practical paper having 02 credits shall be of 50 marks out of which 75% marks shall be for semester examination and 25% marks for internal assessment.
f) The question paper for each theory paper shall have five questions. There shall be one question from each of the 4 units of the course and one question shall contain objective type/short answer questions covering all the units of the course. The candidate shall have to answer all five questions. There shall, however, be internal choices within a unit. The choice shall be given by setting alternative questions from the same unit. The question paper should be such that it covers all the topics of that course.
g) The duration of the semester examination of a theory course shall be three hours. Practical exams of a lab course shall be of at least four hours duration. The practical examination shall be conducted by aninternal and external examiner.
h) The question paper for semester examinations shall be set either by the external examiner or an internal examiner. The Board of Studies of the department shall draw a panel of names of examiners, both internal and external, for approval by the Vice Chancellor/Dean. If the external examiner isunable to send the question paper by the deadline set by the examination branch of the University, the dean after consultation with the examination branch shall get the paper set internally by a faculty. The papers set by the examiners can be moderatedby a moderation committee. Teachers appointed on contractual basis with an appointment of less than one academic session, and temporary as well as ad-hoc teachers may not ordinarily be appointed as examiners. All such teachers, however, will be expected to assist in the practical examination.

a) **Cumulative Grade Point Average (CGPA):** It is a measure of overall cumulative performance of a student over all semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters. It is expressed up to two decimal places.
b) **Grade Point:** It is a numerical weight allotted to each letter grade on a 10-point scale.
c) **Letter Grade:** It is an index of the performance of students in a said course. Grades are denoted by letters O, A+, A, B+, B, C, P and F.
d) **Programme:** An educational programme leading to award of a Degree, diploma or certificate.
e) **Semester Grade Point Average (SGPA):** It is a measure of performance of work done in a semester. It is ratio of total credit points secured by a student in various courses registered in a semester and the total course credits taken during that semester. It shall be expressed up to two decimal places.
f) **Semester:** Each semester will consist of 15-18 weeks of academic work equivalent to not less than 90 actual teaching days. The odd semester may be scheduled from July to November and even semester from December to April.
g) **Transcript or Grade Card or Certificate:** Based on the grades earned, a grade certificate shall be issued to all the registered students after every semester. The grade certificate will display the course details (code, title, number of credits, grade secured) along with SGPA of that semester and CGPA earned till that semester.

**20. Semester System and Choice Based Credit System**

The semester system accelerates the teaching-learning process and enables vertical and horizontal mobility in learning. The credit-based semester system provides flexibility in

designing curriculum and assigning credits based on the course content and hours of teaching. The choice based credit system provides a 'Cafeteria' type approach in which the students can take courses of their choice, learn at their own pace, undergo additional courses and acquire more than the required credits, and adopt an interdisciplinary approach to learning.

**21. Types of Courses:**

Courses in a programme may be of three kinds according to CBCS: Core, Elective and Foundation

**22. Classification of Result:**

a) Two methods -relative grading or absolute grading- have been in vogue for awarding grades in a course. The relative grading is based on the distribution (usually normal distribution) of marks obtained by all the students of the course and the grades are awarded based on cut-off marks or percentile. Under the absolute grading, the marks are converted to grades based on pre-determined class intervals.

b) Following grading system with 10 point scale shall be followed to represent performance of students in the examination:

c) **Grades and Grade Points:**

| Letter Grade | Grade Point | Marks |
|---|---|---|
| O (Outstanding) | 10 | 90 – 100 |
| A+ (Excellent) | 9 | 80 – 89 |
| A (Very Good) | 8 | 70 – 79 |
| B+ (Good) | 7 | 60 – 69 |
| B (Above Average) | 6 | 50 – 59 |
| C (Average) | 5 | 45 – 49 |
| P (Pass) | 4 | 40 – 44 |
| F (Fail) | 0 | Less than 40 |
| AB (Absent) | 0 | |

**23. Classification of results:**

Following grading system with 10 point scale shall be followed to represent performance of students in the examination:

| %age marks | Grade | Grade Point | Performance level |
|---|---|---|---|
| >80 | A + | 10 | Outstanding |
| 75-<80 | A | 9 | Excellent |
| 70-<75 | B+ | 8 | Very good |
| 60-<70 | B | 7 | Good |
| 50-<60 | C | 6 | Average |
| 45-<50 | D | 5 | Below Average |
| 40-<45 | E | 4 | Marginal |
| <40 | F | 0 | Fail |
| Absent | I | - | Incomplete |

If a candidate does not write a paper, He/She will be awarded “I” grade. To pass the course, the student must obtain a minimum of ‘E’ grade. Minimum CGPA required for the award of degree shall be 5.

**24. Earned credits (EC):**

The credits for the courses in which a student has obtained E (minimum passing grade for a course) or a higher grade in the semester exam shall be counted as credits earned by him/her. Any course in which a student has obtained 'F' or 'I' grade shall not be counted towards his/her earned credits.

**25. Evaluation of Performance:**

SGPA (Semester Grade Point Average) shall be awarded on successful completion of each semester. CGPA or Cumulative Grade Point Average, which is the Grade Point Average for all the completed semesters at any point in time shall be awarded in each semester on successful completion of the current semester as well as all of the previous semester. In 1st semester, CGPA is not applicable.

**26. Calculation of SGPA and CGPA of A Student in a Semester:**

$$SGPA = \frac{\Sigma \text{ (Earned Credits X Grade Point)}}{\Sigma \text{ (Total Course Credits in a Semester)}}$$

$$CGPA = \frac{\Sigma_{j=1}^{m} \text{ (Earned Credits X grade point)}}{\Sigma \text{ (Total Course Credit in a Semester)}}$$

*where m is the number of semesters passed*

**27. Promotion**

a) Promotion from 1st semester to 2nd semester, from 3rd semester to 4th semester and from 5th semester to 6th semester shall be automatic.

b) A student shall be promoted from 2nd to 3rd semester and from 4th to 5th semester of the programme provided that student has passed 50% papers of I and II semesters taken together or III and IV semester taken together, including practical and tutorial papers.

c) Students who do not fulfil the promotion criteria as given above shall be declared failed in the part concerned. However, they shall have the option to retain the marks in the papers in which they have secured Pass marks.

d) A student who has to reappear in a paper prescribed for Semester I/III/V may do so only in the Semester examinations to be held in November/December and a student who has to reappear in a paper prescribed for Semester II/IV/VI may do so only in the examination to be held in April/May.

e) A candidate will be given a total number of 3 attempts, inclusive of the first attempt, to clear the papers in which s/he fails. The promotion to the next higher class will be considered subject to rules relating to passing the 1st and 2nd/3rd and 4th-semester examinations within two academic years.

f) Award of the degree shall be subject to successfully completing all the requirements of the programme of study within six years from admission.

g) A detained student is not allowed to reappear in-sessional tests.

h) The minimum marks required to pass any paper in a semester shall be 40% in theory and in Practical. The student must secure 40% in the End Semester Examination and 40% in the total of End Semester Examination & Internal Assessment of the paper for both theory

and practical separately.

i) For the 6th semester students, a student can appear in a supplementary examination in all backlog papers after the declaration of their final semester results

**28. Classification of Successful Candidates:**

The result of successful candidates who fulfil the criteria for the award of B.Sc Hons. shall be classified after the 6th semester, on the basis of his/her CGPA of all the sixsemesters. Classification shall be done on the basis of the following criteria:

a) S/he will be awarded "1st Division" if his/her final CGPA is 6.75 or above
b) S/he will be awarded "2nd Division" if his/her final CGPA is 6 or above but less than 6.75
c) S/he will be awarded "Pass" if his/her final CGPA is 5 or above but less than 6.
d) S/he will be treated as "Fail" if his/her final CGPA is less than 5

**29. Span Period:**

a. 1st and 2nd Semester Exams: Within two years from the first admission to the programme
b. All requirements of B.Sc. Hons. Degree within a total period of **six years** from the date of their first admission.

**30. Improvement:**

A candidate, with Grade C, D or E, who wishes to improve the previous performance will be allowed to do so after the declaration of the result of 6th semester as per the following regulation:

a) A student shall be allowed only once to reappear in the semester examination of up to six theory courses along with regular students of that semester to improve upon the previous performance. The examination fee charged from such candidates shall be double the current examination fee.
b) Such a student shall inform the Head of the Department in writing of his/her intention to improve the performance two months before the date of semester examination is to be held.
c) If the student improves the performance, s/he shall be required to submit the earlier mark-sheet/degree. A new mark-sheet and degree shall be issued. The new mark-sheet/degree shall bear the year in which the student improved the grade.
d) In case the grade obtained in improvement is lower than the one obtained earlier, the higher grade shall be retained.

**31. Conduct and Discipline:**

- Disciplinary policies of Jamia Hamdard are put in place to promote civility on campus and to ensure a secure andacademically enriching environment.
- Students are expected to show personal integrity, respect for university resources and respect for others' rights.
- Students are expected to adhere to the rules and regulations of the University. Any violation will be handled according to the rules set forth in the Disciplinary policies of the university.

# SEMESTER-I

# Scheme of courses

| No. | Core papers | AECs | Generic Electives |
|---|---|---|---|
| 1. | Basics of computer science and statisticsBCH-CC1 TH (4 C)<br><br>Basics of computer science and statisticsBCH-CC1-TU (2 C) | AEC1: English Communication (2 C) | Basics of Physics and Biology GE1A TH (4C)<br><br>Basics of Physics and Biology GE1A-TU (2C)<br>(For **Maths** students)<br><br>Or<br>Basics of Physics and Maths GE1B TH (4C)<br><br>Basics of Physics and Maths GE1B-TU (2C)<br>(For **Biology** students) |
| 2. | Basics of chemistry BCH-CC2 TH (4 C)<br><br>Basics of chemistry BCH-CC2 PR (2 C) | AEC2: Environment Studies (2 C) | |

# Core Papers

**SEMESTER I**
**PAPER CODE: BCH-CC1TH**
**PAPER TITLE: BASICS OF COMPUTER SCIENCE AND STATISTICS**

**TOTAL HOURS: 60** **CREDITS: 04**

## SECTION A: BASICS OF COMPUTER SCIENCE (02 credits)

### Unit – I: Elements of Computer Systems

Computer: Definition, Characteristics, Hardware & Software, Computer Organization. Operating Systems: Multi-tasking, Multi programming, Multiuser. Types of Operating System: MS-Windows, Unix/Linux, Mac OS. Database Models: Network, Hierarchical, Relational, Object Oriented. MS-Office: MS-Word, MS-Excel, MS-Power Point, MS-Access.

### Unit – II: Information Technology

Elements of Computer Network. Network Topologies: Ring, Bus, Star, Mesh, Hybrid. Internet, Intranet, WWW, URL, Email, HTTP, HTML, Website, Portal, Web Browser, E-Commerce, IP Address. Issues and Threats of Cyber & Information Security: Virus, Worms, Trojan, Malware, Ransom ware, Anti-Virus, Basics of Computer Trouble Shooting.

## SECTION B: STATISTICS (02 credits)

### UNIT I

Types of Data, Collection of data; Primary & Secondary data, Classification and Graphical representation of Statistical data. Measures of central tendency and Dispersion. Measures of Skewness and Kurtosis. Probability classical & axiomatic definition of probability, Theorems on total and compound probability), Elementary ideas of Binomial, Poisson and Normal distributions.

### UNIT II

Confidence level, critical region, testing of hypothesis and standard error, large sample test and small sample test. Problems on test of significance, t-test, chi-square test for goodness of fit and analysis of variance (ANOVA)) Correlation and Regression. Emphasis on examples from Biological Sciences.

**Suggested Reading for section A**


1. Rajaraman V., Adabala, Neeharika, "Fundamentals of Computer" 6th ed., PHI, 2014, ISBN 10: 8120350677
2. Sinha & Sinha, "Computer Fundamentals", 6th ed., BPB Publications, 2007, ISBN 10: 8176567523.
3. Kahate A., "Introduction to Database Management System", Pearson's Education, 2004, ISBN: 813170078X
4. Norton P, "Introduction to Computers", Mc Graw Hills, 2010, ISBN 10: 0070671206
5. Online Tutorial, Jone L. & Curtis F., "Microsoft Office 2016: Step by Step", Microsoft Press, 2015, ISBN: 978-0-7356-9923-6.


**Suggested Reading for Section B**


1. Le CT (2003) Introductory biostatistics. 1st edition, John Wiley, USA
2. Glaser AN (2001) High YieldTM Biostatistics. Lippincott Williams and Wilkins, USA
3. Edmondson A and Druce D (1996) Advanced Biology Statistics, Oxford University Press.
4. Danial W (2004) Biostatistics: A foundation for Analysis in Health Sciences, John Wiley and Sons Inc.

5. M.V.Ismail (2008)Biostatistics, Ist Edition, Laxmi ublication Pvt. Ltd.

| SEMESTER I |
|---|
| **PAPER CODE: BCH-CC02 TH**<br>**PAPER TITLE: BASICS OF CHEMISTRY** |
| **Total Credits: 06 - (BCH-CC02TH -24, BCH-CC02PR -02)**<br>**Total Lectures: BCH-CC02TH - 60, BCH-CC02PR -60** |

**Objectives:**The core course Basics of chemistry is designed to understand the basic and fundamental concepts of chemical bonding, molecular structure, inter/intramolecular interactions, thermodynamics and organic chemistry. The course is imbued with different theories of Chemical bonding, Important principles of thermodynamics, Hybridization in organic compounds, Molecular forces, Concept of reactive intermediates, Aromaticity and basic concepts of Stereochemistry.

## Course Learning Objectives:

**On completion of the course, the student will be able to:**

**CLO 1** Understand and explain the Basic concepts of chemical bonding, fundamentals of Thermodynamics, Hybridisation in organic compounds and stereochemistry. (Cognitive level: Understand).

**CLO 2** Learn and understand the concept of reactive intermediates, their structure, formation, factors influencing their stability and the fate of reactive intermediates including some important reactions/rearrangements they undergo. (Cognitive level: Learn and Understand).

**CLO 3** Understand the terms optical rotation and optical activity, specific rotation and calculate the specific rotations of optically active substances. (Cognitive level: Understand).

**CLO 4** Apply the fundamental concepts to distinguish enantiomers, Diastereomers & mesomers and to assign Relative Configurations (D/L), Absolute Configuration (R/S) of chiral centers and use the fundamental concepts of Resolution to separate the two enantiomers from the mixture in their optically pure form and calculate the specific rotation of optically active compounds. (Cognitive level: Apply).

**CLO 5** Practically validate the effect of inter/intramolecular forces on physical properties such as solubility, melting and boiling points of different compounds. (Cognitive level: Validate).

**CLO 6** Practically validate the influence of impurities on melting point (Cognitive level: Validate and analyze).

**Mapping of CLOs with PLOS**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 | CLO 5 | CLO 6 |
|---|---|---|---|---|---|---|
| **PSO 1.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO 2.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO 3.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO 4.** | **2** | **3** | **3** | **2** | **2** | **2** |
| **PSO 5.** | **2** | **2** | **3** | **3** | **2** | **2** |
| **PSO 6.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 7.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO1** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO2** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO3** | **3** | **3** | **3** | **2** | **2** | **2** |
| **PSO4** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO5** | **2** | **2** | **3** | **3** | **2** | **2** |
| **PSO6** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO7** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO8** | **2** | **2** | **2** | **2** | **3** | **3** |
| **PSO9** | **2** | **2** | **2** | **2** | **3** | **3** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

# Core Paper

**SEMESTER I**
**PAPER CODE: BCH-CC2 TH**
**PAPER TITLE: BASICS OF CHEMISTRY**

**TOTAL HOURS: 60** **CREDITS: 04**

**Unit 1 Chemical Bonding and Molecular Structure Ionic Bonding [15 Hours]**

Lattice energy and solvation energy. Born-Haber cycle and its applications, polarizing power and polarizability, Fajan's rules, ionic character in covalent compounds, Covalent Bonding: VB Approach, Lewis theory, VSEPR theory to explain the shapes of molecules, salient features of the Valence bond (VB) theory and the concept of hybridization, MO Approach: limitations of the VB approach, salient features of the MO theory. Rules for the LCAO method, bonding and anti-bonding MOs and their characteristics for s-s-, s-p and p-p combinations of atomic orbitals, nonbonding combinations of orbitals MO treatment of homonuclear diatomic molecules of 1st period and heteronuclear diatomic molecules such as CO, HF.

**Unit 2 Chemical Thermodynamics [15 Hours]**

Qualitative idea of thermodynamics. First Law of Thermodynamics: Calculation of work (w), heat (q), changes in internal energy ($\Delta E$) and enthalpy ($\Delta H$) for expansion or compression of ideal gases under isothermal and adiabatic conditions for both reversible and irreversible processes. Calculation of w,q, $\Delta E$, and $\Delta H$ for processes involving changes in physical states. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formation, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature Kirchhoff's equation. Second law of thermodynamics, concept of entropy, Gibbs free energy and Helmoltz free energy. Calculations of entropy change and free energy change for reversible and irreversible processes under isothermal and adiabatic conditions. Criteria of spontaneity, Gibbs Helmholtz equation. Maxwell's relations. Statements of Third Law of thermodynamics: calculation of absolute entropies of substances.

**Unit 3 Fundamentals of Organic Chemistry [15 Hours]**

Hybridization in organic compounds, cleavage of covalent bond, homolysis and heterolysis, Electronic effects: Electronic effects and their applications – inductive, resonance and hyperconjugation effects. Structure and relative stability of reactive carbon species – carbocations, carbanions, free radicals and carbenes, Molecular Forces: types of intermolecular and intra-molecular forces and their characteristics: dipole-dipole, dipoleinduced dipole and dispersion (London) forces. Hydrogen bond (both intramolecular and intermolecular), Effect of inter/intramolecular forces on physical properties such as solubility, vapour pressure, melting and boiling points of different compounds, Aromaticity.

**Unit 4 Stereochemistry [15 Hours]**

Stereochemistry and its importance. Geometrical isomerism, cis-trans and E/Z nomenclature Optical isomerism – optical activity, plane polarized light, enantiomerism, chirality, specific

molar rotation, Stereoisomerism with two chiral centrers: Diastereomers, mesoisomers, Resolution of racemic modification. Projection diagrams of stereoisomers: Fischer, Newman and Sawhorse projections. Relative Configuration: D/L designation. Absolute Configuration: R/S designation of chiral centres, Conformational isomerism – ethane, butane and cyclohexane, diagrams and relative stability of conformers.

**Suggested Reading**


1. J.D.Lee: A New Concise Inorganic Chemistry, E.L.B.S.
2. P.W. Atkins: Physical Chemistry, Oxford University Press
3. R.T. Morrison & R.N.Boyd: Organic Chemistry, Prentice Hall
4. James E.Huheey etal. : Inorganic Chemistry: Principles of Structure and reactivity

# Core paper

**SEMESTER I**
**PAPER CODE: BCH-CC2 PR**
**TITLE: BASICS OF CHEMISTRY**

**TOTAL HOURS: 60** **CREDITS: 02**

**Checking the calibration of the thermometer**

- Purification of organic compounds by crystallization using the following solvents:
  - Water
  - Alcohol
  - Alcohol-Water
- Determination of the melting points of above compounds and unknown organic compounds (Kjeldahl method and electrically heated melting point apparatus)
- Effect of impurities on the melting point – mixed melting point of two unknown organic compounds
- Determination of boiling point of liquid compounds. (boiling point lower than and more than 100 °C by distillation and capillary method)

***Suggested Reading:***

- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical OrganicChemistry, 5th Ed.,* Pearson (2012)

**Teaching Learning Process:**

- Lectures in classrooms
- Peer learning
- Hands-on learning using lab practical's, videos, presentations, seminars
- Technology-driven Learning

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments, Group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

**Keywords:**
Chemical bonding, molecular structure, thermodynamics, Hybridisation, Stereochemistry

## Ability Enhancement Course

**SEMESTER I**
**PAPER CODE: BCH-AEC1**
**PAPER TITLE: ENGLISH COMMUNICATION**

**TOTAL HOURS: 30** **CREDITS: 02**

Preamble: The purpose of this course is to introduce students to the theory, fundamentals and tools of communication and to develop in them vital communication skills which should be integral to personal, social and professional interactions. One of the critical links among human beings and an important thread that binds society together is the ability to share thoughts, emotions and ideas through various means of communication: both verbal and non-verbal. In the context of rapid globalization and increasing recognition of social and cultural pluralities, the significance of clear and effective communication has substantially enhanced. The present course hopes to address some of these aspects through an interactive mode of teaching-learning process and by focusing on various dimensions of communication skills. Some of these are: Language of communication, various speaking skills such as personal communication, social interactions and communication in professional situations such as interviews, group discussions and office environments, important reading skills as well as writing skills such as report writing, notetaking etc. While, to an extent, the art of communication is natural to all living beings, in today's world of complexities, it has also acquired some elements of science. It is hoped that after studying this course, students will find a difference in their personal and professional interactions. The recommended readings given at the end are only suggestive; the students and teachers have the freedom to consult other materials on various units/topics given below. Similarly, the questions in the examination will be aimed towards assessing the skills learnt by the students rather than the textual content of the recommended books.

**Unit I**

**Introduction:** Theory of Communication, Types and modes of Communication.

**Language of Communication:** Verbal and Non-verbal (Spoken and Written) Personal, Social and Business Barriers and Strategies Intra-personal, Inter-personal and Group communication.
**Speaking Skills**: Monologue, Dialogue Group Discussion, Effective Communication/Mis-Communication Interview, Public Speech.

**Unit II**

**Reading and Understanding:** Close Reading, Comprehension, Summary Paraphrasing, Analysis and Interpretation, Translation (from Indian language to English and vice-versa) Literary/Knowledge Texts.
**Writing Skills:** Documenting, Report Writing, Making notes, Letter writing.

**Recommended Readings:**


1. Fluency in English - Part II, Oxford University Press, 2006.
2. Business English, Pearson, 2008.
3. Language, Literature and Creativity, Orient Blackswan, 2013.
4. Language through Literature (forthcoming) ed. Dr. Gauri Mishra, Dr Ranjana Kaul, Dr Brati Biswas

# Ability Enhancement Course

**SEMESTER I**
**PAPER CODE: BCH-AEC2**
**PAPER TITLE: ENVIORNMENTAL STUDIES**

**TOTAL HOURS: 30** **CREDITS: 02**

**UNIT 1: THE MULTIDISCIPLINARY NATURE OF ENVIRONMENTAL STUDIES**

Definition, scope and importance, Need for public awareness.

**UNIT 2:**
**NATURAL RESOURCES: RENEWABLE AND NON RENEWABLE RESOURCES:**

a) Natural resources and associated problems
   - Forest resources: Use and over-exploitation, deforestation, case studies, Timber extraction, mining, dams and their effects on forests, and tribal people.
   - Water resources: Use and over-utilization of surface and ground water, floods, drought, conflicts over water, dam's benefits and problems.
   - Mineral Resources: Use and exploitation, environmental effects of extracting and using mineral resources, case studies.
   - Food Resources: World food problems, changes caused by agriculture and over grazing, effects of modern agriculture, fertilizers- pesticides problems, water logging, salinity, case studies.
   - Energy Resources: Growing energy needs, renewable and nonrenewable energy sources, use of alternate energy sources, case studies
   - Land Resources: Land as a resource, land degradation, man induced landslides, soil erosion, and desertification.

b) Role of individual in conservation of natural resources.
c) Equitable use of resources for sustainable life styles.

**UNIT 3: ECO SYSTEMS**

- Concept of an eco-system
- Structure and function of an eco-system.
- Producers, consumers, decomposers.
- Energy flow in the eco systems.
- Ecological succession.
- Food chains, food webs and ecological pyramids.
- Introduction, types, characteristic features, structure and function of the following eco systems:
- Forest ecosystem
- Grass land ecosystem
- Desert ecosystem.
- Aquatic eco systems (ponds, streams, lakes, rivers, oceans, estuaries)

## UNIT 4: BIODIVERSITY AND IT'S CONSERVATION

- Introduction-Definition: genetics, species and ecosystem diversity.
- Biogeographically classification of India.
- Value of biodiversity: consumptive use, productive use, social, ethical, aesthetic and option values
- Biodiversity at global, national and local level.
- India as a mega diversity nation.
- Hot-spots of biodiversity.
- Threats to biodiversity: habitats loss, poaching of wild life, man wildlife conflicts.
- Endangered and endemic spaces of India.
- Conservation of biodiversity: in-situ and ex-situ conservation of biodiversity.

## UNIT 5: ENVIRONMENTAL POLLUTION

- Definition Causes, effects and control measures of:
  a. Air pollution
  b. Water pollution
  c. Soil pollution
  d. Marine pollution
  e. Noise pollution
  f. Thermal pollution
  g. Nuclear hazards
- Solid waste Management: Causes, effects and control measures of urban and
- industrial wastes
- Role of an individual in prevention of pollution
- Pollution case studies
- Disaster management: Floods, earth quake, cyclone and land slides

**Suggested Readings:**

1. Textbook of Environmental studies, Erach Bharucha, UGC
2. Fundamental concepts in Environmental Studies, D D Mishra, S Chand & Co Ltd

# Generic Elective

**SEMESTER I**
**PAPER CODE: BSC-GE01THA**
**PAPER TITLE: BASICS OF PHYSICS AND BIOLOGY**

**TOTAL HOURS: 60** **CREDITS: 04**

## SECTION A: BASICS OF PHYSICS (02 CREDITS)

**UNIT-I**

a) Oscillations: Periodic motion, time period, frequency, Simple Harmonic Motion (SHM) and its equations, phase, restoring force, Kinetic Energy and Potential Energy in SHM.
b) Electromagnetic waves: Electromagnetic Spectrum, Electromagnetic waves and their characteristics, Maxwell's Equations

**UNIT-II**

a) Interference due to division of amplitude and division of wave fronts, Young's double slit Experiment, Principle of Superposition, Theory of Biprism, Newtons' Rings.
b) LASER: Introduction, Temporal and Spatial Coherence, Principle of LASER, Stimulated and spontaneous emission. Einstein's Coefficients, He-Ne Laser, Ruby Laser, Applications of Lasers.

## SECTION B: BASICS OF BIOLOGY (02 CREDITS)

**UNIT-I**

a) **Animal and Plant Kingdom**
Salient features and classification of plants into major groups - Algae, Bryophyta, Pteridophyta, Gymnospermae and Angiospermae. Salient features and classification of animals, non-chordates up to phyla level and chordates up to class.

a) **Cell-The Unit of Life**
Cell as the basic unit of life: Structure of prokaryotic and eukaryotic cells; Plant cell and animal cell; Cell envelope, cell membrane, cell wall; Cell organelles - structure and function. Elementary idea of cell cycle, mitosis, meiosis and their significance.

b) **Biomolecules**
Chemical constituents of living cells: biomolecules, structure and function of proteins, carbohydrates, lipids, nucleic acids.

**UNIT-II**

**a) Human and Plant Physiology**
Plant: basic concepts of transport, photosynthesis, respiration and reproduction in higher plants.
Human: Basic concepts of digestion and absorption; respiration, body fluids and circulation; excretion, nervous system, and reproduction.

b) **Basic Principles of Inheritance and Variation**
Mendelian Inheritance; Deviations from Mendelism-Incomplete dominance, Co-dominance, Multiple alleles and Inheritance of blood groups, Pleiotropy; Elementary idea of polygenic inheritance; Chromosome theory of inheritance; Chromosomes and genes;

**Suggested Reading**


1. Ajoy Ghatak, Optics, TMH
2. D.S.Mathur, Mechanics
3. Griffith, Electrodynamics
4. Brij Lal and Subramaniyam, Optics

# Generic Elective

**SEMESTER I**
**PAPER CODE: BSC-GE01TH B**
**PAPER TITLE: BASICS OF PHYSICS AND MATHEMATICS**

**TOTAL HOURS: 60** **CREDITS: 04**

## SECTION A: BASICS OF PHYSICS (02 CREDITS)

**UNIT-I**

a) Oscillations: Periodic motion, time period, frequency, Simple Harmonic Motion (SHM) and its equations, phase, restoring force, Kinetic Energy and Potential Energy in SHM.
b) Electromagnetic waves: Electromagnetic Spectrum, Electromagnetic waves and their characteristics, Maxwell's Equations

**UNIT-II**

a) Interference due to division of amplitude and division of wave fronts, Young's double slit Experiment, Principle of Superposition, Theory of Biprism, Newtons' Rings.
b) LASER: Introduction, Temporal and Spatial Coherence, Principle of LASER, Stimulated and spontaneous emission. Einstein's Coefficients, He-Ne Laser, Ruby Laser, Applications of Lasers.

## SECTION B: BASICS OF MATHEMATICS (02 CREDITS)

**UnitI**: **Matrices and Determinants**

**Matrices**: Concept, notation, order, equality, types of matrices, zero and identity matrix, transpose of a matrix, symmetric and skew symmetric matrices. Operation on matrices: Addition and multiplication and multiplication with a scalar. Simple properties of addition, multiplication and scalar multiplication.

**Determinants**: Determinant of a square matrix (up to 3 x 3 matrices), properties of determinants, minors, co-factors and applications of determinants in finding the area of a triangle. Adjoint and inverse of a square matrix.

**Unit II: Calculus**

**Continuity and Differentiability:** Continuity and Derivative, derivative of composite functions, chain rule, derivative of implicit functions. Concept of exponential and logarithmic functions.
Derivatives of logarithmic and exponential functions. Logarithmic differentiation, derivative of functions expressed in parametric forms. Second order derivatives.

**Integrals:** Integration as inverse process of differentiation. Integration of a variety of functions by substitution, by partial fractions and by parts, Evaluation of simple integrals of the following types and problems based on them. Definite integrals as a limit of a sum, Basic properties of definite integrals and evaluation of definite integrals.

**Differential Equations:**Definition, order and degree, general and particular solutions of a differential equation. Formation of differential equation whose general solution is given.

**Suggested Reading**


1. Ajoy Ghatak, Optics, TMH
2. D.S.Mathur, Mechanics
3. Griffith, Electrodynamics
4. Brij Lal and Subramaniyam, Optics

# SEMESTER II

| Core Papers | Generic Electives |
|---|---|
| BCH-CC3TH (4 C)<br>BCH-CC3 PR (2 C) | GE2 (6 C)*option is available for 6 credit transfer from MOOCs/SWAYAM platform* |
| BCH-CC4TH (4 C)<br>BCH-CC4 PR (2 C) | |
| BCH-CC5 TH (4 C)<br>BCH-CC5 PR (2 C) | |

| SEMESTER – II<br>INORGANIC CHEMISTRY – I |
|---|
| PAPER CODE: BCH-CC03 TH<br>PAPER TITLE: CHEMISTRY OF S AND P BLOCK ELEMENTS |
| Total Credit: 4Total Lectures: 60 |
| |

**Objectives:** The course will be a "walk" through the periodic table with focus on the main group elements. This includes a brief history of the respective element, a description of the most important compounds (*syntheses, structures, physical properties and reactivities*) and a discussion of trends within the different groups.

**Course Learning Objectives:**

**On completion of the course, the student will be able to:**

**CLO 1** Understand the methods of mineral beneficiation and preliminary techniques of transition from ore to metal. (Cognitive level – understand)

**CLO 2** Understand the periodic behavior of s and p block elements related to their electronic structure and their reactivity is included the principles governing their reactivity, periodic properties like electronegativity, electron affinity, atomic and ionic radii etc. (Cognitive level – understand)

**CLO 3** Analyse the nature of bonding in compounds of the main group elements including oxides, hydrides, nitrides, interhalogens, noble gases and inorganic polymers. (Cognitive level – analyse)

**CLO 4** Analyse the physical and chemical behaviour of alkali and alkaline earth metals. (Cognitive level – analyse)

**CLO 5** Describe the structure of boranes, lewis acid nature of boron trihalides, synthesis of silicones, preparation & industrial applications of nitride, preparations & applications of polymeric phosphonitrilic compounds. (Cognitive level – evaluate)

**CLO 6** Describe fundamental aspects of main group chemistry, including trends in oxidation states and compound and complex formation tendency. Describe the variety of different methods for synthesizing inorganic materials and principles of inorganic polymer synthesis. (Cognitive level – evaluate)

**CLO 7** synthesize the complexes. (Cognitive level: synthesis)

**Mapping of CLOs with PLOs**

| | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 | CLO-6 | CLO-7 |
|---|---|---|---|---|---|---|---|
| PLO-1 | 2 | 2 | 3 | 3 | 3 | 2 | 3 |
| PLO-2 | 2 | 3 | 3 | 2 | 3 | 3 | 2 |
| PLO-3 | 2 | 2 | 3 | 2 | 2 | 2 | 3 |
| PLO-4 | 3 | 3 | 2 | 2 | 2 | 2 | 3 |
| PLO-5 | 3 | 3 | 2 | 3 | 2 | 3 | 2 |
| PLO-6 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| PLO-7 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| PSO-1 | 2 | 2 | 3 | 3 | 3 | 3 | 2 |
| PSO-2 | 2 | 2 | 2 | 3 | 2 | 3 | 2 |
| PSO-3 | 3 | 3 | 3 | 3 | 3 | 2 | 3 |
| PSO-4 | 3 | 3 | 3 | 2 | 2 | 2 | 2 |
| PSO-5 | 2 | 3 | 2 | 2 | 2 | 2 | 2 |
| PSO-6 | 2 | 2 | 2 | 2 | 3 | 3 | 2 |
| PSO-7 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| PSO-8 | 3 | 3 | 2 | 3 | 2 | 3 | 3 |
| PSO-9 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

# Core paper

## Semester II

### PAPER CODE: BCH-CC3 TH

### PAPER TITLE: CHEMISTRY OF S AND P-BLOCK ELEMENTS

**TOTAL HOURS: 60** **CREDITS: 04**

**UNIT I: GENERAL PRINCIPLES OF METALLURGY [15Hours]**

Chief modes of occurrence of metals based on standard electrode potentials. Ellingham diagrams for reduction of metal oxides using carbon and carbon monoxide as reducing agent. Electrolytic Reduction, Hydrometallurgy with reference to cyanide process for silver and gold. Methods of purification of metals: Electrolytic process, van Arkel-de Boer process and Mond's process, Zone refining.

**UNIT II : CHEMISTRY OF *S* BLOCK ELEMENTS [15Hours]**

- General characteristics: melting point, flame colour, reducing nature, diagonal relationships and anomalous behaviour of first member of each group.
- Reactions of alkali and alkaline earth metals with oxygen, hydrogen, nitrogen and water.
- Common features such as ease of formation, thermal stability and solubility of the following alkali and alkaline earth metal compounds: hydrides, oxides, peroxides, superoxides, carbonates, nitrates, sulphates.
- Complex formation tendency of s-block elements; structure of the following complexes: crown ethers and cryptates of Group I; basic beryllium acetate, beryllium nitrate, EDTA complexes of calcium and magnesium.
- Solutions of alkali metals in liquid ammonia and their properties.

**UNIT III CHEMISTRY OF *P* BLOCK ELEMENTS [15Hours]**

Electronic configuration, atomic and ionic size, metallic/non-metallic character, melting point, ionization enthalpy, electron gain enthalpy, electronegativity, Allotropy of C, P, S; inert pair effect, diagonal relationship between B and Si and anomalous behaviour of first member of each group.

**UNIT IV [15Hours]**

**A: Structure, bonding and properties: acidic/basic nature, stability, ionic/covalent nature,oxidation/reduction, hydrolysis, action of heat of the following.**

- Hydrides: hydrides of Group 13 (only diborane), Group 14, Group 15 (EH3 where E N, P, As, Sb, Bi), Group 16 and Group 17.
- Oxides: oxides of phosphorus, sulphur and chlorine
- Oxoacids: oxoacids of phosphorus and chlorine; peroxoacids of sulphur
- Halides: halides of silicon and phosphorus

**B: Preparation, properties, structure and uses of the following compounds:**

- Borazine
- Silicates, silicones,
- Phosphonitrilic halides {(PNCl2)n where n = 3 and 4}
- Interhalogen and pseudohalogen compounds
- Clathrate compounds of noble gases, xenon fluorides (MO treatment of XeF2).

**Suggested Reading**


1. Lee, J.D. Concise Inorganic Chemistry, Pearson Education 2010
2. Douglas, B.E; Mc Daniel, D.H. & Alexander, J.J. *Concepts & Models of Inorganic Chemistry 3 rd Ed.*, John Wiley Sons, N.Y. 1994.
3. Greenwood, N.N. & Earnshaw. *Chemistry of the Elements*, Butterworth- Heinemann 1997.
4. Cotton, F.A. & Wilkinson, G. *Advanced Inorganic Chemistry*, Wiley, VCH, 1999.
5. Miessler, G. L. & Donald, A. Tarr. *Inorganic Chemistry 3rd Ed.(adapted)*, Pearson, 2009Shriver, D.F., Atkins P.

# Core paper

**SEMESTER II**
**INORGANIC CHEMISTRY I**
**PAPER CODE: BCH-CC3 PR**
**TITLE: S- AND P-BLOCK ELEMENTS**

**TOTAL HOURS: 60** **CREDITS: 02**

**(A) Iodo / Iodimetric Titrations**

(i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).
(ii) Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodimetrically
(iii) Estimation of available chlorine in bleaching powder iodometrically.

**(B) Inorganic preparations**

(i) Cuprous Chloride, $Cu2Cl_2$
(ii) Preparation of Manganese(III) phosphate, $MnPO_4.H_2O$
(iii) Preparation of Aluminium potassium sulphate $KAl(SO_4)2.12H_2O$ (Potash alum) orChrome alum.

***Suggested Reading:***


- Mendham, J., *A. I. Vogel's Quantitative Chemical Analysis 6th Ed.,* Pearson, 2009.


**Teaching Learning Process:**

- Lectures in classrooms
- Peer learning
- Hands-on learning using videos, presentations, seminars
- Technology-driven Learning

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes.
  - Presentations, assignments, group discussions, projects, viva-voce to enhance critical thinking skills and personality.
- Semester-end Examination: a critical indicator of students's learning and teaching methods adopted by teachers throughout the semester.


**Keywords:**
Metallurgy, Periodic table, diagonal relationships, anomalous behavior, compounds of alkali metals, compounds of alkaline earth metals, periodic properties, allotropy, silicates, silicones, Phosphonitrilic halides, Interhalogen compounds, pseudohalogen compounds and Clathrate compounds.

| SEMESTER II<br>PHYSICAL CHEMISTRY-I |
|---|
| PAPER CODE: BCH-CC04<br>PAPER TITLE: STATES OF MATTER & IONIC EQUILIBRIUM |
| Total Credits: 4 Total Lectures: 60 |

**Objectives:**The core course physical chemistry-I is designed to strengthen the basic and fundamental concepts of physical chemistry. The course is imbued with the applications of these concepts, gaseous, liquid and solid state and ionic equilibria and their physical properties concepts are introduced.

**Course Learning Objectives:**

**On completion of the course, the student will be able to:**

1. Understand and explain the different nature and behavior of solid, liquid and gaseous states based on fundamental concepts learnt (Remember and understand).
2. Learn and understand the kinetic molecular theory of gases including collision frequency, collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence (Remember and understand).
3. Formulate the molecular understanding and determination of the physical properties of common liquids by recalling and correlating the fundamental changes in their properties by the addition of solutes (Analyze and apply).
4. Analyse and read powder diffraction crystallographic patterns of common salts (NaCl, CsCl and KCl) using Bragg's law (rotating crystal and powder pattern method) (Analyze and apply).
5. Use the fundamental symmetry concepts to identify and analyse various symmetry elements and symmetry operations, the qualitative idea of point and space groups (Analyze and apply).
6. Use the fundamental ionic equilibria concepts to understand various chemical transformations in the laboratory and in our day to day life (Analyze and apply).

**Mapping of CLOs with PLOS**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 | CLO 5 | CLO 6 |
|---|---|---|---|---|---|---|
| PLO1. | 3 | 3 | 2 | 2 | 2 | 2 |
| PLO2. | 3 | 3 | 2 | 2 | 2 | 2 |
| PLO3. | 3 | 3 | 2 | 2 | 2 | 2 |
| PLO4. | 2 | 3 | 3 | 3 | 2 | 2 |
| PLO5. | 2 | 2 | 3 | 3 | 3 | 2 |
| PLO6. | 2 | 2 | 2 | 2 | 3 | 3 |
| PLO7. | 2 | 2 | 2 | 2 | 3 | 3 |
| PSO 1. | 3 | 3 | 2 | 2 | 2 | 2 |
| PSO 2. | 3 | 3 | 2 | 2 | 2 | 2 |
| PSO 3. | 3 | 3 | 3 | 3 | 2 | 2 |
| PSO 4. | 2 | 2 | 2 | 2 | 3 | 3 |
| PSO 5. | 2 | 2 | 3 | 3 | 3 | 2 |
| PSO 6. | 2 | 2 | 2 | 2 | 3 | 3 |
| PSO 7. | 2 | 2 | 2 | 2 | 3 | 3 |
| PSO 8. | 2 | 2 | 2 | 2 | 2 | 3 |
| PSO 9. | 2 | 2 | 2 | 2 | 2 | 3 |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

# Core paper

## PAPER CODE: BCH-CC4 TH

**PAPER TITLE: STATES OF MATTER & IONIC EQUILIBRIUM**
**PHYSICAL CHEMISTRY-I**
**SEMESTER II**

**TOTAL HOURS: 60** **CREDITS: 04**

**UNIT I: GASEOUS STATE** **[22 Lectures]**

Kinetic molecular model of a gas: postulates and derivation of the kinetic gas equation; collision frequency; collision diameter; mean free path and viscosity of gases, including their temperature and pressure dependence, the relation between mean free path and coefficient of viscosity, calculation of σ from η; variation of viscosity with temperature and pressure. Maxwell distribution and its use in evaluating molecular velocities (average, root mean square and most probable) and average kinetic energy, law of equipartition of energy, degrees of freedom and molecular basis of heat capacities. The behaviour of real gases: Deviations from ideal gas behaviour, compressibility factor, Z, and its variation with pressure for different gases. Causes of deviation from ideal behaviour. van der Waals equation of state, its derivation and application in explaining real gas behaviour, mention of other equations of state (Berthelot, Dietrici); virial equation of state; van der Waals equation expressed in virial form and calculation of Boyle temperature. Isotherms of real gases and their comparison with van der Waals isotherms, continuity of states, critical state, relation between critical constants and van der Waals constants, law of corresponding states.

**UNIT II: LIQUID STATE** **[10 Lectures]**

Qualitative treatment of the structure of the liquid state; Radial distribution function; physical properties of liquids; vapour pressure, surface tension and coefficient of viscosity, and their determination. Effect of addition of various solutes on surface tension and viscosity. Explanation of cleansing action of detergents. Temperature variation of viscosity of liquids and comparison with that of gases. Qualitative discussion of the structure of water.

**UNIT III: SOLID STATE** **[10 Lectures]**

Nature of the solid-state, law of constancy of interfacial angles, the law of rational indices, Miller indices, elementary ideas of symmetry, symmetry elements and symmetry operations, the qualitative idea of point and space groups, seven crystal systems and fourteen Bravais lattices; X-ray diffraction, Bragg's law, a simple account of rotating crystal method and powder pattern method. Analysis of powder diffraction patterns of NaCl, CsCl and KCl. Defects in crystals. Glasses and liquid crystals.

**UNIT IV: IONIC EQUILIBRIA** **[18 Lectures]**

Strong, moderate and weak electrolytes, degree of ionization, factors affecting the degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect; dissociation constants of mono-, di-and triprotic acids (exact treatment).

Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions; derivation of Henderson equation and its applications; buffer capacity, buffer range, buffer action and applications of buffers in analytical chemistry and biochemical processes in the human body. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle. Qualitative treatment of acid-base titration curves (calculation of pH at various stages). Theory of acid-base indicators; selection of indicators and their limitations. Multistage equilibria in polyelectrolyte systems; hydrolysis and hydrolysis constants.

**Suggested Reading (Theory)**


1. Atkins, P. W. & Paula, J. de Atkin's Physical Chemistry 10th Ed., Oxford University 12 Press (2014).
2. Ball, D. W. Physical Chemistry Thomson Press, India (2007).
3. Castellan, G. W. Physical Chemistry 4th Ed. Narosa (2004).
4. Mortimer, R. G. Physical Chemistry 3rd Ed. Elsevier: NOIDA, UP (2009).
5. Engel, T. & Reid, P. Physical Chemistry 3rd Ed. Pearson (2013).

# Core paper

**SEMESTER II**
**PHYSICAL CHEMISTRY I**
**PAPER CODE: BCH-CC4 PR**
**TITLE: STATES OF MATTER & IONIC EQUILIBRIUM**

**TOTAL HOURS: 60** **CREDITS: 02**

1. **Surface tension measurements.**
   a) Determine the surface tension by (i) drop number (ii) drop weight method.
   b) Study the variation of surface tension of detergent solutions with concentration.
2. **Viscosity measurement using Ostwald's viscometer.**
   a) Determination of viscosity of aqueous solutions of (i) polymer (ii) ethanol and (iii) sugar at room temperature.
   b) Study the variation of viscosity of sucrose solution with the concentration of solute.
3. **Indexing of a given powder diffraction pattern of a cubic crystalline system.**
4. **pH metry.**
   a) Study the effect on pH of addition of HCl/ NaOH to solutions of acetic acid, sodium acetate and their mixtures.
   b) Preparation of buffer solutions of different pH.
   c) Sodium acetate-acetic acid.
   d) Ammonium chloride-ammonium hydroxide.
   e) pH metric titration of (i) strong acid vs. strong base, (ii) weak acid vs. strong base.
   f) Determination of dissociation constant of a weak acid.

**Suggested Reading (Practical)**


1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry8th Ed.; McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W. H. Freeman & Co.: New York (2003).


**Teaching Learning Process:**

- Lectures in classrooms
- Peer learning
- Hands-on learning using lab practicals, videos, presentations, seminars
- Technology-driven Learning

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments, group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of students's learning and teaching methods adopted by teachers throughout the semester.


**Keywords:**Gaseous state, Liquid state, Solid state, Ionic Equilibria, Surface Tension, Viscosity, Mean free path, Maxwell distribution.

# Core paper

**SEMESTER II**
**ORGANIC CHEMISTRY-I**

**PAPER CODE: BCH-CC05**
**PAPER TITLE: HYDROCARBONS**

**Total Credits: 06 - (BCH-CC05TH -04, BCH-CC05PR -02)**
**Total Lectures: BCH-CC05TH - 60, BCH-CC05PR -60**

**Objectives:** The core course Organic chemistry-I is designed to strengthen the basic and fundamental concepts of organic chemistry. The course is imbued with the applications of these concepts, and the functional groups- alkanes, alkenes, alkynes, and aromatic hydrocarbons and their synthesis and reactivity concepts are introduced.

**Course Learning Objectives:**

**On completion of the course, the student will be able to:**

**CLO 1** Understand and explain the different nature and behavior of organic compounds based on fundamental concepts learned. **(Cognitive level: Remember and understand)**

**CLO 2** Learn and understand many organic reaction mechanisms including Free Radical Substitution, Electrophilic Addition and Electrophilic Aromatic Substitution. **(Cognitive level: Remember and understand)**

**CLO 3** Formulate the mechanism of organic reactions by recalling and correlating the fundamental properties of the reactants involved. **(Cognitive level: Analyze and evaluate)**

**CLO 4** Use the fundamental reactivity concepts to identify and analyze reaction mechanisms including Free Radical Substitution, Electrophilic Addition, and Electrophilic Aromatic Substitution. **(Cognitive level: Analyze and evaluate)**

**CLO 5** Use the fundamental reactivity concepts to bring about chemical transformations in the laboratory and synthesize small molecules useful to society. (**Cognitive level: Apply)**

**Mapping of CLOs with PLOS**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 | CLO 5 |
|---|---|---|---|---|---|
| **PLO8.** | **3** | **3** | **2** | **2** | **2** |
| **PLO9.** | **3** | **3** | **2** | **2** | **2** |
| **PLO10.** | **3** | **3** | **2** | **2** | **2** |
| **PLO11.** | **2** | **3** | **3** | **3** | **2** |
| **PLO12.** | **2** | **2** | **3** | **3** | **3** |
| **PLO13.** | **2** | **2** | **2** | **2** | **3** |
| **PLO14.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 10.** | **3** | **3** | **2** | **2** | **2** |
| **PSO 11.** | **3** | **3** | **2** | **2** | **2** |
| **PSO 12.** | **3** | **3** | **3** | **3** | **2** |
| **PSO 13.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 14.** | **2** | **2** | **3** | **3** | **3** |
| **PSO 15.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 16.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 17.** | **2** | **2** | **2** | **2** | **2** |
| **PSO 18.** | **2** | **2** | **2** | **2** | **2** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

## BCH-CC05TH: Course Contents

**Credits: 04, Laboratory periods: 60**

**UNIT I: CHEMISTRY OF ALIPHATIC HYDROCARBONS [24 Lectures]**

A. **Carbon-Carbon sigma bonds** Chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Wurtz-Fittig Reactions, Free radical substitutions: Halogenation -relative reactivity and selectivity.

B. **Carbon-Carbon pi bonds:** Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations.Reactions of alkenes: Electrophilic additions their mechanisms (Markownikoff/ Anti Markownikoff addition), mechanism of oxymercuration-demercuration, hydroborationoxidation, ozonolysis, reduction (catalytic and chemical), syn and anti-hydroxylation (oxidation). 1,2-and 1,4-addition reactions in conjugated dienes and, Diels-Alder reaction; Allylic and benzylic bromination and mechanism, e.g. propene, 1-butene, toluene, ethyl benzene. Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

**UNIT II: CYCLOALKANES AND CONFORMATIONAL ANALYSIS [08 Lectures]**

Types of cycloalkanes and their relative stability, Baeyer strain theory, Conformation analysis of alkanes: Relative stability: Energy diagrams of cyclohexane: Chair, Boat and Twist boat forms; Relative stability with energy diagrams.

**UNIT III: AROMATIC HYDROCARBONS AROMATICITY [18 Lectures]**

Hückel's rule, aromatic character of arenes, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the groups.

**UNIT IV: POLYNUCLEAR HYDROCARBONS [10 Lectures]**

Aromaticity of polynuclear hydrocarbons, structure elucidation of naphthalene; Preparation and properties of naphthalene, phenanthrene and anthracene.

## PAPER CODE: BCH-CC5 PR: Course contents
## Credits: 2, Laboratory periods: 60

1. **Chromatography**
   a) Separation of a mixture of two amino acids by ascending and horizontal paper chromatography.
   b) Separation of a mixture of two sugars by ascending paper chromatography.
   c) Separation of a mixture of o-and p-nitrophenol or o-and p-aminophenol by thin-layer chromatography (TLC).
2. **Identification of simple organic compounds**
   Functional group tests for alcohols, phenols, carbonyl and carboxylic acid group.
3. **Analysis of simple organic compounds** Analysis of Carbohydrate: aldoses and ketoses, reducing and non-reducing sugars.
   Combustion, reactions with halogens and potassium permanganate, as well as solubility to characterize hydrocarbons.
4. **Organic Preparation:**
   a. Bromination of acetanilide/aniline/phenol
   b. Nitration of nitrobenzene/toluene

**Suggested Reading (Theory)**


- Morrison, R. N.; Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Finar, I. L. Organic Chemistry (Volume 1& 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
- Solomons, T. W. G.; Fryhle, C. B. ; Snyder, S. A. (2016),Organic Chemistry, 12th Edition, Wiley.
- Bruice, P. Y. (2017),Organic Chemistry, 8th Edition, Pearson.
- Clayden, J.; Greeves, N.; Warren, S. (2012), Organic Chemistry, Oxford.


**Suggested Reading (Practicals)**


- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical OrganicChemistry, 5th Ed.*, Pearson (2012)
- Ahluwalia, V.K.; Dhingra, S. (2004), Comprehensive Practical Organic Chemistry: Qualitative Analysis, University Press.
- Vogel's Textbook of Practical Organic Chemistry, Pearson.
- Leonard, J.; Lygo, B.; Procter, G. Advanced Practical Organic Chemistry, CRC Press.


**Teaching Learning Process:**

- Lectures in classrooms
- Peer learning
- Hands-on learning using lab practicals, videos, presentations, seminars
- Technology-driven Learning

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments , Group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.


**Keywords:**
Alkanes, Alkenes, Alkynes,Aromatic Hydrocarbons, Cycloalkanes

# SEMESTER III

| Core Papers | SEC | Generic electives |
|---|---|---|
| BCH-CC6 TH (4 C)<br>BCH-CC6 PR (2 C) | SEC (2C)<br>*Any two from SEC-1 to SEC-6* | GE3 (6 C) *option is available for 6 credit transfer from MOOCs/SWAYAM platform* |
| BCH-CC7 TH (4 C)<br>BCH-CC7 PR (2 C) | | |

**SEMESTER III**
**PHYSICAL CHEMISTRY II**

**PAPER CODE: BCH-CC06**
**PAPER TITLE: PHASE EQUILIBRIA AND CHEMICAL KINETICS**

**Total Credits: 06 - (BCH-CC06TH -04, BCH-CC06PR -02)**
**Total Lectures: BCH-CC06TH - 60, BCH-CC06PR -60**

## Objectives:

The core course Phase Equilibria and Chemical Kinetics is designed to strengthen the basic and fundamental concepts of physical Chemistry. The course is imbued with the applications of these concepts, the chemical equilibrium, phase equilibria, chemical kinetics and concepts of colligative properties are introduced.

## Course Learning Objectives:

**On completion of the course, the student will be able to:**

**CLO 1** Understand and explain the different nature and behavior of chemical and phase equilibria concepts learnt.(Cognitive level: Understand).

**CLO 2** Learn and understand many concepts of degree of freedom, chemical kinetics and solution.(Cognitive level: learn and understand).

**CLO 3** Solving many numerical problems related to prepare solution of different strength. (Cognitive level: Analyze and apply).

**CLO 4** Derive fundamental and applied derivation of chemical equilibria, kinetics and phase equlibria.(Cognitive level: Apply).

**CLO 5** Determination of molecular mass using colligative property.(Cognitive level: Determine).

**Mapping of CLOs with PLOS**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 | CLO 5 |
|---|---|---|---|---|---|
| PLO1. | 3 | 3 | 2 | 2 | 2 |
| PLO2. | 3 | 3 | 2 | 2 | 2 |
| PLO3. | 3 | 3 | 2 | 2 | 2 |
| PLO4. | 2 | 3 | 3 | 2 | 2 |
| PLO5. | 2 | 2 | 3 | 3 | 2 |
| PLO6. | 2 | 2 | 2 | 3 | 3 |
| PLO7. | 2 | 2 | 2 | 3 | 3 |
| PSO1 | 3 | 3 | 2 | 2 | 2 |
| PSO2 | 3 | 3 | 2 | 2 | 2 |
| PSO3 | 3 | 3 | 3 | 2 | 2 |
| PSO4 | 2 | 2 | 2 | 3 | 3 |
| PSO5 | 2 | 2 | 3 | 3 | 2 |
| PSO6 | 2 | 2 | 2 | 3 | 3 |
| PSO7 | 2 | 2 | 2 | 3 | 3 |
| PSO8 | 2 | 2 | 2 | 2 | 3 |
| PSO9 | 2 | 2 | 2 | 2 | 3 |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

## Core paper

**PAPER CODE: BCH-CC6 TH**
**TITLE: PHASE EQUILIBRIA AND CHEMICAL KINETICS**
**PHYSICAL CHEMISTRY II**
**SEMESTER III**

**TOTAL HOURS: 60** **CREDITS: 04**

**UNIT I: CHEMICAL EQUILIBRIUM [15 Hours]**

Criteria of thermodynamic equilibrium, degree of advancement ofreaction, chemical equilibria in ideal gases. Thermodynamic derivation of relation between Gibbs free energy of reaction and reaction quotient. Equilibrium constants and their quantitative dependence on temperature, pressure and concentration (Le Chatelier Principle, Quantitatively)). Free energy of mixing and spontaneity. equilibrium between ideal gases and a pure condensed phase.

**UNIT II: PHASE EQUILIBRIA [15 Hours]**

Concept of phases, components and degrees of freedom, derivation of Gibbs Phase Rule fornon-reactive and reactive systems; Clausius-Clapeyron equation and its applications to solidliquid,liquid-vapour and solid-vapour equilibria, phase diagram for one component systems,with applications.Phase diagrams for systems of solid-liquid equilibria involving eutectic, congruent andincongruent melting points, solid solutions.

Three component systems, water-chloroform-acetic acid system, triangular plots.*Binary solutions:* Gibbs-Duhem-Margules equation, its derivation and applications tofractional distillation of binary miscible liquids (ideal and non-ideal), azeotropes, lever rule,partial miscibility of liquids, CST, miscible pairs, steam distillation.Nernst distribution law: its derivation and applications.

**Unit III: CHEMICAL KINETICS [15 Hours]**

Order and molecularity of a reaction, rate laws in terms of the advancement of a reaction,differential and integrated form of rate expressions up to second order reactions, experimentalmethods of the determination of rate laws, kinetics of complex reactions (integrated rateexpressions up to first order only): (i) Opposing reactions (ii) parallel reactions and (iii)consecutive reactions and their differential rate equations (steady-state approximation inreaction mechanisms) (iv) chain reactions.

Temperature dependence of reaction rates; Arrhenius equation; activation energy. Collisiontheory of reaction rates, Lindemann mechanism, qualitative treatment of the theory ofabsolute reaction rates.

**UNIT IV: SOLUTIONS AND COLLIGATIVE PROPERTIES [15 Hours]**

Dilute solutions; lowering of vapour pressure, Raoult's and Henry's Laws and their applications. Thermodynamic derivation using chemical potential to derive relations between the four colligative properties [(i) relative lowering of vapour pressure (ii) elevation of boiling point, (iii) Depression of freezing point, (iv) osmotic pressure] andamount of solute. Applications in calculating molar masses of normal, dissociated and associatedsolutes in solution.

**Suggested Reading:**


1. Peter Atkins & Julio De Paula, *Physical Chemistry* 10th Ed., Oxford University Press(2014).
2. Castellan, G. W. *Physical Chemistry*, 4th Ed., Narosa (2004).
3. McQuarrie, D. A. & Simon, J. D., *Molecular Thermodynamics*, Viva Books Pvt. Ltd.New Delhi (2004).
4. Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
5. Assael, M. J.; Goodwin, A. R. H.; Stamatoudis, M.; Wakeham, W. A. & Will, S.*Commonly Asked Questions in Thermodynamics.* CRC Press: NY (2011).
6. Zundhal, S.S. *Chemistry concepts and applications* Cengage India (2011).
7. Ball, D. W. *Physical Chemistry* Cengage India (2012).
8. Mortimer, R. G. *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP (2009).
9. Levine, I. N. *Physical Chemistry 6th Ed.,* Tata McGraw-Hill (2011).
10. Metz, C. R. *Physical Chemistry 2nd Ed.*, Tata McGraw-Hill (2009).

# Core paper

**PAPER CODE: BCH-CC6 PR**
**TITLE: PHASE EQUILIBRIA AND CHEMICAL KINETICS**
**PHYSICAL CHEMISTRY- II**
**SEMESTER III**

**TOTAL HOURS: 60** **CREDITS: 02**

**Phase Equibria:**

I. Determination of critical solution temperature and composition at CST of the phenol water system and to study the effect of impurities of sodium chloride and succinic acid on it.
II. Phase equilibria: Construction of the phase diagram using cooling curves or ignition tubemethod: a. simple eutectic and b. congruently melting systems.
III. Distribution of acetic/ benzoic acid between water and chloroform or cyclohexane.
IV. Study the equilibrium of at least one of the following reactions by the distribution method:

a. $I_2(aq) + I^-(aq) \rightarrow I_3(aq)$
b. $Cu^{2+}(aq) + nNH_3 \rightarrow Cu(NH_3)_n^{2+}$

**Potentiometry:**

Perform the following potentiometric titrations: i. Strong acid vs. strong base ii. Weak acid vs. strong base iii. Dibasic acid vs. strong base iv. Potassium dichromate vs. Mohr's salt

***Suggested Reading***


- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011). 25
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.; McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H.Freeman & Co.: New York (2003).


**Teaching Learning Process:**

- Lectures in classrooms
- Peer learning
- Hands-on learning using lab practicals, videos, presentations, seminars
- Technology-driven Learning

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments , Group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

**Keywords:**

Phase Equilibria, Chemical Equilibrium, Chemical Kinetics, Solutions And Colligative Properties

| SEMESTER III<br>ORGANIC CHEMISTRY-II |
| --- |
| **PAPER CODE: BCH-CC07TH**<br>**PAPER TITLE: HALOGENS, OXYGEN AND NITROGEN CONTAINING FUNCTIONAL GROUPS** |
| **Total Credits: 06 - (BCH-CC07TH -04, BCH-CC07PR -02)**<br>**Total Lectures: BCH-CC07TH - 60, BCH-CC07PR -60** |

**Objectives:**The core course Organic chemistry-II is designed to strengthen the basic and fundamental concepts of functional groups and their characteristic physical and chemical properties. The course is permeated with the applications of these concepts of Halogens, Oxygen and Nitrogen containing functional groups, their identification, distinction, synthesis and reactivity concepts are introduced.

**Course Learning Objectives:**

**On completion of the course, the student will be able to:**

**CLO 1.** Understand and explain the different nature and behaviour of organic compounds based on fundamental concepts learnt. (Cognitive level: Understand).

**CLO 2.** Learn and understand many organic reaction mechanisms including Nucleophilic Substitution, Eliminations, Nucleophilic additions, Nucleophilic addition-Eliminations, Grignard reaction, applications of BuLi, Bouvaelt-Blanc Reduction, Pinacol-Pinacolone rearrangement, Oxidative cleavage of glycols by periodic acid and lead tetraacetate, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangement, Darzens epoxidation, Aldol & Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro reaction, Wittig reaction, haloform reaction, Beckmann rearrangement and Benzil-Benzilic acid rearrangement, Baeyer Villiger oxidation, Clemmensen reduction, Wolff-Kishner reduction, reductions using $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC, Michael addition, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmann Bromamide reaction,Curtius rearrangement, Gabriel phthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustivemethylation, Hofmann-elimination reaction, Schotten Baumann reaction, Sandmeyer reaction, Balz-Schiemann reaction. (Cognitive level: Learn and Understand).

**CLO 3.** Formulate the mechanisms of organic reactions by recalling and correlating the fundamental properties of the reactants involved. (Cognitive level: Learn and Understand).

**CLO 4.** Use the fundamental reactivity concepts to identify and analyze reaction mechanisms including Nucleophilic addition, Substitution, Aromatic Nucleophilic substitution, functional group interconversions. (Cognitive level: Learn, Understand and analyze).

**CLO 5.** Practically apply the basic oxidation/reduction reactions for functional group transformations. (Cognitive level: Apply).

**CLO 6.** Apply the fundamental reactivity concepts to bring about chemical transformations in the laboratory and synthesize small molecules useful to society. (Cognitive level: Apply).

**Mapping of CLOs with PLOS**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 | CLO 5 | CLO 6 |
|---|---|---|---|---|---|---|
| **PLO1.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO2.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO3.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO4.** | **2** | **3** | **3** | **2** | **2** | **2** |
| **PLO5.** | **2** | **2** | **3** | **3** | **2** | **2** |
| **PLO6.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PLO7.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 1.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO 2.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO 3.** | **3** | **3** | **3** | **2** | **2** | **2** |
| **PSO 4.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 5.** | **2** | **2** | **3** | **3** | **2** | **2** |
| **PSO 6.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 7.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 8.** | **2** | **2** | **2** | **2** | **3** | **3** |
| **PSO 9.** | **2** | **2** | **2** | **2** | **3** | **3** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

# Core Paper

**SEMESTER III**
**PAPER CODE: BCH-CC7 TH**
**ORGANIC CHEMISTRY-II**
**TITLE: HALOGENS, OXYGEN AND NITROGEN CONTAINING FUNCTIONAL GROUPS**

**TOTAL HOURS: 60** **CREDITS: 04**

**UNIT I: CHEMISTRY OF HALOGENATED HYDROCARBONS: [15 Hours]**

*Alkyl halides:* Methods of preparation, nucleophilic substitution reactions – $SN_1$, $SN_2$ and SNi mechanisms with stereochemical aspects and effect of solvent etc.; nucleophilic substitution vs. elimination.
*Aryl halides:* Preparation, including preparation from diazonium salts. nucleophilic aromatic substitution; SNAr, Benzyne mechanism.
Relative reactivity of alkyl, allyl/benzyl, vinyl and aryl halides towards nucleophilic substitution reactions.
Organometallic compounds of Mg and Li – Use in synthesis of organic compounds.

**UNIT II: ALCOHOLS, PHENOLS, ETHERS AND EPOXIDES AND CARBONYL COMPUNDS [15 Hours]**

*Alcohols:* preparation, properties and relative reactivity of 1°, 2°, 3° alcohols, Bouvaelt-Blanc Reduction; Preparation and properties of glycols: Oxidation by periodic acid and lead tetraacetate, Pinacol-Pinacolone rearrangement;
*Phenols:* Preparation and properties; Acidity and factors effecting it, Ring substitution reactions, Reimer–Tiemann and Kolbe's–Schmidt Reactions, Fries and Claisen rearrangements with mechanism;
*Ethers and Epoxides:* Preparation and reactions with acids. Reactions of epoxides with alcohols, ammonia derivatives and $LiAlH_4$
*Carbonyl compounds:* Structure, reactivity and preparation; Nucleophilic additions, Nucleophilic addition-elimination reactions with ammonia derivatives with mechanism; Mechanisms of Aldol and Benzoin condensation, Knoevenagel condensation, Claisen-Schmidt, Perkin, Cannizzaro and Wittig reaction, Beckmann and Benzil-Benzilic acid rearrangements, haloform reaction and Baeyer Villiger oxidation, α-substitution reactions, oxidations and reductions (Clemmensen, Wolff-Kishner, $LiAlH_4$, $NaBH_4$, MPV, PDC and PGC);Addition reactions of unsaturated carbonyl compounds: Michael addition. Active methylene compounds: Keto-enol tautomerism. Preparation and synthetic applications of diethyl malonate and ethyl acetoacetate.

**UNIT III: CARBOXYLIC ACIDS AND THEIR DERIVATIVES [15 Hours]**

Preparation, physical properties and reactions of monocarboxylic acids: Typical reactions of dicarboxylic acids, hydroxy acids and unsaturated acids: succinic/phthalic, lactic, malic, tartaric, citric, maleic and fumaric acids; Preparation and reactions of acid chlorides, anhydrides, esters and amides; Comparative study of nucleophilic sustitution at acyl group -Mechanism of acidic and alkaline hydrolysis of esters, Claisen condensation, Dieckmann and Reformatsky reactions, Hofmannbromamide degradation and Curtius rearrangement.

**Sulphur containing compounds:**

Preparation and reactions of thiols, thioethers and sulphonic acids.

**UNIT IV: NITROGEN CONTAINING FUNCTIONAL GROUPS [15 Hours]**

Preparation and important reactions of nitro and compounds, nitriles and isonitriles
Amines: Effect of substituent and solvent on basicity; Preparation and properties: Gabrielphthalimide synthesis, Carbylamine reaction, Mannich reaction, Hoffmann's exhaustive methylation, Hofmann-elimination reaction; Distinction between 1°, 2°and 3°amines with Hinsberg reagent and nitrous acid.
Diazonium Salts: Preparation and their synthetic applications.

**Suggested Readings**


1. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India) Pvt.Ltd. (Pearson Education).
2. Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd.=(Pearson Education).
3. Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.  McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage Learning India Edition, 2013.

# Core Paper

**SEMESTER III**
**ORGANIC CHEMISTRY II**
**PAPER CODE: BCH-CC7 PR**
**TITLE: HALOGEN, OXYGEN AND NITROGEN CONTAINING FUNCTIONAL GROUPS**

**TOTAL HOURS: 60** **CREDITS: 02**

## Organic preparations:

i. Acetylation of one of the following compounds: amines (aniline, *o*-, *m*-, *p*toluidinesand *o*-, *m*-, *p*-anisidine) and phenols (β-naphthol, vanillin, salicylic acid) by any one method:
   a. Using conventional method.
   b. Using green approach

ii. Benzolyation of one of the following amines (aniline, *o*-, *m*-, *p*- toluidines and *o*-,*m*-, *p*-anisidine) and one of the following phenols (β-naphthol, resorcinol, pcresol)by Schotten-Baumann reaction.

iii. Oxidation of ethanol/ isopropanol (Iodoform reaction).

iv. Bromination of any one of the following:
   a. Acetanilide by conventional methods
   b. Acetanilide using green approach (Bromate-bromide method)

v. Nitration of any one of the following:
   a. Acetanilide/nitrobenzene by conventional method
   b. Salicylic acid by green approach (using ceric ammonium nitrate).

vi. Selective reduction of *meta* dinitrobenzene to *m*-nitroaniline.

vii. Reduction of *p*-nitrobenzaldehyde by sodium borohydride.

viii. Hydrolysis of amides and esters.

ix. Semicarbazone of any one of the following compounds: acetone, ethyl methylketone, cyclohexanone, benzaldehyde.

x. *S*-Benzylisothiouronium salt of one each of water soluble and water insoluble acids(benzoic acid, oxalic acid, phenyl acetic acid and phthalic acid).

xi. Aldol condensation using either conventional or green method.

xii. Benzil-Benzilic acid rearrangement.

The compounds prepared may be used for recrystallization, melting point and TLC.

**Reference Books**


- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
- Furniss, B.S., Hannaford, A.J., Smith, P.W.G. & Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.* Pearson (2012)
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry:Preparation and Quantitative Analysis,* University Press (2000).


**Teaching Learning Process:**

- Lectures in classrooms
- Peer learning
- Hands-on learning using lab practical's, videos, presentations, seminars
- Technology-driven Learning

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments, Group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

**Keywords:** Functional groups, Halogens, Oxygen, Nitrogen

# SEMESTER IV

| Core papers | DSE | GE |
|---|---|---|
| BCH-CC8 TH (4 C)<br>BCH-CC8 PR (2 C) | DSE TH (4 C)<br>DSE PR (2 C)<br>(Any one from DSE I-IX) | GE4 (6 C) *option is available for 6 credit transfer from MOOCs/SWAYAM platform* |
| BCH-CC9 TH (4 C)<br>BCH-CC9 PR (2 C) | | |

**SEMESTER IV**
**INORGANIC CHEMISTRY – II**
**PAPER CODE: BCH-CC8 PR**
**PAPER TITLE: COORDINATION CHEMISTRY**
**Total Credits: 02Total Lectures: 60**

**Objectives:**The transition metals have a special property of forming coordination complexes. This is due to the high charge to mass ratio and the availability of d-orbitals. The advances in coordination chemistry provide various complex compounds that we use in various industries. These include mining & metallurgy, medical sciences etc. to name a few. Many of the biological compounds are coordination complexes e.g., haemoglobin, myoglobin, chlorophyll etc. There are numerous other coordination compounds that play an important role in biological processes.

**Course Learning Objectives:**

**At the end of this semester, each student will be able to:**

**CLO 1** Understand the role of metals and metal complexes in biological system. (Cognitive level – understand)
**CLO 2** Understand the lanthanide chemistry and the principle of the separation of the lanthanide ions based on ion-exchange chromatography. (Cognitive level – understand)
**CLO 3** Understand the procedure for the preparation of the transition metal complexes and examine the change in the physical state of the reaction mixture during analysis. (Cognitive level - analyse)
**CLO 4** Analyse the standard reduction potentials of some transition metal ions in different oxidation state and draw the Ellingham diagram. (Cognitive level – analyse)
**CLO 5** Discuss the key features of coordination compounds including the variety of structures, oxidation numbers, electronic configurations, coordination numbers, ligands field, chelates bonding, stability of complexes. (Cognitive level – evaluate)
**CLO 6** Discuss the electronic configuration, oxidation states, lanthanide contractions, magnetic properties and electronic spectra of the lanthanides and actinides. (Cognitive level – evaluate)
**CLO 7** Describe Werner's theory, valence bond theory, crystal field theory of coordination compounds and explain isomerism in coordination compounds. (Cognitive level – evaluate)
**CLO 8** Explain the chemical properties of the coordination complexes of the transition metal ions in different oxidation states. (Cognitive level – create)
**CLO 9** Develop a methodology for the complex formation of different transition metal ions. (Cognitive level – create)

**Mapping of CLOs with PLOs**

| | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 | CLO-6 | CLO-7 | CLO-8 | CLO-9 |
|---|---|---|---|---|---|---|---|---|---|
| **PLO1.** | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 | 3 |
| **PLO2.** | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 3 |
| **PLO3.** | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 2 |
| **PLO4.** | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 3 |
| **PLO5.** | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 3 | 3 |
| **PLO6.** | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 3 | 3 |
| **PLO7.** | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PSO 1.** | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 3 |
| **PSO 2.** | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 |
| **PSO 3.** | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PSO 4.** | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 | 3 |
| **PSO 5.** | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 3 |
| **PSO 6.** | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 | 3 |
| **PSO 7.** | 3 | 2 | 2 | 3 | 2 | 3 | 3 | 3 | 3 |
| **PSO 8.** | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 |
| **PSO 9.** | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

## Core paper

**SEMESTER IV**
**INORGANIC CHEMISTRY II**
**PAPER CODE: BCH-CC8 TH**
**TITLE: COORDINATION CHEMISTRY**

**TOTAL HOURS: 60** **CREDITS: 04**

### UNIT I: COORDINATION CHEMISTRY [20 Hours]

Werner's theory, valence bond theory (inner and outer orbital complexes), electroneutrality principle and back bonding. Crystal field theory, measurement of 10 Dq (Δo), CFSE in weak and strong fields, pairing energies, factors affecting the magnitude of 10 Dq (Δo, Δt).
Octahedral vs. tetrahedral coordination, tetragonal distortions from octahedral geometry Jahn-Teller theorem, square planar geometry. Qualitative aspect of Ligand field and MO Theory.
IUPAC nomenclature of coordination compounds, isomerism in coordination compounds. Stereochemistry of complexes with 4 and 6 coordination numbers. Chelate effect, polynuclear complexes, Labile and inert complexes.

### UNIT II: TRANSITION ELEMENTS [15 Hours]

General group trends with special reference to electronic configuration, colour, variable valency, magnetic and catalytic properties, ability to form complexes. Stability of various oxidation states and e.m.f. (Latimer & Bsworth diagrams). Difference between the first, second and third transition series. Chemistry of Ti, V, Cr Mn, Fe and Co in various oxidation states (excluding their metallurgy).

### UNIT III: LANTHANOIDS AND ACTINOIDS [10 Hours]

Electronic configuration, oxidation states, colour, spectral and magnetic properties, lanthanide contraction, separation of lanthanides (ion-exchange method only).

### UNIT IV: BIOINORGANIC CHEMISTRY [15 Hours]

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals.
Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine.
Iron and its application in bio-systems, Haemoglobin; Storage and transfer of iron.

**Suggested Reading:**


1. Purcell, K.F & Kotz, J.C. *Inorganic Chemistry* W.B. Saunders Co, 1977.
2. Huheey, J.E., *Inorganic Chemistry*, Prentice Hall, 1993.
3. Lippard, S.J. & Berg, J.M. *Principles of Bioinorganic Chemistry* Panima Publishing
4. Company 1994.
5. Cotton, F.A. & Wilkinson, G, *Advanced Inorganic Chemistry* Wiley-VCH, 1999
6. Basolo, F, and Pearson, R.C. *Mechanisms of Inorganic Chemistry*, John Wiley &
7. Sons, NY, 1967.
8. Greenwood, N.N. & Earnshaw A. *Chemistry of the Elements*, Butterworth-Heinemann, 1997.

# Core paper

**SEMESTER IV**
**INORGANIC CHEMISTRY II**
**PAPER CODE: BCH-CC8 PR**
**TITLE: COORDINATION CHEMISTRY**

**TOTAL HOURS: 60** **CREDITS: 02**

**Gravimetric Analysis:** **[20 Hours]**

1. Estimation of nickel (II) using Dimethylglyoxime (DMG).
2. Estimation of copper as CuSCN
3. Estimation of iron as Fe2O3 by precipitating iron as Fe(OH)3.
4. Estimation of Al(III) by precipitating with oxine and weighing as Al(oxine)3(aluminiumoxinate).

**Inorganic Preparations:** **[20 Hours]**

1. Tetraamminecopper (II) sulphate, $[Cu(NH_3)_4]SO_4.H_2O$
2. Acetylacetonate complexes of $Cu^{2+}/Fe^{3+}$
3. Tetraamminecarbonatocobalt (III) nitrate
4. Potassium tri(oxalato)ferrate(III)

**Properties of Complexes** **[20Hours]**

Measurement of 10 Dq by spectrophotometric method

1. Verification of spectrochemical series.
2. Synthesis of ammine complexes of Ni(II) and its ligand exchange reactions (e.g.
3. Bidentate ligands like acetylacetone, DMG, glycine) by substitution method.

***Suggested Reading***


- Vogel, A.I. A text book of Quantitative Analysis, ELBS 1986.
- G. Marr and B.W. Rockett, Practical Inorganic Chemistry, Van Nostrand Reinhold. 1972


**Teaching Learning Process:**

- Lectures in classrooms
- Peer learning
- Hands-on learning using videos, presentations, seminars.
- Technology-driven Learning

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments, group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of students' learning and teaching methods adopted by teachers throughout the semester.


**Keywords:**

Werner's theory, electroneutrality principle, CFSE, Jahn-Teller theorem, nomenclature, isomerism, Chelate effect, Latimer & Bsworth diagrams, oxidation states, lanthanide, Metal ions in biological systems, gravimetric analysis, Inorganic synthesis, coordination complexes.

**SEMESTER IV**
**ORGANIC CHEMISTRY III**
**PAPER CODE: BCH-CC9 TH**
**TITLE: HETEROCYCLIC AND NATURAL PRODUCT CHEMISTRY**

**Total hours: 60 Hours** **Credit :04**

**Objective:** Learnthe heterocyclic compound and their abundance in nature as scaffolds of interest in medicinal and material sciences. Criteria for the classification of natural products and understand their biological role. Introduction of various methods for the construction of heterocyclic scaffolds and famous scientists worked in the fields of chemistry through their synthesis. Correlating the material and biological importance with their molecular structures, biosynthesis and chemical synthesis.

**Course Learning objectives:**

On completion of this course the students will be able to:

**CLO 1** Understand classification of natural products on the basis of source, properties and uses (**Learn and Understand**)

**CLO 2** Learn the key synthesis for the construction of various scaffolds. Methods for the determination of their structures and chracterstics. (**Understand and differentiate**)

**CLO 3** Explain and correlate the methods, reactions and their mechanism for the elucidations of famous natural products (**explain and correlate)**

**CLO 4** Understand the biosynthetic pathways for the design of various routes for achieving the synthesis of notable structures(**Understand and correlate**)

**CLO 5** Analyze the biological systems on the basis of their basic units (small molecules). (**learn, apply and modify**)

**Mapping of CLOs with PLOs**

| | CLO1 | CLO2 | CLO3 | CLO4 | CLO5 |
|---|---|---|---|---|---|
| **PLO1.** | 3 | 3 | 3 | 2 | 2 |
| **PLO2.** | 2 | 3 | 3 | 3 | 2 |
| **PLO3.** | 2 | 2 | 3 | 3 | 2 |
| **PLO4.** | 2 | 2 | 2 | 3 | 3 |
| **PLO5.** | 1 | 2 | 2 | 2 | 3 |
| **PLO6.** | 1 | 1 | 1 | 2 | 3 |
| **PLO7.** | 1 | 1 | 1 | 2 | 3 |
| **PSO 1.** | 3 | 3 | 3 | 2 | 2 |
| **PSO 2.** | 2 | 3 | 3 | 3 | 2 |
| **PSO 3.** | 2 | 2 | 3 | 3 | 2 |
| **PSO 4.** | 2 | 2 | 2 | 3 | 2 |
| **PSO 5.** | 2 | 2 | 2 | 2 | 3 |
| **PSO 6.** | 2 | 2 | 2 | 2 | 3 |
| **PSO 7.** | 1 | 2 | 2 | 2 | 3 |
| **PSO 8.** | 1 | 1 | 2 | 2 | 3 |
| **PSO 9.** | 1 | 1 | 1 | 2 | 3 |

## Core paper

**SEMESTER IV**
**ORGANIC CHEMISTRY III**
**PAPER CODE: BCH-CC9 TH**
**TITLE: HETEROCYCLIC AND NATURAL PRODUCT CHEMISTRY**

**TOTAL HOURS: 60** **CREDITS: 04**

### UNIT I: HETEROCYCLIC COMPOUNDS [16 Hours]

Classification and nomenclature, structure, aromaticity in 5-numbered and 6-membered ringscontaining one heteroatom; synthesis, reactions and mechanism of substitution reactions of:furan, pyrrole (paal-knorr synthesis, knorr pyrrole synthesis, hantzsch synthesis),thiophene, pyridine (hantzsch synthesis), pyrimidine, structure elucidation of indole,fischer indole synthesis and madelung synthesis), structure elucidation of quinoline and isoquinoline, skraup synthesis, friedlander's synthesis, knorr quinoline synthesis, doebner- miller synthesis, bischler-napieralski reaction, pictet-spengler reaction, pomeranz-fritsch reactionderivatives of furan: furfural and furoic acid.

### UNIT II: ALKALOIDS [15 Hours]

Natural occurrence, General structural features, Isolation and their physiological actionHoffmann'sexhaustive methylation, Emde's modification, Structure elucidation andsynthesis of Hygrine and Nicotine. Medicinal importance of Nicotine, Hygrine, Quinine,Morphine, Cocaine, and Reserpine.

### UNIT III: TERPENES [15 Hours]

Occurrence, classification, isoprene rule; Elucidation of structure and synthesis of Citral,Neral and α-terpineol.

### UNIT IV: NUCLEIC ACIDS [15 Hours]

Components of nucleic acids, Nucleosides and nucleotides;Structure, synthesis and reactions of: Adenine, Guanine, Cytosine, Uracil and Thymine;Structure of polynucleotides.

**Suggested Reading:**


- Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India)Pvt. Ltd. (Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 1*), Dorling Kindersley (India) Pvt. Ltd.(Pearson Education).
- Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry ofNatural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
- Acheson, R.M. *Introduction to the Chemistry of Heterocyclic compounds,* JohnWelly & Sons (1976).
- Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.
- McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage LearningIndia Edition, 2013.
- Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P)Ltd. Pub.
- Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, OxfordUniversityPress.
- Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Parakashan(2010).

# Core paper

**SEMESTER IV**
**ORGANIC CHEMISTRY III**
**PAPER CODE: BCH-CC9 PR**
**TITLE: HETEROCYCLIC AND NATURAL PRODUCT CHEMISTRY**

**TOTAL HOURS: 60** **CREDITS: 02**

- Detection of extra elements.
- Functional group test for nitro, amine and amide groups.
- Qualitative analysis of unknown organic compounds containing simple functional groups (alcohols, carboxylic acids, phenols and carbonyl compounds)

**Suggested Reading**


- Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
- Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic Chemistry, 5th Ed.,* Pearson (2012)
- Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry:*
- *Preparation and Quantitative Analysis*, University Press (2000).
- Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry:*
- *Qualitative Analysis*, University Press (2000).


**Teaching Learning Process:**

1. The teaching Learning Progression for the course is student centric
2. Intelligent mix of conventional and modern methods is opted both through whiteboard and education animations using available free computational tools.
3. Engaging students in cooperative and synergistic learning.

**Assessment Methods:**

1. Continuous Evaluation: by monitoring the progress of students' learning.
2. Class Tests, Worksheets and assessments.
3. Assignments, and projects, to enhance critical thinking skills and personality.
4. Semester-end Examination: a critical indicator of students' learning of theoretical concepts

**Keywords:**Heterocyclic compounds, Alkaloids, Terpenes, Nucleic acids

# SEMESTER V

| Core papers | DSE |
|---|---|
| BCH-CC10 TH (4 C)<br>BCH-CC10 PR (2 C) | DSE TH (4 C)<br>DSE PR (2 C)<br>(Any two from DSE I-IX) |
| BCH-CC11 TH (4 C)<br>BCH-CC11 PR (2 C) | |

**SEMESTER V**
**PHYSICAL CHEMISTRY-III**

**PAPER CODE: BCH-CC10TH**
**PAPER TITLE: TITLE: ELECTROCHEMISTRY**

**Total Credits: 06 - (BCH-CC10TH -04, BCH-CC10PR -02)**
**Total Lectures: BCH-CC10TH - 60, BCH-CC10PR -60**

**Objectives:**The core course Electrochemistry is designed to strengthen the basic and fundamental concepts of physical Chemistry. The course is imbued with the applications of these concepts, the chemical conductance, metallic conductance, strong and weak electrolytes and concepts of electrical and magnetic properties are introduced.

**Course Learning Objectives:**

**On completion of the course, the student will be able to:**

**CLO 1.** Understand and explain the different nature and behavior of strong and weak electrolytes.(Cognitive level: Understand).

**CLO 2.** Learn and understand many concepts of electrolytic conductace variance with dilution.(Cognitive level: Learn and understand).

**CLO 3.** Solving many numerical problems related to ionic strength and transport number.(Cognitive level: Apply).

**CLO 4.** Derive fundamental and applied derivation related to conductivity, concentration cell.(Cognitive level: Analyze and derive).

**CLO 5.** Determination of electrical and magnetic properties at molecular level. (Cognitive level: Apply).

**Mapping of CLOs with PLOS**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 | CLO 5 |
|---|---|---|---|---|---|
| **PLO1.** | **3** | **3** | **2** | **2** | **2** |
| **PLO2.** | **3** | **3** | **2** | **2** | **2** |
| **PLO3.** | **3** | **3** | **2** | **2** | **2** |
| **PLO4.** | **2** | **3** | **3** | **2** | **2** |
| **PLO5.** | **2** | **2** | **3** | **3** | **2** |
| **PLO6.** | **2** | **2** | **2** | **3** | **3** |
| **PLO7.** | **2** | **2** | **2** | **3** | **3** |
| **PSO 1.** | **3** | **3** | **2** | **2** | **2** |
| **PSO 2.** | **3** | **3** | **2** | **2** | **2** |
| **PSO 3.** | **3** | **3** | **3** | **2** | **2** |
| **PSO 4.** | **2** | **2** | **2** | **3** | **3** |
| **PSO 5.** | **2** | **2** | **3** | **3** | **2** |
| **PSO 6.** | **2** | **2** | **2** | **3** | **3** |
| **PSO 7.** | **2** | **2** | **2** | **3** | **3** |
| **PSO 8.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 9.** | **2** | **2** | **2** | **2** | **3** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

## Core paper

**SEMESTER V**
**PHYSICAL CHEMISTRY III**
**PAPER CODE: BCH-CC10 TH**
**TITLE: ELECTROCHEMISTRY**

**TOTAL HOURS: 60** **CREDITS: 04**

**UNIT I: CONDUCTANCE [18 Hours]**

Arrhenius theory of electrolytic dissociation. Conductivity, equivalent and molarconductivityand their variation with dilution for weak and strong electrolytes. Molar conductivity atinfinite dilution. Kohlrausch law of independent migration of ions. Debye-Hückel-Onsagerequation, Wien effect, Debye-Falkenhagen effect, Walden's rules.

Ionic velocities, mobilities and their determinations, transference numbers and their relationto ionic mobilities, determination of transference numbers using Hittorf and MovingBoundary methods. Applications of conductance measurement: (i) degree of dissociation ofweak electrolytes, (ii) ionic product of water (iii) solubility and solubility product ofsparingly soluble salts, (iv) conductometric titrations, and (v) hydrolysis constants of salts.

**UNIT II: ELECTROCHEMISTRY [18 Hours]**

Quantitative aspects of Faraday's laws of electrolysis, rules of oxidation/reduction of ionsbased on half-cell potentials, applications of electrolysis in metallurgy and industry.

Chemical cells, reversible and irreversible cells with examples. Electromotive force of a celland its measurement, Nernst equation; Standard electrode (reduction) potential and itsapplication to different kinds of half-cells. Application of EMF measurements in determining(i) free energy, enthalpy and entropy of a cell reaction, (ii) equilibrium constants, and (iii) pHvalues, using hydrogen, quinone-hydroquinone, glass and SbO/Sb2O3 electrodes.

Concentration cells with and without transference, liquid junction potential; determination ofactivity coefficients and transference numbers. Qualitative discussion of potentiometrictitrations (acid-base, redox, precipitation).

**UNIT IV: ELECTRICAL & MAGNETIC PROPERTIES OF ATOMS AND MOLECULES**

Basic ideas of electrostatics, Electrostatics of dielectric media, Clausius-Mosotti equation,Lorenz-Laurentz equation, Dipole moment and molecular polarizabilities and theirmeasurements. Diamagnetism, Para-magnetism, magnetic susceptibility and its measurement,molecular interpretation. **[10 Hours]**

**Suggested Reading:**


- Atkins, P.W & Paula, J.D. *Physical Chemistry*, 10th Ed., Oxford University Press(2014).
- Castellan, G. W. *Physical Chemistry 4th Ed.,* Narosa (2004).
- Mortimer, R. G. *Physical Chemistry 3rd Ed.,* Elsevier: NOIDA, UP (2009).
- Barrow, G. M., *Physical Chemistry 5th Ed.,* Tata McGraw Hill: New Delhi (2006).
- Engel, T. & Reid, P. *Physical Chemistry 3rd Ed.,* Prentice-Hall (2012).
- Rogers, D. W. *Concise Physical Chemistry* Wiley (2010).

# Core paper

**SEMESTER V**
**PHYSICAL CHEMISTRY III**
**PAPER CODE: BCH-CC10 PR**
**TITLE: ELECTROCHEMISTRY**

**TOTAL HOURS: 60** **CREDITS: 02**

## Conductometry

1. Determination of cell constant
2. Determination of conductivity, molar conductivity, degree of dissociation and dissociation constant of a weak acid.
3. Perform the following conductometric titrations: i. Strong acid vs. strong base ii. Weak acid vs. strong base iii. Mixture of strong acid and weak acid vs. strong base iv. Strong acid vs. weak base

## Chemical Kinetics:

1. Study the kinetics of the following reactions.
2. Iodide-persulphate reaction (i) Initial rate method; (ii)Integrated rate method
3. Acid hydrolysis of methyl acetate with hydrochloric acid.
4. Saponification of ethyl acetate.
5. Comparison of the strengths of HCl and $H_2SO_4$ by studying kinetics of hydrolysis of methyl acetate.

***Suggested Reading***


1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.:New Delhi (2011).
2. Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.;McGraw-Hill: New York (2003).
3. Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman &Co.: New York (2003).


**Teaching Learning Process:**

- Lectures in classrooms
- Peer learning
- Hands-on learning using lab practicals, videos, presentations, seminars
- Technology-driven Learning

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments , Group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

**Keywords:**
Conductance, Electrochemistry, Electrical & Magnetic Properties Of Atoms And Molecules

**SEMESTER V**
**ORGANIC CHEMISTRY-III**

**PAPER CODE: BCH-CC11TH**
**PAPER TITLE: BIOMOLECULES**

**Total Credits: 06 - (BCH-CC11TH -04, BCH-CC11PR -02)**
**Total Lectures: BCH-CC11TH - 60, BCH-CC11PR -60**

**Objectives:** The core course Biomolecules is designed to strengthen the basic and fundamental concepts of various biomolecules and their physical and biological importance. The course is permeated with the biological importance of various biomolecules including Peptides, Enzymes, Lipids and Pharmaceutical compounds, their metabolism and mechanism of action.

**Course Learning Objectives:**

**On completion of the course, the student will be able to:**

**CLO 1.** Understand the construction of various biomolecules, their structural features and classifications. (Cognitive level: Understand).

**CLO 2.** Learn and understand the synthesis of amino acids, solution phase/solid phase synthesis of peptides, Mechanism of enzyme action, factors affecting enzyme action, role of coenzymes and cofactors in biological reactions, enzyme specificity, phenomenon of enzyme inhibition, classification of lipids, oils and fats, Concept of Energy in Biosystems including different metabolic pathways, Synthesis of some important therapeutic drugs including Paracetamol, Ibuprofen, Chloroquine, chloramphenicol and Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C & antacid (ranitidine). (Cognitive level: learn and understand).

**CLO 3.** Formulate the mechanisms of organic reactions involved in peptide synthesis & pharmaceutical agents by recalling and correlating the fundamental properties of the reactants involved. (Cognitive level: Understand and analyze).

**CLO 4.** Use the fundamental concepts of protecting groups, peptide synthesis, analysis of fats & oils and classification & nomenclature of enzymes in order to identify and analyze reactions of biocatalysts. (Cognitive level: Identify and analyze).

**CLO 5.** Apply the fundamental concepts to analyze the lipid quality. (Cognitive level: Apply).

**CLO 6.** Synthesize small molecules useful to society using biocatalysts and other reagents. (Cognitive level: Synthesis).

**Mapping of CLOs with PLOS**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 | CLO 5 | CLO 6 |
|---|---|---|---|---|---|---|
| **PLO1.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO2.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO3.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO4.** | **2** | **3** | **3** | **2** | **2** | **2** |
| **PLO5.** | **2** | **2** | **3** | **3** | **2** | **2** |
| **PLO6.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PLO7.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 1.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO 2.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO 3.** | **3** | **3** | **3** | **2** | **2** | **2** |
| **PSO 4.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 5.** | **2** | **2** | **3** | **3** | **2** | **2** |
| **PSO 6.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 7.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 8.** | **2** | **2** | **2** | **2** | **3** | **3** |
| **PSO 9.** | **2** | **2** | **2** | **2** | **3** | **3** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

## Core paper

**PAPER CODE: BCH-CC11 TH**
**TITLE: BIOMOLECULES**
**ORGANIC CHEMISTRY IV**
**SEMESTER V**

**TOTAL HOURS: 60** **CREDITS: 04**

### UNIT I: AMINO ACIDS, PEPTIDES AND PROTEINS [15 Hours]

Amino acids, Peptides and their classification.α-Amino Acids - Synthesis, ionic properties and reactions. Zwitterions, p*K*a values, isoelectric point and electrophoresis; Study of peptides: determination of their primary structures-end group analysis, methods of peptide synthesis. Synthesis of peptides using N-protecting, C-protecting and C-activating groups -Solid-phase synthesis.

### UNIT II: ENZYMES [15 Hours]

Introduction, classification and characteristics of enzymes. Salient features of active site of enzymes. Mechanism of enzyme action (taking trypsin as example), factors affecting enzyme action, coenzymes and cofactors and their role in biological reactions, specificity of enzyme action (including stereospecificity), enzyme inhibitors and their importance, phenomenon of inhibition (competitive, uncompetitive and non-competitive inhibition including allosteric inhibition).

### UNIT III: LIPIDS [15 Hours]

Introduction to oils and fats; common fatty acids present in oils and fats, Hydrogenation of fats and oils, Saponification value, acid value, iodine number. Reversion and rancidity.

**Concept of Energy in Bio-systems**

Cells obtain energy by the oxidation of food stuff (organic molecules). Introduction to metabolism (catabolism, anabolism).

ATP: The universal currency of cellular energy, ATP hydrolysis and free energy change. Agents for transfer of electrons in biological redox systems: NAD+, FAD. Conversion of food to energy: Outline of catabolic pathways of carbohydrate- glycolysis, fermentation, Krebs cycle. Overview of catabolic pathways of fat and protein. Interrelationship in the metabolic pathways of protein, fat and carbohydrate. Caloric value of food, standard caloric content of food types.

### UNIT IV: PHARMACEUTICAL COMPOUNDS: STRUCTURE AND IMPORTANCE

Classification, structure and therapeutic uses of antipyretics: Paracetamol (with synthesis), Analgesics: Ibuprofen (with synthesis), Antimalarials: Chloroquine (with synthesis). Anelementary treatment of Antibiotics and detailed study of chloramphenicol, Medicinal values of curcumin (haldi), azadirachtin (neem), vitamin C and antacid (ranitidine).

**[15 Hours]**

**Reference Books:**


- Berg, J.M., Tymoczko, J.L. & Stryer, L. (2006) *Biochemistr*y. 6th Ed. W.H. Freemanand Co.
- Nelson, D.L., Cox, M.M. & Lehninger, A.L. (2009) *Principles of Biochemistry. IVEdition.* W.H. Freeman and Co.
- Murray, R.K., Granner, D.K., Mayes, P.A. & Rodwell, V.W. (2009) *Harper's*
- *Illustrated Biochemistry.* XXVIII edition. Lange Medical Books/ McGraw-Hill.

## Core paper

**SEMESTER V**
**ORGANIC CHEMISTRY III**
**PAPER CODE: BCH-CC11 PR**
**TITLE: BIOMOLECULES**

**TOTAL HOURS: 60** **CREDITS: 02**

1. Estimation of glycine by Sorenson's formalin method.
2. Study of the titration curve of glycine.
3. Estimation of proteins by Lowry's method.
4. Study of the action of salivary amylase on starch at optimum conditions.
5. Effect of temperature on the action of salivary amylase.
6. Saponification value of an oil or a fat.
7. Determination of Iodine number of an oil/ fat.
8. Isolation and characterization of DNA from onion/ cauliflower/peas.

***Suggested Reading***


- Manual of Biochemistry Workshop, 2012, Department of Chemistry, University of Delhi.
- Arthur, I. V. Quantitative Organic Analysis, Pearson.


**Teaching Learning Process:**
- Lectures in classrooms
- Peer learning
- Hands-on learning using lab practical's, videos, presentations, seminars
- Technology-driven Learning

**Assessment Methods:**
- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments, Group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

**Keywords:** Biomolecules, Amino acids, Peptides, Enzymes, Lipids, Therapeutic drugs

# SEMESTER VI

| Core Papers | DSE |
|---|---|
| BCH-CC12 TH (4 C)<br>BCH-CC12 PR (2 C) | DSE TH (4 C)<br>DSE PR (2 C)<br>(Any one from DSE I-IX except those opted in semester V) |
| BCH-CC13 TH (4 C)<br>BCH-CC13 PR (2 C) | |
| BCH-CC14 TH (4 C)<br>BCH-CC14 PR (2 C) | |

**SEMESTER VI**
**PHYSICAL CHEMISTRY-IV**
**PAPER CODE: BCH-CC12**
**PAPER TITLE: QUANTUM CHEMISTRY AND SPECTROSCOPY**
**Total Credits: 04 Total Lectures: 60**

**Objectives:**The course acquaints the learner with different tools and techniques of identifying and characterizing chemical compounds by spectroscopic methods (Rotation, Vibrational, Raman and Electronic) which involve interactions of analytes with electromagnetic radiations viz. UV-Visible, IR and radio waves. This course also teaches the understanding, interpretation and use of NMR and ESR of small organic molecules present in materials that find everyday applications and have revolutionized society, i.e., polymers, medicinal and analytical chemistry. The course also reviews the quantum mechanical aspect of chemistry and various aspects of chemical bonding and their importance.

**Course Learning Objectives:**

**On completion of the course, the student will be able to:**

**CLO 1** Gain insight into basic principles of Rotation, Vibrational, Raman and Electronic, NMR and EMR spectroscopic techniques (Remember and understand).

**CLO 2** Learn about the Quantum mechanical aspect of chemistry including the Heisenberg Uncertainty principle, Schrödinger equation, and discussion of solution and wave functions (Understand and analyze).

**CLO 3** Understand the concepts of chemical bonding and appreciate the advancement for various theories like covalent bonding, valence bond and molecular orbital approaches, LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules and bonding and antibonding orbitals(Understand and analyze).

**CLO 4** Identify different compounds using various characterization methods (Understand and analyze).

**CLO 5** Use spectroscopic techniques to determine the structure and orientation of known and unknown compounds (Understand, analyze and apply).

**CLO 6** Analyze and comment on the effect of structure on the various spectra of the organic compounds in water (analyze and apply).

**Mapping of CLOs with PLOS**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 | CLO 5 | CLO 6 |
|---|---|---|---|---|---|---|
| PLO1. | 3 | 3 | 3 | 2 | 2 | 2 |
| PLO2. | 3 | 3 | 3 | 2 | 2 | 2 |
| PLO3. | 2 | 3 | 3 | 2 | 2 | 2 |
| PLO4. | 2 | 3 | 3 | 3 | 2 | 2 |
| PLO5. | 2 | 2 | 2 | 2 | 3 | 3 |
| PLO6. | 2 | 2 | 2 | 2 | 2 | 3 |
| PLO7. | 2 | 2 | 2 | 2 | 2 | 3 |
| PSO1 | 3 | 3 | 3 | 2 | 2 | 2 |
| PSO2 | 3 | 3 | 3 | 2 | 2 | 2 |
| PSO3 | 3 | 3 | 3 | 2 | 2 | 2 |
| PSO4 | 2 | 2 | 2 | 3 | 3 | 3 |
| PSO5 | 2 | 2 | 3 | 3 | 2 | 2 |
| PSO6 | 2 | 2 | 2 | 3 | 3 | 2 |
| PSO7 | 2 | 2 | 2 | 2 | 3 | 3 |
| PSO8 | 2 | 2 | 2 | 2 | 2 | 3 |
| PSO9 | 2 | 2 | 2 | 2 | 2 | 3 |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

# Core paper

**SEMESTER VI**
**PHYSICAL CHEMISTRY IV**
**PAPER CODE: BCH-CC12 TH**
**TITLE: QUANTUM CHEMISTRY AND SPECTROSCOPY**

**TOTAL HOURS: 60** **CREDITS: 04**

**UNIT I: QUANTUM CHEMISTRY [15 Lectures]**

Postulates of quantum mechanics, quantum mechanical operators, and commutation rules, Schrödinger equation and its application to free particle and ―particle-in-abox‖(rigorous treatment), quantization of energy levels, zero-point energy and Heisenberg Uncertainty principle; wave functions, probability distribution functions, nodal properties, Extension to two and three-dimensional boxes, separation of variables, degeneracy.

Qualitative treatment of simple harmonic oscillator model of vibrational motion: Setting up of Schrödinger equation and discussion of solution and wave functions. The vibrational energy of diatomic molecules and zero-point energy.

Angular momentum. Rigid rotator model of rotation of the diatomic molecule. Schrödinger equation in Cartesian and spherical polar (Derivation not required). Separation of variables. Spherical harmonics. Discussion of solution (Qualitative).

Qualitative treatment of hydrogen atom and hydrogen-like ions: setting up of Schrödinger equation in spherical polar coordinates, radial part, and quantization of energy (only final energy expression). Average and most probable distances of an electron from the nucleus. Setting up of Schrödinger equation for many-electron atoms (He, Li). Need for approximation methods. Statement of variation theorem and application to simple systems (particle-in-a-box, harmonic oscillator, hydrogen atom).

**Unit III: CHEMICAL BONDING [10 Lectures]**

Covalent bonding, valence bond and molecular orbital approaches, LCAOMO treatment of H2+. Bonding and antibonding orbitals. Qualitative extension to $H_2$.Comparison of LCAO-MO and VB treatments of H2 (only wave functions, detailed solution not required) and their limitations. Refinements of the two approaches (Configuration Interaction forMO, ionic terms in VB). Qualitative description of LCAO-MO treatment of homonuclear and heteronuclear diatomic molecules (HF, LiH).

**UNIT II: MOLECULAR SPECTROSCOPY [20 Lectures]**

Interaction of electromagnetic radiation with molecules and various types of spectra; Born Oppenheimer approximation.

*Rotation spectroscopy*: Selection rules, intensities of spectral lines, determination of bond lengths of diatomic and linear triatomic molecules, isotopic substitution.

*Vibrational spectroscopy*: Classical equation of vibration, computation of force constant, the amplitude of diatomic molecular vibrations, anharmonicity, Morse potential, dissociation energies, fundamental frequencies, overtones, hot bands, degrees of freedom for polyatomic molecules, modes of vibration, the concept of group frequencies.

*Vibration-rotation spectroscopy*: diatomic vibrating rotator, P, Q, R branches.

*Raman spectroscopy*: Qualitative treatment of Rotational Raman effect; Effect of nuclear spin, Vibrational Raman spectra, Stokes and anti-Stokes lines; their intensity difference, rule of mutual exclusion.

Electronic spectroscopy: Franck-Condon principle, electronic transitions, singlet and tripletstates, fluorescence and phosphorescence, dissociation and predissociation, calculation ofelectronic transitions of polyenes using free electron model.

**Unit IV: NUCLEAR MAGNETIC RESONANCE SPECTROSCOPY [15 Lectures]**

*Nuclear Magnetic Resonance (NMR) spectroscopy*: Principles of NMR spectroscopy, Larmor precession, chemical shift and low-resolution spectra, different scales (δ and T), spin-spin coupling, and high-resolution spectra, interpretation of PMR spectra of organic molecules.

*Electron Spin Resonance (ESR) spectroscopy*: Its principle, hyperfine structure, ESR of simple radicals.

**Suggested Reading (Theory)**


- Banwell, C. N. & McCash, E. M. Fundamentals of Molecular Spectroscopy 4th Ed. TataMcGraw-Hill: New Delhi (2006).
- Chandra, A. K. Introductory Quantum Chemistry Tata McGraw-Hill (2001).
- House, J. E. Fundamentals of Quantum Chemistry 2nd Ed. Elsevier: USA (2004).
- Lowe, J. P. & Peterson, K. Quantum Chemistry, Academic Press (2005).
- Kakkar, R. Atomic & Molecular Spectroscopy, Cambridge University Press (2015).

# Core paper

**SEMESTER VI**
**PHYSICAL CHEMISTRY IV**
**PAPER CODE: BCH-CC12 PR**
**TITLE: QUANTUM CHEMISTRY & SPECTROSCOPY**

**TOTAL HOURS: 60** **CREDITS: 02**

**Colorimetry**

1. Verify Lambert-Beer's law and determine the concentration of CuSO4/KMnO4/K2Cr2O7
2. in a solution of unknown concentration
3. Determine the concentrations of KMnO4 and K2Cr2O7 in a mixture.
4. Study the kinetics of iodination of propanone in acidic medium.
5. Determine the amount of iron present in a sample using 1, 10-phenathroline.
6. Determine the dissociation constant of an indicator (phenolphthalein).
7. Study the kinetics of interaction of crystal violet/ phenolphthalein with sodium
8. hydroxide.
9. Analysis of the given vibration-rotation spectrum of HCl(g)

**Adsorption**

1. Verify the Freundlich and Langmuir isotherms for adsorption of acetic acid on activatedcharcoal.

**UV/Visible spectros**copy

- Study the 200-500 nm absorbance spectra of KMnO4 and K2Cr2O7 (in 0.1 M H2SO4) anddetermine the λmax values. Calculate the energies of the two transitions in different units(J molecule-1, kJ mol-1, cm-1 , eV).
- Study the pH-dependence of the UV-Vis spectrum (200-500 nm) of K2Cr2O7.
- Record the 200-350 nm UV spectra of the given compounds (acetone, acetaldehyde, 2-propanol, acetic acid) in water. Comment on the effect of structure on the UV spectra oforganic compounds.

***Suggested Reading***


- Khosla, B. D.; Garg, V. C. & Gulati, A., Senior Practical Physical Chemistry, R. Chand &Co.: New Delhi (2011).
- Garland, C. W.; Nibler, J. W. & Shoemaker, D. P. Experiments in Physical Chemistry 8th Ed.;McGraw-Hill: New York (2003).
- Halpern, A. M. & McBane, G. C. Experimental Physical Chemistry 3rd Ed.; W.H. Freeman &Co.: New York (2003).


**Teaching Learning Process:**

- The teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods, like animations etc.
- Engaging students in cooperative learning.
- Problem-solving to enhance comprehension.

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations by individual student/ small group of students, assignments and projects enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical applications of the concepts

**Keywords:**

Molecular Spectroscopy, Rotational Spectra, Vibrational spectroscopy, Raman Spectra and Electronic Spectroscopy, NMR, ESR, Chemical bonding, Quantum Chemistry.

**Semester – VI**
**Inorganic Chemistry – IV**
**Paper Code: BCH-CC13 TH**
**Paper Title: Organometallic Chemistry**

**Total Credits:04** **Total Lectures:60**

**Paper Code: BCH-CC3P**
**Paper Title: S- AND P-BLOCK ELEMENTS**
**Total Credits: 02Total Hours: 60**

Objectives:The selective course of inorganic chemistry is designed to strengthen the basic and fundamental concepts of organometallic and bioinorganic chemistry.Organometallic compounds have played a critical role in catalysis and organic synthesis, often leading to more efficient use of reagents, higher yields of products, and less use of energy. Bioinorganic chemistry includes the study of both natural phenomena such as the behavior of metalloproteins as well as artificially introduced metals, including those that are non-essential, in medicine and toxicology. Iodometry can be used to quantify oxidizing agents, whereas iodimetry can be used to quantify reducing agents. Iodometry involves indirect titration of iodine liberated by reaction with the analyte, whereas iodimetry involves direct titration using iodine as the titrant.

At the end of this semester, each student will be able to:

**CLO 1** Describe the principles of qualitative analysis: anions & cations identification, separation by applying basic principles such as solubility product & common ion effect. (Cognitive level-remember)

**CLO 2** Understand the basic principles for the identification and separation of different cations and categories these ions into different groups based on separation technique. (Cognitive level-understand)

**CLO 3** Understand the procedure for the preparation of the transition metal complexes and employ the procedure for the quantification of the ions using iodometry and iodimetry methods. (Cognitive level - apply)

**CLO 4** Describe the effect of excess and deficiency of the essential trace metals and the disadvantages of the toxic metal ions (Hg, Pb, Cd and As). (Cognitive level-evaluate)

**CLO 5** Describe the synthesis of metal carbonyl, metal nitrosyl, metal dinitrogen and metal carbonyl hydride clusters, non-aromatic metal complexes: metal alkenes and metal alkynes and aromatic complexes: cyclopentadienyl compounds, cycloheptatriene and tropylium complexes. (Cognitive level-evaluate)

**CLO 6** Explain the reaction mechanism in carbonyl compounds: substitution, elimination, oxidative addition, reductive elimination and insertion and catalytic reactions: Hydrogenation (Wilkinson catalyst), Tolmann catalytic loop, synthesis gas ($H_2$ + CO), (hydroformylation) oxo process, Wacker process, synthetic gasoline and Ziegler-Natta catalyst. (Cognitive level-create)

**Mapping of CLOs with PLOs**

| | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 | CLO-6 |
|---|---|---|---|---|---|---|
| PLO-1 | 2 | 2 | 3 | 2 | 3 | 3 |
| PLO-2 | 2 | 3 | 3 | 3 | 3 | 2 |
| PLO-3 | 2 | 2 | 2 | 2 | 2 | 3 |
| PLO-4 | 3 | 2 | 3 | 2 | 2 | 2 |
| PLO-5 | 2 | 3 | 3 | 2 | 2 | 3 |
| PLO-6 | 3 | 2 | 3 | 3 | 3 | 3 |
| PLO-7 | 3 | 2 | 2 | 3 | 3 | 3 |
| PSO-1 | 2 | 2 | 2 | 3 | 2 | 3 |
| PSO-2 | 2 | 3 | 3 | 2 | 2 | 3 |
| PSO-3 | 2 | 3 | 3 | 3 | 2 | 3 |
| PSO-4 | 2 | 2 | 3 | 3 | 3 | 3 |
| PSO-5 | 3 | 2 | 2 | 2 | 2 | 2 |
| PSO-6 | 3 | 3 | 2 | 2 | 3 | 2 |
| PSO-7 | 2 | 2 | 2 | 2 | 2 | 3 |
| PSO-8 | 3 | 3 | 3 | 3 | 3 | 3 |
| PSO-9 | 3 | 3 | 3 | 3 | 3 | 3 |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

# Core paper

**SEMESTER VI**
**INORGANIC CHEMISTRY IV**
**PAPER CODE: BCH-CC13 TH**
**TITLE: ORGANOMETALLIC CHEMISTRY**

**TOTAL HOURS: 60** **CREDITS: 04**

**UNIT 1: THEORETICAL PRINCIPLES IN QUALITATIVE ANALYSIS ($H_2S$ SCHEME) [Hours = 10]**

Basic principles involved in analysis of cations and anions. Solubility products, common ion effect. Principles involved in separation of cations into groups and choice of group reagents. Interfering anions (fluoride, borate, oxalate and phosphate) and need to remove them after Group II.

**UNIT 1I: ORGANOMETALLIC COMPOUNDS [25Hours]**

Definition and classification of organometallic compounds on the basis of bond type. Concept of hapticity of organic ligands. Metal carbonyls: 18 electron rule, electron count of mononuclear, polynuclear and substituted metal carbonyls of 3d series. General methods of preparation (direct combination, reductive carbonylation, thermal and photochemical decomposition) of mono and binuclear carbonyls of 3d series. Structures of mononuclear and binuclear carbonyls of Cr, Mn, Fe, Co and Ni using VBT. π-acceptor behaviour of CO (MO diagram of CO to be discussed), synergic effect and use of IR data to explain extent of back bonding. Zeise's salt: Preparation and structure, evidence of synergic effect and comparison of synergic effect with that in carbonyls. Metal Alkyls: Important structural features of methyl lithium (tetramer) and trialkyl aluminium (dimer), concept of multicentre bonding in these compounds.
Ferrocene: Preparation and reactions (acetylation, alkylation, metallation, Mannich Condensation). Structure and aromaticity. Comparison of aromaticity and reactivity with that of benzene.

**Unit III: BIOINORGANIC CHEMISTRY [15 Hours]**

Metal ions present in biological systems, classification of elements according to their action in biological system. Geochemical effect on the distribution of metals. Sodium / K-pump, carbonic anhydrase and carboxypeptidase. Excess and deficiency of some trace metals. Toxicity of metal ions (Hg, Pb, Cd and As), reasons for toxicity, Use of chelating agents in medicine, Cisplatin as an anti-cancer drug.
Iron and its application in bio-systems, Haemoglobin, Myoglobin; Storage and transfer of iron.

**Unit IV: CATALYSIS BY ORGANOMETALLIC COMPOUNDS [10 Hours]**

Study of the following industrial processes and their mechanism:1. Alkene hydrogenation (Wilkinson's Catalyst), 2. Synthetic gasoline (Fischer Tropsch reaction), 3. Polymerisation of ethene using Ziegler-Natta catalyst

**Suggested Reading**


1. Vogel, A.I. *Qualitative Inorganic Analysis*, Longman, 1972
2. Svehla, G. *Vogel's Qualitative Inorganic Analysis*, 7th Edition, Prentice Hall, 1996-03-07.
3. Lippard, S.J. & Berg, J.M., *Principles of Bioinorganic Chemistry* Panima Publishing Company 1994.
4. Cotton, F.A., Wilkinson, G., & Gaus, P.L. *Basic Inorganic Chemistry 3rd Ed.;* Wiley India,
5. Huheey, J. E.; Keiter, E.A. & Keiter, R.L. *Inorganic Chemistry, Principles of Structure and Reactivity 4thEd* Harper Collins 1993, Pearson,2006.
6. Sharpe, A.G. *Inorganic Chemistry*, 4th Indian Reprint (Pearson Education) 2005
7. Douglas, B. E.; McDaniel, D.H. & Alexander, J.J. *Concepts and Models inInorganic Chemistry3rdEd.,* John Wiley and Sons, NY, 1994.
8. Greenwood, N.N. & Earnshaw, A. *Chemistry of the Elements 2nd Ed*, Elsevier,1997 (Ziegler Natta Catalyst and Equilibria in Grignard Solution).
9. Lee, J.D. *Concise Inorganic Chemistry 5th Ed.,* John Wiley and sons 2008.
10. Powell, P. *Principles of Organometallic Chemistry*, Chapman and Hall, 1988.
11. Shriver, D.D., Atkins, P. and Langford, C.H., *Inorganic Chemistry 2nd Ed.,* Oxford University Press, 1994.
12. Purcell, K.F. & Kotz, J.C., *Inorganic Chemistry*, W.B. Saunders Co. 1977
13. Miessler, G. L. & Tarr, Donald A., *Inorganic Chemistry 4th Ed.,* Pearson, 2010.
14. Collman, James P. et al. *Principles and Applications of Organotransition Metal Chemistry.* Mill Valley, CA University Science Books, 1987.

# Core paper

**SEMESTER VI**
**INORGANIC CHEMISTRY IV**
**PAPER CODE: BCH-CC13 PR**
**TITLE: ORGANOMETALLIC CHEMISTRY**

**TOTAL HOURS: 60** **CREDITS: 02**

**(A) Iodo / Iodimetric Titrations** **[Hours = 30]**

(i) Estimation of Cu(II) and $K_2Cr_2O_7$ using sodium thiosulphate solution (Iodimetrically).
(ii) Estimation of (i) arsenite and (ii) antimony in tartar-emetic iodimetrically
(iii) Estimation of available chlorine in bleaching powder iodometrically.

**(B) Inorganic preparations** **[Hours = 30]**

(i) Cuprous Chloride, $Cu_2Cl_2$
(ii) Preparation of Manganese(III) phosphate, $MnPO_4.H_2O$
(iii) Preparation of Aluminium potassium sulphate $KAl(SO_4)_2.12H_2O$ (Potash alum) or Chrome alum.

**Suggested Reading:**


1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.


**Teaching Learning Process:**

- Lectures in classrooms
- Peer learning
- Hands-on learning using lab practicals, videos, presentations, seminars
- Technology-driven Learning

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments, group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of students's learning and teaching methods adopted by teachers throughout the semester.


**Keywords:**
Solubility products, common ion effect, organometallic compounds, back bonding, Zeise's salt, Bioinorganic Chemistry, metalloproteins, hemoglobin, chlorophyll, catalysis, Iodometry, iodimetry, oxidising agent, reducing agent, transition metal complexes.


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**SEMESTER VI**
**ORGANIC CHEMISTRY-IV**

**PAPER CODE: BCH-CC14**
**PAPER TITLE: SPECTROSCOPY AND POLYMERS**

**Total Credits: 06 - (BCH-CC14TH -04, BCH-CC14PR -02)**
**Total Lectures: BCH-CC14TH - 60, BCH-CC14PR -60**

**Objectives:**The course acquaints the learner with different tools and techniques of identifying and characterizing organic compounds by spectroscopic methods which involve interactions of analytes with electromagnetic radiations viz. UV-Visible, IR, and radio waves. This course also teaches the use of small organic molecules in producing materials that find everyday applications and have revolutionized society, i.e., polymers. The course also reviews the chemistry of carbohydrates and their importance

**Course Learning Objectives:**

**On completion of the course, the student will be able to:**

7. Gain insight into basic principles of UV, IR and NMR spectroscopic techniques. **(Cognitive level: Remember and understand)**
8. Learn about the chemistry of natural and synthetic polymers including fabrics and rubbers. **(Cognitive level: Remember and understand)**
9. Understand the chemistry of biodegradable and conducting polymers and appreciate the need for biodegradable polymers with an emphasis on basic principles. **(Cognitive level: Remember and understand)**
10. Identify different compounds using chemical characterization methods **(Cognitive level: Analyze and evaluate)**
11. Use spectroscopic techniques to determine the structure and stereochemistry of known and unknown compounds. (**Cognitive level: Apply**)
12. Preparation of commercially important Dyes, Polymers using the learned chemistry concepts (**Cognitive level: Apply)**

**Mapping of CLOs with PLOS**

**Mapping of CLOs with PLOs**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 | CLO 5 |
|---|---|---|---|---|---|
| **PLO15.** | **3** | **3** | **2** | **2** | **2** |
| **PLO16.** | **3** | **3** | **2** | **2** | **2** |
| **PLO17.** | **3** | **3** | **2** | **2** | **2** |
| **PLO18.** | **2** | **3** | **3** | **3** | **2** |
| **PLO19.** | **2** | **2** | **3** | **3** | **3** |
| **PLO20.** | **2** | **2** | **2** | **2** | **3** |
| **PLO21.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 19.** | **3** | **3** | **2** | **2** | **2** |
| **PSO 20.** | **3** | **3** | **2** | **2** | **2** |
| **PSO 21.** | **3** | **3** | **3** | **3** | **2** |
| **PSO 22.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 23.** | **2** | **2** | **3** | **3** | **3** |
| **PSO 24.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 25.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 26.** | **2** | **2** | **2** | **2** | **2** |
| **PSO 27.** | **2** | **2** | **2** | **2** | **2** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

# BCH-CC14TH: Course contents
## Credits: 4, Periods: 60

**UNIT I: UV AND IR SPECTROSCOPY [17 Lectures]**

General principles Introduction to absorption and emission spectroscopy.

*UV Spectroscopy:* Types of electronic transitions, λmax, Chromophores and Auxochromes, Bathochromic and Hypsochromic shifts, Intensity of absorption; Application of Woodward, Rules for calculation of λmax for the following systems: α,β unsaturated aldehydes, ketones, carboxylic acids and esters; Conjugated dienes: alicyclic, homoannular and heteroannular; Extended conjugated systems (aldehydes, ketones and dienes); the distinction between cis and trans isomers.

*IR Spectroscopy:* Fundamental and non-fundamental molecular vibrations; IR absorption positions of O, N and S containing functional groups; Effect of H-bonding, conjugation, resonance and ring size on IR absorptions; Fingerprint region and its significance; application in functional group analysis.Applications of IR and UVfor identification of simple organic molecules.

**Unit III: NMR SPECTROSCOPY [12 Lectures]**

*NMR Spectroscopy:* Basic principles of Proton Magnetic Resonance, chemical shift andfactors influencing it; Spin – Spin coupling and coupling constant; Anisotropic effects in alkene, alkyne, aldehydes and aromatics, Interpretation of NMR spectra of simplecompounds.

Applications of NMR spectroscopy for identification of simple organic molecules.

**UNIT II: CARBOHYDRATES [15 Lectures]**

Occurrence, classification and their biological importance.Monosaccharides: Constitution and absolute configuration of glucose and fructose, epimersand anomers, mutarotation, determination of ring size of glucose and fructose, Haworthprojections and conformational structures; Interconversions of aldoses and ketoses; Killiani-Fischer synthesis and Ruff degradation;Disaccharides – Structure elucidation of maltose, lactose and sucrose.; Polysaccharides – Elementary treatment of starch, cellulose and glycogen.

**Unit IV: POLYMERS [16 Lectures]**

Introduction and classification including di-block, tri-block and amphiphilic polymers;Number average molecular weight, Weight average molecular weight, Degree with examples of polymerization, Polydispersity Index.Polymerisation reactions -Addition and condensation -Mechanism of cationic, anionic and free radical addition polymerization; Metallocene-based Ziegler-Natta polymerisation of alkenes Preparation and applications of plastics – thermosetting (phenol-formaldehyde, Polyurethanes) and thermosoftening (PVC, polythene); Fabrics – natural and synthetic (acrylic, polyamido, polyester); Rubbers – natural and synthetic: Buna-S, Chloroprene and Neoprene; Vulcanization; Polymer additives; Introduction to liquid crystal polymers; Biodegradable and conducting polymers withexamples.

## PAPER CODE: BCH-CC14 PR
## Credits: 2, Laboratory Periods: 60

1. Extraction of caffeine from tea leaves.
2. Preparation of sodium polyacrylate.
3. Preparation of urea formaldehyde.
4. Qualitative analysis of unknown organic compounds containing monofunctionalgroups (carbohydrates, aryl halides, aromatic hydrocarbons, nitro compounds, aminesand amides) and simple bifunctional groups, for e.g. salicylic acid, cinnamic acid,nitro phenols, etc.
6. Identification of simple organic compounds by IR spectroscopy and NMR spectroscopy (Spectra to be provided).
7. Preparation of methyl orange.

### Suggested Reading (Theory)


1. Kalsi, P. S. *Textbook of Organic Chemistry 1st Ed.*, New Age International (P)Ltd. Pub.
2. Morrison, R. T. & Boyd, R. N. *Organic Chemistry*, Dorling Kindersley (India)Pvt. Ltd. (Pearson Education).
3. Billmeyer, F. W. *Textbook of Polymer Science*, John Wiley & Sons, Inc.
4. Gowariker, V. R.; Viswanathan, N. V. & Sreedhar, J. *Polymer Science*, New AgeInternational (P) Ltd. Pub.
5. Finar, I. L. *Organic Chemistry* (*Volume 2: Stereochemistry and the Chemistry ofNatural Products*), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
6. Graham Solomons, T.W. *Organic Chemistry*, John Wiley & Sons, Inc.
7. McMurry, J.E. *Fundamentals of Organic Chemistry*, 7th Ed. Cengage LearningIndia Edition, 2013.
8. Clayden, J.; Greeves, N.; Warren, S.; Wothers, P.; *Organic Chemistry*, OxfordUniversity Press.
9. Singh, J.; Ali, S.M. & Singh, J. *Natural Product Chemistry*, Prajati Prakashan(2010).
10. Kemp, W. *Organic Spectroscopy*, Palgrave.
11. Pavia, D. L. *et al. Introduction to Spectroscopy* 5th Ed. Cengage Learning India Ed.(2015
12. Solomons, T. W. G.; Fryhle, C. B. ; Snyder, S. A. (2016),Organic Chemistry, 12th Edition, Wiley.
13. Bruice, P. Y. (2017),Organic Chemistry, 8th Edition, Pearson.
14. Clayden, J.; Greeves, N.; Warren, S. (2012), Organic Chemistry, Oxford.


### Suggested Reading (Practicals)


1. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education (2009)
2. Vogel, A.I. *Quantitative Organic Analysis*, Part 3, Pearson (2012).
3. Mann, F.G. & Saunders, B.C. *Practical Organic Chemistry*, Pearson Education(2009)
4. Furniss, B.S.; Hannaford, A.J.; Smith, P.W.G.; Tatchell, A.R. *Practical Organic*
5. *Chemistry, 5th Ed.*, Pearson (2012)
6. Ahluwalia, V.K. & Aggarwal, R. *Comprehensive Practical Organic Chemistry:*
7. *Preparation and Quantitative Analysis*, University Press (2000).
8. Ahluwalia, V.K. & Dhingra, S. *Comprehensive Practical Organic Chemistry:Qualitative Analysis*, University Press (2000).


**Teaching Learning Process:**

- The teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Problem-solving to enhance comprehension.

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations by individual student/ small group of students, assignments , projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquird in the lab

**Keywords:** UV, IR, NMR,Dyes, Fabrics, Rubbers, Polymers.

# DSE I-IX (ELECTIVES)

**(BCH-DSE1-9)**

| SEMESTER V<br>ANALYTICAL CHEMISTRY-I | |
|---|---|
| **PAPER CODE: BCH-DSE01<br>PAPER TITLE: ANALYTICAL METHODS IN CHEMISTRY** | |
| **Total Credits: 04** | **Total Lectures: 60** |

**Objectives:**The elective course analytical chemistry is designed to strengthen the basic and fundamental concepts of analytical chemistry. The course is imbued with the applications of these concepts, qualitative and quantitative aspects of the analysis, complexation, thermogravimetric principles and their spectroscopic properties concepts are introduced.

**Course Learning Objectives:**

**On completion of the course, the student will be able to:**

1. Understand and explain the different qualitative and quantitative aspects of the analysis of different samples based on fundamental concepts learnt (Remember and understand).
2. Learn and understand the various statistical analysis of data including F, Q and t test (Remember and understand).
3. Formulate the molecular understanding and determination of the physical properties of common organic compounds by recalling and correlating the fundamental changes in their properties while undergoing the chemical transformation (Understand and Analyze and apply).
4. Analyze and read the spectrum of common organic compounds using Beer-Lambert's law and other spectroscopic laws (Analyze and apply).
5. Analyze and read the composition of a mixture using selective complexation and other thermogravimetric principles (Analyze and apply).
6. Use the fundamental spectroscopic concepts to identify and analyses the composition of metal complexes using Job's method of continuous variation and mole ratio method (Analyze and apply).
7. Use the fundamental chromatography concepts to understand various chemical transformations in the laboratory and in our day to day (Analyze and apply).

**Mapping of CLOs with PLOS**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 | CLO 5 | CLO 6 | CLO7 |
|---|---|---|---|---|---|---|---|
| **PLO1.** | **3** | **3** | **2** | **2** | **2** | **2** | **2** |
| **PLO2.** | **3** | **3** | **2** | **2** | **2** | **2** | **2** |
| **PLO3.** | **3** | **3** | **2** | **2** | **2** | **2** | **2** |
| **PLO4.** | **2** | **3** | **3** | **3** | **3** | **2** | **2** |
| **PLO5.** | **2** | **2** | **3** | **3** | **3** | **3** | **2** |
| **PLO6.** | **2** | **2** | **2** | **2** | **2** | **3** | **3** |
| **PLO7.** | **2** | **2** | **2** | **2** | **2** | **3** | **3** |
| **PSO 1.** | **3** | **3** | **2** | **2** | **2** | **2** | **2** |
| **PSO 2.** | **3** | **3** | **2** | **2** | **2** | **2** | **2** |
| **PSO 3.** | **3** | **3** | **3** | **3** | **3** | **2** | **2** |
| **PSO 4.** | **2** | **2** | **2** | **2** | **2** | **3** | **3** |
| **PSO 5.** | **2** | **2** | **3** | **3** | **3** | **3** | **2** |
| **PSO 6.** | **2** | **2** | **2** | **2** | **2** | **3** | **3** |
| **PSO 7.** | **2** | **2** | **2** | **2** | **2** | **3** | **3** |
| **PSO 8.** | **2** | **2** | **2** | **2** | **2** | **2** | **3** |
| **PSO 9.** | **2** | **2** | **2** | **2** | **2** | **2** | **3** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

# DSE

## PAPER CODE: BCH-DSE1 TH
## TITLE: ANALYTICAL METHODS IN CHEMISTRY

**TOTAL HOURS: 60** **CREDITS: 04**

### UNIT I:QUALITATIVE AND QUANTITATIVE ASPECTS OF ANALYSIS

Sampling, evaluation of analytical data, errors, accuracy and precision, methods of their expression, normal law of distribution if indeterminate errors, statistical test of data; F, Q and t test, rejection of data, and confidence intervals.

**[10 Lectures]**

### UNIT II:OPTICAL METHODS OF ANALYSIS

Origin of spectra, the interaction of radiation with matter, fundamental laws of spectroscopy and selection rules, the validity of Beer-Lambert's law.

*UV-Visible Spectrometry:* Basic principles of instrumentation (choice of source, monochromator and detector) for single and double beam instrument;

*Basic principles of quantitative analysis:* estimation of metal ions from aqueous solution, geometrical isomers, keto-enol tautomers. Determination of the composition of metal complexes using Job's method of continuous variation and mole ratio method.

*Infrared Spectrometry:* Basic principles of instrumentation (choice of source, monochromator & detector) for single and double beam instrument; sampling techniques. Structural illustration through interpretation of data, Effect and importance of isotope substitution.

*Flame Atomic Absorption and Emission Spectrometry:* Basic principles of instrumentation (choice of source, monochromator, detector, choice of flame, and Burner designs. Techniques of atomization and sample introduction; Method of background correction, sources of chemical interferences and their method of removal. Techniques for the quantitative estimation of trace level of metal ions from water samples. **[20 Lectures]**

### UNIT III: THERMAL AND ELECTROANALYTICAL METHODS OF ANALYSIS

Theory of thermogravimetry (TG), the basic principle of instrumentation. Techniques for quantitative estimation of Ca and Mg from their mixture.

Classification of electroanalytical methods, the basic principle of pH metric, potentiometric and conductometric titrations. Techniques used for the determination of equivalence points. Techniques used for the determination of pKa values.

[**15 Lectures]**

### UNIT IV: SEPARATION TECHNIQUES

*Solvent extraction*: Classification, principle, and efficiency of the technique.

*Mechanism of extraction*: extraction by solvation and chelation. The technique of extraction: batch, continuous, and counter-current extractions. Qualitative and quantitative aspects of solvent extraction: extraction of metal ions from aqueous solution, extraction of organic species from the aqueous and nonaqueous media.

*Chromatography*: Classification, principle, and efficiency of the technique. Mechanism of separation: adsorption, partition & ion exchange. Development of chromatograms: frontal, elution and displacement methods.

*Qualitative and quantitative aspects of chromatographic methods of analysis*: IC, GLC, GPC, TLC and HPLC.

*Stereoisomeric separation and analysis*: Measurement of optical rotation, calculation of enantiomeric excess (ee)/ diastereomeric excess (de) ratios and determination of enantiomeric composition using NMR, Chiral solvents and chiral shift reagents. Chiral chromatographic techniques using chiral columns (GC and HPLC).

Role of computers in instrumental methods of analysis. [**15 Lectures]**

**Suggested Reading (Theory)**


1. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
2. Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
3. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
4. Harris, D.C.: Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
5. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
6. Skoog, D.A. Holler F.J. & Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Ed.
7. Mikes, O. Laboratory Hand Book of Chromatographic & Allied Methods, Elles
8. Harwood Series on Analytical Chemistry, John Wiley & Sons, 1979.
9. Ditts, R.V. Analytical Chemistry; Methods of separation, van Nostrand, 1974.

# PAPER CODE: BCH-DSE01PR
# PAPER TITLE: ANALYTICAL METHODS IN CHEMISTRY
**Total Credits: 02 Total Lectures: 60**

1. **Separation Techniques:** *Chromatography Separation of mixtures.*
   c) Paper chromatographic separation of $Fe^{3+}$, $Al^{3+}$, and $Cr^{3+}$.
   d) Separation and identification of the monosaccharides present in the given mixture (glucose & fructose) by paper chromatography. Reporting the Rf values.
   e) Separate a mixture of Sudan yellow and Sudan Red by TLC technique and identify them on the basis of their $R_f$ values.
   f) Chromatographic separation of the active ingredients of plants, flowers, and juices by TLC.
2. **Solvent Extractions.**
   a) To separate a mixture of $Ni^{2+}$& $Fe^{2+}$ by complexation with DMG and extracting the $Ni^{2+}$-DMG complex in chloroform, and determine its concentration by spectrophotometry.
   b) Solvent extraction of zirconiu with amberliti LA-1, separation from a mixture of iron and gallium.
3. Determine the pH of the given aerated drinks fruit juices, shampoos, and soaps.
4. Determination of Na, Ca, Li in cola drinks and fruit juices using flame photometric techniques.
5. **Analysis of soil.**
   a) Determination of pH of soil.
   b) Total soluble salt.
   c) Estimation of calcium, magnesium, phosphate, nitrate.
6. **Ion exchange.**
   a) Determination of exchange capacity of cation exchange resins and anion exchange resins.
   b) Determination of exchange capacity of cation exchange resins and anion exchange resins.
   c) Separation of metal ions from their binary mixture.
   d) Separation of amino acids from organic acids by ion-exchange chromatography.
7. **Spectrophotometry.**
   a) Determination of pKa values of indicator using spectrophotometry.
   b) Structural characterization of compounds by infrared spectroscopy.
   c) Determination of dissolved oxygen in the water.
   d) Determination of chemical oxygen demand (COD).
   e) Determination of Biological oxygen demand (BOD).
   f) Determine the composition of the Ferric-salicylate/ ferric-thiocyanate complex by Job's method.

**Suggested Reading (Practical)**


1. Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).
2. Mendham, J., A. I. Vogel's Quantitative Chemical Analysis 6th Ed., Pearson, 2009.
3. Willard, H.H. et al.: Instrumental Methods of Analysis, 7th Ed. Wardsworth Publishing Company, Belmont, California, USA, 1988.
4. Christian, G.D. Analytical Chemistry, 6th Ed. John Wiley & Sons, New York, 2004.
5. Harris, D.C. Exploring Chemical Analysis, 9th Ed. New York, W.H. Freeman, 2016.
6. Khopkar, S.M. Basic Concepts of Analytical Chemistry. New Age International Publisher, 2009.
7. Skoog, D.A. Holler F.J. and Nieman, T.A. Principles of Instrumental Analysis, Cengage Learning India Edition.
8. Mikes, O. & Chalmes, R.A. Laboratory Handbook of Chromatographic & Allied Methods, Elles Harwood Ltd. London.
9. Ditts, R.V. Analytical Chemistry: Methods of separation. Van Nostrand, New York, 1974.

**Teaching Learning Process:**

- The teaching Learning Process for the course is student centric
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of students' learning.
  - Class Tests, Worksheets.
  - Assignments, and projects, to enhance critical thinking skills and personality.
- Semester-end Examination: a critical indicator of students' learning of theoretical concepts and practical skills acquired in the lab.

**Keywords:** Errors, Accuracy, Precision, Spectroscopy, Beer-Lambert's law, instrumentation, Chromatography, thermogravimetry, electroanalytical methods, pH metric, potentiometric and conductometric titrations.

**SEMESTER V**
**DISCIPLINE SPECIFIC ELECTIVE COURSE**
**PAPER CODE: BCH-DSE2 TH**
**TITLE: MOLECULAR MODELLING & DRUG DESIGN**

**Total hours: 60 Hours Credit :04**

**Objective:** Learn the basic chemistry behind drug discovery, design and development. This subject is designed to impart fundamental knowledge on the structure, chemistry and mathematical aspects beyond the chemistry. The subject emphasizes on learning how communications were made between computers and chemistry using simple mathematical models, importance of physicochemical properties. The syllabus also emphasizes on understanding the practical applications.

**Course learning objectives:**

On completion of this course the students will be able to:

**CLO 1** To revise and understand basic physicochemical properties and theoretical methods for their determination (Learn and Understand)

**CLO 2** Understand the in-silico aspects and find suitable modules and system requirement. Differentiate between the freeware and commercial software. (Understand and differentiate)

**CLO 3** Understand the methods and basic requirements for simple calculations associated with different properties. Basics of Structural Activity Relationship (SAR) of different class of drugs. (learn, develop and plan)

**CLO 4** Learn Minimization and related methods for exploring the energy surface. Understand Non-derivative method, First and second order minimization methods. Utilization simple Computer simulation methods. Understanding Simple thermodynamic properties and Phase Space. Boundaries. (Learn and correlate)

**CLO 5** Applications of various theories in understanding macromolecular system. Differentiate the binding and inhibition actions of ligands(learn, apply and modify)

**Mapping of CLOs with PLOs**

| | CLO1 | CLO2 | CLO3 | CLO4 | CLO5 |
|---|---|---|---|---|---|
| PLO1 | 3 | 3 | 3 | 2 | 2 |
| PLO2 | 2 | 3 | 3 | 3 | 2 |
| PLO3 | 2 | 2 | 3 | 3 | 2 |
| PLO4 | 2 | 2 | 2 | 3 | 3 |
| PLO5 | 1 | 2 | 2 | 2 | 3 |
| PLO6 | 1 | 1 | 1 | 2 | 3 |
| PLO7 | 1 | 1 | 1 | 2 | 3 |
| PSO1 | 3 | 3 | 3 | 2 | 2 |
| PSO2 | 2 | 3 | 3 | 3 | 2 |
| PSO3 | 2 | 2 | 3 | 3 | 2 |
| PSO4 | 2 | 2 | 2 | 3 | 2 |
| PSO5 | 2 | 2 | 2 | 2 | 3 |
| PSO6 | 2 | 2 | 2 | 2 | 3 |
| PSO7 | 1 | 2 | 2 | 2 | 3 |
| PSO8 | 1 | 1 | 2 | 2 | 3 |
| PSO9 | 1 | 1 | 1 | 2 | 3 |

**Teaching Learning Process:**

1. Introducing basic mathematical tools using excel and VB script
2. The teaching Learning Progression for the course is student centric
3. Intelligent mix of conventional and modern methods is opted both through whiteboard and education animations using available free computational tools.
4. Engaging students in cooperative and synergistic learning.

**Assessment Methods:**

1. Continuous Evaluation: by monitoring the progress of students' learning.
2. Class Tests, Worksheets.
3. Assignments, and projects, to enhance critical thinking skills and personality.
4. Semester-end Examination: a critical indicator of students' learning of theoretical concepts

**Keywords:**
Potential energy surface, Molecular Dynamics, Inhibition and binding constant, Mathematical models

# DSE

## PAPER CODE: BCH-DSE2 TH

## TITLE: MOLECULAR MODELLING & DRUG DESIGN

**TOTAL HOURS: 60** **CREDITS: 04**

**Unit I: INTRODUCTION TO MOLECULAR MODELLING [10Hours]**

Introduction. Useful Concepts in Molecular Modelling: Coordinate Systems. Potential Energy Surfaces. Molecular Graphics. Surfaces. Computer Hardware and Software. The Molecular Modelling Literature.

**Unit II: FORCE FIELDS [10Hours]**

Fields. Bond Stretching. Angle Bending. Introduction to nonbonded interactions. Electrostatic interactions. van der Waals Interactions. Hydrogen bonding in Molecular Mechanics. Force Field Models for the Simulation of Liquid Water.

**UnitIII: ENERGY MINIMIZATION AND COMPUTER SIMULATION MOLECULAR DYNAMICS & MONTE CARLO SIMULATION [16 Hours]**

Minimization and related methods for exploring the energy surface. Non-derivative method, First and second order minimization methods. Computer simulation methods. Simple thermodynamic properties and Phase Space. Boundaries. Analyzing the results of a simulation and estimating errors.

Molecular Dynamics Simulation Methods. Molecular Dynamics using simple models. Molecular Dynamics with continuous potentials. Molecular Dynamics at constant temperature and pressure. Metropolis method. Monte Carlo simulation of molecules. Models used in Monte Carlo simulations of polymers.

**UNIT IV: STRUCTURE PREDICTION AND DRUG DESIGN [14 Hours]**

Structure prediction - Introduction to comparative Modeling. Sequence alignment. Constructing and evaluating a comparative model. Predicting protein structures by' Threading', Molecular docking. Structure based de novo ligand design.

Drug Discovery – Chemoinformatics – QSAR.

**Suggested Reading:**


- A.R. Leach, *Molecular Modelling Principles and Application*, Longman, 2001.
- J.M. Haile, *Molecular Dynamics Simulation Elementary Methods*, John Wiley andSons, 1997.
- Satya Prakash Gupta, *QSAR and Molecular Modeling*, Springer – AnamayaPublishers, 2008.

**SEMESTER V**
**DISCIPLINE SPECIFIC ELECTIVE (PRACTICAL) COURSE**
**PAPER CODE: BCH-DSE2 PR**
**TITLE: MOLECULAR MODELLING & DRUG DESIGN**

**Total Hours: 60Hours** **Credit :02**

**Objective**

**Learn** the basic concepts and software for understanding structural aspects, reactions and transition states. Analysing the therapeutic value of drugs. The subject emphasizes on structure activity relationships of simple molecules and importance of physicochemical properties.

**Course Learning objectives:**

On completion of this course the students will be able to:

**CLO 1** To revise and understand basic physicochemical properties and theoretical methods for their determination (**Learn and Understand**)

**CLO 2** Understand the in-silico aspects and find suitable modules and system requirement. Differentiate between the freeware and commercial software. (**Understand and differentiate**)

**CLO 3** Perform simple calculations for evaluating the thermodynamic parameter (**develop and plan**)

**CLO 4** Learn and perform Minimization using Non-derivative method, First and second order minimization methods..(Learn and correlate)

**CLO 5** Applications of molecular docking and dynamic calculations. (learn, apply and modify)

**Mapping of CLOs with PLOs**

| | CLO1 | CLO2 | CLO3 | CLO4 | CLO5 |
|---|---|---|---|---|---|
| **PLO1** | **3** | **3** | **3** | **2** | **2** |
| **PLO2** | **2** | **3** | **3** | **3** | **2** |
| **PLO3** | **2** | **2** | **3** | **3** | **2** |
| **PLO4** | **2** | **2** | **2** | **3** | **3** |
| **PLO5** | **1** | **2** | **2** | **2** | **3** |
| **PLO6** | **1** | **1** | **1** | **2** | **3** |
| **PLO7** | **1** | **1** | **1** | **2** | **3** |
| **PSO1** | **3** | **3** | **3** | **2** | **2** |
| **PSO2** | **2** | **3** | **3** | **3** | **2** |
| **PSO3** | **2** | **2** | **3** | **3** | **2** |
| **PSO4** | **2** | **2** | **2** | **3** | **2** |
| **PSO5** | **2** | **2** | **2** | **2** | **3** |
| **PSO6** | **2** | **2** | **2** | **2** | **3** |
| **PSO7** | **1** | **2** | **2** | **2** | **3** |
| **PSO8** | **1** | **1** | **2** | **2** | **3** |
| **PSO9** | **1** | **1** | **1** | **2** | **3** |

**Teaching Learning Process:**

5. Introducing basic mathematical tools using excel and VB script
6. The teaching Learning Progression for the course is student centric
7. Intelligent mix of conventional and modern methods is opted both through whiteboard and education animations using available free computational tools.
8. Engaging students in cooperative and synergistic learning.

**Assessment Methods:**

5. Continuous Evaluation: by monitoring the progress of students' learning.
6. Class Tests, Worksheets and assessments.
7. Assignments, and projects, to enhance critical thinking skills and personality.
8. Semester-end Examination: a critical indicator of students' learning of theoretical concepts

**Keywords:**
Potential energy surface, Molecular Dynamics, Inhibition and binding constant, Mathematical models

# PAPER CODE: BCH-DSE2 PR
## TITLE: MOLECULAR MODELLING & DRUG DESIGN

**TOTAL HOURS: 60** **CREDITS: 02**

1. Compare the optimized C-C bond lengths in ethane, ethene, ethyne and benzene.Visualize the molecular orbitals of the ethane σ bonds and ethene, ethyne, benzeneand pyridine π bonds.
2. Perform a conformational analysis of butane. (b) Determine the enthalpy ofisomerization of *cis* and *trans* 2-butene.
3. Visualize the electron density and electrostatic potential maps for LiH, HF, $N_2$, NOand CO and comment. Relate to the dipole moments. Animate the vibrations of thesemolecules.
4. Relate the charge on the hydrogen atom in hydrogen halides with their acidcharacter.
5. (b) Compare the basicities of the nitrogen atoms in ammonia, methylamine,dimethylamine andtrimethylamine.
6. (a) Compare the shapes of the molecules: 1-butanol, 2-butanol, 2-methyl-1-propanol,and 2-methyl-2-propanol. Note the dipole moment of each molecule. (b) Show howthe shapes affect the trend in boiling points: (118 ºC, 100 ºC, 108 ºC, 82 ºC,respectively).
7. Build and minimize organic compounds of your choice containing the followingfunctional groups. Note the dipole moment of each compound: (a) alkyl halide (b)aldehyde (c) ketone (d) amine (e) ether (f) nitrile (g) thiol (h) carboxylic acid (i) ester) amide.
8. (a) Determine the heat of hydration of ethylene. (b) Compute the resonance energy ofbenzene by comparison of its enthalpy of hydrogenation with that of cyclohexene.
9. Arrange 1-hexene, 2-methyl-2-pentene, (*E*)-3-methyl-2-pentene, (*Z*)-3-methyl-2-pentene, and 2,3-dimethyl-2-butene in order of increasing stability.
10. (a) Compare the optimized bond angles $H_2O$, $H_2S$, $H_2Se$. (b) Compare the HAH bondangles for the second row dihydrides and compare with the results from qualitativeMO theory.

***Note:*** Software: ChemSketch, ArgusLab (www.planaria-software.com), (dasher.wustl.edu/ffe), WebLab Viewer, Hyperchem, or any similar software.

**Suggested Reading**


1. A.R. Leach, *Molecular Modelling Principles and Application*, Longman, 2001.
2. J.M. Haile, *Molecular Dynamics Simulation Elementary Methods*, John Wiley andSons, 1997.
3. Gupta, S.P. *QSAR and Molecular Modeling*, Springer - Anamaya Publishers, 2008.

**SEMESTER V**
**PAPER CODE: BCH-DSE3 TH**
**TITLE: NOVEL INORGANIC SOLIDS**
**Total Credit: 04Total Lectures: 60**
**Paper Code: BCH-DSE3 PR**
**Paper Title: NOVEL INORGANIC SOLIDS**
**Total Credits: 02Total Hours: 60**

**Objectives:**Solid electrolytes, commonly known as super ionic conductors or fast ionic conductors, form a special class of ionic solids that offer high ionic conductivity, i.e., in the range of 0.01–0.1 S/cm. From last two decades solid electrolytes have tremendous attention due to the fascinating possibility of a wide range of applications that include electrochemical devices like solid-state batteries, pacemakers, solid-state gas sensors, etc.Nanoparticles (NPs) are solid colloidal particles with dimensions in the range of a few nanometres to a few hundred nanometres. Due to their unique structural, magnetic, mechanical and electrical properties, NPs are used in a wide range of applications including biosensing, drug delivery, bioimaging, catalysis, nanomanufacturing, lubrication, electronics, textile manufacturing, and water treatment systems.

**Course Learning Objectives:**

**On completion of the course, the student will be able to:**

- **CLO 1** Understand the synthesis and inorganic solids, hydrogel, and composite materials. (Cognitive level – understand)
- **CLO 2** Understand the synthesis and classification of the nanomaterials and metal nanoparticles. (Cognitive level – understand)
- **CLO 3** Employ the procedure for the preparation of solid electrolytes and nanomaterials. (Cognitive level - apply)
- **CLO 4** Analyse the physical and chemical behaviour of the synthesized compounds. (Cognitive level – analyse)
- **CLO 5** Describe the applications of the solid electrolytes, nanomaterials and composite materials. (Cognitive level – evaluate)
- **CLO 6** Develop the new methods for synthesis of solid electrolytes, hydrogel and nanoparticles and explain the chemical properties of the synthesized compounds (Cognitive level – create).

**Mapping of CLOs with PLOs**

| | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 | CLO-6 |
|---|---|---|---|---|---|---|
| **PLO1.** | 2 | 2 | 3 | 3 | 3 | 2 |
| **PLO2.** | 2 | 3 | 3 | 2 | 3 | 3 |
| **PLO3.** | 2 | 2 | 3 | 2 | 2 | 2 |
| **PLO4.** | 3 | 3 | 2 | 2 | 2 | 2 |
| **PLO5.** | 3 | 3 | 2 | 3 | 2 | 3 |
| **PLO6.** | 2 | 2 | 3 | 3 | 3 | 3 |
| **PLO7.** | 2 | 2 | 2 | 2 | 3 | 3 |
| **PSO 1.** | 2 | 2 | 3 | 3 | 3 | 3 |
| **PSO 2.** | 2 | 2 | 2 | 3 | 2 | 3 |
| **PSO 3.** | 3 | 3 | 3 | 3 | 3 | 2 |
| **PSO 4.** | 3 | 3 | 3 | 2 | 2 | 2 |
| **PSO 5.** | 2 | 3 | 2 | 2 | 2 | 2 |
| **PSO 6.** | 2 | 2 | 2 | 2 | 3 | 3 |
| **PSO 7.** | 2 | 2 | 3 | 3 | 3 | 3 |
| **PSO 8.** | 3 | 3 | 2 | 3 | 2 | 3 |
| **PSO 9.** | 3 | 3 | 3 | 3 | 3 | 3 |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

# DSE

## PAPER CODE: BCH-DSE3 TH
## TITLE: NOVEL INORGANIC SOLIDS

**TOTAL HOURS: 60** **CREDITS: 04**

**Unit I: Synthesis and modification of inorganic solids: [15 Hours]**
Conventional heat and beat methods, Co-precipitation method, Sol-gel methods, Hydrothermal method, Ion-exchange and Intercalation methods. Inorganic solids of technological importance: Solid electrolytes – Cationic, anionic, mixed Inorganic pigments – coloured solids, white and black pigments. Molecular material and fullerides, molecular materials & chemistry – one-dimensional metals, molecular magnets, inorganic liquid crystals.

**Unit II: Nanomaterials: [15 Hours]**

Overview of nanostructures and nanomaterials: classification. Preparation of gold and silver metallic nanoparticles, self-assembled nanostructures-control of nanoarchitecture-one dimensional control. Carbon nanotubes and inorganic nanowires. Bio-inorganic nanomaterials, DNA and nanomaterials, natural and antisical nanomaterials, bio-nano composites.

Unit III: Composite materials: **[15 Hours]**
Composite materials: Introduction, limitations of conventional engineering materials, role of matrix in composites, classification, matrix materials, reinforcements, metal-matrix composites, polymer-matrix composites, fiber-reinforced composites, environmental effects on composites, applications of composites.

**Unit IV: Introduction to engineering materials for mechanical construction: [15 Hours]**

Composition, mechanical and fabricating characteristics and applications of various types of cast irons, plain carbon and alloy steels, copper, aluminum and their alloys like duralumin, brasses and bronzes cutting tool materials, super alloys thermoplastics, thermosets and composite materials.
Specialty polymers: Conducting polymers - Introduction, conduction mechanism, polyacetylene, polyparaphenylene and polypyrrole, applications of conducting polymers, Ion-exchange resins and their applications. Ceramic & Refractory: Introduction, classification, properties, raw materials, manufacturing and applications.

***Suggested Reading:***


1. Shriver & Atkins. *Inorganic Chemistry*, Peter Alkins, Tina Overton, JonathanRourke, Mark Weller and Fraser Armstrong, 5th Edition, Oxford University Press(2011-2012)
2. Adam, D.M. *Inorganic Solids: An introduction to concepts in solid-state structuralchemistry*. John Wiley & Sons, 1974.
3. Poole, C.P. & Owens, F.J. *Introduction to Nanotechnology* John Wiley & Sons, 2003.
4. Rodger, G.E. *Inorganic and Solid State Chemistry*, Cengage Learning India Edition,2002.

# DSE

**PAPER CODE: BCH-DSE3PR**
**TITLE: NOVEL INORGANIC SOLIDS**

**TOTAL HOURS: 60** **CREDITS: 02**

1. Determination of cation exchange method
2. Determination of total difference of solids.
3. Synthesis of hydrogel by co-precipitation method.
4. Synthesis of silver and gold metal nanoparticles.

***Suggested Reading***


- Fahlman, B.D. *Materials Chemistry,* Springer, 2004.


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**Teaching Learning Process:**

- Lectures in classrooms
- Peer learning
- Hands-on learning using videos, presentations, seminars
- Technology-driven Learning

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes.
  - Presentations, assignments, group discussions, projects, viva-voce to enhance critical thinking skills and personality.
- Semester-end Examination: a critical indicator of students's learning and teaching methods adopted by teachers throughout the semester.

**Keywords:**

Nanomaterials, Inorganic solid, solid electrolytes, composite materials, hydrogel, chromatography.

**PAPER CODE: BCH-DSE 04**
**PAPER TITLE: POLYMER CHEMISTRY**

**Total Credits: 06 - (BCH-DSE 04TH -04, BCH-DSE 04 PR -02)**
**Total Lectures: BCH-DSE 04 TH - 60, BCH-DSE 04 PR -60**

**Objectives:**
The primary objective of this paper is to help the student to know about the synthesis, properties and applications of polymers.

**Course Learning Outcomes: By the end of this course, students will be able to:**

1. Know about history of polymeric materials and their classification **(Cognitive level: Remember and understand)**
2. Know about solid and solution properties of polymers **((Cognitive level: Remember and understand)**
3. Learn properties and applications of various useful polymers in our daily life (**Cognitive level: Remember and understand)**
4. Learn about different mechanisms of polymerization and polymerization techniques **(Cognitive level: Remember and understand)**
5. Learn about different methods of finding out average molecular weight of polymers (**Cognitive level: Remember and understand)**
6. Differentiate between polymers and copolymers **(Cognitive level: Apply and evaluate**)
7. Differentiate between glass transition temperature (Tg) and crystalline melting point (Tm) (**Cognitive level: Apply and evaluate)**
8. Evaluate kinetic chain length of polymers based on their mechanism Determine Tg and Tm **(Cognitive level: Apply and evaluate)**
9. Characterize polymers **(Cognitive level: Apply and evaluate)**
10. Synthesize molecules using different polymerization techniques **(Cognitive level: Create)**

**Mapping of CLOs with PLOS**

| | CLO1 | CLO2 | CLO3 | CLO4 | CLO5 | CLO6 | CLO7 | CLO8 | CLO9 | CLO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **PLO1.** | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 |
| **PLO2.** | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 |
| **PLO3.** | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **PLO4.** | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| **PLO5.** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| **PLO6.** | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 |
| **PLO7.** | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 |
| **PSO 1.** | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 |
| **PSO 2.** | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 |
| **PSO 3.** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| **PSO 4.** | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 |
| **PSO 5.** | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| **PSO 6.** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| **PSO 7.** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| **PSO 8.** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| **PSO 9.** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

## BCH-DSE TH: Course contents

**Credits: 4** **Periods: 60**

**Unit I: INTRODUCTION AND HISTORY OF POLYMERIC MATERIALS:**
Different schemes of classification of polymers, Polymer nomenclature, Molecular forces and chemical bonding in polymers, Texture of Polymers.
**Functionality and its importance:** Criteria for synthetic polymer formation, classification of polymerization processes, Relationships between functionality, extent of reaction and degree of polymerization. Bifunctional systems, Poly-functional systems. **[15 hours]**

**Unit II: Kinetics of Polymerization:** **[15 hours]**
Mechanism and kinetics of step growth, radical chain growth, ionic chain (both cationic andanionic) and coordination polymerizations, Mechanism and kinetics of copolymerization,polymerization techniques.
Crystallization and crystallinity: Determination of crystalline melting point and degree of crystallinity, Morphology of crystalline polymers, Factors affecting crystalline melting point. Nature and structure of polymers-Structure Property relationships.

**Unit III: Determination of molecular weight of polymers** (*Mn*, *Mw*, etc) **[15 hours]**

End group analysis, viscometry, light scattering and osmotic pressure methods. Molecular weight distribution and its significance. Poly dispersity index.
**Glass transition temperature (Tg) and determination of Tg**, Free volume theory, WLF equation, Factors affecting glass transition temperature (Tg).
**Polymer Solution** – Criteria for polymer solubility, Solubility parameter, Thermodynamics of polymer solutions, entropy, enthalpy, and free energy change of mixing of polymer solutions, Flory- Huggins theory, Lower and Upper critical solution temperatures.

**Unit IV: Properties of Polymer**s (Physical, thermal, Flow & Mechanical Properties).**[15 hours]**
Brief introduction to preparation, structure, properties and application of the following polymers: polyolefins, polystyrene and styrene copolymers, poly(vinyl chloride) and related polymers, poly(vinyl acetate) and related polymers, acrylic polymers, fluoro polymers, polyamides and related polymers. Phenol formaldehyde resins (Bakelite, Novalac), polyurethanes, silicone polymers, polydienes, Polycarbonates, Conducting polymers, [polyacetylene, polyaniline, poly(p-phenylene sulphide polypyrroles, polythiophene)].

## BCH-DSE PR: Course contents

**Credits: 02** **Lab. hours: 60**

### A. Polymer synthesis

1. Free radical solution polymerization of styrene (St) / Methyl Methacrylate (MMA) /Methyl Acrylate (MA) / Acrylic acid (AA).
   a) Purification of monomer
   b) Polymerization using benzoyl peroxide (BPO) / 2,2'-azo-bis-isobutylonitrile =(AIBN)
2. Preparation of nylon 66/6
3. Interfacial polymerization, preparation of polyester from isophthaloyl chloride (IPC) and phenolphthalein
4. Redox polymerization of acrylamide
5. Precipitation polymerization of acrylonitrile
6. Preparation of urea-formaldehyde resin
7. Preparations of novalac resin/ resold resin.
8. Microscale Emulsion Polymerization of Poly(methylacrylate).

### B. Polymer characterization

1. Determination of molecular weight by viscometry:
   a) Polyacrylamide-aq. $NaNO_2$ solution
   b) (Poly vinyl proplylidine (PVP) in water
2. Determination of the viscosity-average molecular weight of poly (vinyl alcohol) (PVOH) and the fraction of "head-to-head" monomer linkages in the polymer.
3. Determination of molecular weight by end group analysis: Polyethylene glycol (PEG)(OH group).
4. Testing of mechanical properties of polymers.
5. Determination of hydroxyl number of a polymer using colorimetric method.

### C. Polymer analysis

1. Estimation of the amount of HCHO in the given solution by sodium sulphite method
2. Instrumental Techniques
3. IR studies of polymers
4. DSC analysis of polymers
5. Preparation of polyacrylamide and its electrophoresis

**Suggested Reading (Theory):**


- R.B. Seymour & C.E. Carraher: *Polymer Chemistry: An Introduction,* Marcel Dekker,Inc. New York, 1981.
- G. Odian: *Principles of Polymerization*, 4th Ed. Wiley, 2004.
- F.W. Billmeyer: *Textbook of Polymer Science*, 2nd Ed. Wiley Interscience, 1971.
- P. Ghosh: Polymer Science & Technology, Tata McGraw-Hill Education, 1991.
- R.W. Lenz: *Organic Chemistry of Synthetic High Polymers.* Interscience Publishers, NewYork, 1967.


**Suggested Reading (Practical):**


- M.P. Stevens, *Polymer Chemistry: An Introduction*, 3rd Ed., Oxford University Press,1999.
- H.R. Allcock, F.W. Lampe & J.E. Mark, *Contemporary Polymer Chemistry,* 3rd ed.Prentice-Hall (2003)
- F.W. Billmeyer, *Textbook of Polymer Science*, 3rd ed. Wiley-Interscience (1984)

- J.R. Fried, *Polymer Science and Technology*, 2nd ed. Prentice-Hall (2003)
- P. Munk & T.M. Aminabhavi, *Introduction to Macromolecular Science*, 2nd ed. JohnWiley & Sons (2002)
- L. H. Sperling, *Introduction to Physical Polymer Science*, 4th ed. John Wiley & Sons(2005)
- M.P. Stevens, *Polymer Chemistry: An Introduction* 3rd ed. Oxford University Press(2005).
- Seymour/ Carraher's Polymer Chemistry, 9th ed. by Charles E. Carraher, Jr. (2013).


**Teaching Learning Process:**

- The teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Problem-solving to enhance comprehension.

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
    - Class Tests, Worksheets and Quizzes
    - Presentations by individual student/ small group of students, assignments, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab

**Keywords:** Polymer synthesis, Characterization, Fabrics, Analysis, Rubbers, Polymers.

**PAPER CODE: BCH-DSE5 TH**
**TITLE: GREEN CHEMISTRY**

**Total Credits: 06 - (BCH-DSE5TH-04, BCH-DSE5PR -02)**
**Total Lectures: BCH-DSE5TH - 60, BCH- DSE5PR -60**

**Objectives:**The core course Green Chemistry is designed to strengthen the basic and fundamental concepts of sustainable development which involve reduction in waste generation and better atom economy by producing harmless product.

**Course Learning Objectives:**

**On completion of the course, the student will be able to:**

**CLO 1.** Understand and explain the different twelve principal of Green Chemistry.(Cognitive level: learn and understand).

**CLO 2.** Learn and understand many concepts of atom economy.(Cognitive level: learn and understand).

**CLO 3.** Solving many waste generation problem by new concepts of super critical fluids, ionic liquids etc.(Cognitive level: understand and analyze)

**CLO 4.** Designing safer method of organic synthesis using microwave and biocatalyst.(Cognitive level: synthesis).

**CLO 5.** Application of green chemistry in daily life like using safer solvents in dry cleaning. (Cognitive level: apply).

**Mapping of CLOs with PLOS**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 | CLO 5 |
|---|---|---|---|---|---|
| **PLO1.** | **3** | **3** | **2** | **2** | **2** |
| **PLO2.** | **3** | **3** | **2** | **2** | **2** |
| **PLO3.** | **3** | **3** | **2** | **2** | **2** |
| **PLO4.** | **2** | **3** | **3** | **2** | **2** |
| **PLO5.** | **2** | **2** | **3** | **3** | **2** |
| **PLO6.** | **2** | **2** | **2** | **3** | **3** |
| **PLO7.** | **2** | **2** | **2** | **3** | **3** |
| **PSO 1.** | **3** | **3** | **2** | **2** | **2** |
| **PSO 2.** | **3** | **3** | **2** | **2** | **2** |
| **PSO 3.** | **3** | **3** | **3** | **2** | **2** |
| **PSO 4.** | **2** | **2** | **2** | **3** | **3** |
| **PSO 5.** | **2** | **2** | **3** | **3** | **2** |
| **PSO 6.** | **2** | **2** | **2** | **3** | **3** |
| **PSO 7.** | **2** | **2** | **2** | **3** | **3** |
| **PSO 8.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 9.** | **2** | **2** | **2** | **2** | **3** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

# DSE

**PAPER CODE: BCH-DSE5 TH**
**TITLE: GREEN CHEMISTRY**

**TOTAL HOURS: 60** **CREDITS: 04**

**Unit I: INTRODUCTION TO GREEN CHEMISTRY:** What is Green Chemistry? Need for Green Chemistry; Goals of Green Chemistry.Limitations/ Obstacles in the pursuit of the goals of Green ChemistryPrinciples of Green Chemistry and Designing a Chemical synthesis: Twelve principles of Green Chemistry with their explanations and examples and special emphasis on the following:Designing a Green Synthesis using these principles; Prevention of Waste/ byproducts;maximum incorporation of the materials used in the process into the final products ,Atom Economy, calculation of atom economy of the rearrangement, addition,substitution and elimination reactions.Prevention/ minimization of hazardous/ toxic products reducing toxicity.risk = (function) hazard × exposure; waste or pollution prevention hierarchy.**(15 Hours**)

**Unit II: GREEN SOLVENTS:**Supercritical fluids, water as a solvent for organic reactions, ionicliquids, fluorous biphasic solvent, PEG, solventless processes, immobilized solventsand how to compare greenness of solvents; Energy requirements for reactions – alternative sources of energy: use of microwavesand ultrasonic energy; Selection of starting materials; avoidance of unnecessary derivatization – careful useof blocking/protecting groups; Use of catalytic reagents (wherever possible) in preference to stoichiometric reagents;catalysis and green chemistry, comparison of heterogeneous and homogeneouscatalysis, biocatalysis, asymmetric catalysis and photocatalysis.; Prevention of chemical accidents designing greener processes, inherent safer design,principle of ISD "What you don't have cannot harm you", greener alternative toBhopal Gas Tragedy (safer route to carcarbaryl) and Flixiborough accident (saferroute to cyclohexanol) subdivision of ISD, minimization, simplification, substitution,moderation and limitation.: Strengthening/ development of analytical techniques to prevent and minimize thegeneration of hazardous substances in chemical processes. (**15Hours**)

**Unit III: [18 Hours]**

**EXAMPLES OF GREEN SYNTHESIS/ REACTIONS AND SOME REAL WORLD CASES:**

Green Synthesis of the following compounds: adipic acid, catechol, disodiumiminodiacetate (alternative to Strecker synthesis); Microwave assisted reactions in water: Hofmann Elimination, methyl benzoate to benzoicacid, oxidation of toluene and alcohols; microwave assisted reactions in organic solventsDiels-Alder reaction andDecarboxylation reaction; Ultrasound assisted reactions: sonochemical Simmons-Smith Reaction (Ultrasonicalternative to Iodine); Surfactants for carbon dioxide – replacing smog producing and ozone depletingsolvents with CO2 for precision cleaning and dry cleaning of garments; Designing of Environmentally safe marine antifoulant; Rightfit pigment: synthetic azopigments to replace toxic organic and inorganicpigments.; An efficient, green synthesis of a compostable and widely applicable plastic (polylactic acid) made from corn.8 Healthier Fats and oil by Green Chemistry: Enzymatic Inter esterification forproduction of no Trans-Fats and Oils; Development of Fully Recyclable Carpet: Cradle to Cradle Carpeting.

**Unit IV: FUTURE TRENDS IN GREEN CHEMISTRY [12 Hours]**

Oxidation reagents and catalysts; Biomimetic, multifunctional reagents; Combinatorial greenchemistry; Proliferation of solventless reactions; co crystal controlled solid state synthesis(C2S3); Green chemistry in sustainable development.

***Suggested Reading:***


1. Ahluwalia, V.K. & Kidwai, M.R. *New Trends in Green Chemistry*, AnamalayaPublishers (2005).
2. Anastas, P.T. & Warner, J.K.: *Green Chemistry - Theory and Practical*, OxfordUniversity Press (1998).
3. Matlack, A.S. *Introduction to Green Chemistry*, Marcel Dekker (2001).
4. Cann, M.C. & Connely, M.E. *Real-World cases in Green Chemistry*, AmericanChemical Society,Washington (2000).
5. Ryan, M.A. & Tinnesand, M. *Introduction to Green Chemistry*, American ChemicalSociety, Washington (2002).
6. Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition,2010.

# DSE

**PAPER CODE: BCH-DSE5PR**
**TITLE: GREEN CHEMISTRY**

**TOTAL HOURS: 60** **CREDITS: 02**

**Safer starting materials**

1. Preparation and characterization of nanoparticles of gold using tea leaves.
2. **Using renewable resources:** Preparation of biodiesel from vegetable/ waste cooking oil.
3. **Avoiding waste:** Principle of atom economy: Use of molecular model kit to stimulate the reaction to investigate how the atomeconomy can illustrate Green Chemistry.
4. Preparation of propene by two methods can be studied
    - Triethylamine ion + OH- → propene + trimethylpropene + water
    - 1-propanolH2SO4/
    - Propene + water
5. Other types of reactions, like addition, elimination, substitution and rearrangementshould also be studied for the calculation of atom economy.
6. **Use of enzymes as catalysts:** Benzoin condensation using Thiamine Hydrochloride as a catalyst instead of cyanide.
7. **Alternative Green solvents:**Extraction of D-limonene from orange peel using liquid CO2 prepared form dry ice.
8. Mechanochemical solvent free synthesis of azomethines
9. **Alternative sources of energy:**
    - Solvent free, microwave assisted one pot synthesis of phthalocyanine complex ofcopper.
    - Photoreduction of benzophenone to benzopinacol in the presence of sunlight.

***Suggested Reading:***


- Anastas, P.T & Warner, J.C. *Green Chemistry: Theory and Practice*, OxfordUniversity Press (1998).
- Kirchoff, M. & Ryan, M.A. *Greener approaches to undergraduate chemistryexperiment*. American Chemical Society, Washington DC (2002).
- Ryan, M.A. *Introduction to Green Chemistry*, Tinnesand; (Ed), American ChemicalSociety, Washington DC (2002).
- Sharma, R.K.; Sidhwani, I.T. & Chaudhari, M.K. I.K. *Green Chemistry Experiment:A monograph International Publishing House Pvt Ltd. New Delhi*. Bangalore CISBN978-93-81141-55-7 (2013).
- Cann, M.C. & Connelly, M. E. *Real world cases in Green Chemistry*, AmericanChemical Society (2008).
- Cann, M. C. & Thomas, P. *Real world cases in Green Chemistry*, American ChemicalSociety (2008).
- Lancaster, M. *Green Chemistry: An Introductory Text* RSC Publishing, 2nd Edition,2010.
- Pavia, D.L., Lampman, G.M., Kriz, G.S. & Engel, R.G. *Introduction to OrganicLaboratory Techniques: A Microscale and Macro Scale Approach*, W.B.Saunders,1995.


**Teaching Learning Process:**

- The teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Problem-solving to enhance comprehension.

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
    - Class Tests, Worksheets and Quizzes
    - Presentations by individual student/ small group of students, assignments , projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquird in the lab

**Keywords:**
Green Chemistry, Green Synthesis, Green Solvents, Future Trends in Green Chemistry.

| Paper Code: BCH-DSE6 TH<br>Paper Title: INDUSTRIAL CHEMICALS AND ENVIRONMENT |
|---|
| Total Credits: 04Total Hours: 60 |
| SEMESTER V |
| Paper Code: BCH-DSE6 PR<br>Paper Title: INDUSTRIAL CHEMICALS AND ENVIRONMENT |
| Total Credits: 02Total Hours: 60 |

**Objectives**: After industrial revolution, manufacturing and technology made advances which resulted in more factories and more industries. These factories cause air and water pollution. This course teaches about the source of energy and the treatment against the water pollution, air pollution and nuclear pollution. This course also teaches the manufacturing the inorganic chemical on industrial level.

**Course Learning Objectives**:

At the end of this semester, each student will be able to:

**CLO 1** Understand the procedure for the synthesis of inorganic chemicals on industrial level. (Cognitive level - understand)

**CLO 2** Understand the about the ecosystem, biogeochemical cycle, nuclear pollution and the source of air and water pollution. (Cognitive level - understand)

**CLO 3** Understand the determination of dissolved oxygen in water, Chemical Oxygen Demand (COD) and Biological Oxygen Demand (BOD)

**CLO 4** Employ the techniques for measuring the pollutions and then purification of air and water pollution. (Cognitive level - apply)

**CLO 5** Employ the procedure for the synthesis of the inorganic chemicals and examine the change in the physical state of the reaction. (Cognitive level - analyse)

**CLO 6** Describe the source of energy like coal, petrol and natural gas, nuclear fusion / fission, solar energy, hydrogen, geothermal, tidal and hydel, etc. (Cognitive level - evaluate)

**Mapping of CLOs with PLOS**

| | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 | CLO-6 |
|---|---|---|---|---|---|---|
| PLO1. | 2 | 2 | 2 | 2 | 3 | 2 |
| PLO2. | 2 | 3 | 2 | 3 | 2 | 3 |
| PLO3. | 2 | 2 | 3 | 3 | 3 | 3 |
| PLO4. | 3 | 2 | 3 | 2 | 3 | 3 |
| PLO5. | 2 | 3 | 2 | 3 | 2 | 2 |
| PLO6. | 2 | 3 | 3 | 3 | 3 | 3 |
| PLO7. | 3 | 2 | 2 | 2 | 3 | 3 |
| PSO 1. | 2 | 2 | 3 | 2 | 2 | 2 |
| PSO 2. | 3 | 3 | 2 | 2 | 2 | 2 |
| PSO 3. | 3 | 3 | 3 | 3 | 3 | 3 |
| PSO 4. | 2 | 2 | 3 | 3 | 2 | 3 |
| PSO 5. | 3 | 2 | 3 | 2 | 2 | 3 |
| PSO 6. | 3 | 3 | 2 | 2 | 2 | 2 |
| PSO 7. | 2 | 2 | 3 | 3 | 3 | 3 |
| PSO 8. | 2 | 3 | 2 | 3 | 3 | 3 |
| PSO 9. | 2 | 3 | 3 | 3 | 3 | 3 |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

# DSE

**PAPER CODE: BCH-DSE6 TH**

**TITLE: INDUSTRIAL CHEMICALS AND ENVIRONMENT**

**TOTAL HOURS: 60** **CREDITS: 04**

**UNIT I: INDUSTRIAL GASES AND INORGANIC CHEMICALS: [15 Hours]**

Industrial Gases: Large scale production, uses, storage and hazards in handling of the following gases: oxygen, nitrogen, argon, neon, helium, hydrogen, acetylene, carbon monoxide, chlorine, fluorine, sulphur dioxide and phosgene.

*Inorganic Chemicals:* Manufacture, application, analysis and hazards in handling the following chemicals: hydrochloric acid, nitric acid, sulphuric acid, caustic soda, common salt, borax, bleaching powder, sodium thiosulphate, hydrogen peroxide, potash alum, chrome alum, potassium dichromate and potassium permanganate; Industrial Metallurgy: Preparation of metals (ferrous and nonferrous) and ultrapure metals for semiconductor technology.

**UNIT II: ENVIRONMENT AND ITS SEGMENTS: [15 Hours]**

Ecosystems. Biogeochemical cycles of carbon, nitrogen and Sulphur. Air Pollution: Major regions of atmosphere. Chemical and photochemical reactions in atmosphere. Air pollutants: types, sources, particle size and chemical nature; Photochemical smog: its constituents and photochemistry. Environmental effects of ozone, Major sources of air pollution.

Pollution by $SO_2$, $CO_2$, CO, NOx, $H_2S$ and other foul smelling gases. Methods of estimation of CO, NOx, SOx and control procedures.

Effects of air pollution on living organisms and vegetation. Greenhouse effect and Global warming, Ozone depletion by oxides of nitrogen, chlorofluorocarbons and Halogens, removal of sulphur from coal. Control of particulates.

**UNIT III: WATER POLLUTION: [15 Hours]**

Hydrological cycle, water resources, aquatic ecosystems, Sources and nature of water pollutants, Techniques for measuring water pollution, Impacts of water pollution on hydrological and ecosystems.

Water purification methods. Effluent treatment plants (primary, secondary and tertiary treatment). Industrial effluents from the following industries and their treatment: electroplating, textile, tannery, dairy, petroleum and petrochemicals, agro, fertilizer, etc.

Sludge disposal. Industrial waste management, incineration of waste. Water treatment and purification (reverse osmosis, electro dialysis, ion exchange). Water quality parameters for waste water, industrial water and domestic water.

**UNIT IV: ENERGY & ENVIRONMENT: [15 Hours]**

Sources of energy: Coal, petrol and natural gas. Nuclear Fusion / Fission, Solar energy, Hydrogen, geothermal, Tidal and Hydel, etc. Nuclear Pollution: Disposal of nuclear waste, nuclear disaster and its management. Introduction to biocatalysis: Importance in "Green Chemistry" and Chemical Industry.

**Suggested Reading:**


- E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, WileyPublishers, New Delhi.
- J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
- S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. NewDelhi.
- K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
- S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.
- S.E. Manahan, *Environmental Chemistry*, CRC Press (2005).
- G.T. Miller, *Environmental Science* 11th edition. Brooks/ Cole (2006).
- A. Mishra, *Environmental Studies*. Selective and Scientific Books, New Delhi (2005).

# DSE

**PAPER CODE: BCH-DSE6PR**
**TITLE: INDUSTRIAL CHEMICALS AND ENVIRONMENT**

**TOTAL HOURS: 60** **CREDITS: 02**

1. Determination of dissolved oxygen in water.
2. Determination of Chemical Oxygen Demand (COD)
3. Determination of Biological Oxygen Demand (BOD)
4. Percentage of available chlorine in bleaching powder.
5. Measurement of chloride, sulphate and salinity of water samples by simple titration
6. method (AgNO3 and potassium chromate).
7. Estimation of total alkalinity of water samples (CO32-, HCO3-) using double titration method.
8. Measurement of dissolved CO2.
9. Study of some of the common bio-indicators of pollution.
10. Estimation of SPM in air samples.
11. Preparation of borax/ boric acid.

***Suggested Reading*:**


1. E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
2. R.M. Felder, R.W. Rousseau: *Elementary Principles of Chemical Processes*, WileyPublishers, New Delhi.
3. J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
4. S. S. Dara: *A Textbook of Engineering Chemistry*, S. Chand & Company Ltd. NewDelhi.
5. K. De, *Environmental Chemistry*: New Age International Pvt., Ltd, New Delhi.
6. S. M. Khopkar, *Environmental Pollution Analysis*: Wiley Eastern Ltd, New Delhi.


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**Teaching Learning Process:**

- Lectures in classrooms
- Peer learning
- Hands-on learning using lab practicals, videos, presentations, seminars
- Technology-driven Learning

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments, group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of students' learning and teaching methods adopted by teachers throughout the semester.


**Keywords:**
Industrial gases, inorganic chemicals, air pollution, water pollution, nuclear pollution, energy sources, titration.

**Paper Code: BCH-DSE7 TH**
**Paper Title: INDUSTRIAL CHEMICALS AND ENVIRONMENT**
**Total Credits: 04 Total Lectures: 60**
**Semester – V**
**Paper Code: BCH-DSE7 PR**
**Paper Title: INORGANIC MATERIALS OF INDUSTRIAL IMPORTANCE**
**Total Credits: 02Total Hours: 60**

**Objectives:**

**Course Learning Objectives:**
**At the end of this semester, each student will be able to:**

**CLO 1** Classify the glasses, ceramics, alloys and surface coatings. (Cognitive level-understand)

**CLO 2** Understand the manufacturing procedure of the fertilizers; Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate; (Cognitive level-understand)

**CLO 3** Understand the characteristic and working of batteries. (Cognitive level - understand)

**CLO 4** Describe thegeneral principles and properties of homogenous and heterogenous catalysis and their industrial applications. (Cognitive level-evaluate)

**CLO 5** Describe the procedure for the estimation of calcium and phosphoric acid from their corresponding fertilizers. (Cognitive level-evaluate)

**CLO 6** Explain the catalysis of different catalysts. (Cognitive level-create)

**Mapping of CLOs with PLOs**

| | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 | CLO-6 |
|---|---|---|---|---|---|---|
| PLO1. | 2 | 2 | 3 | 2 | 3 | 3 |
| PLO2. | 2 | 3 | 3 | 3 | 3 | 2 |
| PLO3. | 2 | 2 | 2 | 2 | 2 | 3 |
| PLO4. | 3 | 2 | 3 | 2 | 2 | 2 |
| PLO5. | 2 | 3 | 3 | 2 | 2 | 3 |
| PLO6. | 3 | 2 | 3 | 3 | 3 | 3 |
| PLO7. | 3 | 2 | 2 | 3 | 3 | 3 |
| PSO 1. | 2 | 2 | 2 | 3 | 2 | 3 |
| PSO 2. | 2 | 3 | 3 | 2 | 2 | 3 |
| PSO 3. | 2 | 3 | 3 | 3 | 2 | 3 |
| PSO 4. | 2 | 2 | 3 | 3 | 3 | 3 |
| PSO 5. | 3 | 2 | 2 | 2 | 2 | 2 |
| PSO 6. | 3 | 3 | 2 | 2 | 3 | 2 |
| PSO 7. | 2 | 2 | 2 | 2 | 2 | 3 |
| PSO 8. | 3 | 3 | 3 | 3 | 3 | 3 |
| PSO 9. | 3 | 3 | 3 | 3 | 3 | 3 |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

# DSE

## PAPER CODE: BCH-DSE7 TH
## TITLE: INDUSTRIAL CHEMICALS AND ENVIRONMENT

**TOTAL HOURS: 60** **CREDITS: 04**

**UNIT I: SILICATE INDUSTRIES: [15 Hours]**

***Glass:*** Glassy state and its properties, classification (silicate and non-silicate glasses). Manufacture and processing of glass. Composition and properties of the following types of glasses: Soda lime glass, lead glass, armoured glass, safety glass, borosilicate glass, fluorosilicate, colored glass, photosensitive glass. *Ceramics:* Important clays and feldspar, ceramic, their types and manufacture. High technology ceramics and their applications, superconducting and semiconducting oxides, fullerenes carbon nanotubes and carbon fiber. *Cements:* Classification of cement, ingredients and their role, Manufacture of cement and thermosetting process, quick setting cements.

**UNIT II: [15 Hours]**

**Fertilizers**: Different types of fertilizers. Manufacture of the following fertilizers: Urea, ammonium nitrate, calcium ammonium nitrate, ammonium phosphates; polyphosphate, superphosphate, compound and mixed fertilizers, potassium chloride, potassium sulphate; Surface Coatings: Objectives of coatings surfaces, preliminary treatment of surface, classification of surface coatings. Paints and pigments-formulation, composition and related properties. Oil paint, Vehicle, modified oils, Pigments, toners and lakes pigments, Fillers, Thinners, Enamels, emulsifying agents. Special paints (Heat retardant, Fire retardant, Eco-friendly paint, Plastic paint), Dyes, Wax polishing, Water and Oil paints, additives, Metallic coatings (electrolytic and electroless), metal spraying and anodizing.

**UNIT III: [15 Hours]**

**Batteries**: Primary and secondary batteries, battery components and their role, Characteristics of Battery. Working of following batteries: Pb acid, Li-Battery, Solid state electrolyte battery. Fuel cells, Solar cell and polymer cell; Alloys: Classification of alloys, ferrous and non-ferrous alloys, Specific properties of elements inalloys. Manufacture of Steel (removal of silicon decarbonization, demanganization, desulphurization dephosphorization) and surface treatment (argon treatment, heat treatment, nitriding, carburizing). Composition and properties of different types of steels.

**UNIT IV: CATALYSIS: [15 Hours]**

General principles and properties of catalysts, homogenous catalysis (catalytic steps and examples) and heterogenous catalysis (catalytic steps and examples) and their industrial applications, Deactivation or regeneration of catalysts. Phase transfer catalysts, application of zeolites as catalysts. Chemical explosives: Origin of explosive properties in organic compounds, preparation and explosive properties of lead azide, PETN, cyclonite (RDX). Introduction to rocket propellants.

***Suggested Reading*:**


- *E. Stocchi: Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
- R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, WileyPublishers, New Delhi.
- W. D. Kingery, H. K. Bowen, D. R. Uhlmann: *Introduction to Ceramics*, WileyPublishers, New Delhi.
- J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
- P. C. Jain, M. Jain: *Engineering Chemistry,* Dhanpat Rai & Sons, Delhi.
- R. Gopalan, D. Venkappayya, S. Nagarajan: *Engineering Chemistry,* VikasPublications, New Delhi.
- Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut(1996).


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# DSE

## PAPER CODE: BCH-DSE7PR
## TITLE: INORGANIC MATERIALS OF INDUSTRIALIMPORTANCE

**TOTAL HOURS: 60** **CREDITS: 02**

1. Determination of free acidity in ammonium sulphate fertilizer.
2. Estimation of Calcium in Calcium ammonium nitrate fertilizer.
3. Estimation of phosphoric acid in superphosphate fertilizer.
4. Electroless metallic coatings on ceramic and plastic material.
5. Determination of composition of dolomite (by complexometric titration).
6. Analysis of (Cu, Ni); (Cu, Zn ) in alloy or synthetic samples.
7. Analysis of Cement.
8. Preparation of pigment (zinc oxide).

***Suggested Reading:***


- E. Stocchi: *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK.
- R. M. Felder, R. W. Rousseau: *Elementary Principles of Chemical Processes*, WileyPublishers, New Delhi.60
- W. D. Kingery, H. K. Bowen, D. R. Uhlmann: *Introduction to Ceramics*, WileyPublishers, New Delhi.
- J. A. Kent: Riegel's *Handbook of Industrial Chemistry*, CBS Publishers, New Delhi.
- P. C. Jain, M. Jain: *Engineering Chemistry*, Dhanpat Rai & Sons, Delhi.
- R. Gopalan, D. Venkappayya, S. Nagarajan: *Engineering Chemistry*, VikasPublications, New Delhi.
- Sharma, B.K. & Gaur, H. *Industrial Chemistry*, Goel Publishing House, Meerut (1996).


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**Teaching Learning Process:**

- Lectures in classrooms
- Peer learning
- Hands-on learning using lab practicals, videos, presentations, seminars
- Technology-driven Learning

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments, group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of students' learning and teaching methods adopted by teachers throughout the semester.

**Keywords**: Glass, ceramics, fertilizers, surface coating, batteries, alloys, catalysis, cement.

| SEMESTER II |
|---|
| **PAPER CODE: BCH-DSE 08**<br>**PAPER TITLE:INSTRUMENTAL METHODS OF CHEMICAL ANALYSIS** |
| **Total Credits: 06 - (BCH-DSE 08TH -04, BCH-DSE 08 PR -02)**<br>**Total Lectures: BCH-DSE 08 TH - 60, BCH-DSE 08 PR -60** |

**Objectives:** The primary objective of this paper is to help the student to know about the various instrumental methods of chemical analysis.

**Course Learning Outcomes: By the end of this course, students will be able to:**

1. Know about the various spectroscopic methods of analysis and their classification, advantages and applications **(Cognitive level: Remember and understand)**
2. Know about the basics of electromagnetic radiation and Molecular spectroscopy **(Cognitive level: Remember and understand)**
3. Learn properties and applications of various molecular spectroscopy in our daily life (**Cognitive level: Remember and understand)**
4. Learn about different safety practices in the chemistry laboratory **(Cognitive level: Remember and understand)**
5. Learn about the construction of different instruments used for chemical analysis (**Cognitive level: Remember and understand)**
6. Usage of these instruments for analyzing the progress of a reaction or Collection, preservation, and control of blood evidence being used for DNA testing **(Cognitive level: Apply and evaluate**)
7. Differentiate between chemical environment of the protons, structural isomers and stereo-isomers sing NMR peak position and splitting (**Cognitive level: Apply and evaluate)**
8. Detection of illegal drugs or steroids in athletes, flammable accelerants or explosives in the laboratory, anthrax or cocaine confirmation and pollutants or illegal dumping **(Cognitive level: Apply and evaluate)**
9. Analyzing electronic Transitions in Organic Molecules and Fibre **(Cognitive level: Apply and evaluate)**
10. Synthesize molecules and characterize them using different techniques **(Cognitive level: Create and analyze)**

**Mapping of CLOs with PLOS**

| | CLO1 | CLO2 | CLO3 | CLO4 | CLO5 | CLO6 | CLO7 | CLO8 | CLO9 | CLO10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **PLO1.** | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 |
| **PLO2.** | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 1 |
| **PLO3.** | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 |
| **PLO4.** | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| **PLO5.** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| **PLO6.** | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 |
| **PLO7.** | 1 | 1 | 1 | 1 | 1 | 2 | 2 | 2 | 3 | 3 |
| **PSO 1.** | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 |
| **PSO 2.** | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 | 2 |
| **PSO 3.** | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 2 |
| **PSO 4.** | 3 | 3 | 3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 |
| **PSO 5.** | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| **PSO 6.** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| **PSO 7.** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| **PSO 8.** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |
| **PSO 9.** | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 3 | 3 |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

**BCH-DSE8 TH: Course contents**
**Credits: 4, Periods: 60**

**Unit I: INTRODUCTION TO SPECTROSCOPIC METHODS OF ANALYSIS**

Recap of the spectroscopic methods covered in detail in the core chemistry syllabus: Treatment of analytical data, including error analysis. Classification of analytical methods and the types of instrumental methods. Consideration of electromagnetic radiation; Molecular spectroscopy: Infrared spectroscopy: Interactions with molecules: absorption and scattering. Means of excitation (light sources), separation of spectrum (wavelength dispersion, time resolution), detection of the signal (heat, differential detection), interpretation of spectrum (qualitative, mixtures, resolution), advantages of Fourier Transform (FTIR). Samples and results expected. Applications: Issues of quality assurance and quality control, Special problems for portable instrumentation and rapid detection. **[15 Hours]**

**Unit II: UV-Visible/ Near IR [20 Hours]**

Emission, absorption, fluorescence and photoaccoustic. Excitation sources (lasers, time resolution), wavelength dispersion (gratings, prisms, interference filters, laser, placement of sample relative to dispersion, resolution), Detection of signal (photocells, photomultipliers, diode arrays, sensitivity and S/N), Single and Double Beam instruments, Interpretation (quantification, mixtures, absorption vs. fluorescence and the use of time, photoaccoustic, fluorescent tags).

Mass spectrometry (electrical discharges): Making the gaseous molecule into an ion (electron impact, chemical ionization), Making liquids and solids into ions (electrospray, electrical discharge, laser desorption, fast atom bombardment), Separation of ions on basis of mass to charge ratio, Magnetic, Time of flight, Electric quadrupole. Resolution, time and multiple separations, Detection and interpretation (how this is linked to excitation).

NMR spectroscopy: Principle, Instrumentation, Factors affecting chemical shift, Spin-coupling.

**Unit III: Separation techniques [12 Hours]**

Chromatography: Gas chromatography, liquid chromatography, supercritical fluids, Importance of column technology (packing, capillaries), Separation based on increasing number of factors (volatility, solubility, interactions with stationary phase, size, electrical field), Detection: simple vs. specific (gas and liquid), Detection as a means of further analysis (use of tags and coupling to IR and MS), Electrophoresis (plates and capillary) and use with DNA analysis.

**Unit IV: Elemental analysis [13 Hours]**

**Atomic spectroscopy:** Atomic absorption, Atomic emission, and Atomic fluorescence. Excitation and getting sample into gas phase (flames, electrical discharges, plasmas), Wavelength separation and resolution (dependence on technique), Detection of radiation (simultaneous/scanning, signal noise), Interpretation (errors due to molecular and ionic species, matrix effects, other interferences).

**Electroanalytical Methods:** Potentiometry & Voltammetry, Radiochemical Methods, X-ray analysis and electron spectroscopy (surface analysis)

## BCH-DSE8 PR: Course contents
## Credits: 02, Lab. Hours: 60

1. Safety Practices in the Chemistry Laboratory
2. Determination of the isoelectric pH of a protein.
3. Titration curve of an amino acid.
4. Determination of the void volume of a gel filtration column.
5. Determination of a Mixture of Cobalt and Nickel (UV/Vis spec.)
6. Study of Electronic Transitions in Organic Molecules (i.e., acetone in water)
7. IR Absorption Spectra (Study of Aldehydes and Ketones)
8. Determination of Calcium, Iron, and Copper in Food by Atomic Absorption
9. Quantitative Analysis of Mixtures by Gas Chromatography (i.e., chloroform andcarbon tetrachloride)
10. Separation of Carbohydrates by HPLC
11. Determination of Caffeine in Beverages by HPLC
12. Potentiometric Titration of a Chloride-Iodide Mixture
13. Cyclic Voltammetry of the Ferrocyanide/ Ferricyanide CoupleNuclear Magnetic Resonance
14. Use of fluorescence to do "presumptive tests" to identify blood or other body fluids.
15. Use of "presumptive tests" for anthrax or cocaine
16. Collection, preservation, and control of blood evidence being used for DNA testing
17. Use of capillary electrophoresis with laser fluorescence detection for nuclear DNA (Y-chromosome only or multiple chromosome)
18. Use of sequencing for the analysis of mitochondrial DNA
19. Laboratory analysis to confirm anthrax or cocaine
20. Detection in the field and confirmation in the laboratory of flammable accelerants or explosives
21. Detection of illegal drugs or steroids in athletes
22. Detection of pollutants or illegal dumping
23. Fibre analysis

**Suggested Reading (Theory):**


1. D.A. Skoog, F.J. Holler & S. Crouch (ISBN 0-495-01201-7) Principles of Instrumental Analysis, Cengage Learning India Edition, 2007.
2. Willard, Merritt, Dean, Settle, Instrumental Methods of Analysis, 7th ed, IBH Book House, New Delhi.
3. P.W. Atkins, & J.D. Paula, Physical Chemistry, 10th Ed., Oxford University Press (2014).
4. R. Kakkar, Atomic and Molecular Spectroscopy: Concepts and Applications. Cambridge University Press, 2015.
5. G. W. Castellan, Physical Chemistry 4th Ed., Narosa (2004).
6. C. N. Banwell, & E. M. McCash, Fundamentals of Molecular Spectroscopy 4th Ed. Tata McGraw-Hill: New Delhi (2006).
7. B.C. Smith, Infrared Spectral Interpretations: A Systematic Approach. CRC Press, 1998.
8. W.J. Moore, Physical Chemistry Orient Blackswan, 1999.


**Suggested Reading (Practical):**


1. D.A. Skoog, F.J. Holler & T.A. Nieman, Principles of Instrumental Analysis, Cengage Learning India Ed.
2. H.H. Willard, L. L. Merritt, J. Dean, & F.A. Settoe, Instrumental Methods of Analysis,7th Ed. Wadsworth Publishing Company Ltd., Belmont, California, USA, 1988.

**Teaching Learning Process:**

- The teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Problem-solving to enhance comprehension.

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations by individual student/ small group of students, assignments, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab

**Keywords:** Analytical methods, electromagnetic radiation, Molecular spectroscopy, Fourier Transform Infrared spectroscopy, error analysis, Characterization, Analysis, absorption and scattering, Emission, fluorescence and photoaccoustic, Mass spectrometry, NMR spectroscopy, chemical shift, Chromatography, supercritical fluids, Electrophoresis, Elemental analysis, Atomic spectroscopy, Electroanalytical Methods, Potentiometry & Voltammetry, Radiochemical Methods, X-ray analysis and electron spectroscopy (surface analysis).

**PAPER CODE: BCH-DSE 09**
**PAPER TITLE:DISSERTATION**

**Total Credits: 06** **Total Lectures: 60**

**Objectives:**The purpose of this course is to engage students in active learning and to develop their analytical thinking and problem-solving abilities under the guidance of a mentor. This course will instruct students how to carry out scientific research so that they can go on to get professional training or venture into research and development in any field of chemistry.

**Course Learning Outcomes: By the end of this course, students will be able to:**

1. Think critically, plan and carry out a research project independently. **(Cognitive level: Apply)**
2. Gather, analyze and execute data in the right manner **(Cognitive level: Analyze).**
3. Acquire proficiency in handling instruments **(Cognitive level: understand and apply).**
4. Enhance scientific writing skill **(Cognitive level: create).**

**Mapping of CLOs with PLOS**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 |
|---|---|---|---|---|
| **PLO1.** | **3** | **3** | **2** | **2** |
| **PLO2.** | **3** | **3** | **2** | **2** |
| **PLO3.** | **3** | **3** | **2** | **2** |
| **PLO4.** | **2** | **3** | **3** | **2** |
| **PLO5.** | **2** | **2** | **3** | **3** |
| **PLO6.** | **2** | **2** | **2** | **3** |
| **PLO7.** | **2** | **2** | **2** | **3** |
| **PSO 1.** | **3** | **3** | **2** | **2** |
| **PSO 2.** | **3** | **3** | **2** | **2** |
| **PSO 3.** | **3** | **3** | **3** | **2** |
| **PSO 4.** | **2** | **2** | **2** | **3** |
| **PSO 5.** | **2** | **2** | **3** | **3** |
| **PSO 6.** | **2** | **2** | **2** | **3** |
| **PSO 7.** | **2** | **2** | **2** | **3** |
| **PSO 8.** | **2** | **2** | **2** | **2** |
| **PSO 9.** | **2** | **2** | **2** | **2** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

## BCH-DSE9: Course contents
## Credits: 6 Periods: 60

A. A project/thesis work of 06 credits could be undertaken in the Sixth semester.

B. The thesis work shall include the experimental work on a specified topic and submission of the thesis towards the end of the Semester VI. The project work/thesis shall be evaluated as per the guidelines proposed by the Board of Studies and specified in the syllabus.

C. The evaluation of the dissertation, project presentation and viva-voce will be conducted by external examiner. The project shall comprise of the three components namely Part A, Part B and Part C. Part A will be assigned 50 marks and will comprise of submission of a project report after completion of the project. Part B will be assigned 50 marks and will comprise of a presentation on the topic of student's project work carried out in department/industry/institute/research Centre. Part C will be assigned 50 marks and will include a viva-voce examination

**Teaching Learning Process:**

- Learning by doing is the major teaching-learning strategy for realizing the objectives envisaged in work related to research project.

**Assessment Methods:**

- There will be periodic assessment of the progress of research work carried out under the mentorship of a faculty member.

# Skill Enhancement Courses
# SEC
## (BCH-SEC1 to BCH-SEC6)

| SEMESTER V<br>DISCIPLINE SPECIFIC ELECTIVE COURSE | | |
|---|---|---|
| **Semester V** | **TOTAL HOURS: 30HRS** | **Credit :02** |
| **PAPER CODE: BCH-SEC1<br>TITLE: CHEMOINFORMATICS** | | |

**Objective:** Learn the basic chemistry behind drug discovery, design and development. This subject is designed to impart fundamental knowledge on the structure, chemistry and mathematical aspects beyond the chemistry. The subject emphasizes on learning how communications were made between computers and chemistry using simple mathematical models, importance of physicochemical properties. The syllabus also emphasizes on understanding the practical applications.

**Course Learning Objectives:**

**On completion of this course the students will be able to:**

**CLO 1** To revise and understand basic physicochemical properties and theoretical methods for their determination. Use of chemoinformatics in various fields of sciences (**Learn and Understand**)

**CLO 2** Understand the in-silico aspects and find suitable modules and system requirement. Differentiate between the freeware and commercial software and their roles in generating fingerprint informations of molecules. (**Understand and differentiate**)

**CLO 3** Understand the methods and basic requirements for simple calculations associated with different properties. Basics of Structural Activity Relationship (SAR) of different class of drugs. Management of information as data.(**learn, develop and manage**)

**CLO 4** Learn predictions and related methods for NMR, IR and UV like properties Utilizing Non-derivative method, First and second order minimization methods. Utilization simple Computer simulation methods. (**Learn and correlate**)

**CLO 5** Applications of various theories in understanding macromolecular system. Differentiate the binding and inhibition actions of ligands. Screening of large libraries as per one's desired requirement(**learn, apply and modify**)

**Mapping of CLOs with PLOs**

| | CLO1 | CLO2 | CLO3 | CLO4 | CLO5 |
|---|---|---|---|---|---|
| **PLO1** | **3** | **3** | **3** | **2** | **2** |
| **PLO2** | **2** | **3** | **3** | **3** | **2** |
| **PLO3** | **2** | **2** | **3** | **3** | **2** |
| **PLO4** | **2** | **2** | **2** | **3** | **3** |
| **PLO5** | **1** | **2** | **2** | **2** | **3** |
| **PLO6** | **1** | **1** | **1** | **2** | **3** |
| **PLO7** | **1** | **1** | **1** | **2** | **3** |
| **PSO1** | **3** | **3** | **3** | **2** | **2** |
| **PSO2** | **2** | **3** | **3** | **3** | **2** |
| **PSO3** | **2** | **2** | **3** | **3** | **2** |
| **PSO4** | **2** | **2** | **2** | **3** | **2** |
| **PSO5** | **2** | **2** | **2** | **2** | **3** |
| **PSO6** | **2** | **2** | **2** | **2** | **3** |
| **PSO7** | **1** | **2** | **2** | **2** | **3** |
| **PSO8** | **1** | **1** | **2** | **2** | **3** |
| **PSO9** | **1** | **1** | **1** | **2** | **3** |

# SEC

**PAPER CODE: BCH-SEC1**
**TITLE: CHEMOINFORMATICS**

**TOTAL HOURS: 30** **CREDITS: 02**

**UNIT I: Introduction to Chemoinformatics: (6 Hours)**
History and evolution of chemoinformatics, Use of chemoinformatics, Prospects of chemoinformatics, Molecular Modelling and Structure elucidation.

**UNIT II: Representation of molecules and chemical reactions: (6 Hours)**
Nomenclature, Different types ofnotations, SMILES coding, Matrix representations, Structure of Molfiles and Sdfiles,Libraries and toolkits, Different electronic effects, Reaction classification.

**UNIT III: Searching chemical structures: (8 Hours)**
Full structure search, sub-structure search, basic ideas,similarity search, three dimensional search methods, basics of computation of physical andchemical data and structure descriptors, data visualization.

**UNIT IV: Applications: (10 Hours)**
Prediction of Properties of Compounds; Linear Free Energy elations;Quantitative Structure-Property Relations; Descriptor Analysis; Model Building; ModelingToxicity; Structure-Spectra correlations; Prediction of NMR, IR and Mass spectra; ComputerAssisted Structure elucidations; Computer Assisted Synthesis Design, Introduction to drugdesign; Target Identification and Validation; Lead Finding and Optimization; Analysis ofHTS data; Virtual Screening; Design of Combinatorial Libraries; Ligand-Based and StructureBased Drug design; Application of Cheminformatics in Drug Design.

**Hands-on Exercises**

***Suggested Reading:***


- Andrew R. Leach & Valerie, J. Gillet (2007) *An introduction to Chemoinformatics.*Springer: The Netherlands.
- Gasteiger, J. & Engel, T. (2003) *Chemoinformatics: A text-book.* Wiley-VCH.
- Gupta, S. P. (2011) *QSAR & Molecular Modeling.* Anamaya Pub.: New Delhi.


**Teaching Learning Process:**

1. Introducing basic mathematical tools using excel and VB script
2. The teaching Learning Progression for the course is student centric
3. Intelligent mix of conventional and modern methods is opted both through whiteboard and education animations using available free computational tools.
4. Engaging students in cooperative and synergistic learning.

**Assessment Methods:**

1. Continuous Evaluation: by monitoring the progress of students' learning.
2. Class Tests, Worksheets.
3. Assignments, and projects, to enhance critical thinking skills and personality.
4. Semester-end Examination: a critical indicator of students' learning of theoretical concepts

**Keywords:**
Potential energy surface, Molecular Dynamics, Inhibition and binding constant, Mathematical models

# SEC

**PAPER CODE: BCH-SEC2**
**TITLE: INTELLECTUAL PROPERTY RIGHTS (IPR)**

**TOTAL HOURS: 30** **CREDITS: 02**

**UNIT I: INTRODUCTION TO INTELLECTUAL PROPERTY:** Historical Perspective, Different Types of IP, Importance of protecting IP.Copyrights: Introduction, How to obtain, Differences from Patents: Trade Marks, Introduction, How to obtain, Different types of marks – Collective marks, certification marks,service marks, Trade names, etc.Differences from Designs.; Patents: Historical Perspective, Basic and associated right, WIPO, PCT system, TraditionalKnowledge, Patents and Healthcare – balancing promoting innovation with public health,Software patents and their importance for India.

**UNIT II: GEOGRAPHICAL INDICATIONS:**Definition, rules for registration, prevention of illegal exploitation, importance to India.Industrial Designs: Definition, How to obtain, features, International design registration: Layout design of integrated circuits: Circuit Boards, Integrated Chips, and Importance for electronic industry.

**UNIT III: TRADE SECRETS:** Introduction and Historical Perspectives, Scope of Protection, Risks involved and legalaspects of Trade Secret Protection.Different International agreements(a) Word Trade Organization (WTO):General Agreement on Tariffs & Trade (GATT), Trade; Related Intellectual Property Rights (TRIPS) agreement; General Agreement on Trade related Services (GATS); Madrid Protocol; Berne Convention; Budapest Treaty; Paris Convention

**UNIT IV: WIPO AND TRIPS: IPR** and Plant Breeders Rights, IPR and Biodiversity, **IP Infringement issue and enforcement** – Role of Judiciary, Role of law enforcement, agencies – Police, Customs etc. Economic Value of Intellectual Property – Intangible assets, and their valuation, Intellectual Property in the Indian Context – Various laws in India, Licensing and technology transfer.

***Suggested Reading:***


- Acharya, N.K. *Textbook on intellectual property rights,* Asia Law House (2001).
- Guru, M. & Rao, M.B. *Understanding Trips: Managing Knowledge in DevelopingCountries*, Sage Publications (2003).
- Ganguli, P. *Intellectual Property Rights: Unleashing the Knowledge Economy,* TataMcGraw-Hill (2001).
- Miller, A.R. & Davis, M.H. *Intellectual Property: Patents, Trademarks andCopyright in a Nutshell,* West Group Publishers (2000).
- Watal, J. *Intellectual property rights in the WTO and developing countries,* OxfordUniversity Press, New Delhi.


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# PAPER CODE: BCH-SEC3
# TITLE: PHARMACEUTICAL CHEMISTRY

**TOTAL HOURS: 30** **CREDITS: 02**

**Objective:** Providing the essential knowledge base and laboratory resources to prepare students for careers as professionals in the field of chemistry and for studying chemistry. Understand the principles of different areas of chemistry (organic, inorganic, physical and analytical). Develop as independent thinkers who are responsible for their own learning. Develop transferable quantitative skills.

**Course Learning Objectives:**

**Students will gain an understanding of:**

**CLO 1** the use of an analytical balance for mass measurement, the use of graduated cylinders, graduated pipettes, and volumetric pipettes for volumetric measurement and the use of thermometers and temperature probes (learn, understand and differentiate)

**CLO 2** Analysis of data using a spreadsheet program such as Excel. (analyse and assess)

**CLO 3** Learn the principles influencing reactivity, including acid-base behaviors. To carry out organic reactions and how to prepare their solutions. (Understand and apply)

**CLO 4** Learn laboratory techniques such as distillation, extraction and crystallization and the quantitative assessment of data. (remember and develop)

**CLO 5** Communicate the results of their experiments primarily via written laboratory reports. (Arrange and represent)

**CLO 6** Understand the proper laboratory safety and techniques (Understand, remember and apply)

**Mapping of CLOs with PLOs and PSOs**

| | CLO1 | CLO2 | CLO3 | CLO4 | CLO5 | CLO6 |
|---|---|---|---|---|---|---|
| **PLO1** | 3 | 3 | 3 | 2 | 2 | 2 |
| **PLO2** | 2 | 3 | 3 | 3 | 2 | 2 |
| **PLO3** | 1 | 2 | 3 | 3 | 3 | 2 |
| **PLO4** | 1 | 1 | 2 | 3 | 3 | 3 |
| **PLO5** | 1 | 1 | 1 | 2 | 3 | 3 |
| **PLO6** | 1 | 1 | 1 | 1 | 2 | 3 |
| **PLO7** | 1 | 1 | 1 | 1 | 1 | 3 |
| **PSO1** | 3 | 3 | 3 | 2 | 2 | 2 |
| **PSO2** | 2 | 3 | 3 | 3 | 2 | 2 |
| **PSO3** | 2 | 2 | 3 | 3 | 3 | 2 |
| **PSO4** | 2 | 2 | 2 | 3 | 3 | 2 |
| **PSO5** | 2 | 2 | 2 | 2 | 3 | 2 |
| **PSO6** | 2 | 2 | 2 | 2 | 2 | 3 |
| **PSO7** | 1 | 2 | 2 | 2 | 2 | 3 |
| **PSO8** | 1 | 1 | 2 | 2 | 2 | 3 |
| **PSO9** | 1 | 1 | 1 | 2 | 2 | 3 |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

# SEC

## PAPER CODE: BCH-SEC3
## TITLE: PHARMACEUTICAL CHEMISTRY

**TOTAL HOURS: 30** **CREDITS: 02**

**UNIT I: DRUGS & PHARMACEUTICALS (8 Hours)**
Drug discovery, design and development; Basic Retrosynthetic approach. Synthesis of therepresentative drugs of the following classes: analgesics agents, antipyretic agents, anti-inflammatory agents (Aspirin, paracetamol, lbuprofen).

**UNIT II:SYNTHESIS OF ANTI INFECTIOUS AGENTS**: **(8 Hours)**
Synthesis of therepresentative drugs of the following classes:antibiotics (Chloramphenicol);antibacterial and antifungal agents (Sulphonamides; Sulphanethoxazol, Sulphacetamide,Trimethoprim); antiviral agents (Acyclovir), HIV-AIDS relateddrugs (AZT-Zidovudine)

**UNIT III: SYNTHESIS OF CNS AND CARDIOVASCULAR AGENTS: (7 Hours)**
Synthesis of therepresentative drugs of the following classes:Central Nervous System agents (Phenobarbital,Diazepam),Cardiovascular (Glyceryl trinitrate), antilaprosy (Dapsone)

**UNIT IV: FERMENTATION (7 Hours)**
Aerobic and anaerobic fermentation. Production of (i) Ethyl alcohol and citric acid, (ii)Antibiotics; Penicillin, Cephalosporin, Chloromycetin and Streptomycin, (iii) Lysine,Glutamic acid, Vitamin B2, Vitamin B12 and Vitamin C.

***Suggested Reading***


- Patrick, G. L. *Introduction to Medicinal Chemistry, Oxford University* Press, UK, 2013.
- Singh, H. & Kapoor, V.K. *Medicinal and Pharmaceutical Chemistry,* VallabhPrakashan, Pitampura, New Delhi, 2012.
- Foye, W.O., Lemke, T.L. & William, D.A.: *Principles of Medicinal Chemistry*, 4th ed., B.I. Waverly Pvt. Ltd. New Delhi.


**Teaching Learning Process:**
1. The teaching Learning Progression for the course is student centric
2. Intelligent mix of conventional and modern methods is opted both through whiteboard and education animations using available free computational tools.
3. Engaging students in cooperative and synergistic learning.

**Assessment Methods:**
1. Continuous Evaluation: by monitoring the progress of students' learning.
2. Class Tests, Worksheets.
3. Assignments, and projects, to enhance critical thinking skills and personality.
4. Semester-end Examination: a critical indicator of students' learning of theoretical concepts


**Keywords:**
Solvent, purity, Crystallization, Colligative properties, Reaction and distillation Assembly.

**PAPER CODE: BCH- SEC04TH**
**PAPER TITLE:CHEMISTRY OF COSMETICS & PERFUMES**

**Total Credits: 02 Total Lectures: 30**

**Objectives:**The course chemistry of cosmetics & perfumes is designed to understand the basic chemistry of cosmetics & perfumes and their formulations. The course is permeated with the ***preparation and uses of the*** Hair dye, hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, nail polish, creams, antiperspirants and artificial flavours, Essential oils.

**Course Learning Objectives:**

**On completion of the course, the student will be able to:**

**CLO 1** Understand the basic chemistry of cosmetics & perfumes and their formulations. (Cognitive level: learn and understand).

**CLO 2** Learn and understand the basic mechanism behind the hair dyes, chemical composition of hair spray, shampoo, suntan lotions, face powder, lipsticks, talcum powder, nail enamel, nail polish, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours, Essential oils. (Cognitive level: learn and understand).

**CLO 3** Learn and understand the preparations of shampoo, shaving creams, hair removers. (Cognitive level: learn and understand).

**CLO 4** Formulate the mechanisms of organic reactions involved in the preparation of Hair Dyes and some of the essential oils. (Cognitive level: learn, understand and formulate).

**CLO 5** Understand the toxic effects several cosmetics & perfumery agents. (Cognitive level: learn and understand).

**CLO 6** Apply the fundamental concepts to prepare new formulations of cosmetics & perfumes (Cognitive level: Apply).

**Mapping of CLOs with PLOS**

| | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 | CLO-6 |
|---|---|---|---|---|---|---|
| **PLO1.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO2.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO3.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO4.** | **2** | **3** | **3** | **2** | **2** | **2** |
| **PLO5.** | **2** | **2** | **3** | **3** | **2** | **2** |
| **PLO6.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PLO7.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 1.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO 2.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO 3.** | **3** | **3** | **3** | **2** | **2** | **2** |
| **PSO 4.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 5.** | **2** | **2** | **3** | **3** | **2** | **2** |
| **PSO 6.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 7.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 8.** | **2** | **2** | **2** | **2** | **3** | **3** |
| **PSO 9.** | **2** | **2** | **2** | **2** | **3** | **3** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

# PAPER CODE: BCH-SEC4
# TITLE: CHEMISTRY OF COSMETICS & PERFUMES

**TOTAL HOURS: 30** **CREDITS: 02**

**UNIT I:** **[15Hours]**

***A general study including preparation and uses of the following:*** Hair dye, hair spray, shampoo, suntan lotions, face powder.

***A general study including preparation and uses of the following:*** lipsticks, talcum powder, nail enamel, creams (cold, vanishing and shaving creams), antiperspirants and artificial flavours.

**UNIT II:** **[15Hours]**

***A general study including preparation and uses of the following:*** Essential oils and their importance in cosmetic industries with reference to Eugenol, Geraniol, sandalwood oil, eucalyptus, rose oil, 2-phenyl ethyl alcohol, Jasmone, Civetone, Muscone.

Preparation of talcum powder, shampoo, Preparation of enamels, Preparation of hair remover, face cream, nail polish and nail polish remover.

***Suggested Reading***


- Stocchi, E. *Industrial Chemistry*, Vol-I, Ellis Horwood Ltd. UK (1990).
- Jain, P.C. & Jain, M. *Engineering Chemistry* Dhanpat Rai & Sons, Delhi.
- Sharma, B.K. & Gaur, H. *Industrial Chemistry,* Goel Publishing House, Meerut(1996).


**Teaching Learning Process:**

- Lectures in classrooms
- Peer learning
- Videos, presentations, seminars
- Technology-driven Learning

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments, Group dscussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

**Keywords:** Cosmetics, Perfumes, Essential oils, Hair dye,Hair sprays, lipsticks, talcum powder.

**PAPER CODE: BCH- SEC05TH**
**PAPER TITLE:PESTICIDE CHEMISTRY**

**Total Credits: 02 Total Lectures: 30**

**Objectives:** The course Pesticide Chemistry is designed to understand the basic chemistry of pesticides; their benefits and adverse effects. The course is permeated with the classification, synthesis and the analysis of pesticides.

**Course Learning Objectives:**

**On completion of the course, the student will be able to:**

**CLO 1** Learn and understand the basics of pesticides; their benefits and adverse effects. (Cognitive level: learn and understand).

**CLO 2** Learn and understand thesynthesis and technical manufacture and uses of representative pesticides. (Cognitive level: learn and understand).

**CLO 3** Learn and understand synthesis and technical manufacture and uses of Carbamates (Carbofuran and carbaryl); Quinones (Chloranil), Anilides (Alachlor and Butachlor).(Cognitive level: learn and understand).

**CLO 4** Analyze the acidity/alkalinity in given sample of pesticide formulations as per BIS specifications. (Cognitive level: Analyze).

**CLO 5** Prepare simple organophosphates, phosphonates and thiophosphates. (Cognitive level: Synthesis).

**CLO 6** Apply the fundamental concepts to prepare new generation pesticide(Cognitive level: Apply).

**Mapping of CLOs with PLOS**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 | CLO 5 | CLO 6 |
|---|---|---|---|---|---|---|
| **PLO1.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO2.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO3.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO4.** | **2** | **3** | **3** | **2** | **2** | **2** |
| **PLO5.** | **2** | **2** | **3** | **3** | **2** | **2** |
| **PLO6.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PLO7.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO1** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO2** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO3** | **3** | **3** | **3** | **2** | **2** | **2** |
| **PSO4** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO5** | **2** | **2** | **3** | **3** | **2** | **2** |
| **PSO6** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO7** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO8** | **2** | **2** | **2** | **2** | **3** | **3** |
| **PSO9** | **2** | **2** | **2** | **2** | **3** | **3** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

# SEC

## PAPER CODE: BCH-SEC5
## TITLE: PESTICIDE CHEMISTRY

**TOTAL HOURS: 30** **CREDITS: 02**

**UNIT I:**General introduction to pesticides (natural and synthetic), benefits and adverse effects, changing concepts of pesticides, structure activity relationship,

**UNIT II:**Synthesis and technicalmanufacture and uses of representative pesticides in the following classes: Organochlorines(DDT, Gammexene,); Organophosphates (Malathion, Parathion )

**Unit III:**Synthesis and technicalmanufacture and uses of Carbamates (Carbofuranand carbaryl); Quinones(Chloranil), Anilides (Alachlor and Butachlor).

**Unit IV:** To calculate acidity/alkalinity in given sample of pesticide formulations as perBIS specifications; Preparation of simple organophosphates, phosphonates and thiophosphates

**Suggested Reading**


- Cremlyn, R. *Pesticides. Preparation and Modes of Action*, John Wiley & Sons, NewYork, 1978.


**Teaching Learning Process:**

1. Lectures in classrooms
2. Peer learning
3. videos, presentations, seminars
4. Technology-driven Learning

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments, Group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.


**Keywords:** Pesticides, DDT, Gammexene, Malathion, Parathion, Carbofuranand carbaryl, Chloranil.

**SEMESTER III**
**PAPER CODE: BCH-SEC6**
**PAPER TITLE: FUEL CHEMISTRY**

**Total Credits: 02 - (CHG--SEC6)**
**Total Lectures: CHG-C TH - 30**

**Objectives:**In this course Students learn about fuel chemistry e.g. renewable energy sources, calorific value of fuel, Fractional Distillation, Cracking, clean fuels, Petrochemicals, governing the industrial fuel chemistry. The basic concepts like will be discussed. The student will be acquainted with importance of fuel chemical and will be familiarized with terms like composition and Refining of crude petroleum, LNG, bio-gas, fuels derived from biomass, synthetic fuels (gaseous and liquids), clean fuels. The student will also learn about the Lubricants and its characteristics like viscosity index, cloud point, pore point.

## Course Learning Objectives:

**On completion of the course, the student will be able to:**

**CLO 1** Gain insight into the history of energy sources (renewable and non-renewable) and classification of various fuel as per their calorific value. **(Cognitive level: Remember and understand)**

**CLO 2** Understand and describe about the composition, carbonization, gasification and liquefaction and Solvent Refining of coal and its uses various industries.**(Cognitive level: Remember and understand)**

**CLO 3** Understand the Fractionation of coal tar, uses of coal tar bases chemicals, and requisites of a good metallurgical coke, Coal gas, producer gas and water gas-composition and Fractional Distillation, Cracking. **(Cognitive level: Remember and understand)**

**CLO 4** Classify and explain the properties of lubricants (viscosity index, cloud point, pore point) and their determination. (**Cognitive level: Remember, understand and apply)**

**CLO 5** Explain and perform various experiments to derive the fuel from waste **(Cognitive level: Understand and apply)**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 | CLO 5 |
|---|---|---|---|---|---|
| **PLO22.** | **3** | **3** | **2** | **2** | **2** |
| **PLO23.** | **3** | **3** | **2** | **2** | **2** |
| **PLO24.** | **3** | **3** | **2** | **2** | **2** |
| **PLO25.** | **2** | **3** | **3** | **3** | **2** |
| **PLO26.** | **2** | **2** | **3** | **3** | **3** |
| **PLO27.** | **2** | **2** | **2** | **2** | **3** |
| **PLO28.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 28.** | **3** | **3** | **2** | **2** | **2** |
| **PSO 29.** | **3** | **3** | **2** | **2** | **2** |
| **PSO 30.** | **3** | **3** | **3** | **3** | **2** |
| **PSO 31.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 32.** | **2** | **2** | **3** | **3** | **3** |
| **PSO 33.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 34.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 35.** | **2** | **2** | **2** | **2** | **2** |
| **PSO 36.** | **2** | **2** | **2** | **2** | **2** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

## BCH-SEC6: Course contents
**Credits: 2, Hours: 30**

**Unit I: Review of energy sources (5 Lectures)**

Review of energy sources (renewable and non-renewable). Classification of fuels and their calorific value.

**Unit II: Coal (8 Lectures)**

Uses of coal (fuel and nonfuel) in various industries, its composition, carbonization of coal. Coal gas, producer gas and water gas—composition and uses. Fractionation of coal tar, uses of coal tar bases chemicals, requisites of a good metallurgical coke, Coal gasification (Hydro gasification and Catalytic gasification), Coal liquefaction and Solvent Refining.

**Unit III: Solutions and Phase Equilibria (12 Lectures)**

Composition of crude petroleum, Refining and different types of petroleum products and their applications. Fractional Distillation (Principle and process), Cracking (Thermal and catalytic cracking), Reforming Petroleum and non-petroleum fuels (LPG, CNG, LNG, bio-gas, fuels derived from biomass), fuel from waste, synthetic fuels (gaseous and liquids), clean fuels. Petrochemicals: Vinyl acetate, Propylene oxide, Isoprene, Butadiene, Toluene and its derivatives Xylene.

**Unit IV: Lubricants (5 Lectures)**

Classification of lubricants, lubricating oils (conducting and non-conducting)Solid and semisolid lubricants, synthetic lubricants. Properties of lubricants (viscosity index, cloud point, pore point) and their determination.

**Reference Books:**


1. E. Stocchi, Industrial Chemistry, Vol-I, Ellis Horwood Ltd. UK (1990).
2. P.C. Jain & M. Jain, Engineering Chemistry Dhanpat Rai & Sons, Delhi.75.
3. B.K. Sharma, & H. Gaur, Industrial Chemistry, Goel Publishing House, Meerut (1996).


### Teaching Learning Process:

- The teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Problem-solving to enhance comprehension.

### Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations by individual student/ small group of students, assignments, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and analytical skills acquired in the classroom


**Keywords:**

Renewable energy sources, calorific value, Fractional Distillation, Cracking, clean fuels, Petrochemicals, Lubricants, viscosity index, cloud point, pore point.

# GE

**PAPER CODE: A TH**
**TITLE: MATHEMATICS-I: (CALCULUS & DIFFERENTIAL EQUATIONS)**

**TOTAL HOURS: 60** **CREDITS: 04**

**UNIT-1: Calculus**
Indeterminate forms, Curvature, Cartesian, Polar and parametric formulae for radius of curvature, Applications of definite integrals to evaluate surface areas and volumes of revolutions.

**UNIT-2: Multivariable Calculus: Differentiation**

Differentiation of functions of several variables, Euler's theorem on homogeneous functions, Directional derivatives, Total derivative, Gradient, Curl and divergence.

**UNIT-3: Multivariable Calculus: Integration**

Double and triple integrals, Change of order of integration in double integrals, Change of variables, Theorems of Green, Gauss and Stokes (without proof).

**UNIT-4: First Order Ordinary & Partial Differential Equations**

Exact, linear and Bernoulli's equations, Euler's equations, Equations not of first degree: equations solvable for p, equations solvable for y, equations solvable for x and Clairaut's type. First order partial differential equations, solutions of first order linear and non-linear PDEs,

**Text / Referenes:**


1. G.B. Thomas and R.L. Finney, "Calculus and Analytic geometry", Pearson, 2002.
2. T. Veerarajan, "Engineering Mathematics", McGraw Hill, New Delhi, 2008.
3. B.V. Ramana, "Higher Engineering Mathematics", McGraw Hill, New Delhi, 2010.
4. N.P. Bali and M. Goyal, "A text book of Engineering Mathematics", Laxmi Publications, 2010.
5. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 2000.
6. E. Kreyszig, "Advanced Engineering Mathemactics", John Wiley & Sons, 2006.
7. S.L. Ross, "Differential Equations", Wiley India, 1984.
8. E. A. Coddington, "An Inroduction to Ordinary Differential Equations", Prentice Hall India 1995.
9. E.L. Ince, "Ordinary Differential Equations", Dover Publications, 1958.
10. G. F. Simmons and S.G. Krantz, "Differential Equations", McGraw Hill, 2007.

**PAPER CODE: B TH**
**TITLE: MATHEMATICS-II (PROBABILITY & STATISTICS)**

**TOTAL HOURS: 60** **CREDITS: 04**

**UNIT-1 : Basic Probability**

Probability spaces, conditional probability, independence; Discrete random variables, Independent random variables, the multinomial distribution, Poisson approximation to the binomial distribution, infinite sequences of Bernoulli trials, sums of independent random variables; Expectation of Discrete Random Variables, Moments, Variance of a sum, Correlation coefficient, Chebyshev's Inequality.

**UNIT-2 : Continuous Probability Distributions & Bivariate Distributions**

Continuous random variables and their properties, distributions functions and densities, normal exponential and gamma densities, Bivariate distributions and their properties, distribution of sums and quotients, conditional densities, Bayes' rule.

**UNIT-3: Basic & Applied Statistics**

Measures of Central tendency: Moments, skewness and Kurtosis – Probability distributions: Binomial, Poisson and Normal – evaluation of statistical parameters for these three distributions, Correlations and regression – Rank correlation , Curve fitting by the method of least squares-fitting of straight lines, second degree parabolas and more general curves.

**UNIT-4: Large and Small samples**

Test of significance: Large sample test for single proportion, difference of proportions, single mean, difference of means, and difference of standard deviations. Test for single mean, difference of means and correlation coefficients, test for ratio of variances – Chi-square test for goodnesss of fit and independence of attributes.

**Text / Referenes:**


1. T. Veerarajan, "Engineering Mathematics", TataMcGraw Hill, New Delhi, 2010.
2. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 2000.
3. E. Kreyszig, "Advanced Engineering Mathemactics", John Wiley & Sons, 2006.
4. P.G. Hoel, S.C. Port and C.J. Stone, "Introduction to Probability Theory", Universal Book Stall, 2003.
5. S. Ross, " A First Course in Probability", Pearson Education India, 2002.
6. W. Feller, "A Introduction to Probability Theory and its Applications", Vol. 1, Wiley, 1968.
7. N.P. Baliand M. Goyal,"A Textbook of Engineering Mathematics", Laxmi Publications, 2010.

# Generic Elective Papers (GE) (Minor-Chemistry) (any three) for other Departments/ Disciplines:

**(Credit: 06 each)**

**CHG-A.** Atomic Structure, Bonding, General Organic Chemistry & Aliphatic Hydrocarbons
**CHG-B.** Chemical Energetics, Equilibria & Functional Group Organic Chemistry-I
**CHG-C.** Solutions, Phase Equilibrium, Conductance, Electrochemistry & Functional Group Organic Chemistry-II
**CHG-D.** Chemistry of s- and p-block elements, States of matter and Chemical Kinetics
**CHG-E.** Chemistry of d-block elements, Quantum Chemistry Spectroscopy
**CHG-F.** Organomettalics, Bioinorganic chemistry, Polynuclear hydrocarbons and UV, IR Spectroscopy
**CHG-G.** Molecules of life

**SEMESTER V**
**PAPER CODE: CHG-A TH**
**Paper Title: ATOMIC STRUCTURE, BONDING, TRANSITION ELEMENTS AND COORDINATION CHEMISTRY**
**Total Credit: 04Total Lectures: 60**
**Paper Code: CHG-A PR**
**Total Credits: 02Total Hours: 60**

**Objectives:**The core course of chemistry is designed to strengthen the basic and fundamental concepts of inorganic chemistry. The transition metals have a special property of forming coordination complexes. This is due to the high charge to mass ratio and the availability of d-orbitals. The advances in coordination chemistry provide various complex compounds that we use in various industries.

**Course Learning Objectives:**

**On completion of the course, the student will be able to:**

**Mapping of CLOs with PLOs**

**CLO-1**Understand the atomic structure and shapes of s, p and d atomic orbitals (Cognitive level – understand)

**CLO-2** Understand the geometry of the molecule to learn the VSEPR theory. (Cognitive level – understand)

**CLO-3**Employ the ion-exchange chromatography method for the separation of the lanthanide ions based. (Cognitive level – apply)

**CLO-4**Discuss Bond polarization: covalent bonds polarity & non polarity based on the fajan's rule.. (Cognitive level - analyse)

**CLO-5**Discuss the key features of coordination compounds including the variety of structures, oxidation numbers, electronic configurations, coordination numbers, ligands field, chelates bonding, stability of complexes. (Cognitive level – evaluate)

**CLO-6**Discuss the electronic configuration, oxidation states, lanthanide contractions, magnetic properties and electronic spectra of the lanthanides and actinides. (Cognitive level – evaluate)

**CLO-7** Explain the chemical properties of the coordination complexes of the transition metal ions in different oxidation states. (Cognitive level – create)

**CLO-8** Develop a methodology for the complex formation of different transition metal ions. (Cognitive level – create)

| | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 | CLO-6 | CLO-7 | CLO-8 |
|---|---|---|---|---|---|---|---|---|
| PLO-1 | 2 | 2 | 2 | 2 | 3 | 3 | 3 | 3 |
| PLO-2 | 2 | 3 | 2 | 3 | 2 | 2 | 2 | 3 |
| PLO-3 | 3 | 2 | 2 | 2 | 2 | 3 | 3 | 3 |
| PLO-4 | 2 | 3 | 3 | 3 | 3 | 2 | 2 | 2 |
| PLO-5 | 3 | 2 | 3 | 2 | 3 | 3 | 2 | 3 |
| PLO-6 | 2 | 2 | 3 | 2 | 2 | 3 | 3 | 3 |
| PLO-7 | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| PSO-1 | 2 | 2 | 2 | 3 | 2 | 2 | 2 | 3 |
| PSO-2 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 |
| PSO-3 | 2 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| PSO-4 | 3 | 3 | 2 | 3 | 3 | 3 | 2 | 3 |
| PSO-5 | 2 | 2 | 3 | 2 | 2 | 2 | 3 | 2 |
| PSO-6 | 2 | 3 | 3 | 2 | 3 | 3 | 2 | 3 |
| PSO-7 | 3 | 2 | 2 | 3 | 2 | 3 | 3 | 3 |
| PSO-8 | 3 | 3 | 2 | 3 | 3 | 3 | 3 | 3 |
| PSO-9 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

**PAPER CODE: CHG-ATH**
**TITLE: ATOMIC STRUCTURE, BONDING, TRANSITION ELEMENTS AND COORDINATION CHEMISTRY**
**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

**Unit I: Atomic Structure [17 Hours]**

Review of: Bohr's theory and its limitations, dual behaviour of matter and radiation, de Broglie's relation, Heisenberg Uncertainty principle. Hydrogen atom spectra. Need of a new approach to atomic structure. What is Quantum mechanics? Time independent Schrodinger equation and meaning of various terms in it. Significance of ψ and ψ 2 , Schrödinger equation for hydrogen atom. Radial and angular parts of the hydogenic wavefunctions (atomic orbitals) and their variations for 1s, 2s, 2p, 3s, 3p and 3d orbitals (Only graphical representation). Radial and angular nodes and their significance. Radial distribution functions and the concept of the most probable distance with special reference to 1s and 2s atomic orbitals. Significance of quantum numbers, orbital angular momentum and quantum numbers ml and ms. Shapes of s, p and d atomic orbitals, nodal planes. Discovery of spin, spin quantum number (s) and magnetic spin quantum number (ms). Rules for filling electrons in various orbitals, electronic configurations of the atoms. Stability of half-filled and completely filled orbitals, concept of exchange energy. Relative energies of atomic orbitals, Anomalous electronic configurations.

**Unit II: Chemical Bonding and Molecular Structure [17 Hours]**

Ionic Bonding: General characteristics of ionic bonding. Energy considerations in ionic bonding, lattice energy and solvation energy and their importance in the context of stability and solubility of ionic compounds. Statement of Born-Landé equation for calculation of lattice energy, Born-Haber cycle and its applications, polarizing power and polarizability. Fajan's rules, ionic character in covalent compounds, bond moment, dipole moment and percentage ionic character. Covalent bonding: VB Approach: Shapes of some inorganic molecules and ions on the basis of VSEPR and hybridization with suitable examples of linear, trigonal planar, square planar, tetrahedral, trigonal bipyramidal and octahedral arrangements. Concept of resonance and resonating structures in various inorganic and organic compounds. MO Approach: Rules for the LCAO method, bonding and antibonding MOs and their characteristics for s-s, s-p and p-p combinations of atomic orbitals, nonbonding combination of orbitals, MO treatment of homonuclear diatomic molecules of 1st and 2nd periods 77 (including idea of s-p mixing) and heteronuclear diatomic molecules such as CO, NO and $NO^+$ . Comparison of VB and MO approaches.

**Unit III: Transition Elements (3d series) [10 Hours]**

General group trends with special reference to electronic configuration, variable valency, colour, magnetic and catalytic properties, ability to form complexes and stability of various oxidation states (Latimer diagrams) for Mn, Fe and Cu. Lanthanoids and actinoids: Electronic configurations, oxidation states, colour, magnetic properties, lanthanide contraction, separation of lanthanides (ion exchange method only).

**Unit IV: Coordination Chemistry [16 Hours]**

Valence Bond Theory (VBT): Inner and outer orbital complexes of Cr, Fe, Co, Ni and Cu (coordination numbers 4 and 6). Structural and stereoisomerism in complexes with coordination numbers 4 and 6. Drawbacks of VBT. IUPAC system of nomenclature.

Crystal Field Theory Crystal field effect, octahedral symmetry. Crystal field stabilization energy (CFSE), Crystal field effects for weak and strong fields. Tetrahedral symmetry. Factors affecting the magnitude of D. Spectrochemical series. Comparison of CFSE for Oh and Td complexes, Tetragonal distortion of octahedral geometry. Jahn-Teller distortion, Square planar coordination.

**Reference Books:**


- Lee, J.D. Concise Inorganic Chemistry ELBS, 1991.
- Cotton, F.A., Wilkinson, G. & Gaus, P.L. Basic Inorganic Chemistry, 3rd ed., Wiley.
- Douglas, B.E., McDaniel, D.H. & Alexander, J.J. Concepts and Models in Inorganic Chemistry, John Wiley & Sons.
- Huheey, J.E., Keiter, E.A., Keiter, R.L. & Medhi, O.K. Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Education India, 2006.

**PAPER CODE: CHG-A PR**
**TITLE: ATOMIC STRUCTURE, BONDINGTRANSITION ELEMENTS AND COORDINATION CHEMISTRY**
**Credits: 02**

**Volumetric Analysis**

1. Estimation of sodium carbonate and sodium hydrogen carbonate present in a mixture.
2. Estimation of oxalic acid by titrating it with KMnO4.
3. Estimation of water of crystallization in Mohr's salt by titrating with KMnO4.
4. Estimation of Fe (II) ions by titrating it with K2Cr2O7 using internal indicator.
5. Estimation of Cu (II) ions iodometrically using Na2S2O3.

Semi-micro qualitative analysis (using H2S or other methods) of mixtures - not more than four ionic species (two anions and two cations, excluding insoluble salts) out of the following:

Cations : NH4 + , Pb2+, Bi3+, Cu2+, Cd2+, Fe3+, Al3+, Co2+, Ni2+, Mn2+, Zn2+, Ba2+, Sr2+, Ca2+, K+ Anions : CO3 2– , S2–, SO2–, S2O3 2–, NO3 – , CH3COO– , Cl– , Br– , I– , NO3 – , SO4 2-, PO4 3-, BO3 3-, C2O4 2-, F(Spot tests should be carried out wherever feasible)

1. Estimate the amount of nickel present in a given solution as bis(dimethylglyoximato) nickel(II) or aluminium as oximate in a given solution gravimetrically.
2. Estimation of (i) Mg2+ or (ii) Zn2+ by complexometric titrations using EDTA.
3. Estimation of total hardness of a given sample of water by complexometric titration.

**Reference Books:**


- Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
- Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.


**Teaching Learning Process:**

- Lectures in classrooms
- Peer learning
- Hands-on learning using videos, presentations, seminars.
- Technology-driven Learning

Assessment Methods:

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments, group discussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of students' learning and teaching methods adopted by teachers throughout the semester.


**Keywords**:
Atomic structure, Fajan's rule, VSEPR theory, lanthanide,Jahn-Teller distortion, gravimetric analysis, Inorganic synthesis, coordination complexes.

# PAPER CODE: CHG-B
# PAPER TITLE: ORGANIC CHEMISTRY
**Total Credits: 06 - (CHG-B TH -04, CHG-B PR -02)**
**Total Lectures: CHG-B TH - 60, CHG-B PR -60**

**Objectives:**The course Organic chemistry is designed to strengthen the basic and fundamental concepts ofchemical bonding, different electromeric effects,stereochemistry, functional groups and their characteristic physical and chemical properties. The course is permeated with the preparation, physical and chemical properties of aliphatic hydrocarbons, alkyl halides, aryl halides,alcohols, phenols and ethers.

**Course Learning Objectives:**

**On completion of the course, the student will be able to:**

**CLO 1** Recapitulate the basic concepts of chemical bonding, electromeric effects, reactive intermediates and stereochemistry. Learn and understand the concept of reactive intermediates, their structure, formation, factors influencing their stability and the fate of reactive intermediates including some important reactions/rearrangements they undergo. (Cognitive level: Revise/Recap).

**CLO 2** Understand the terms optical rotation and optical activity, specific rotation and calculate the specific rotations of optically active substances. Apply the fundamental concepts to distinguish enantiomers, Diastereomers & mesomers and to assign Relative Configurations (D/L), Absolute Configuration (R/S) of chiral centers and use the fundamental concepts of Resolution to separate the two enantiomers from the mixture in their optically pure form and calculate the specific rotation of optically active compounds. (Cognitive level: Learn, Understand and Apply).

**CLO 3** Learn and understand the preparation of aliphatic hydrocarbons and their chemical properties and applications in organic synthesis.(Cognitive level: Learn and Understand).

**CLO 4** Learn and understand the chemistry of aromatic hydrocarbons, alkyl halides & ary halides; their preparation, physical and chemical properties including reactions involved in functional group transformations. (Cognitive level: Learn and Understand).

**CLO 5** Learn and understand the chemistry of alcohols, phenols and ethers; their preparation, physical and chemical properties including reactions involved in functional group transformations. (Cognitive level: Learn and Understand).

**CLO 6** Practically detect extra elements (N, S, Cl, Br, I) in organic compounds, detect the functional groups present in the organic compound and apply the basic reactions for functional group transformations. (Cognitive level: analyze, apply and synthesis).

**Mapping of CLOs with PLOS**

| | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 | CLO-6 |
|---|---|---|---|---|---|---|
| **PLO1.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO2.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO3.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO4.** | **2** | **3** | **3** | **2** | **2** | **2** |
| **PLO5.** | **2** | **2** | **3** | **3** | **2** | **2** |
| **PLO6.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PLO7.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 1.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO 2.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO 3.** | **3** | **3** | **3** | **2** | **2** | **2** |
| **PSO 4.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 5.** | **2** | **2** | **3** | **3** | **2** | **2** |
| **PSO 6.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 7.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 8.** | **2** | **2** | **2** | **2** | **3** | **3** |
| **PSO 9.** | **2** | **2** | **2** | **2** | **3** | **3** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

**PAPER CODE: CHG-B TH**
**Title: ORGANICCHEMISTRY**
**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

**UNIT I: Fundamentals of Organic Chemistry (8 Lectures)**

Physical Effects, Electronic Displacements: Inductive Effect, Electromeric Effect, Resonance and Hyperconjugation. Cleavage of Bonds: Homolysis and Heterolysis. Structure, shape and reactivity of organic molecules: Nucleophiles and electrophiles.

Reactive Intermediates: Carbocations, Carbanions and free radicals. Strength of organic acids and bases: Comparative study with emphasis on factors affecting pK values.

Aromaticity: Benzenoids and Hückel's rule.

**Stereochemistry (10 Lectures)**

Conformations with respect to ethane, butane and cyclohexane. Interconversion of Wedge Formula, Newmann, Sawhorse and Fischer representations. Concept of chirality (upto two carbon atoms).

Configuration: Geometrical and Optical isomerism; Enantiomerism, Diastereomerism and Meso compounds). Threo and erythro; D and L; cis - trans nomenclature; CIP Rules: R/ S (for upto 2 chiral carbon atoms) and E / Z Nomenclature (for upto two C=C systems).

**UNIT II: Aliphatic Hydrocarbons (12 Lectures)**

Functional group approach for the following reactions (preparations & reactions) to be studied in context to their structure. Alkanes: (Upto 5 Carbons). Preparation: Catalytic hydrogenation, Wurtz reaction, Kolbe's synthesis, from Grignard reagent. Reactions: Free radical Substitution: Halogenation. Alkenes: (Upto 5 Carbons) Preparation: Elimination reactions: Dehydration of alkenes and dehydrohalogenation of alkyl halides (Saytzeff's rule); cis alkenes (Partial catalytic hydrogenation) and trans alkenes (Birch reduction). Reactions: cis-addition (alk. KMnO4) and trans-addition (bromine), Addition of HX (Markownikoff's and anti-Markownikoff's addition), Hydration, Ozonolysis, oxymecuration-demercuration, Hydroboration-oxidation. Alkynes: (Upto 5 Carbons) Preparation: Acetylene from CaC2 and conversion into higher alkynes; by dehalogenation of tetra halides and dehydrohalogenation of vicinal-dihalides. Reactions: formation of metal acetylides, addition of bromine and alkaline KMnO4, ozonolysis and oxidation with hot alk. KMnO4.

**UNIT III: Functional group approach (preparations & reactions) (8 Lectures)**

Aromatic hydrocarbons Preparation (Case benzene): from phenol, by decarboxylation, from acetylene, from benzene sulphonic acid. Reactions: (Case benzene): Electrophilic substitution: nitration, halogenation and sulphonation. Friedel-Craft's reaction (alkylation and acylation) (upto 4 carbons on benzene). Side chain oxidation of alkyl benzenes (upto 4 carbons on benzene).

Alkyl and Aryl Halides Alkyl Halides (Upto 5 Carbons) Types of Nucleophilic Substitution (SN1, SN2 and SNi) reactions. Preparation: from alkenes and alcohols. Reactions: hydrolysis, nitrite & nitro formation, nitrile & isonitrile formation. Williamson's ether synthesis: Elimination vs substitution. Aryl Halides Preparation: (Chloro, bromo and iodo-benzene case): from phenol, Sandmeyer & Gattermann reactions. Reactions (Chlorobenzene): Aromatic nucleophilic substitution (replacement by –OH group) and effect of nitro substituent. Benzyne Mechanism: KNH2/NH3 (or NaNH2/NH3). Reactivity and Relative strength of C-Halogen bond in alkyl, allyl, benzyl, vinyl and aryl halides.

**UNIT IV: Alcohols, Phenols and Ethers (Upto 5 Carbons) Alcohols (14 Lectures)**
Preparation: Preparation of $1^o$, $2^o$ and $3^o$ alcohols: using Grignard reagent, Ester hydrolysis, Reduction of aldehydes, ketones, carboxylic acid and esters. Reactions: With sodium, HX (Lucas test), esterification, oxidation (with PCC, alk. KMnO4, acidic dichromate, conc. HNO3). Oppeneauer oxidation Diols: (Upto 6 Carbons) oxidation of diols. Pinacol-Pinacolone rearrangement. Phenols: (Phenol case) Preparation: Cumene hydroperoxide method, from diazonium salts. Reactions: Electrophilic substitution: Nitration, halogenation and sulphonation. Reimer- 81 Tiemann Reaction, Gattermann-Koch Reaction, Houben–Hoesch Condensation, Schotten – Baumann Reaction. Ethers (aliphatic and aromatic): Cleavage of ethers with HI. Aldehydes and ketones (aliphatic and aromatic): (Formaldehye, acetaldehyde, acetone and benzaldehyde) Preparation: from acid chlorides and from nitriles. Reactions – Reaction with HCN, ROH, NaHSO3, NH2-G derivatives. Iodoform test. Aldol Condensation, Cannizzaro's reaction, Wittig reaction, Benzoin condensation. Clemensen reduction and Wolff Kishner reduction. Meerwein-Pondorff Verley reduction.

**Reference Books:**


1. Graham Solomon, T.W., Fryhle, C.B. & Dnyder, S.A. Organic Chemistry, John Wiley & Sons (2014).
2. McMurry, J.E. Fundamentals of Organic Chemistry, 7th Ed. Cengage Learning India Edition, 2013.
3. Sykes, P. A Guidebook to Mechanism in Organic Chemistry, Orient Longman, New Delhi (1988). • Eliel, E.L. Stereochemistry of Carbon Compounds, Tata McGraw Hill education, 2000.
4. Finar, I.L. Organic Chemistry (Vol. I & II), E.L.B.S.
5. Morrison, R.T. & Boyd, R.N. Organic Chemistry, Pearson, 2010.
6. Bahl, A. & Bahl, B.S. Advanced Organic Chemistry, S. Chand, 2010.


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## PAPER CODE: CHG-B PR
## TITLE: ORGANIC CHEMISTRY

**(02 Credits)**

1. Detection of extra elements (N, S, Cl, Br, I) in organic compounds (containing upto two extra elements)
2. Separation of mixtures by Chromatography: Measure the Rf value in each case (combination of two compounds to be given)
3. Identify and separate the components of a given mixture of two amino acids (glycine, aspartic acid, glutamic acid, tyrosine or any other amino acid) by paper chromatography
4. Identify and separate the sugars present in the given mixture by paper chromatography.
5. Purification of organic compounds by crystallization (from water and alcohol) and distillation.
6. Criteria of Purity: Determination of melting and boiling points.
7. Preparations: Mechanism of various reactions involved to be discussed.
8. Recrystallisation, determination of melting point and calculation of quantitative yields to be done.
   (a) Bromination of Phenol/Aniline
   (b) Benzoylation of amines/phenols
   (c) Oxime and 2,4-dinitrophenylhydrazone of aldehyde/ketone

**Reference Books**


- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960
- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).


**Teaching Learning Process:**

- Lectures in classrooms
- Peer learning
- Hands-on learning using lab practicals, videos, presentations, seminars
- Technology-driven Learning

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments, Group dscussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

**Keywords:** Reactive intermediates**,** Stereochemistry**,** Functional groups, Halides, alcohols, phenols

## SEMESTER II

### PAPER CODE: CHG-C TH
### PAPER TITLE: PHYSICAL CHEMISTRY

**Total Credits: 06 - (CHG-C TH -04, CHG-C PR -02)**

**Total Lectures: CHG-C TH - 60, CHG-C PR -60**

**Objectives:**In this course Students learn about physical chemistry especially the interrelated subtopics like energetics, equilibrium and conductance. Study of Thermodynamics and thermochemistry, the concept of enthalpy and entropy governing the stability of a wide variety of reacting species. The basic concepts like Le Chatelier's principle, buffer, and solubility product. Raoult's law, Azeotropes, Clausius – Clapeyron equation, Transference number, Liquid junction potential and salt bridge, pH, Phase equilibria, conductometric and potentiometric titrations, degree of dissociation and dissociation constant will be discussed. The student will be acquainted with importance of physical chemical, in the context of energetics and chemical equilibrium through discussions on day to day chemical reactions. The student will also learn about the conductometric and potentiometric titrations.

**Course Learning Objectives:**

**On completion of the course, the student will be able to:**

1. Gain insight into the thermodynamics and thermochemistry and its applications in predicting the feasibility of a chemical reaction **(Cognitive level: Remember and understand)**
2. Understand and describe the terms like Liquid junction potential, transference number and salt bridge and its application. **(Cognitive level: Remember and understand)**
3. Understand the concept of equilibrium e.g., Free energy, Le Chatelier's principle, degree of ionization, Raoult's law, Lever rule. Azeotropes, Critical solution temperature, Gibbs Phase Rule and Clausius – Clapeyron equation and their application **(Cognitive level: Understand and apply)**
4. Explain the use of common ion effect in salt analysis and solubility product principle in medicine (**Cognitive level: Understand and apply)**
5. Explain and perform various conductometeric and Potentiometric titrations (acid-base/ Redox based) **(Cognitive level: Understand and apply)**
6. Apply Le Chatelier's principle in predicting the yield of chemical reaction which has industrial implications. **(Cognitive level: Understand and apply)**
7. Analyzing the energetics and kinetics of different day to day reactions and constructing the phase diagram which of fundamental research interest. **(Cognitive level: Analyze, evaluate and create)**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 | CLO 5 |
|---|---|---|---|---|---|
| **PLO29.** | **3** | **3** | **2** | **2** | **2** |
| **PLO30.** | **3** | **3** | **2** | **2** | **2** |
| **PLO31.** | **3** | **3** | **2** | **2** | **2** |
| **PLO32.** | **2** | **3** | **3** | **3** | **2** |
| **PLO33.** | **2** | **2** | **3** | **3** | **3** |
| **PLO34.** | **2** | **2** | **2** | **2** | **3** |
| **PLO35.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 37.** | **3** | **3** | **2** | **2** | **2** |
| **PSO 38.** | **3** | **3** | **2** | **2** | **2** |
| **PSO 39.** | **3** | **3** | **3** | **3** | **2** |
| **PSO 40.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 41.** | **2** | **2** | **3** | **3** | **3** |
| **PSO 42.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 43.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 44.** | **2** | **2** | **2** | **2** | **2** |
| **PSO 45.** | **2** | **2** | **2** | **2** | **2** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

## CHG-C TH: Course contents

**Credits: 4, Hours: 60**

**Unit I: Chemical Energetics (10 Lectures)**

Review of thermodynamics and the Laws of Thermodynamics. Important principles and definitions of thermochemistry. Concept of standard state and standard enthalpies of formations, integral and differential enthalpies of solution and dilution. Calculation of bond energy, bond dissociation energy and resonance energy from thermochemical data. Variation of enthalpy of a reaction with temperature – Kirchhoff's equation. Statement of Third Law of thermodynamics and calculation of absolute entropies of substances.

**Unit II: Chemical Equilibrium (12 Lectures)**

Free energy change in a chemical reaction. Thermodynamic derivation of the law of chemical equilibrium. Distinction between $\Delta G$ and $\Delta G^o$ , Le Chatelier's principle. Relationships between Kp, Kc and Kx for reactions involving ideal gases. (8 Lectures) Ionic Equilibria: Strong, moderate and weak electrolytes, degree of ionization, factors affecting degree of ionization, ionization constant and ionic product of water. Ionization of weak acids and bases, pH scale, common ion effect. Salt hydrolysis-calculation of hydrolysis constant, degree of hydrolysis and pH for different salts. Buffer solutions. Solubility and solubility product of sparingly soluble salts – applications of solubility product principle.

**Unit III: Solutions and Phase Equilibria (16 Lectures)**

Thermodynamics of ideal solutions: Ideal solutions and Raoult's law, deviations from Raoult's law – non-ideal solutions. Vapour pressure-composition and temperature composition curves of ideal and non-ideal solutions. Distillation of solutions. Lever rule. Azeotropes. Partial miscibility of liquids: Critical solution temperature; effect of impurity on partial miscibility of liquids. Immiscibility of liquids- Principle of steam distillation. Nernst distribution law and its applications, solvent extraction.

Phase Equilibria Phases, components and degrees of freedom of a system, criteria of phase equilibrium. Gibbs Phase Rule and its thermodynamic derivation. Derivation of Clausius – Clapeyron equation and its importance in phase equilibria. Phase diagrams of one-component systems (water and sulphur) and two component systems involving eutectics, congruent and incongruent melting points (lead-silver, $FeCl_3$-$H_2O$ and Na-K only).

**Unit IV: Conductance and Electrochemistry (14 Lectures)**

Conductance Conductivity, equivalent and molar conductivity and their variation with dilution for weak and strong electrolytes. Kohlrausch law of independent migration of ions. Transference number and its experimental determination using Hittorf and Moving boundary methods. Ionic mobility. Applications of conductance measurements: determination of degree of ionization of weak electrolyte, solubility and solubility products of sparingly soluble salts, ionic product of water, hydrolysis constant of a salt. Conductometric titrations (only acid-base).

Electrochemistry Reversible and irreversible cells. Concept of EMF of a cell. Measurement of EMF of a cell. Nernst equation and its importance. Types of electrodes. Standard electrode potential. Electrochemical series. Thermodynamics of a reversible cell, calculation of thermodynamic properties: $\Delta G$, $\Delta H$ and $\Delta S$ from EMF data. Calculation of equilibrium constant from EMF data. Concentration cells with transference and without transference. Liquid junction potential and salt bridge. pH determination using hydrogen electrode and quinhydrone electrode. Potentiometric titrations -qualitative treatment (acid-base and oxidation-reduction only).

## CHG-C PR: Course contents
## Credits: 02, Lab. hours: 60

**(I) Thermochemistry**

a) Determination of heat capacity of calorimeter for different volumes.
b) Determination of enthalpy of neutralization of hydrochloric acid with sodium hydroxide.
c) Determination of enthalpy of ionization of acetic acid.
d) Determination of integral enthalpy of solution of salts ($KNO_3$, $NH_4Cl$).
e) Determination of enthalpy of hydration of copper sulphate.
f) Study of the solubility of benzoic acid in water and determination of $\Delta H$.

**(II) pH measurement**

a) Measurement of pH of different solutions like aerated drinks, fruit juices, shampoos and soaps (use dilute solutions of soaps and shampoos to prevent damage to the glass electrode) using pH-meter.
b) Preparation of buffer solutions: (i) Sodium acetate-acetic acid (ii) Ammonium chloride-ammonium hydroxide Measurement of the pH of buffer solutions and comparison of the values with theoretical values.

**(III) Phase equilibria**

a) Construction of the phase diagram of a binary system (simple eutectic) using cooling curves.
b) Determination of the critical solution temperature and composition of the phenol water system and study of the effect of impurities on it.
c) Study of the variation of mutual solubility temperature with concentration for the phenol water system and determination of the critical solubility temperature.
d) Study of the equilibrium of one of the following reactions by the distribution method:

$$I_2(aq) + I(aq) \longrightarrow I_3^-(aq)$$

$$Cu^{2+}(aq) + xNH_2(aq) \longrightarrow [Cu(NH_3)x]^{2+}$$

**(IV) Conductivity**

a) Determination of cell constant
b) Determination of equivalent conductance, degree of dissociation and dissociation constant of a weak acid.
c) Perform the following conductometric titrations
1) Strong acid vs. strong base
2) Weak acid vs. strong base

**(V) Perform the following potentiometric titrations:**

a) Strong acid vs. strong base
b) Weak acid vs. strong base
c) Potassium dichromate vs. Mohr's salt Section

**Reference Books (Theory):**


a. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
b. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
c. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry, Cengage Learning India Pvt. Ltd.: New Delhi (2009).
d. Mahan, B.H. University Chemistry, 3rd Ed. Narosa (1998).
e. Petrucci, R.H. General Chemistry, 5th Ed., Macmillan Publishing Co.: New York (1985).


**Reference Books (Practicals):**


- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).

**Teaching Learning Process:**

- The teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Problem-solving to enhance comprehension.

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations by individual student/ small group of students, assignments, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab

**Keywords:** Thermochemistry, enthalpy, entropy, Le Chatelier's principle, buffer, solubility product, Raoult's law, Azeotropes, Clausius – Clapeyron equation, Transference number, Liquid junction potential and salt bridge, pH, Phase equilibria, conductometric and potentiometric titrations, degree of dissociation and dissociation constant.

**SEMESTER I**

**PAPER CODE: CHG-D TH**

**PAPER TITLE: STATES OF MATTER & CHEMICAL KINETICS, TRANSITION METALS AND BIORGANIC CHEMISTRY**

**Total Credits: 06 - (CHG-D TH -04, CHG-D PR -02)**

**Total Lectures: CHG-D TH - 60, CHG-D PR -60**

## Objectives:

In this course Students learn about organometallic compounds and bioinorganic chemistry which are currently frontier areas of chemistry providing an interface between organic chemistry, inorganic Chemistry and biology. Study of classification of organometallic compounds, the concept of hapticity and the 18-electron rule governing the stability of a wide variety of organometallic species, basic concepts: metal carbonyls, metal alkyls, Zeise's salt and ferrocene will be taken up. The student will be acquainted with importance of inorganic chemical species, especially metals, in biological systems, through discussions on metal-containing enzymes, the sodium-potassium pump and the applications of iron in physiology, including iron transport and storage system. The student will also learn about the reaction rate, order, activation energy and theories of reaction rates

## Course Learning Objectives:

**On completion of the course, the student will be able to:**

1. Gain insight into the chemistry and applications of transition metals, their oxidation states and important properties **(Cognitive level: Remember and understand)**
2. Define rate of reactions and the factors that affect the rates of reaction. **(Cognitive level: Remember and understand)**
3. Understand the concept of rate laws e.g., order, molecularity, half-life and their determination **(Cognitive level: Understand and apply)**
4. Explain the use of chelating agents in medicine and, specifically, the role of cisplatin in cancer therapy and explain the applications of iron in biological systems with particular reference to haemoglobin, myoglobin, ferritin and transferrin (**Cognitive level: Understand and apply)**
5. Diagrammatically explain the working of the sodium-potassium pump in organisms and the factors affecting it and understand and describe the active sites and action cycles of the metalloenzymes carbonic anhydrase and carboxypeptidase **(Cognitive level: Understand and apply)**
6. Apply various theories of reaction rates to experimental observations. **(Cognitive level: Understand and apply)**
7. Determine kinetics of different reactions.**(Cognitive level: Analyze and evaluate)**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 | CLO 5 |
|---|---|---|---|---|---|
| **PLO36.** | **3** | **3** | **2** | **2** | **2** |
| **PLO37.** | **3** | **3** | **2** | **2** | **2** |
| **PLO38.** | **3** | **3** | **2** | **2** | **2** |
| **PLO39.** | **2** | **3** | **3** | **3** | **2** |
| **PLO40.** | **2** | **2** | **3** | **3** | **3** |
| **PLO41.** | **2** | **2** | **2** | **2** | **3** |
| **PLO42.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 46.** | **3** | **3** | **2** | **2** | **2** |
| **PSO 47.** | **3** | **3** | **2** | **2** | **2** |
| **PSO 48.** | **3** | **3** | **3** | **3** | **2** |
| **PSO 49.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 50.** | **2** | **2** | **3** | **3** | **3** |
| **PSO 51.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 52.** | **2** | **2** | **2** | **2** | **3** |
| **PSO 53.** | **2** | **2** | **2** | **2** | **2** |
| **PSO 54.** | **2** | **2** | **2** | **2** | **2** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

## CHG-D TH: Course contents

**Credits: 4,** **Hours: 60**

**Unit I: Chemistry of 3d metals and Organometallic Compounds (15 Hours)**

Oxidation states displayed by Cr, Fe, Co, Ni and Co. A study of the following compounds (including preparation and important properties); Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$, $Na_3[Co(NO_2)_6$. Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies).

**Unit II: Bio-Inorganic Chemistry and Kinetic Theory of Gases**: **(15 Lectures)**

A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to Na+ , K+ and Mg2+ ions: Na/K pump; Role of Mg2+ ions in energy production and chlorophyll. Role of Ca2+ in blood clotting, stabilization of protein structures and structural role (bones). Postulates of Kinetic Theory of Gases and derivation of the kinetic gas equation. Deviation of real gases from ideal behaviour, compressibility factor, causes of deviation. van der Waals equation of state for real gases. Boyle temperature (derivation not required). Critical phenomena, critical constants and their calculation from van der Waals equation. Andrews isotherms of CO2. Maxwell Boltzmann distribution laws of molecular velocities and molecular energies (graphic representation – derivation not required) and their importance. Temperature dependence of these distributions. Most probable, average and root mean square velocities (no derivation). Collision cross section, collision number, collision frequency, 88 collision diameter and mean free path of molecules. Viscosity of gases and effect of temperature and pressure on coefficient of viscosity (qualitative treatment only).

**Unit III: Liquids and solids** **(15 Lectures)**

Surface tension and its determination using stalagmometer. Viscosity of a liquid and determination of coefficient of viscosity using Ostwald viscometer. Effect of temperature on surface tension and coefficient of viscosity of a liquid (qualitative treatment only). Symmetry elements, unit cells, crystal systems, Bravais lattice types and identification of lattice planes. Laws of Crystallography - Law of constancy of interfacial angles, Law of rational indices. Miller indices. X–Ray diffraction by crystals, Bragg's law. Structures of NaCl, KCl and CsCl (qualitative treatment only). Defects in crystals. Glasses and liquid crystals.

**Unit IV: Chemical Kinetics**

The concept of reaction rates. Effect of temperature, pressure, catalyst and other factors on reaction rates. Order and molecularity of a reaction. Derivation of integrated rate equations for zero, first and second order reactions (both for equal and unequal concentrations of reactants). Half–life of a reaction. General methods for determination of order of a reaction. Concept of activation energy and its calculation from Arrhenius equation. Theories of Reaction Rates: Collision theory and Activated Complex theory of bimolecular reactions. Comparison of the two theories (qualitative treatment only). (15 hours)

## BCH-DSE PR: Course contents

**Credits: 02, Hours: 60**

1. Surface tension measurement (use of organic solvents excluded).
   a) Determination of the surface tension of a liquid or a dilute solution using a stalagmometer.
   b) Study of the variation of surface tension of a detergent solution with concentration.
2. Viscosity measurement (use of organic solvents excluded).
   a) Determination of the relative and absolute viscosity of a liquid or dilute solution using an Ostwald's viscometer.
   b) Study of the variation of viscosity of an aqueous solution with concentration of solute.
3. Chemical Kinetics Study the kinetics of the following reactions.
4. Iodide-persulphate reaction
5. Acid hydrolysis of methyl acetate with hydrochloric acid.
6. Saponification of ethyl acetate.
7. Compare the strengths of HCl and $H_2SO_4$ by studying kinetics of hydrolysis of methyl acetate

**Reference Books (Theory):**


1. Barrow, G.M. Physical Chemistry Tata McGraw-Hill (2007).
2. Castellan, G.W. Physical Chemistry 4th Ed. Narosa (2004).
3. Kotz, J.C., Treichel, P.M. & Townsend, J.R. General Chemistry Cengage Learning India Pvt. Ltd., New Delhi (2009).
4. Mahan, B.H. University Chemistry 3rd Ed. Narosa (1998).
5. Petrucci, R.H. General Chemistry 5th Ed. Macmillan Publishing Co.: New York (1985).
6. Cotton, F.A. & Wilkinson, G. Basic Inorganic Chemistry, Wiley.
7. Shriver, D.F. & Atkins, P.W. Inorganic Chemistry, Oxford University Press.
8. Wulfsberg, G. Inorganic Chemistry, Viva Books Pvt. Ltd.
9. Rodgers, G.E. Inorganic & Solid State Chemistry, Cengage Learning India Ltd., 2008. 89


**Reference Books (Practicals):**


- Svehla, G. Vogel's Qualitative Inorganic Analysis, Pearson Education, 2012.
- Mendham, J. Vogel's Quantitative Chemical Analysis, Pearson, 2009.
- Khosla, B. D.; Garg, V. C. & Gulati, A. Senior Practical Physical Chemistry, R. Chand & Co.: New Delhi (2011).


**Teaching Learning Process:**

- The teaching Learning Process for the course is visualized as largely student-focused.
- Transaction through an intelligent mix of conventional and modern methods.
- Engaging students in cooperative learning.
- Problem-solving to enhance comprehension.

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations by individual student/ small group of students, assignments, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning of theoretical concepts and practical skills acquired in the lab


**Keywords:** Viscosity, organometallic Compounds; carbonyls; 18-electron rule; synergic bonding; metal alkyls; ferrocene; Bioinorganic Chemistry; sodium-potassium pump; carboxypeptidase; carbonic anhydrase; haemoglobin, myoglobin; trace metals; metal toxicity

## PAPER CODE: CHG-E

## PAPER TITLE: FUNCTIONAL 000000000000000ORGANIC GROUP CHEMISTRY, POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY

**Total Credits: 06 - (CHG-E TH -04, CHG-EPR -02)**

**Total Lectures: CHG-E TH - 60, CHG-E PR -60**

### Objectives:

The course "Functional Organic Group Chemistry, Polynuclear Hydrocarbons And UV, IR Spectroscopy"is designed to strengthen the basic and fundamental concepts of organic functional groups and their spectroscopic analysis. The course is permeated with the preparation, physical and chemical properties of carboxylic acids, amines, diazonium salts and amino acids. The course also comprises of the basic chemistry of peptides, proteins and carbohydrates, polynuclear & heteronuclear aromatic compounds and application of spectroscopy to simple organic molecules.

### Course Learning Objectives:

**On completion of the course, the student will be able to:**

**CLO 1** Recapitulate the basic concepts of organic functional groups and polynuclear Hydrocarbons. (Cognitive level: Revise/Recap).

**CLO 2** Learn and understand the preparation and chemical properties of carboxylic acids and their derivatives. (Cognitive level: Learn and Understand).

**CLO 3** Learn and understand the chemistry of amines and diazonium salts; their preparation, physical and chemical properties including reactions involved in functional group transformations. (Cognitive level: Learn and Understand).

**CLO 4** Learn and understand the chemistry of amino acids, peptides, proteins and carbohydrates. Understand the primary, secondary, tertiary and quaternary Structure of proteins. Determine the primary structure of peptides.

**CLO 5** Learn and understand the properties of polynuclear and heteronuclear aromatic compounds with reference to electrophilic and nucleophilic substitution.

**CLO 6** Understand the application of visible, ultraviolet and infrared spectroscopy in organic molecules. Apply these spectroscopic methods in functional group detection of organic compounds. Practically Differentiate a reducing and a nonreducing sugar & Separate amino acids by paper chromatography. Practically perform the qualitative Organic analysis of organic compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and confirm the same by preparation of one derivative.

**Mapping of CLOs with PLOS**

| | CLO1 | CLO 2 | CLO 3 | CLO 4 | CLO 5 | CLO 6 |
|---|---|---|---|---|---|---|
| **PLO1.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO2.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO3.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PLO4.** | **2** | **3** | **3** | **2** | **2** | **2** |
| **PLO5.** | **2** | **2** | **3** | **3** | **2** | **2** |
| **PLO6.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PLO7.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 1.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO 2.** | **3** | **3** | **2** | **2** | **2** | **2** |
| **PSO 3.** | **3** | **3** | **3** | **2** | **2** | **2** |
| **PSO 4.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 5.** | **2** | **2** | **3** | **3** | **2** | **2** |
| **PSO 6.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 7.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 8.** | **2** | **2** | **2** | **2** | **3** | **3** |
| **PSO 9.** | **2** | **2** | **2** | **2** | **3** | **3** |

**3: High-level mapping, 2 - Medium-level mapping, 1 -Low-level mapping.**

**PAPER CODE: CHG-ETH**
**TITLE: FUNCTIONAL ORGANIC GROUP CHEMISTRY, POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY**
**(04 credits)**

Theory: 60 Lectures

**Unit I Functional group approach (12 Lectures)**

The following reactions (preparations & reactions) to be studied in context to the structure.
Carboxylic acids and their derivatives Carboxylic acids (aliphatic and aromatic) Preparation: Acidic and Alkaline hydrolysis of esters. Reactions: Hell – Vohlard - Zelinsky Reaction. Carboxylic acid derivatives (aliphatic): (Upto 5 carbons) Preparation: Acid chlorides, Anhydrides, Esters and Amides from acids and their interconversion. Reactions: Comparative study of nucleophilicity of acyl derivatives. Reformatsky Reaction, Perkin condensation.

Amines and Diazonium Salts Amines (Aliphatic and Aromatic): (Upto 5 carbons) Preparation: from alkyl halides, Gabriel's Phthalimide synthesis, Hofmann Bromamide reaction. Reactions: Hofmann vs. Saytzeff elimination, Carbylamine test, Hinsberg test, with HNO2, Schotten – Baumann Reaction. Electrophilic substitution (case aniline): nitration, bromination, sulphonation. Diazonium salts: Preparation: from aromatic amines. Reactions: conversion to benzene, phenol, dyes.

**Unit II: Amino Acids, Peptides, Proteins and carbohydrates (18 Lectures)**

Preparation of Amino Acids: Strecker synthesis using Gabriel's phthalimide synthesis. Zwitterion, Isoelectric point and Electrophoresis. Reactions of Amino acids: ester of –COOH group, acetylation of –NH2 group, complexation with Cu2+ ions, ninhydrin test. Overview of Primary, Secondary, Tertiary and Quaternary Structure of proteins. Determination of Primary structure of Peptides by degradation Edmann degradation (Nterminal) and C–terminal (thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (t-butyloxycarbonyl and phthaloyl) & Cactivating groups and Merrifield solid-phase synthesis.

**Carbohydrates:** Classification, and General Properties, Glucose and Fructose (open chain and cyclic structure), Determination of configuration of monosaccharides, absolute configuration of Glucose and Fructose, Mutarotation, ascending and descending in monosaccharides. Structure of disacharrides (sucrose, cellobiose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

**Unit III: Polynuclear and heteronuclear aromatic compounds: (12 Lectures)**

Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Naphthalene, Anthracene, Furan, Pyrrole, Thiophene, and Pyridine. (6 Lectures) Active methylene compounds: Preparation: Claisen ester condensation. Keto-enol tautomerism. Reactions: Synthetic uses of ethylacetoacetate (preparation of non-heteromolecules having upto 6 carbon).

**Unit IV: Application of Spectroscopy to Simple OrganicMolecules (18 Lectures)**

Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiation, electronic transitions, λmax & εmax, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating λmax of conjugated dienes and α,β – unsaturated compounds. Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes,

ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions).

**Reference books**


- I.L. Finar: Organic Chemistry (Vol. I & II), E.L.B.S.
- John R. Dyer: Applications of Absorption Spectroscopy of Organic Compounds, Prentice Hall.
- R.M. Silverstein, G.C. Bassler & T.C. Morrill: Spectroscopic Identification of Organic Compounds, John Wiley & Sons. • R.T. Morrison & R.N. Boyd: Organic Chemistry, Prentice Hall.
- Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
- Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.

**PAPER CODE: CHG-E PR**
**TITLE: FUNCTIONAL ORGANIC GROUP CHEMISTRY, POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY**

**(02 credits)**

1. Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.
2. Separation of amino acids by paper chromatography
3. Determination of the concentration of glycine solution by formylation method.
4. Titration curve of glycine
5. Action of salivary amylase on starch
6. Effect of temperature on the action of salivary amylase on starch.
7. Differentiation between a reducing and a nonreducing sugar.

**Reference Books:**


- A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
- A.I. Vogel: Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
- Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
- Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.


**Teaching Learning Process:**

- Lectures in classrooms
- Peer learning
- Hands-on learning using lab practicals, videos, presentations, seminars
- Technology-driven Learning

**Assessment Methods:**

- Continuous Evaluation: by monitoring the progress of student's learning
  - Class Tests, Worksheets and Quizzes
  - Presentations, assignments, Group dscussions, projects, viva-voce to enhance critical thinking skills and personality
- Semester-end Examination: a critical indicator of student's learning and teaching methods adopted by teachers throughout the semester.

**Keywords:**

Carboxylic acids, Amines, Diazonium Salts, Amino Acids, Peptides, Proteins and carbohydrates Polynuclear and heteronuclear aromatic compounds, IR, UV-Visible spectroscopy

**SEMESTER V**
**DISCIPLINE SPECIFIC ELECTIVE (PRACTICAL) COURSE**
**SEMESTER V TOTAL HOURS: 60HRS CREDIT :04**
**PAPER CODE: CHG-F TH**
**TITLE: ORGANOMETALLICS, BIOINORGANIC CHEMISTRY, POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY**

**Objectives:**
Students develop the ability to effectively communicate scientific information and research results in written and oral form. Students learn the laboratory skills needed to design, safely conduct, and interpret chemical research. The primary goal of qualitative research is to provide a complete and detailed description of the experimentation.

**Course Learning objectives:**
On completion of this course the students will be able to:
CLO 1 To acquire knowledge theories and concepts for the classification of essential metals and understand the essence of key metals and their role in biological systemsand learn the concept of separation and its applications in chemical synthesis. (**learn and apply**)
CLO 2 Understanding Organometallic Compounds their Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. (**Memorise and classify**)
CLO 3 To get an idea about the chemical synthesis and reactions of involving some important metal around us. The nature of bonds and their abundance in inorganic complexes Understanding of biological roles of metals as prosthetic groups. (**understand and apply**)
CLO 4 Various Methods for preparing Polynuclear and heteronuclear aromatic compounds and their classification on the basis of source and strutcutres: (**understand and apply**)
**CLO 5** To get an idea about the chemical synthesis and reactions associated with transition metal and organometallic compound as catalyst and understanding their close proximity with enzymes in terms of mechanism. (**understand, apply, record**)
**CLO 6** To learn the interface between organic, inorganic and analytical chemistry. Application of Spectroscopy to Simple Organic Molecules. (**understand, apply and record**)

**Mapping of CLOs with PLOs**

| | CLO-1 | CLO-2 | CLO-3 | CLO-4 | CLO-5 | CLO-6 |
|---|---|---|---|---|---|---|
| **PLO1.** | **3** | **3** | **3** | **2** | **2** | **2** |
| **PLO2.** | **2** | **3** | **3** | **3** | **2** | **3** |
| **PLO3.** | **1** | **2** | **3** | **3** | **3** | **3** |
| **PLO4.** | **1** | **1** | **2** | **3** | **3** | **3** |
| **PLO5.** | **1** | **1** | **1** | **2** | **2** | **2** |
| **PLO6.** | **1** | **1** | **1** | **1** | **2** | **3** |
| **PLO7.** | **1** | **1** | **1** | **1** | **2** | **3** |
| **PSO 1.** | **3** | **3** | **3** | **2** | **2** | **2** |
| **PSO 2.** | **2** | **3** | **3** | **2** | **2** | **3** |
| **PSO 3.** | **2** | **2** | **3** | **3** | **3** | **3** |
| **PSO 4.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 5.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 6.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 7.** | **2** | **2** | **2** | **3** | **3** | **3** |
| **PSO 8.** | **1** | **2** | **2** | **3** | **3** | **3** |
| **PSO 9.** | **1** | **1** | **2** | **3** | **3** | **3** |

**Teaching Learning Process:**

1. The teaching Learning Progression for the course is student centric
2. Intelligent mix of conventional and modern methods is opted both through whiteboard and education animations using available free computational tools.
3. Engaging students in cooperative and synergistic learning.

**Assessment Methods:**

1. Continuous Evaluation: by monitoring the progress of students' learning.
2. Class Tests, Worksheets.
3. Assignments, and projects, to enhance critical thinking skills and personality.
4. Semester-end Examination: a critical indicator of students' learning of theoretical concepts

**Keywords:**

**PAPER CODE: CHG-F TH**
**TITLE: ORGANOMETALLICS, BIOINORGANIC CHEMISTRY, POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY**
**(Credits: Theory-04, Practicals-02)**

**Theory: 60 Lectures**

**Section A: Inorganic Chemistry-3 (30 Lectures)**

**Unit 1 (18Hours)**

Chemistry of 3d metals Oxidation states displayed by Cr, Fe, Co, Ni and Co. A study of the following compounds (including preparation and important properties); Peroxo compounds of Cr, $K_2Cr_2O_7$, $KMnO_4$, $K_4[Fe(CN)_6]$, sodium nitroprusside, $[Co(NH_3)_6]Cl_3$, $Na_3[Co(NO_2)_6]$. (6 Lectures)

Organometallic Compounds Definition and Classification with appropriate examples based on nature of metal-carbon bond (ionic, s, p and multicentre bonds). Structures of methyl lithium, Zeiss salt and ferrocene. EAN rule as applied to carbonyls. Preparation, structure, bonding and properties of mononuclear and polynuclear carbonyls of 3d metals. p-acceptor behaviour of carbon monoxide. Synergic effects (VB approach)- (MO diagram of CO can be referred to for synergic effect to IR frequencies). (12 Lectures)

**Unit II (12 Hours)**

Bio-Inorganic Chemistry A brief introduction to bio-inorganic chemistry. Role of metal ions present in biological systems with special reference to $Na^+$ , $K^+$ and $Mg^{2+}$ ions: Na/K pump; Role of $Mg^{2+}$ ions in energy production and chlorophyll. Role of $Ca^{2+}$ in blood clotting, stabilization of protein structures and structural role (bones).

**Section B: Organic Chemistry-4 (30 Lectures)**

**Unit III (6Hours)**

Polynuclear and heteronuclear aromatic compounds: 91 Properties of the following compounds with reference to electrophilic and nucleophilic substitution: Naphthalene, Anthracene, Furan, Pyrrole, Thiophene, and Pyridine. (6 Lectures)

Active methylene compounds: Preparation: Claisen ester condensation. Keto-enol tautomerism. Reactions: Synthetic uses of ethylacetoacetate (preparation of non-heteromolecules having upto 6 carbon). (6 Lectures)

**Unit IV (18 Hours)**

Application of Spectroscopy to Simple Organic Molecules Application of visible, ultraviolet and infrared spectroscopy in organic molecules. Electromagnetic radiation, electronic transitions, $\lambda_{max}$ & $\varepsilon_{max}$, chromophore, auxochrome, bathochromic and hypsochromic shifts. Application of electronic spectroscopy and Woodward rules for calculating $\lambda_{max}$ of conjugated dienes and $\alpha,\beta$ – unsaturated compounds. Infrared radiation and types of molecular vibrations, functional group and fingerprint region. IR spectra of alkanes, alkenes and simple alcohols (inter and intramolecular hydrogen bonding), aldehydes, ketones, carboxylic acids and their derivatives (effect of substitution on >C=O stretching absorptions). (18 Lectures)

**Reference Books:**


1. James E. Huheey, Ellen Keiter & Richard Keiter: Inorganic Chemistry: Principles of Structure and Reactivity, Pearson Publication.
2. G.L. Miessler & Donald A. Tarr: Inorganic Chemistry, Pearson Publication.
3. J.D. Lee: A New Concise Inorganic Chemistry, E.L.B.S.
4. F.A. Cotton & G. Wilkinson: Basic Inorganic Chemistry, John Wiley & Sons.
5. I.L. Finar: Organic Chemistry (Vol. I & II), E.L.B.S.
6. John R. Dyer: Applications of Absorption Spectroscopy of Organic Compounds, Prentice Hall.
7. R.M. Silverstein, G.C. Bassler & T.C. Morrill: Spectroscopic Identification of Organic Compounds, John Wiley & Sons.
8. R.T. Morrison & R.N. Boyd: Organic Chemistry, Prentice Hall.
9. Peter Sykes: A Guide Book to Mechanism in Organic Chemistry, Orient Longman.
10. Arun Bahl and B. S. Bahl: Advanced Organic Chemistry, S. Chand.

# Semester V
# Discipline specific elective (practical) course

**Semester V** **Total hours: 60hrs** **Credit :02**

## PAPER CODE: CHG-F PR

## TITLE: ORGANOMETALLICS, BIOINORGANIC CHEMISTRY, POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY

**Objectives:**

Students develop the ability to effectively communicate scientific information and research results in written and oral form. Students learn the laboratory skills needed to design, safely conduct, and interpret chemical research. The primary goal of qualitative research is to provide a complete and detailed description of the experimentation. Students will be able to lean the basics techniques to analyze the purity of the organic molecules and to understand theretention factor in chromatography. In addition basic stains used for the detection of amino acids and sugars would be studied, prepared and utilized. Students would be able to learn qualitative test for determining simple organic molecules by exploiting the functional group chemistry. To learn the concept of structural and reactivity aspects in designing test for aldoses, ketose and mono and disaccharides.

**Course Learning objectives:**

On completion of this course the students will be able to:

CLO 7 To acquire knowledge on using chromatography methods for the detections and separation of essential metals and understand the essence and learn the concept of separation and its applications in chemical synthesis. (understand and apply)

CLO 8 To get an idea about the chemical synthesis and reactions of involving some important important metal around us (understand, apply, record)

**CLO 9** To get an idea about the chemical synthesis and reactions of condensation and rearrangement relations. To learn derivatizations of general functional groups (like OH, NH2, CHO, C=O, COOH and dicarboxylic acids. (**understand, apply, record**)

**CLO 10** To learn the interface between organic, inorganic and analytical chemistry in isolation process, property analysis and functional group modification key molecules molecules. (**understand, apply and record**)

**Mapping of CLOs with PLOs**

| | CLO-1 | CLO-2 | CLO-3 | CLO-4 |
|---|---|---|---|---|
| **PLO1.** | **3** | **3** | **3** | **2** |
| **PLO2.** | **2** | **3** | **3** | **3** |
| **PLO3.** | **1** | **2** | **3** | **3** |
| **PLO4.** | **1** | **1** | **2** | **3** |
| **PLO5.** | **1** | **1** | **1** | **2** |
| **PLO6.** | **1** | **1** | **1** | **1** |
| **PLO7.** | **1** | **1** | **1** | **1** |
| **PSO 1.** | **3** | **3** | **3** | **2** |
| **PSO 2.** | **2** | **3** | **3** | **3** |
| **PSO 3.** | **2** | **2** | **3** | **3** |
| **PSO 4.** | **2** | **2** | **2** | **3** |
| **PSO 5.** | **2** | **2** | **2** | **3** |
| **PSO 6.** | **2** | **2** | **2** | **3** |
| **PSO 7.** | **2** | **2** | **2** | **3** |
| **PSO 8.** | **1** | **2** | **2** | **3** |
| **PSO 9.** | 1 | 1 | 2 | 3 |

**Teaching Learning Process:**

4. The teaching Learning Progression for the course is student centric
5. Intelligent mix of conventional and modern methods is opted both through whiteboard and education animations using available free computational tools.
6. Engaging students in cooperative and synergistic learning.

**Assessment Methods:**

5. Continuous Evaluation: by monitoring the progress of students' learning.
6. Class Tests, Worksheets.
7. Assignments, and projects, to enhance critical thinking skills and personality.
8. Semester-end Examination: a critical indicator of students' learning of theoretical concepts

**Keywords:**

## PAPER CODE: CHG-F PR
## TITLE: ORGANOMETALLICS, BIOINORGANIC CHEMISTRY, POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY

**LAB 60 Lectures**

**Section A: Inorganic Chemistry**

1. Separation of mixtures by chromatography: Measure the Rf value in each case. (Combination of two ions to be given) 92 Paper chromatographic separation of Fe3+, A13+ and Cr3+ or Paper chromatographic separation of Ni2+, Co2+, Mn2+ and Zn2+
2. Preparation of any two of the following complexes and measurement of their conductivity:
   a) Tetraamminecarbonatocobalt (III) nitrate
   b) Tetraamminecopper (II) sulphate
   c) Potassium trioxalatoferrate (III) trihydrate

Compare the conductance of the complexes with that of M/1000 solution of NaCl, MgCl2 and LiCl3.

**Section B: Organic Chemistry**

Systematic Qualitative Organic Analysis of Organic Compounds possessing monofunctional groups (-COOH, phenolic, aldehydic, ketonic, amide, nitro, amines) and preparation of one derivative.

### Reference Books:


1. A.I. Vogel: Qualitative Inorganic Analysis, Prentice Hall, 7th Edn.
2. A.I. Vogel: Quantitative Chemical Analysis, Prentice Hall, 6th Edn.
3. Vogel, A.I., Tatchell, A.R., Furnis, B.S., Hannaford, A.J. & Smith, P.W.G., Textbook of Practical Organic Chemistry, Prentice-Hall, 5th edition, 1996.
4. Mann, F.G. & Saunders, B.C. Practical Organic Chemistry Orient-Longman, 1960.

## PAPER CODE: CHG-G TH
## TITLE: MOLECULES OF LIFE

(Credits: Theory-04, Practicals-02)

**Theory: 60 Lectures**

**Unit I Carbohydrates (10 Lectures)**

Classification of carbohydrates, reducing and non-reducing sugars, General properties of glucose and fructose, their open chain structure. Epimers, mutarotation and anomers. Determination of configuration of Glucose (Fischer proof). Cyclic structure of glucose. Haworth projections. Cyclic structure of fructose. Linkage between monosachharides, structure of disacharrides (sucrose, maltose, lactose) and polysacharrides (starch and cellulose) excluding their structure elucidation.

**Unit II Amino Acids, Peptides and Proteins (12 Lectures)**

Classification of Amino Acids, Zwitterion structure and Isoelectric point. Overview of Primary, Secondary, Tertiary and Quaternary structure of proteins. Determination of primary structure of peptides, determination of N-terminal amino acid (by DNFB and Edman method) and C–terminal amino acid (by thiohydantoin and with carboxypeptidase enzyme). Synthesis of simple peptides (upto dipeptides) by N-protection (tbutyloxycarbonyl and phthaloyl) & C-activating groups and Merrifield solid phase synthesis.

**Unit III Enzymes and correlation with drug action (12 Lectures)**

Mechanism of enzyme action, factors affecting enzyme action, Coenzymes and cofactors and their role in biological reactions, Specificity of enzyme action (including stereospecificity), Enzyme inhibitors and their importance, phenomenon of inhibition(Competitive and Noncompetitive inhibition including allosteric inhibition). Drug action-receptor theory. Structure –activity relationships of drug molecules, binding role of –OH group,-NH2 group, double bond and aromatic ring.

**Unit IV Nucleic Acids (10 Lectures)**

Components of nucleic acids: Adenine, guanine, thymine and Cytosine (Structure only), other components of nucleic acids, Nucleosides and nucleotides (nomenclature), Structure of polynucleotides; Structure of DNA (Watson-Crick model) and RNA (types of RNA), Genetic Code, Biological roles of DNA and RNA: Replication, Transcription and Translation.

**Unit V Lipids, Concept of Energy in Biosystems (8 Lectures)**

Lipids Introduction to lipids, classification. Oils and fats: Common fatty acids present in oils and fats, Omega fatty acids, Trans fats, Hydrogenation, Saponification value, Iodine number. Biological importance of triglycerides, phospholipids, glycolipids, and steroids (cholesterol). (8 Lectures)

Calorific value of food. Standard caloric content of carbohydrates, proteins and fats. Oxidation of foodstuff (organic molecules) as a source of energy for cells. Introduction to Metabolism (catabolism, anabolism), ATP: the universal currency of cellular energy, ATP hydrolysis and free energy change. Conversion of food into energy. Outline of catabolic pathways of Carbohydrate- Glycolysis, Fermentation, Krebs Cycle. Overview of catabolic pathways of Fats and Proteins. Interrelationships in the metabolic pathways of Proteins, Fats and Carbohydrates.

### Recommended Texts:


1. Morrison, R. T. & Boyd, R. N. Organic Chemistry, Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
2. Finar, I. L. Organic Chemistry (Volume 1), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
3. Finar, I. L. Organic Chemistry (Volume 2), Dorling Kindersley (India) Pvt. Ltd. (Pearson Education).
4. Nelson, D. L. & Cox, M. M. Lehninger's Principles of Biochemistry 7th Ed., W. H. Freeman.
5. Berg, J.M., Tymoczko, J.L. & Stryer, L. Biochemistry, W.H. Freeman, 2002.

**PAPER CODE: CHG-G PR**
**TITLE: MOLECULES OF LIFE**

**Lab 60 Lectures**

1. Separation of amino acids by paper chromatography
2. To determine the concentration of glycine solution by formylation method.
3. Study of titration curve of glycine
4. Action of salivary amylase on starch
5. Effect of temperature on the action of salivary amylase on starch.
6. To determine the saponification value of an oil/fat.
7. To determine the iodine value of an oil/fat
8. Differentiate between a reducing/ nonreducing sugar.
9. Extraction of DNA from onion/cauliflower
10. To synthesise aspirin by acetylation of salicylic acid and compare it with the ingredient of an aspirin tablet by TLC.

**Recommended Texts:**


1. Furniss, B.S.; Hannaford, A.J.; Rogers, V.; Smith, P.W.G.; Tatchell, A.R. Vogel's Textbook of Practical Organic Chemistry, ELBS.
2. Ahluwalia, V.K. & Aggarwal, R. Comprehensive Practical Organic Chemistry, Universities Press.



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